DOE/LX/07-0108&D1
Primary Document

Site Evaluation Report for Soil Pile I at Paducah Gaseous Diffusion Plant, Paducah, Kentucky

Cleared for Public Release

DOE/LX/07-0108&D1
Primary Document

Site Evaluation Report
for Soil Pile I
at Paducah Gaseous Diffusion Plant,
Paducah, Kentucky

Date Issued—May 2008

Prepared for the
U.S. DEPARTMENT OF ENERGY
Office of Environmental Management

Prepared by
PADUCAH REMEDIATION SERVICES, LLC
managing the
Environmental Remediation Activities at the
Paducah Gaseous Diffusion Plant
under contract DE-AC30-06EW05001

THIS PAGE INTENTIONALLY LEFT BLANK

PREFACE

This *Site Evaluation Report for Soil Pile I at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-0108&D1, (SER) was prepared as a result of implementing the *Sampling and Analysis Plan for Soil Piles at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0015&D2/R1, (DOE 2007a) and associated *Addendum 1-A to the Sampling and Analysis Plan at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-0015/A1&D2/R1.

This SER is the first of four to address soil and rubble pile areas in the vicinity of the Paducah Gaseous Diffusion Plant, as identified in the Notification Letter submitted to U. S Environmental Protection Agency and Kentucky Department for Public Protection, dated February 16, 2007. This SER addresses soil sampling at Soil Pile I located between McCaw Road and Outfall 002 Ditch. It was developed in accordance with the requirement in Section IX of the Federal Facility Agreement for submittal of an integrated removal/remedial Site Evaluation and Solid Waste Management Unit Assessment Report.

THIS PAGE INTENTIONALLY LEFT BLANK

CONTENTS

FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

TABLES

THIS PAGE INTENTIONALLY LEFT BLANK

ACRONYMS

AOC	area of concern
AD	absolute difference
AIP	Agreement in Principle
AL	action level
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
ASER	Annual Site Environmental Report
BJC	Bechtel Jacobs Company LLC
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
COC	contaminant of concern
COPC	chemical of potential concern
CSM	conceptual site model
DOE	U.S. Department of Energy
DOECAP	Department of Energy Consolidated Audit Program
DPT	direct push technology
DQA	data quality assessment
DQO	data quality objective
EDE	effective dose equivalent
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
EU	exposure unit
FFA	Federal Facility Agreement
GPS	global positioning system
GWS	gamma walkover survey
HF	hydrogen fluoride
HI	hazard index
ICP-MS	inductively coupled plasma-mass spectrometer
ISOCS	*In Situ* Object Counting System
KAR	*Kentucky Administrative Regulation*
K_d	sorption coefficient
KDEP	Kentucky Department for Environmental Protection
KPDES	Kentucky Pollutant Discharge Elimination System
LBC	Little Bayou Creek
MARISSM	Multi-Agency Radiological Site Sampling and Investigation Manual
MDA	minimal detectable activity
MDL	method detection limit
MQO	measurement quality objective
MS	matrix spike
MSD	matrix spike duplicate
NA	not applicable
NAL	no action level
ND	nondetect
NIST	National Institute of Standards and Technology
NRC	Nuclear Regulatory Commission
ORPS	Occurrence Reporting and Processing System
OU	operable unit
PAH	polyaromatic hydrocarbon

PCB	polychlorinated biphenyl
PGDP	Paducah Gaseous Diffusion Plant
PPPO	Portsmouth/Paducah Project Office
PRG	Preliminary Remediation Goal
PRS	Paducah Remediation Services, LLC
PSS	Plant Shift Superintendent
QC	quality control
RCRA	Resource Conservation and Recovery Act
RGA	Regional Gravel Aquifer
RME	reasonable maximum exposure
RPD	relative percent difference
SAP	Sampling and Analysis Plan
SER	Site Evaluation Report
SLRA	screening level risk assessment
SRM	standard reference material
SMP	Site Management Plan
SOW	statement of work
STL	Severn Trent Laboratory
SVOC	semivolatile organic compound
SWMU	solid waste management unit
SWOU	Surface Water Operable Unit
TBC	to be considered
TCLP	Toxicity Characteristic Leaching Procedure
TCE	trichloroethene
TSCA	Toxic Substances Control Act
TVA	Tennessee Valley Authority
UCL	upper confidence limit
UHC	underlying hazardous constituent
USEC	United States Enrichment Corporation
UTL	upper tolerance limit
VOA	volatile organic analyte
VOC	volatile organic compound
VSP	Visual Sampling Plan
WKWMA	West Kentucky Wildlife Management Area
XRF	X-ray fluorescence

EXECUTIVE SUMMARY

In November 2006, the U.S. Department of Energy (DOE) identified a number of soil piles outside of the Paducah Gaseous Diffusion Plant (PGDP) industrialized area, with portions showing radioactivity levels greater than twice area background, which has been determined to be 14,000 counts per minute. Following this discovery, DOE undertook a three-phase approach to identify and restrict access to the contaminated soil piles. The phased approach was developed to systematically identify soil piles; determine if access restrictions are required; post and install barriers where elevated radioactivity was identified (i.e., exceeds twice area background); develop a path forward for the characterization of these areas; and plan for future actions. Phase I of the phased approach consisted of identification and posting of contaminated areas adjacent to outfalls or creeks and was completed on December 27, 2006. Phase II consists of the planning and execution of characterization of the soil piles. Phase III will consist of planning and execution of future actions to prevent exposure to contaminated soil, if required (DOE 2007a).

Initial field reconnaissance, field radioactivity measurements, and limited sampling at Soil Pile I were completed in December 2006. Soil Pile I, consisting of about seven acres, represents approximately one percent of the total number of soil piles identified. Results of these efforts showed field radioactivity exceeding twice area background. Based on these findings, an investigation was planned and completed between April and July 2007.

This Site Evaluation Report presents the results of the comprehensive sampling effort completed at Soil Pile I. Sampling and analysis were completed in accordance with the following agency-approved secondary documents:

Sampling and Analysis Plan for Soil Piles at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/LX/07-0015&D2/R1, (SAP) 2007.

Addendum 1-A to the Sampling and Analysis Plan at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/LX/07-0015/A1/&D2/R1, 2007.

PROJECT OBJECTIVES

The principal purpose of the Soil Pile I investigation was to determine if conditions at the site pose an imminent threat to public health, necessitating immediate actions to mitigate threats. Study objectives were developed to support informed decision making. The study was designed to obtain sufficient data of known quality to support the following objectives:

- Establish the nature and extent of contamination of soils in Soil Pile I and adjacent soils, as defined in Section 2.1.
- Establish the mean concentrations of contaminants in soils.
- Determine if soils pose imminent risks to human health.
- Determine if soils contamination exceeds regulatory thresholds.
- If contaminated above regulatory thresholds, determine waste disposition alternatives.

In addition to supporting characterization of soil at Soil Pile I, two objectives were included to aid in evaluating investigative techniques to determine if they might support future investigations at PGDP. These objectives are as follows:

- Evaluate the performance of field measurement techniques to determine their viability for use at other locales at PGDP, and

- Determine if there are chemicals at Soil Pile I that will serve as indicators for other chemicals associated with the PGDP operations.

INVESTIGATION SUMMARY

The following provides the planned sampling activities for Soil Pile I and an accounting of the actual number and types of samples collected. Addendum 1-A to the PGDP Soil Piles SAP specified the collection and analysis of these samples:

- 98 surface samples to undergo field measurements and fixed laboratory analysis
- 577 surface samples to undergo field measurements only
- 106 subsurface samples, where subsurface is defined as soil taken at a depth below 1 ft, to undergo field measurements and fixed laboratory analysis
- 192 subsurface samples to undergo field measurements only
- 5 tree samples for fixed laboratory analysis
- 16 soil samples for analysis to support engineering design of infrastructure removal (e.g., roads)
- A number of contingency samples, as determined by subject matter experts at the time of field activity

During execution of Addendum 1-A, the total number of soil samples collected was as follows:

- 98 surface samples underwent field measurements and fixed laboratory analysis
- 646 surface samples underwent field measurements only
- 51 subsurface samples underwent field measurements and fixed laboratory analysis
- 117 subsurface samples underwent field measurements only
- 5 tree samples for fixed laboratory analysis
- 9 soil samples for analysis to support engineering design of infrastructure removal (e.g., roads)
- 5 contingency surface samples underwent field measurements and fixed laboratory analysis

The differences between planned and actual sample numbers resulted from three factors.

First, the increase in surface field measurements during fieldwork was due to an omission in Table 1 of Addendum 1-A, which did not account for "*additional field measurement samples*" prescribed in the plan. During fieldwork, this omission was identified and these samples were collected to comply with the plan's intent.

Second, the observed differences in subsurface samples result entirely from variations in soil pile height. During planning, the height of Soil Pile I was based on a uniform estimate of 12 ft. Actual field conditions indicate the soil pile height ranges from 2 ft to 12 ft. Because the soil pile height, on average, was less than 8 ft, fewer subsurface samples were required to reach the natural grade.

Third, because there were so few polychlorinated biphenyl (PCB) detections in the subsurface samples and few with detections, planned contingency samples at subsurface locations were not pursued. Instead, contingency samples were collected.

Fourth, the difference in the number of engineering samples was due to fewer required as discussed and agreed upon during scoping meetings held among DOE and its contractors, Kentucky Department for Environmental Protection (KDEP), and U.S. Environmental Protection Agency (EPA) during the summer of 2007.

INVESTIGATON FINDINGS

As part of investigation planning, Soil Pile I was divided into five investigative subunits, as defined in Section 2. Sample results identified a number of constituents in each of the subunits. Comparisons of these concentrations to key benchmark values for PGDP, including background concentrations, no action levels, and the frequency at which each constituent was detected, identified the following as chemicals of potential concern (COPCs) at Soil Pile I.

- **Subunit 1:** antimony, arsenic, beryllium, manganese, uranium, uranium-238, vanadium, cesium-137, and Aroclor-1260.
- **Subunit 2:** antimony, arsenic, beryllium, lead, manganese, and vanadium.
- **Subunit 3:** arsenic, beryllium, uranium, uranium-238, vanadium, and Total PCBs.
- **Subunit 4:** antimony, arsenic, beryllium, iron, uranium, uranium-238, vanadium, and Total PCBs .
- **Subunit 5:** aluminum, antimony, arsenic, barium, beryllium, lead, manganese, vanadium, and cesium-137.

Spatially, the distribution of COPCs is confined to the portion of Soil Pile I that parallels Little Bayou Creek. Localized areas of contamination were noted near the center of the soil pile and at the confluence of Little Bayou Creek and the PGDP Outfall 002 ditch, as described in Section 5. The highest concentrations of COPCs were noted in Soil Pile I surface soils.

Vertical distribution of COPCs corresponds with the spatial distribution noted above, with COPC concentrations decreasing with depth. With few exceptions, concentrations fall below regulatory and risk-based benchmarks in the deepest soil intervals.

SUMMARY OF INVESTIGATION CONCLUSIONS

Nature and Extent of Contamination

Data of known quality were acquired in sufficient quantities to support the development of mean and maximum contaminant concentrations in each investigative subunit. The maximum concentrations were utilized to support quantitative assessment of human health risks, to compare project data with chemical-specific applicable or relevant and appropriate requirements (ARARs), and to allow decision makers to formulate an informed decision as to the need for an action at Soil Pile I, if warranted.

Analysis of the project data identified the minimum and maximum concentrations of contaminants found at the site and in each subunit. The sampling design has successfully identified where contamination is found and has delineated the boundaries of that contamination. The investigation also was successful in identifying localized areas of contamination in the study area that should be considered in developing decisions concerning Soil Pile I. Finally, sufficient data have been acquired to inform decision makers concerning the levels and composition of the contaminants in Soil Pile I.

Assessment of Human Health Risks

The cumulative human health systemic toxicity and excess lifetime cancer risks exceeded the acceptable risk standards as defined by KDEP and EPA and as noted in the Risk Methods Document. The results of the risk assessment indicate that metals were the most important contributors to risk and hazard indices, as identified in Section 6. The metals concentrations/estimates of the mean used to quantify risks and hazards often were less than or equal to published PGDP background levels. When considered without metals, most all of the cumulative risks and hazards are below the standards for all investigative subunits.

Chemical-Specific ARARs

Concentrations of constituents were evaluated against EPA Region 9 Preliminary Remediation Goals (PRGs), as nationally accepted standards, and PGDP background concentrations when applicable for comparison purposes. In surface samples, arsenic and benzo(a)pyrene exceeded the industrial Region 9 PRGs. The 95% upper confidence limit (UCL) concentrations of arsenic exceeded the Region 9 PRG of 1.6 mg/kg in all subunits. Only subunits 2 and 5 with 95% UCL concentrations of 18 mg/kg and 23 mg/kg, respectively, also exceeded the PGDP surface background concentration for arsenic (12 mg/kg) in the PGDP Risk Methods Document. In the case of organic compounds, the maximum detected concentration of benzo(a)pyrene (0.46 mg/kg) in subunit 3 exceeded the Region 9 PRG value of 0.21 mg/kg.

In contingency surface samples, the Region 9 PRGs for arsenic and uranium (200 mg/kg) were exceeded in all 5 samples. The PRG for benzo(a)pyrene was exceeded in 2 of 5 samples and the PRG for Aroclor-1254 (0.74 mg/kg) was exceeded in 4 of 5 contingency samples. The PRG for total chromium (450 mg/kg) was exceeded in 1 of 5 samples.

In subsurface samples, arsenic exceeded the Region 9 PRG of 1.6 mg/kg in all samples collected. Uranium exceeded the Region 9 PRG of 200 mg/kg in 4 of 51 samples: 2 samples collected from subunit 3 at a soil pile depth of 1 to 4 ft; 1 sample collected from subunit 3 at a depth of 4 to 7 ft; and 1 sample collected from subunit 4 at a depth of 1 to 4 ft. Aroclor-1254 was detected in 19 of 51 samples and exceeded the Region 9 PRG of 0.74 mg/kg in 3 samples from subunit 3: 2 samples collected at a depth of 1 to 4 ft; and 1 sample collected at 4 to 7 ft. Benzo(a)pyrene was detected in 4 of 52 subsurface samples and exceeded the PRG of 0.21 mg/kg in 1 sample from subunit 4, collected at a depth of 4 to 7 ft. Dibenz(a,h)anthracene was detected in 1 of 52 samples and exceeded the PRG of 0.21 mg/kg in subunit 4, collected at a depth of 4 to 7 ft. Arsenic, chromium, uranium, Aroclor-1254, benzo(a)pyrene, and dibenz(a,h)anthracene were further evaluated in the screening level risk assessment provided in Section 6.

The results of sampling completed at Soil Pile I show detections for two volatile organic compounds: ethylbenzene (0.9 µg/kg) and m,p-xylene (1.6 µg/kg). Each compound is well below the allowable soil levels in excavated materials to be used for unrestricted off-site purposes: ethylbenzene = 900 µg/kg and total xylene = 5,000 µg/kg, respectively (KDWM 2006). Both also are several orders of magnitude below published PGDP no action limits for child recreator contact with soil/sediment: ethylbenzene = 23,400 µg/kg and total xylene = 2,540,000 µg/kg, respectively (DOE 2001).

PCBs were detected above the Toxic Substances Control Act (TSCA) self-implementing cleanup level for low occupancy levels of 25 mg/kg at only one location. The result was 79 mg/kg with all other results below 15 mg/kg.

Field Method Performance

The following summarizes the examination of field measurement technique effectiveness for use on future projects at PGDP.

Field Grade XRF

The Soil Pile I investigation demonstrates that X-ray fluorescence (XRF) is a quantitative tool that may be used for total uranium and lead during future investigations. It is suitable to deploy for characterization and removal verification at PGDP in the future, when site-specific lead and uranium action limits are greater than the instrument-specific method detection limit.

Field PCB Test Method

A limited population of positive PCB concentrations was available for comparison at Soil Pile I. Only four pairs of samples with detections above the detection limit were available. The method has demonstrated that it can reliably predict the presence of PCBs above 4 ppm; however, the method also exhibited a 6% false positive rate. For purposes of performing initial site screening to determine PCB presence or absence, these two factors together are positive, in that, the method will reliably predict PCBs when they are present at levels approaching TSCA benchmarks of 25 (risk standard) and 50 ppm (TSCA disposal standard).

In Situ Object Counting System

The *In Situ* Object Counting System (ISOCS) used for the Soil Pile I investigation was employed in an *ex situ* manner, meaning it was deployed in a controlled environment, during sample analysis. ISOCS accurately measures gamma-emitting radioisotopes when they are present at levels within its operating range. Evaluation of the method comparing it with laboratory uranium-238 results indicates a strong correlation when laboratory data for uranium-238 is detected above the ISOCS minimum detectable activity range. Method accuracy is sound and the false positive rate is very low; however, method insensitivity for this project would allow the method to be used only as a screening tool. Until additional information is available, ISOCS should not be used to support risk assessment, nor as the sole basis for making regulatory related decisions. It can be used to evaluate uranium-238 distribution when a sufficient quantity of fixed laboratory data is available from corresponding locations.

Sodium Iodide Detector

There is a correlation observed between the gamma walkover survey (GWS) results obtained using a sodium iodide detector and the total uranium results acquired using both field and laboratory methods. The GWS was a solid predictor of where elevated levels of uranium and uranium daughters would be found during the Soil Pile I investigation. Although the method will remain a qualitative method for measuring field radioactivity, the GWS may have a high degree of utility in support of investigation planning.

Indicator Chemicals

A qualitative relationship between PCBs, uranium, and uranium daughters was observed at Soil Pile I. In all cases, when PCBs were detected above benchmark values, total uranium and uranium-238 also were detected. The number of samples available for mathematical comparison is relatively small; however, there is a clear relationship between the two contaminants. The reverse relationship is not true: PCBs were not always detected when uranium and uranium daughters were detected. Since the correlation is unilateral (i.e., uranium only in the presence of PCBs), the most logical source would be PCBs that are contaminated with uranium and its daughters.

1. INTRODUCTION

The Paducah Gaseous Diffusion Plant (PGDP), located approximately 10 miles west of Paducah, Kentucky and 3.5 miles south of the Ohio River in the western part of McCracken County, is an active uranium enrichment facility owned by the U.S. Department of Energy (DOE) and has been operating since the early 1950s. Bordering the PGDP Reservation to the northeast, between the plant and the Ohio River, is a Tennessee Valley Authority (TVA) reservation on which is located the Shawnee Steam Plant.

PGDP was owned and managed first by the Atomic Energy Commission and then the Energy Research and Development Administration, a DOE predecessor; DOE then owned and managed PGDP until 1993. On July 1, 1993, the United States Enrichment Corporation (USEC) assumed management and operation of the PGDP enrichment facilities under a lease agreement with DOE. DOE still owns the enrichment complex and is responsible for environmental management activities associated with its past operation of PGDP (CERCLIS# KY8-890-008-982). DOE is the lead agency for response actions under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and the U.S. Environmental Protection Agency (EPA) and the Kentucky Environmental and Public Protection Cabinet are regulatory oversight agencies.

Solid Waste Management Units (SWMUs) and areas of concern (AOCs) at PGDP have been grouped into operable units (OUs) for evaluation of response actions. Each OU is designed to aid in the remediation of contaminated media associated with PGDP. Per the Site Management Plan (SMP) (DOE 2007b), DOE, EPA, and the Commonwealth of Kentucky have designated the Soils OU Strategic Initiative. The primary objective of the initiative is to take actions necessary to prevent both on-site and off-site human exposure that presents an unacceptable risk, to provide safe environmental conditions for industrial workers performing ongoing gaseous diffusion plant operations, and to implement actions that provide the greatest opportunities to achieve significant risk reduction before site closure.

This Site Evaluation Report (SER) has been developed in accordance with the requirement in Section IX of the PGDP Federal Facility Agreement (FFA) for the submittal of an integrated removal/remedial Site Evaluation Report/SWMU Assessment Report. The report is organized as follows:

- Historical Context
- Project Scope
- Project Objectives
- Execution of Sampling Strategy
- Investigation Findings
- Conclusions

1.1 PROJECT SCOPE

On November 2, 2006, Soil Pile I was discovered by DOE along Little Bayou Creek, outside of the PGDP industrialized area (Figure 1). Initial field radiation surveys of Soil Pile I by DOE's contractor, Paducah Remediation Services, LLC, (PRS) showed elevated levels of radioactivity. Based on these initial field results, DOE planned to determine if Soil Pile I poses an immediate threat to human health or public safety. A sampling plan to evaluate Soil Pile I was developed and approved by the regulatory agencies. The provisions for this program are contained in two DOE secondary documents:

- *Sampling and Analysis Plan for the Soil Piles at Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0015&D2/R1, (SAP) 2007.

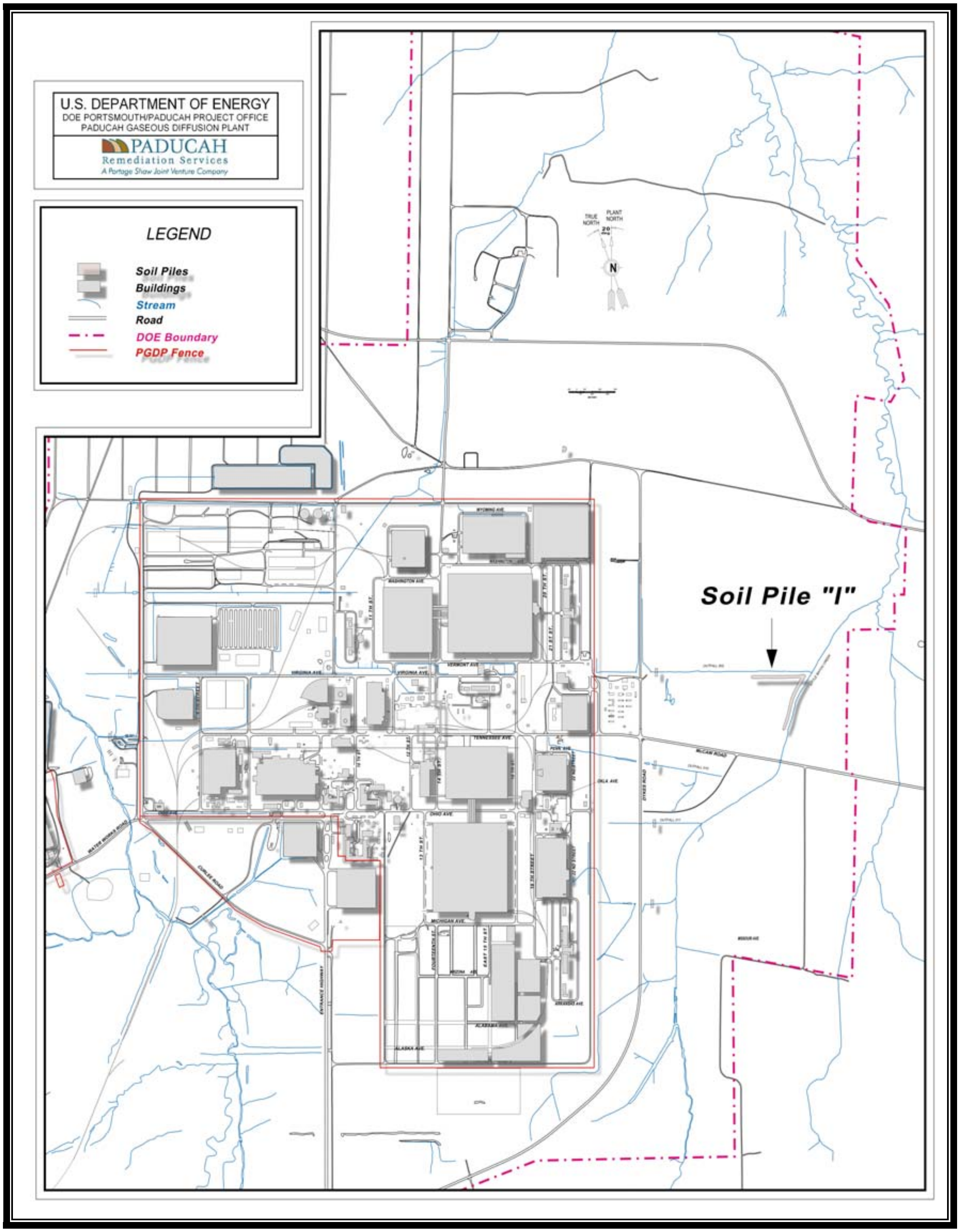


Figure 1. Soil Pile I Site Map

- *Addendum 1-A to the Sampling and Analysis Plan at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0015/A1/&D2/R1, 2008

The scope of the sampling plan was to acquire sufficient data from Soil Pile I and adjacent soils, as defined in Section 2.1, to support decision making. Key considerations include the following:

- What is the nature and extent of contamination in Soil Pile I and adjoining soils?

- Do the soil piles and/or adjoining soils pose risks to human health?

- Do contaminants in the soil piles and/or in adjoining soils exceed regulatory thresholds?

- If actions are required, what are the appropriate remedies to address elevated contaminant concentrations?

In addition, the following were considered:

- Can field methods acquire data of adequate quality, under site-specific conditions, to support waste management or characterization decision making at similar locations?

- Are there chemicals present that will predict the occurrence of other chemicals, such that they can be used to support future decision making?

Addendum 1-A was implemented at Soil Pile I between April and July 2007. This SER presents the results of that effort and includes the data generated from field activities, an evaluation of project data quality and usability, assessment of the potential risks to human health, and conclusions.

As noted in both the SAP and Addendum 1-A, the focus of the investigation was to evaluate conditions in the Soil Pile I and in adjacent soils. The scope of the project was to examine conditions, evaluate potential human health risks, and compare Soil Pile I contaminant concentrations versus chemical-specific applicable or relevant and appropriate requirement (ARARs) to support informed decision making.

1.2 PROJECT OBJECTIVES

The principal study objective of the Soil Pile I sampling effort was to determine if contamination is present and, if so, determine the nature and extent of soil contamination in Soil Pile I and in adjoining soils. The data quality objectives (DQOs) include the following:

- Establish the nature and extent of contamination in Soil Pile I and adjacent soils.
- Establish the mean concentrations of contaminants in soils.
- Determine if soils pose imminent risks to human health.
- Determine if soils contamination exceeds regulatory thresholds.
- If contaminated, determine waste disposition alternatives.

In addition to supporting characterization at Soil Pile I, two objectives were included to aid in evaluating investigative techniques to determine if they might support future investigations at PGDP. These are the objectives for the supplemental investigative techniques:

- Evaluate the performance of field measurement techniques to determine their viability for use at other locales at PGDP, and

- Determine if there are chemicals at Soil Pile I that will serve as indicators for other chemicals as a result of PGDP operations.

1.3 REGULATORY OVERVIEW

PGDP was placed on the National Priorities List on May 31, 1994. In accordance with Section 120 of CERCLA, DOE entered into an FFA with EPA Region 4 and Kentucky on February 13, 1998 (EPA 1998). The FFA established one set of consistent requirements for achieving comprehensive site remediation in accordance with the Resource Conservation and Recovery Act (RCRA) and CERCLA, including stakeholder involvement. The Soil Pile I investigation was designed to support CERCLA decisions concerning the soil pile. Site-specific ARARs were considered in the preparation of the SAP and Addendum 1-A; only those ARARs invoked by sampling and analysis activities were considered. The SAP and Addendum 1-A were used to support the site evaluation in accordance with Section IX of the FFA.

The DOE Portsmouth/Paducah Project Office (PPPO) is responsible for environmental management activities associated with PGDP (CERCLIS# KY8-890-008-982) and serves as the lead agency for remedial actions at PGDP. EPA Region 4 and Kentucky Department for Environmental Protection (KDEP) serve as the regulatory oversight agencies for the facility.

Soil Pile I, identified as Soil Pile number 115 in the notification letter dated February 16, 2007, has been designated as SWMU 561. The SWMU unit name is identified as Soil Pile I and also has been referred to in previous documentation as “Area 7” due to the configuration of the soil piles. Soil Pile I was identified in the notification letter dated February 16, 2007.

1.4 PROJECT BACKGROUND

Following the November 2, 2006, discovery and notifications to the regulators of Soil Pile I, field efforts were initiated. This initial effort included a preliminary radiological survey of Soil Pile I and adjoining soils; initial reconnaissance noted elevated radioactivity in the portion of the soil pile paralleling Little Bayou Creek (Figure 2). Measurements taken during this field effort showed field radioactivity at levels ranging from twice to more than seven times area background.

In December 2006, limited soil sampling was completed at Soil Pile I to further assess site conditions. The results of the initial sampling effort indicated levels above background of radionuclides, metals, and polychlorinated biphenyls (PCBs).[1] Based on this, DOE conducted planning for more comprehensive sampling at Soil Pile I.

A complete gamma walkover survey (GWS) was performed for Soil Pile I. The results of this effort confirmed initial field effort, showing elevated radioactivity in the portion of Soil Pile I paralleling Little Bayou Creek. To protect the public from any potential for exposure, Soil Pile I was cordoned off using rope barriers, and an occurrence report was developed. The 2006 Occurrence Reporting and Processing System (ORPS) summarized the observed field conditions.

---

[1] December 2006 sample results are summarized in Table 2 of the PGDP Soil Piles SAP, DOE/LX/07-0015&D2/R1.

During the preparation of the 2006 occurrence reports for Soil Pile I, several historical occurrence reports were discovered. These reports noted that limited sampling was completed for soil piles south of McCaw Road. The data showed results similar to those found in 2006: elevated radioactivity and elevated concentrations of radionuclides, metals, and PCBs.[2]

The origin of Soil Pile I remains unknown; however, available information indicates that many of the PGDP-related soil piles originated from excavations associated with the creation, periodic dredging, and cleanout of the outfalls, ditches, and creeks that comprise the PGDP surface water management system.

The following lists all known occurrence reports for the PGDP soil piles:

- EM-ORO--BJC-PGDPENVRES-2001-0015—Discovery of Contaminated Soil Pile West of Little Bayou Creek;
- EM-ORO--BJC-PGDPENVRES-2002-0008—Discovery of Radiologically Contaminated Soil Outside of Controlled Area - South of KPDES Outfall 11;
- EM-ORO--BJC-PGDPENVRES-2003-0002—Discovery of Contaminated Soil Pile near KDPES Outfall 008; and
- EM-PPPO-PRS-PGDPENVRES-2006-0013—Legacy Contamination in Excess of 10 *CFR* 835 Limits Discovered Outside Controlled Area.

---

[2] Results for the 2001 efforts are also summarized in Table 2 of the SAP.

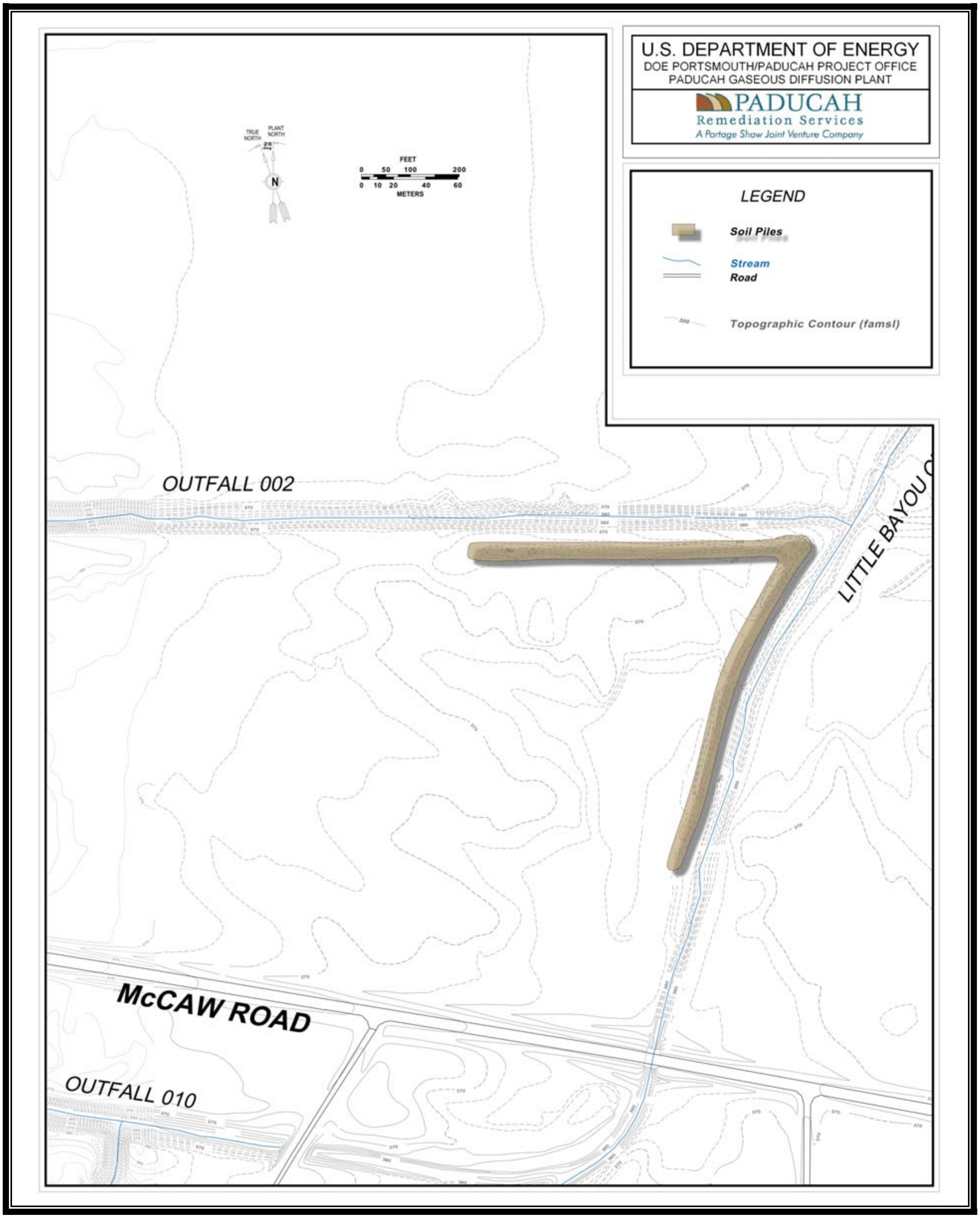


Figure 2. Soil Pile I

2. AREA DESCRIPTION

2.1 SOIL PILE I

The physical location of Soil Pile I is described by the following:

- Eastern boundary begins at 37^{o}06’38” north latitude/88^{o}47’39” west longitude.
- East-West axis extends along Outfall 002 to confluence of Little Bayou Creek Study Area to 37^{o}06’37” north latitude/88^{o}47’33” west longitude.
- North-South axis beginning at confluence of Outfall 002 extends south along Little Bayou Creek Study Area to 37^{o}06’33” north latitude/88^{o}47’38” west longitude.

The distinctive area categorized as “soil pile” consists of systematic berm-like formations beginning at the confluence of Little Bayou Creek and Outfall 002, extending approximately 700 ft west along Outfall 002 and 700 ft south along Little Bayou Creek. The soil pile footprints vary in width from 12–30 ft, ranging in height from 2–12 ft, with the average height at 8 ft. Based on civil survey results of Soil Pile I acquired in 2007, the volume of the soil berms is estimated at 10,000 yd^3 (Figure 3).

There are two other distinct areas adjacent to Soil Pile I: (1) the interior area, which lies west and south of the soil pile; and (2) the buffer areas, which separate the soil piles from Outfall 002 to the north and Little Bayou Creek to the east. The interior area covers approximately seven acres when measured from the eastern and southern terminuses of the soil piles. The interior area is forested and slopes gently to a bisecting drainage channel that intersects Little Bayou Creek.

The buffer area along Outfall 002 appears to have been improved in the past, with the grade generally level to the surrounding area and has the appearance of a road now partially overgrown with trees and ground vegetation. Improvements to the buffer area along Little Bayou Creek are not as evident, as vegetative regrowth in this area is more extensive. In addition, the buffer/soil pile interface is less discrete. The interior area is consistent with the surrounding natural grade.

Current and expected future land use of the Soil Pile I area is recreational as is the land owned by DOE that is licensed to the West Kentucky Wildlife Management Area (WKWMA). The nearest resident is approximately 1,000 ft to the east.

2.2 GEOLOGY AND SOILS

The PGDP and Soil Pile I are located in the Jackson Purchase Region of Western Kentucky, which represents the northern tip of the Mississippi Embayment portion of the Coastal Plain. The Jackson Purchase Region is an area of land that includes all of Kentucky west of the Tennessee River. The stratigraphic sequence in the region consists of Cretaceous, Tertiary, and Quaternary sediments unconformably overlying Paleozoic bedrock.

Relative to the shallow groundwater flow system in the vicinity of the PGDP, the continental deposits and the overlying loess and alluvium are of key importance. The continental deposits locally consist of an upper silt member, with lesser sand and gravel interbeds, and a thick, basal sand and gravel member, which fills a buried river valley. A subcrop of the Porters Creek Clay, located beneath and immediately

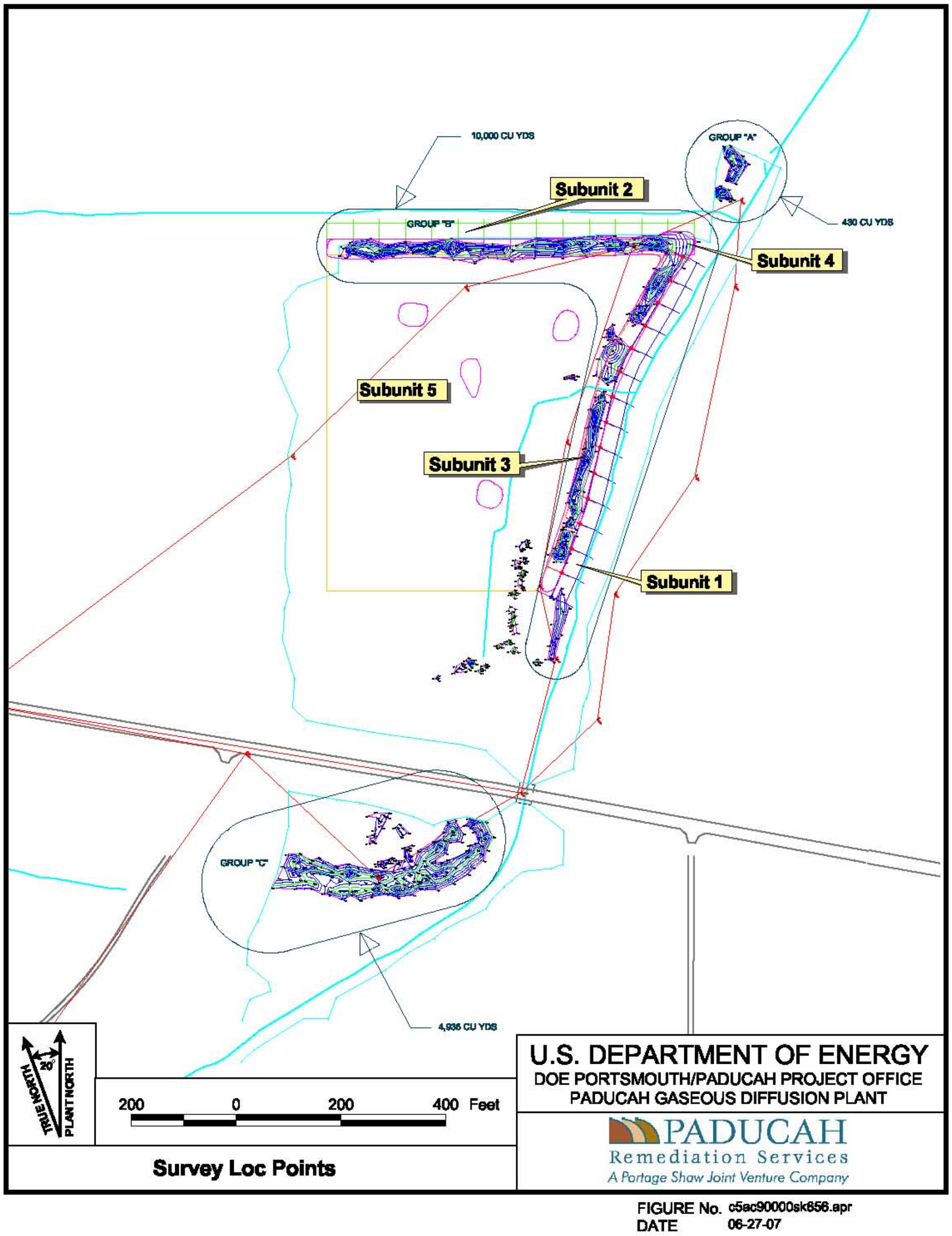


Figure 3. Civil Survey Results – Soil Pile I

south of the PGDP marks the south extent of the buried river valley. Fine sand and clay of the McNairy Formation directly underlie the continental deposits. These continental deposits are continuous from beneath the PGDP to beyond the present course of the Ohio River.

The general soil map for Ballard and McCracken counties indicates that three soil associations are found within the vicinity of the PGDP (USDA 1976): the Rosebloom-Wheeling-Dubbs association, the Grenada-Calloway association, and the Calloway-Henry association. The predominant soil association in the vicinity of the PGDP is the Calloway-Henry association, which consists of nearly level, somewhat poorly drained, medium-textured soils on upland positions.

Although the soil over most of the PGDP may be Henry silt loam with a transition to Calloway, Falaya-Collins, and Vicksburg away from the site, many of the characteristics of the original soil have been lost due to industrial activity that has occurred over the past 50+ years. Activities that have disrupted the original soil classifications include filling, mixing, and grading.

2.3 HYDROGEOLOGY

PGDP and Soil Pile I are located in the western portion of the Ohio River drainage basin, approximately 15 miles downstream of the confluence of the Ohio River with the Tennessee River and approximately 35 miles upstream of the confluence of the Ohio River with the Mississippi River. Locally, the PDGP is within the drainage areas of the Ohio River, Bayou Creek (also known as Big Bayou Creek), and Little Bayou Creek.

The PGDP is situated on the divide between the two creeks. Surface flow is east-northeast toward Little Bayou Creek and west-northwest toward Bayou Creek. Bayou Creek is a perennial stream on the western boundary of the plant that flows generally northward, from approximately 2.5 miles south of the plant site to the Ohio River. Little Bayou Creek becomes a perennial stream at the east outfalls of PGDP. The Little Bayou Creek drainage originates within WKWMA and extends northward and joins Bayou Creek near the Ohio River. Drainage areas for both creeks are generally rural; however, they receive surface drainage from numerous swales that drain residential and commercial properties, including WKWMA, PGDP, and TVA Shawnee Steam Plant. The confluence of the two creeks is approximately 4.8 km (3 miles) north of the plant site, just upstream of the location at which the combined flow of the creeks discharges into the Ohio River (DOE 2006a).

Most of the flow within Bayou and Little Bayou Creeks is from process effluents or surface water runoff from the PGDP. Contributions from PGDP comprise approximately 85% of flow within Bayou Creek and 100% of flow within Little Bayou Creek. A network of ditches discharges effluent and surface water runoff from PGDP to the creeks. Plant discharges are monitored at the Kentucky Pollutant Discharge Elimination System (KPDES) outfalls prior to discharge into the creeks. Outfalls 002, 010, 011, and 012 receive water from the eastern-most portion of the plant and discharge to Little Bayou Creek upstream or adjacent to Soil Pile I (DOE 2006a).

The local groundwater flow system at the PGDP site occurs within the sands of the Cretaceous McNairy Formation, Pliocene Terrace Gravel, Plio-Pleistocene lower continental gravel deposits and upper continental deposits, and Holocene alluvium. The primary local aquifer is the Regional Gravel Aquifer (RGA). The RGA consists of the Quaternary sand and gravel facies of the lower continental deposits and Holocene alluvium found adjacent to the Ohio River and is of sufficient thickness and saturation to constitute an aquifer. These deposits have an average thickness of 9.1 m (30 ft), and range up to 15.24 m (50 ft) along an axis that trends east–west through the plant site. The RGA is the primary local aquifer. Groundwater flow is predominantly north toward the Ohio River (DOE 2006a).

2.4 POTENTIAL SOURCES OF CONTAMINATION

A number of documented contamination sources at PGDP may have contributed to conditions in the PGDP Outfalls, Little Bayou Creek, and to observed conditions at Soil Pile I. The following describes known sources and provides an evaluation of potential transport mechanisms for contaminants found at PGDP. Figure 4 provides an overview of the PGDP industrial complex and the associated surface water management system.

2.4.1 Building C-340

One potential source of contaminants in the PGDP surface water drainage system is the C-340 facility. Building C-340 is located near the eastern edge of the PGDP at the corner of 22nd Street and Oklahoma Avenue. Historical leaks and spills at C-340 likely resulted in releases that traveled from floor drains through the storm sewer system, into Outfall 011, and discharged to Little Bayou Creek. Recorded spills and releases from C-340 include contaminants such as PCB oil, as documented in ORPS reports, Plant Shift Superintendent (PSS) logs, and Annual Site Environmental Reports (ASERs).

Primary processes in the C-340 Reduction and Metals Facility were the reduction of uranium hexafluoride (UF_6) to uranium tetrafluoride (UF_4) and the conversion of UF_4 to metallic uranium. The facility became operational in 1956 and continued operating until 1977, when shut down of primary processes began. After shutdown, C-340 was used as a training school, a valve test facility, a pilot plant for the study of liquid/gas scrubber systems, and a waste pilot plant for the stabilization of uranium chips. A uranium metal remolding project was conducted in the mid-1980s at C-340. The building was closed in 1991 and remains inactive in 2008. Past operations conducted in C-340 are provided in the *Paducah Gaseous Diffusion Plant Building Directory, Primary Processes, and Possible Release Pathways* (PRS 2007).

The following are the primary chemicals employed at C-340 during active operations:

- UF_6
- Hydrogen
- Magnesium fluoride
- Magnesium
- Trichloroethene (TCE)

PCBs were used in electrical and hydraulic systems; hydrogen fluoride (HF), UF_4, and uranium metal were produced during plant operations. A Freon system was used to condense gaseous HF produced in the conversion of UF_6 to UF_4, and a potassium hydroxide scrubber was used to remove uncondensed HF from the process off-gas. Both nitrogen and small quantities of UF_6 were used to test valves during operations and uranium metal and TCE were used during the uranium chip fixation studies. The noted chemicals were used as part of C-340 operations through 1977 (DOE 2006a).

Until 1977, floor drains in C-340 were connected to the PGDP storm sewer system, which flowed to Outfall 011 and discharged to Little Bayou Creek. Cooling water from the HF condenser system also drained to the storm sewer system; during facility shutdown the drains were sealed. Initially, effluent from the HF scrubber also was discharged to the floor drains. In the early 1970s, the scrubber began draining to self-contained tanks. The captured effluent subsequently was trucked to C-410-D for neutralization and precipitation and then was discharged to the North-South Diversion Ditch (DOE 2006a).

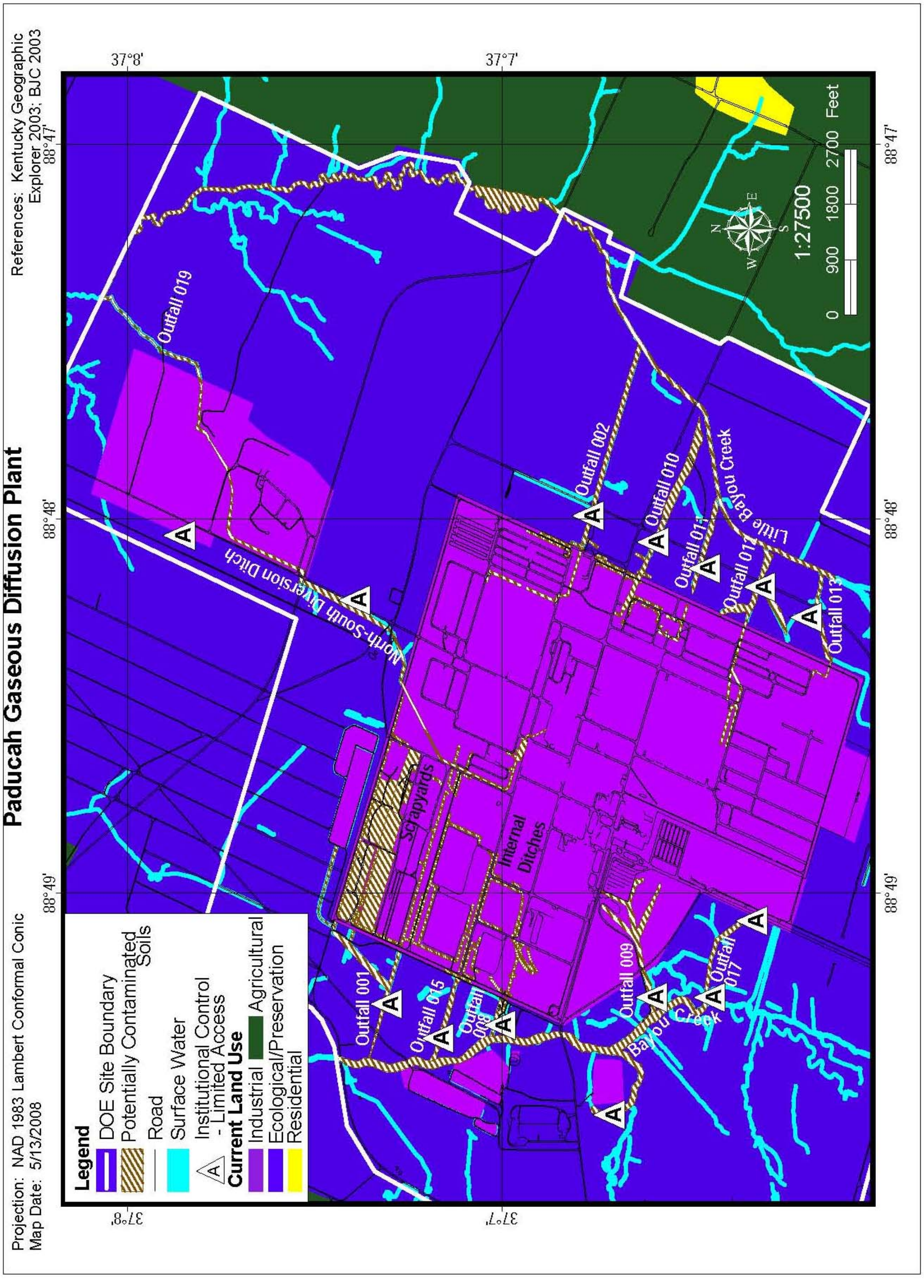


Figure 4. PGDP Outfall Locations

2.4.2 Sources to Outfall 010

Outfall 010 is likely a primary source of historical releases to Little Bayou Creek and may have contributed to observed conditions at Soil Pile I. Its associated ditches drain several PGDP facilities including the following:

- C-331 Process Building
- C-531 Complex
- C-617-B Lagoon

The C-331 Process Building drains to Outfall 010 via the storm sewer system, while the C-531 Complex is drained through internal plant ditches. Discharges from Outfall 010 are collected in a sump and pumped to the C-617-B Treatment Lagoon. C-331 is located in the east-central portion of PGDP at the corner of Tennessee Avenue and 16th Street. The C-531 Complex and the C-617-B Treatment Lagoon are both located near the east-central boundary of the PGDP on 22nd Street. The wastewater can be directed either to Outfall 010 or Outfall 011 (DOE 2006a). Contaminants include radionuclides, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and heavy metals.

2.4.3 Documented Releases/Spills

Other possible contaminant sources to Little Bayou Creek may include releases resulting from surface water runoff, originating at spill or release sites inside the PGDP industrial complex, prior to their remediation. These include releases documented in the following reports or logs:

- ORPS spanning from approximately 1990 to the present,
- PSS logs spanning from 1984 through 1990, and
- ASERs from 1984 until 2006.

The occurrence reports and document summary forms from the PSS logs provide a description of the spills and releases and contain pertinent information such as the date and time of release, known or suspected contaminants, estimated quantities of material(s) released, and a description of the actions taken.

The types of chemicals involved in historical spills and releases contained in the ORPS include PCBs, recirculated cooling water containing chromium, chilled chromated water, landfill leachate, gasoline and diesel fuel, and various oils. The types of spills and releases documented in the PSS logs include PCBs, recirculated cooling water, TCE, sanitary waste water, chromated water, paint pigment, gasoline, diesel, miscellaneous oil, uranium, technetium-99, and observed oil sheens in the outfall discharges. Spills and releases reported in the ASERs include recirculated cooling water, chilled water, TCE, battery acid, transformer oil, diesel fuel, soda ash, and landfill leachate.

As required by the SAP and Addendum 1-A, VOCs were not sampled in surface soils because the rapid degradation of VOC contaminants exposed to atmosphere and sunlight; however, the VOC contaminants were collected at depth and analyzed using VOC Method SW-8260.

2.5 CONTAMINANT TRANSPORT MECHANISMS

While the origin of Soil Pile I is unknown, available information indicates that many of the PGDP related soil piles originated from excavations associated with the creation, periodic dredging, and cleanout of the outfalls, ditches, and creeks that comprise the PDGP surface water management system. Little Bayou Creek historically has received effluent discharges and storm water runoff from various plant processes (e.g., C-340 Building, electrical switchyards, cooling towers) known to contain uranium, PCBs, polyaromatic hydrocarbons (PAHs), TCE, chromium, and other contaminants noted previously. Waste streams from PGDP that could have entered Little Bayou Creek likely would have originated from (1) storm water run-off from contaminated SWMUs and AOCs; (2) industrial wastewater from plant operations through permitted KPDES outfall ditches; and (3) migration of spills from plant-related activities prior to cleanup. Transport mechanisms likely include both dissolved constituents and sediment in storm water runoff (DOE 2006a).

The PGDP surface water management system discharges to Little Bayou Creek through several outfalls, which may be associated with Soil Pile I including the following:

- Outfall 002
- Outfall 010
- Outfall 011
- Outfall 012

Figure 4 illustrates where outfalls discharge relative to PGDP. An investigation was conducted for on-site areas for the Surface Water Operable Unit (SWOU). Elevated levels of radionuclides, metals, and SVOCs were observed in localized areas within the SWOU outfalls and ditches, indicating contaminant transport in the drainage system has occurred, particularly in ditches associated with Outfall 010, which discharges to the east of PGDP (DOE 2006a).

During the SWOU on-site investigation, transport modeling of contaminants in Outfalls 002, 010, 011, and 012 indicated that contaminant concentrations were below indicator levels, reducing the likelihood that these outfalls are serving as continuous sources of contaminant loading in Little Bayou Creek. Ongoing monitoring supports this conclusion. No exceedances of KPDES parameters have occurred at these outfalls since 2000, with the exception of one exceedance at Outfall 012 in 2004 (USEC 2007a).

Because Outfall 010 is known to contain localized areas of contamination inside the PGDP industrialized area, it is reasonable to conclude that surface water and sediment transport has served as a possible source of contamination in Little Bayou Creek. If maintenance of Little Bayou Creek and Outfalls 002 and 010 are the origin of the material in Soil Pile I, it is reasonable to conclude that elevated constituents found there are directly related to historical releases that have discharged through Outfall 010 (DOE 2006a).

2.6 SUMMARY OF RECENT ENVIRONMENTAL MONITORING RESULTS

Little Bayou Creek is subject to routine environmental monitoring under DOE Order 450.1 (previously DOE Order 5400.1). The KPDES Permit and DOE Orders identify the monitoring and discharge limits for surface water. Table 1 summarizes environmental monitoring data collected from Outfalls 002, 010, and 011 since 2001.

Table 1. Environmental Monitoring Summary Data 2001–2007

Sampling Activity	Analysis	Media	Unit	Minimum	Maximum	*Average
Outfall 002						
FEBRUARY EMPSW03-02	Antimony	Water	mg/L	ND	0.2	0.2
1st QTR 2007 USEC-K107	Antimony	Water	µg/L	5.0	5.0	5.0
FEBRUARY EMPSW03-02	Arsenic	Water	mg/L	ND	0.2	0.2
1st QTR 2007 USEC-K107	Arsenic	Water	µg/L	1.2	10.0	5.6
FEBRUARY EMPSW03-02	Manganese	Water	mg/L	ND	0.1	ND
KPDES for 2000 USEC-K00	PCB, Total	Water	µg/L	0.1	0.2	0.2
JULY EMPSW01-04	PCB-1016	Water	µg/L	0.2	0.2	0.2
JULY EMPSW01-04	PCB-1221	Water	µg/L	0.2	0.2	0.2
JULY EMPSW01-04	PCB-1232	Water	µg/L	0.1	0.2	0.2
JULY EMPSW01-04	PCB-1242	Water	µg/L	0.1	0.2	0.1
JULY EMPSW01-04	PCB-1248	Water	µg/L	0.1	0.2	0.1
JULY EMPSW01-04	PCB-1254	Water	µg/L	0.1	0.2	0.1
JULY EMPSW01-04	PCB-1260	Water	µg/L	0.1	0.2	0.1
JULY EMPSW01-04	PCB-1268	Water	µg/L	0.1	0.2	0.1
JULY EMPSW01-04	Uranium	Water	mg/L	ND	0.1	ND
JULY - EMPSW02-04	Uranium	Water	pCi/L	1.6	40	21
NOVEMBER EMPSW05-01	Uranium	Water	mg/L	ND	0.1	ND
JULY EMPSW01-04	Uranium	Water	pCi/L	30.0	40.0	33.0
2nd QTR 2007 USEC-K207	Uranium	Water	µg/L	16.4	16.4	16.4
JULY EMPSW01-04	Uranium-238	Water	pCi/L	ND	1.5	0.8
FEBRUARY EMPSW03-02	Vanadium	Water	mg/L	ND	ND	ND
Outfall 010						
Semiannual Sediment Sampling	Antimony	Sediment	mg/kg	20.0	20.0	20.0
1st QTR 2006 USEC-K106	Antimony	Water	mg/L	0.1	0.2	0.2
January 2001 -02 A	Antimony	Water	µg/L	4.3	60.0	12.0
November 2000 -03	Antimony	Water	µg/L	10.0	60.0	30.0
Fall - EMPSD02-01	Antimony	Sediment	mg/kg	20.0	20.0	20.0
Semiannual Sediment Sampling	Arsenic	Sediment	mg/kg	5.0	20.0	10.0
USEC KPDES for 2001	Arsenic	Water	mg/L	0.2	0.2	0.2
January 2001 -02 A	Arsenic	Water	µg/L	2.7	10.0	9.3
November 2000 -03	Arsenic	Water	µg/L	1.9	10.0	8.4
Fall - EMPSD02-01	Arsenic	Sediment	mg/kg	5.0	5.0	5.0
Semiannual Sediment Sampling	Manganese	Sediment	mg/kg	53.9	195.0	109.0
Priority Pollutants for 2002	Manganese	Water	mg/L	0.0	0.0	0.0
AIP Surface Water Samples	Manganese	Water	µg/L	3.7	183.0	31.6
November 2000 -03	Manganese	Water	µg/L	4.6	12.3	8.6

Table 1. Environmental Monitoring Summary Data 2001–2007 (Continued)

Sampling Activity	Analysis	Media	Unit	Minimum	Maximum	*Average
1st QTR 2006 USEC-K106	PCB, Total	Water	µg/L	0.2	0.3	0.2
Semiannual Sediment Sampling	PCB-1016	Sediment	µg/kg	60.0	100.0	70.0
JULY EMPSW01-04	PCB-1016	Water	µg/L	0.2	0.2	0.2
Semiannual Sediment Sampling	PCB-1221	Sediment	µg/kg	100.0	100.0	100.0
JULY EMPSW01-04	PCB-1221	Water	µg/L	0.2	0.3	0.2
Semiannual Sediment Sampling	PCB-1232	Sediment	µg/kg	90.0	100.0	92.5
JULY EMPSW01-04	PCB-1232	Water	µg/L	0.1	0.2	0.2
Semiannual Sediment Sampling	PCB-1242	Sediment	µg/kg	70.0	200.0	110.0
JULY EMPSW01-04	PCB-1242	Water	µg/L	0.1	0.2	0.1
Semiannual Sediment Sampling	PCB-1248	Sediment	µg/kg	80.0	100.0	85.0
NOVEMBER EMPSW03-01	PCB-1248	Water	µg/L	0.1	0.3	0.1
Semiannual Sediment Sampling	PCB-1254	Sediment	µg/kg	60.0	100.0	70.0
JULY EMPSW01-04	PCB-1254	Water	µg/L	0.1	0.2	0.1
Semiannual Sediment Sampling	PCB-1260	Sediment	µg/kg	90.0	200.0	133.0
JULY EMPSW01-04	PCB-1260	Water	µg/L	0.1	0.2	0.1
Semiannual Sediment Sampling	PCB-1268	Sediment	µg/kg	100.0	100.0	100.0
JULY EMPSW01-04	PCB-1268	Water	µg/L	0.1	0.2	0.1
Semiannual Sediment Sampling	Uranium	Sediment	mg/kg	100.0	200.0	133.0
Semiannual Sediment Sampling	Uranium	Sediment	µg/g	0.4	7.2	3.4
NOVEMBER EMPSW03-01	Uranium	Water	mg/L	ND	0.1	ND
AIP Surface Water Samples	Uranium	Water	µg/L	500.0	500.0	500.0
KPDES for 2001	Uranium	Water	mg/L	ND	0.1	ND
Fall - EMPSD02-01	Uranium, Dissolved	Sediment	mg/kg	100.0	100.0	100.0
Fall - EMPSD02-01	Uranium, Dissolved	Sediment	µg/g	6.3	6.3	6.3
Fall - EMPSD02-01	Uranium-238	Sediment	pCi/g	2.4	2.4	2.4
Semiannual Sediment Sampling	Uranium-238	Sediment	pCi/g	130.0	130.0	130.0
First quarter 2003	Uranium-238	Water	pCi/L	ND	362.0	19.0
November 2000 -03	Uranium-238	Water	pCi/L	2.0	7.4	4.5
Semiannual Sediment Sampling	Vanadium	Sediment	mg/kg	10.8	17.4	15.1
AIP Surface Water Samples	Vanadium	Water	µg/L	1.6	50.0	31.6
November 2000 -03	Vanadium	Water	µg/L	1.3	50.0	40.3
Fall - EMPSD02-01	Vanadium	Sediment	mg/kg	15.8	15.8	15.8

Table 1. Environmental Monitoring Summary Data 2001–2007 (Continued)

Sampling Activity	Analysis	Media	Unit	Minimum	Maximum	*Average
Outfall 011						
Outfall Sampling 2000	Antimony	Water	mg/L	ND	0.2	0.2
December 2000–2004	Antimony	Water	µg/L	5.0	10.0	6.7
December 2000–2005	Antimony	Water	µg/L	10.0	10.0	10.0
AIP Outfall Sampling 2000	Arsenic	Water	mg/L	ND	0.2	0.2
December 2000–2004	Arsenic	Water	µg/L	1.3	10.0	7.1
December 2000–2005	Arsenic	Water	µg/L	10.0	10.0	10.0
AIP Outfall Sampling 2000	Manganese	Water	mg/L	ND	0.1	ND
December 2000–2004	Manganese	Water	µg/L	61.0	61.0	61.0
December 2000–2005	Manganese	Water	µg/L	35.9	35.9	35.9
KPDES for 2000	PCB, Total	Water	µg/L	0.1	1.2	0.2
JULY EMPSW01-04	PCB-1016	Water	µg/L	0.2	0.2	0.2
JULY EMPSW01-04	PCB-1221	Water	µg/L	0.2	0.2	0.2
JULY EMPSW01-04	PCB-1232	Water	µg/L	0.1	0.2	0.2
JULY EMPSW01-04	PCB-1242	Water	µg/L	0.1	0.2	0.1
JULY EMPSW01-04	PCB-1248	Water	µg/L	0.1	0.2	0.1
JULY EMPSW01-04	PCB-1254	Water	µg/L	0.1	0.2	0.1
JULY EMPSW01-04	PCB-1260	Water	µg/L	0.1	1.2	0.1
JULY EMPSW01-04	PCB-1268	Water	µg/L	0.1	0.2	0.1
JULY EMPSW01-04	Uranium	Water	mg/L	ND	0.4	0.2
KPDES for 2000	Uranium	Water	mg/L	ND	2.9	0.1
First quarter 2003	Uranium-238	Water	pCi/L	ND	877.9	160.6
AIP Outfall Sampling 2000	Uranium-238	Water	pCi/L	315.0	315.0	315.0
AIP Outfall Sampling 2000	Vanadium	Water	mg/L	ND	ND	ND
December 2000–2004	Vanadium	Water	µg/L	1.4	1.4	1.4
AIP Outfall Sampling 2000	Vanadium	Water	mg/L	0.1	0.1	0.1
December 2000–2005	Vanadium	Water	µg/L	50.0	50.0	50.0

AIP = Agreement in Principle. ND = Not Detected

***** Variations in constituent values often result from different detection limits between analytical methods and contract laboratories. Where minimum and maximum results are the same, reported concentrations are nondetects.

Monitoring data are presented to illustrate there have been no recent (2000 to present) major contaminant releases through the PGDP surface water drainage system; to demonstrate that on-site efforts to minimize releases have been effective; and that surface water and sediment transport presently are not acting as significant or continuous sources of contamination to Little Bayou Creek. Overall, the monitoring results indicate that any releases of materials from plant operations that may have acted as source(s) of contamination at Soil Pile I are likely historical.

2.6.1 Discussion of Previous Investigations

From 2001 to 2002, field radiation surveys and limited sampling took place in soil piles south of McCaw Road (areas known as AOCs 492 and 541). Results of these efforts indicated elevated levels of radionuclides, metals, and SVOCs.

Once identified in 2006, similar activities were completed to better understand Soil Pile I. Efforts included an initial field visit, a GWS, and sampling of surface soils. The 2006 results also showed elevated field radioactivity (Figure 5) and measurable radionuclides, metals, and SVOCs in select locations.

The following constituents were detected in soils collected from soil piles south of McCaw Road and Soil Pile I. They are grouped by type (i.e., radionuclides, semivolatile organics, and metals). Figure 6 illustrates the locations of samples collected during previous sampling efforts.

Radionuclides

- Cobalt-60
- Potasium-40
- Plutonium-239/240
- Thorium-230
- Technetium-99
- Total Uranium
- Uranium-234
- Uranium-235
- Uranium-238

Semivolatile Organics

- Benzo(a)anthracene
- Benzo(ghi)perylene
- Benzo(b)fluoranthene
- Benzo(a)pyrene
- Chrysene
- Carbazole
- Dibenz(a,h)anthracene
- Di-n-butylphthalate
- Fluorene
- Fluoranthene
- Total PCBs

Metals

- Barium
- Copper
- Cobalt
- Chromium
- Calcium
- Iron
- Lead
- Manganese

The constituents are consistent with process history and sources at the PGDP facility. For example, the presence of total uranium, uranium-238, uranium-235, and decay products is indicative of the facility's primary function as a uranium enrichment operation. Similarly, PCB sources in soils and sediments are known to be present at PGDP.

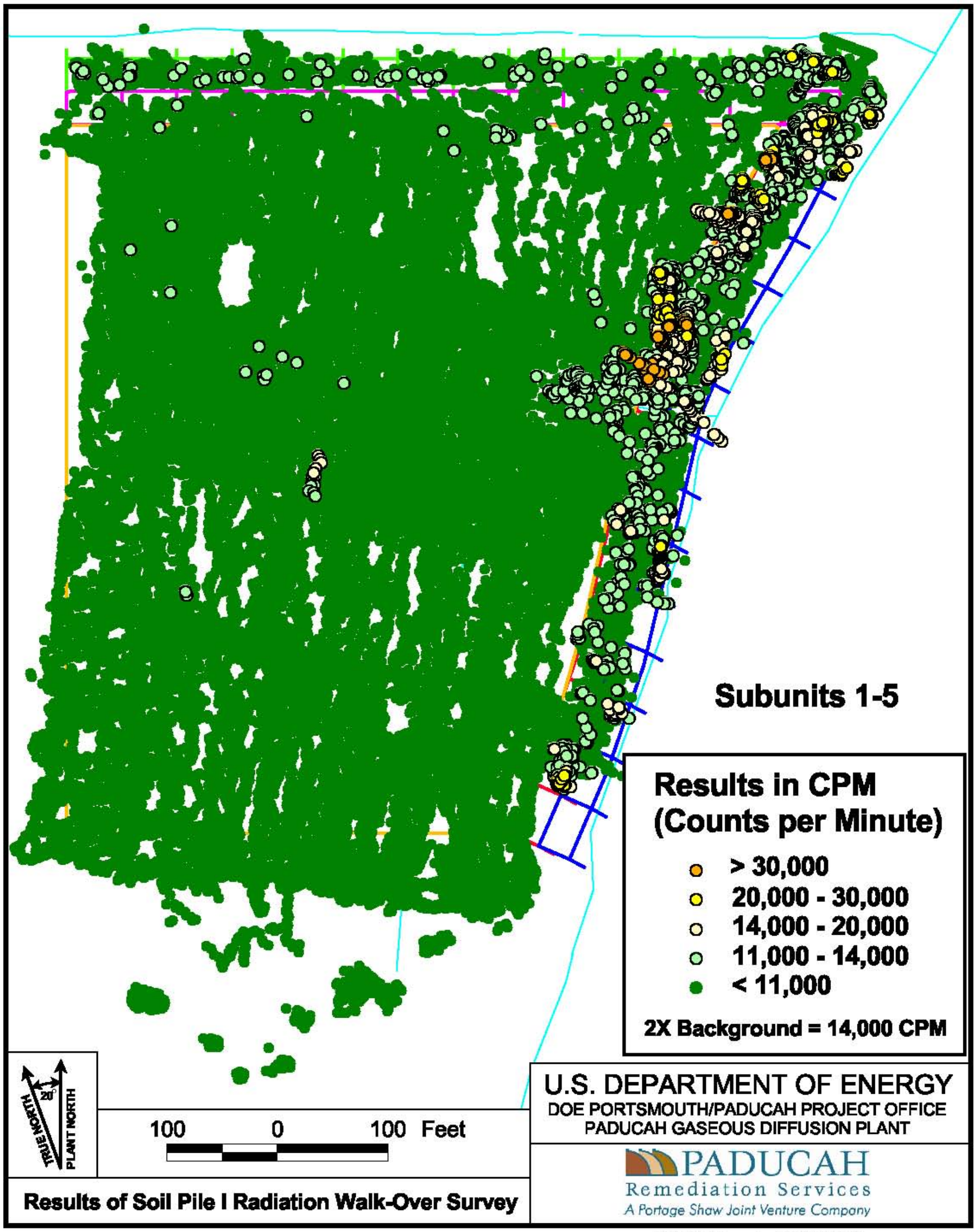


FIGURE No. c5ac90000sk643r3.apr
DATE 04-08-08

Figure 5. Soil Pile I Gamma Walkover Survey

2.6.1.1 Usability/comparability of historical data

As Figure 6 illustrates, soil samples were collected previously in 2001/2002 from two different areas, AOCs 492 and 541. Soil Pile I data were collected in 2006 and 2007.

While the 2006 Soil Pile I sampling results provide insight into conditions at Soil Pile I, it is important for data users to consider that the samples collected for this effort were biased, having been acquired from locations exhibiting the highest field radioactivity measurements. As a result, the sample data likely represents radionuclide concentrations at the high end of the concentration range for Soil Pile I and likely for other constituents (e.g., PCBs). Although knowing the maximum contaminant concentration is important, the 2006 results may or may not be representative of sitewide conditions. In fact, the results of the Soil Pile I investigation indicate the 2006 biased samples do not represent sitewide conditions. Rather, they likely represent only the most contaminated locations in the study area (See Section 5.4, Discussion of Results).

Note: For purposes of evaluating project data in this SER, biased samples collected in December 2006 and the corresponding contingency samples collected from the same locations in 2007, have not been included in summary statistics for the site (Appendix C). The data were managed in this way because both sets of samples were collected using field screening techniques to identify sample locations exhibiting the highest concentrations of contaminants.

2.6.1.2 Comparison of DOE and KDEP 2006 sample results

As part of the initial sampling effort at Soil Pile I (December 2006), collocated biased samples were collected by the Commonwealth of Kentucky from each of the five locations sampled by DOE. Table 2 provides a comparison of DOE and KDEP results obtained from the 2006 effort. The comparison relies on a measure of relative percent difference[3] (RPD) to illustrate the comparability/variability in the two data sets, which provides a direct measure of the precision between the two data sets. Typically, results ≤ 35% RPD are considered acceptable for soil matrices.

Nearly all of the DOE/KDEP values are comparable, with the exception of PCBs in three of four samples. The observed PCB variability may be attributable to the sample matrix (soil), the relatively high levels measured in the samples, laboratory error, and/or because the samples were collocated rather than split samples.

---

[3] RPD is defined in Section 3.2.1 of the PGDP Soil Piles Sampling and Analysis Plan, DOE/LX/07-0015&D2/R1.

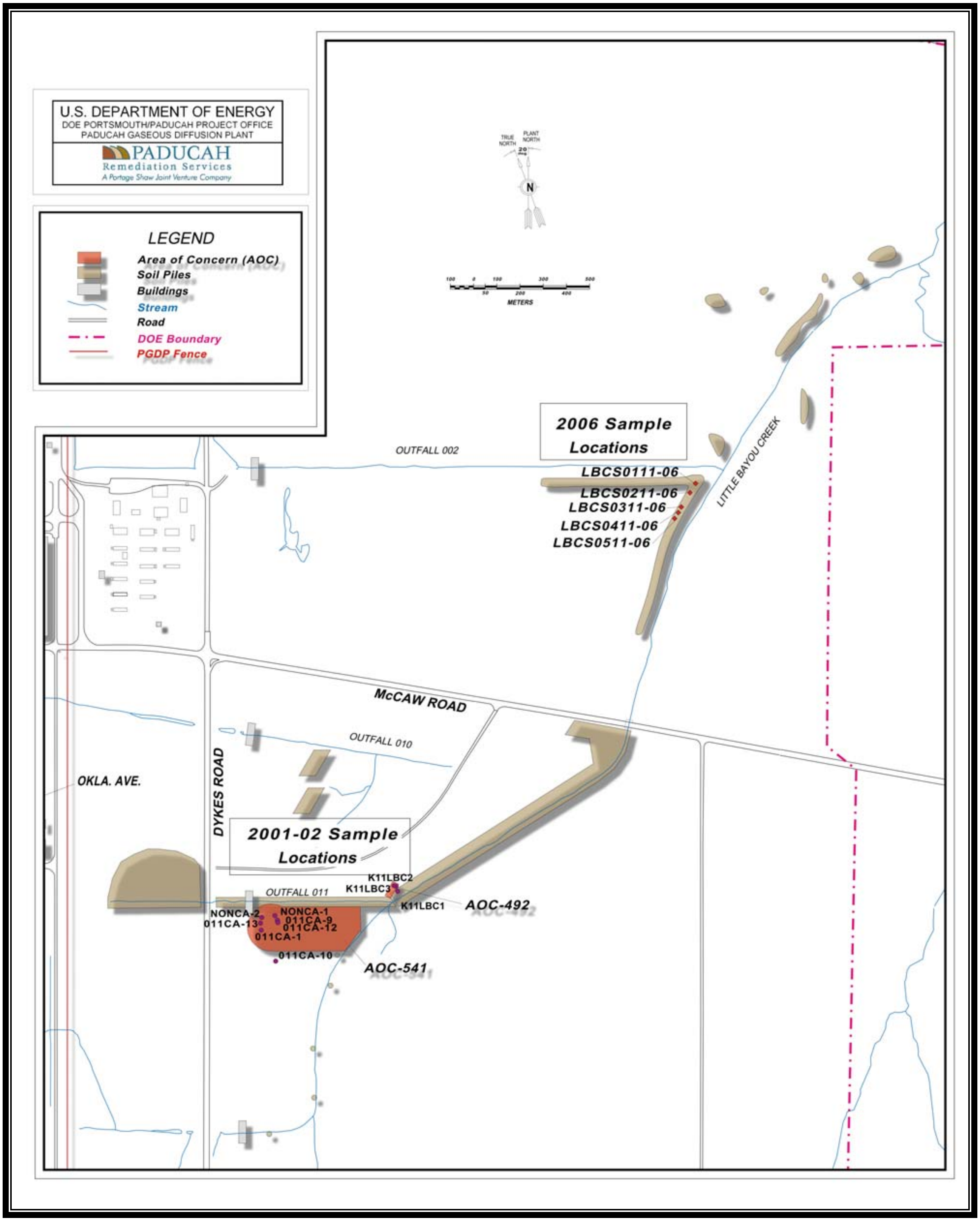


Figure 6. Sample Locations from Previous Soil Pile Investigations

]

Table 2. Comparison of 2006 DOE and KDEP Collocated Sample Results

Sample Number	Analysis	DOE Result	KY Result	RPD
LBCS0111-06	PCB, Total (µg/kg)	810	660	20%
	Uranium-238 (pCi/g)	179	137	27%
	Total Uranium (pCi/g)	205	156	27%
	Chromium (mg/kg)	209	184	13%
LBCS0211-06	PCB, Total (µg/kg)	23,900	12,700	61%
	Uranium-238 (pCi/g)	511	730	35%
	Total Uranium (pCi/g)	574	809	34%
	Chromium (mg/kg)	127	176	32%
LBCS0311-06	PCB, Total (µg/kg)	3,160	1,770	56%
	Uranium-238 (pCi/g)	458	451	2%
	Total Uranium (pCi/g)	516	505	2%
	Chromium (mg/kg)	163	235	36%
LBCS0411-06	PCB, Total (µg/kg)	4,630	6,200	29%
	Uranium-238 (pCi/g)	172	187	8%
	Total Uranium (pCi/g)	196	215.9	10%
	Chromium (mg/kg)	932	1370	38%
LBCS0511-06	PCB, Total (µg/kg)	46,900	15,700	100+%
	Uranium-238 (pCi/g)	1,340	1,120	18%
	Total Uranium (pCi/g)	1,490	1,247	18%
	Chromium (mg/kg)	168	205	20%

DOE = U.S. Department of Energy LBC = Little Bayou Creek
KY = Kentucky
KY PCB, Total = Sum of detected Aroclors
KY Total Uranium = Sum of detected uranium isotopes
RPD = relative percent difference

THIS PAGE INTENTIONALLY LEFT BLANK

3. FIELD AND ANALYTICAL METHODS

3.1 SOIL PILE I SAMPLING APPROACH

The Soil Pile I sampling approach was designed to accomplish the project objectives, which are stated in Section 1.2. The approach was developed by PRS at the direction of DOE. This approach is detailed in the DOE-, EPA-, and Commonwealth of Kentucky-approved SAP and Addendum 1-A. A summary of the sampling approach and other field activities is provided in the following sections.

3.1.1 Systematic Random Sampling

To support characterization, a stratified, systematic-random sampling approach was developed for Soil Pile I. This approach included dividing the study area into five investigative subunits (Figure 7). Once divided, the linear subunits (1-4) were further segregated into 14 evenly spaced segments. Four segments were randomly selected from each subunit for comprehensive systematic sampling, fixed laboratory analysis, and field measurements on surface and subsurface samples. This represented comprehensive data acquisition for approximately 30% of the soil pile. The justification for the random segment selection and sampling density is further discussed in Addendum 1-A.

For those segments undergoing systematic sampling, five lateral locations were combined into a single composite surface sample, which underwent fixed laboratory and field analysis. Five sets of composites were collected from each random segment. Three subsurface locations also were sampled in each segment, with a sample acquired from each 3 ft interval of the soil pile, to 2 ft below the natural grade. Figure 8 depicts the sampling grid employed in the randomly selected segments.

In the remainder of the segments, systematic field measurements were obtained, providing data from subunit areas located between those randomly selected for systematic sampling. Field measurements were acquired from both surface and subsurface samples every 30 ft to provide insight into potential contaminant distribution over the entire span of subunits 1-4. Figure 9 illustrates the locations where only field measurements were collected.[4]

The 2006 GWS in Subunit 5 showed no field radioactivity greater than twice background. As detailed in Section 1.2.3 of Addendum 1-A, these results were considered in conjunction with Multi-Agency Radiological Site Sampling and Investigation Manual (MARSSIM) guidance in categorizing Subunit 5 as a “Class 2 Area,” defined as, “areas that have the potential for contamination or known contamination, but are not expected to exceed the cleanup levels” (EPA 2000).

MARSSIM calls for less rigorous sampling to characterize nature and extent in Class 2 Areas, as contamination is less likely to occur. As a result, a simple random sampling grid was developed using Visual Sampling Plan© (VSP) and employed over the entirety of subunit 5. Each randomly selected location underwent both fixed laboratory analyses and field measurements. In addition, five locations were systematically placed around each definitive location, with each of these undergoing field measurements only.

---

[4] Field measurements included *ex situ* radioactivity measurements using ISOC, RCRA metals using an XRF spectrometer, and field PCB measurements employing immunoassay test kits.

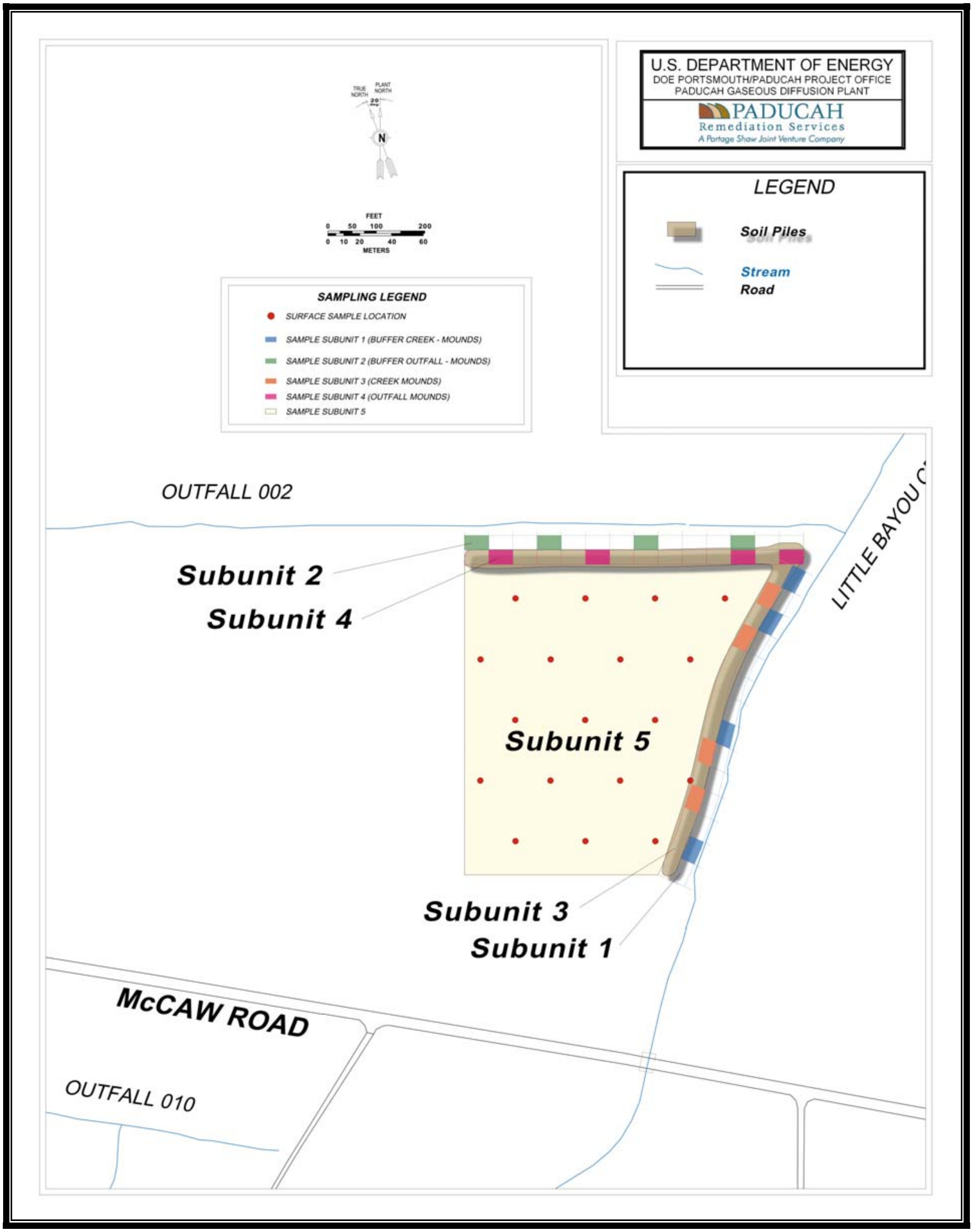


Figure 7. Soil Pile I Investigative Subunits

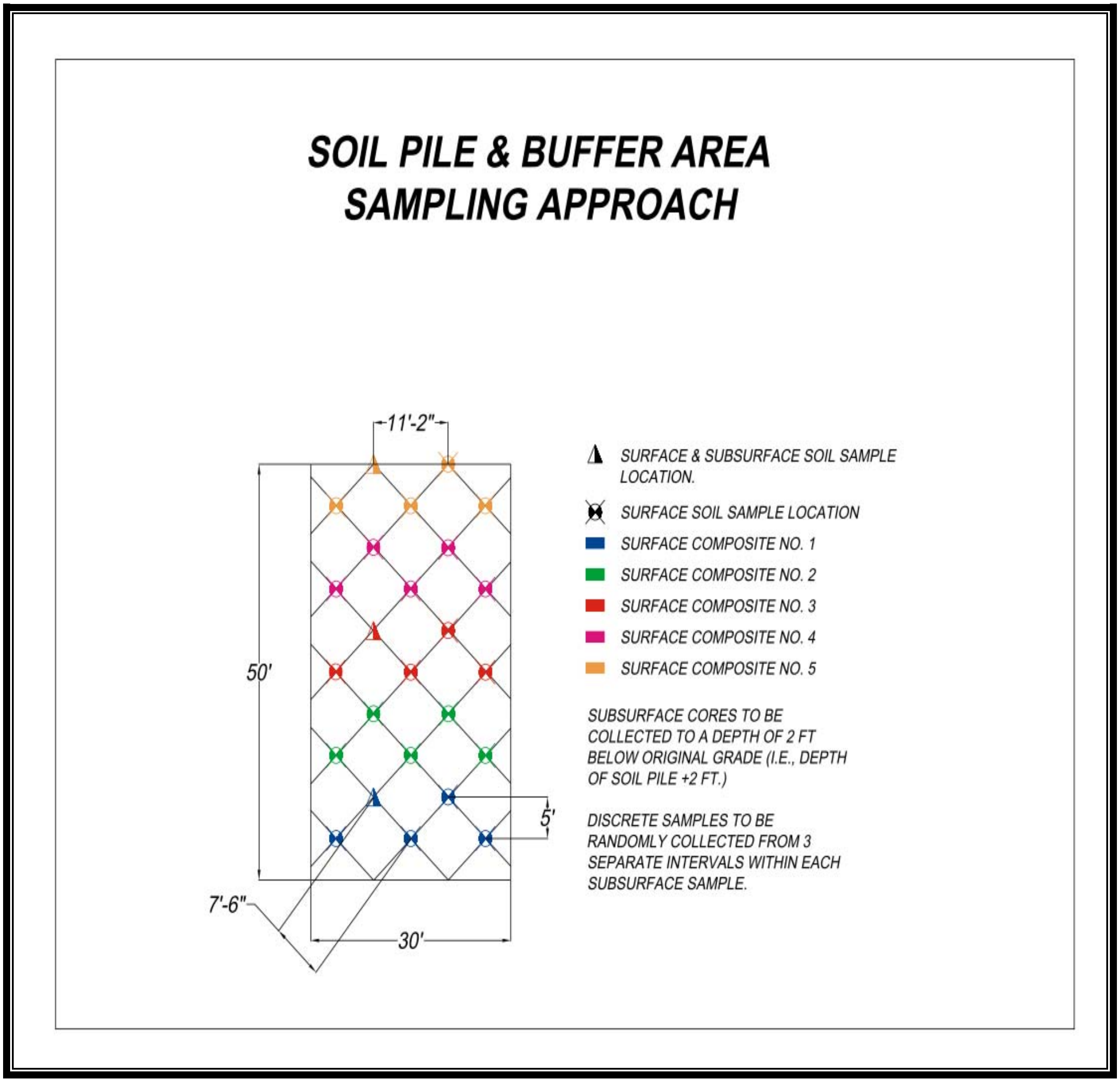


Figure 8. Soil Pile I Systematic Sampling Grid

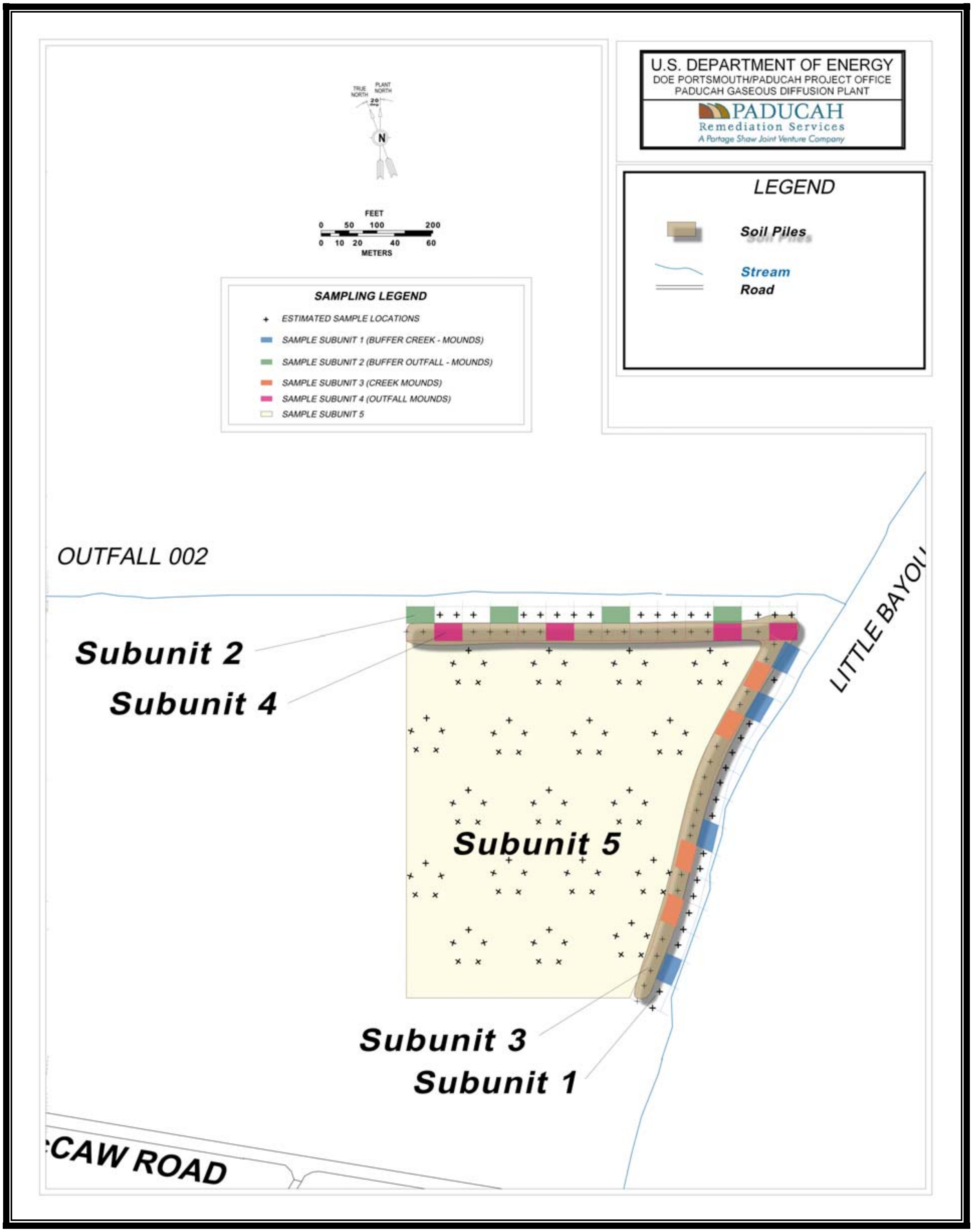


Figure 9. Planned Field Measurement Only Locations

3.1.2 Contingency Sampling

The Soil Pile I sampling approach also included provisions for contingency sampling to allow for the collection of data for unexpected field conditions or to augment project data based on real time results. Contingency samples originally were planned for collection in subunit 5 and in the soil pile where the highest field PCB measurements were observed. In subunit 5, they were planned to account for observations during initial field reconnaissance, which indicated there may be small sub piles of soil in the interior area. During the investigation, mounded areas above the natural grade were not observed. As a result, contingency samples were not collected in subunit 5. Similarly, during field sampling, high levels of PCBs were not observed for systematic field samples; therefore, planned contingency samples were not collected.

Because contingency was available as part of the sampling plan and after DOE and PRS met with KDEP and EPA, a joint decision was made to collect soil samples from the original biased locations in subunit 3 because these had exhibited the highest levels of radioactivity, metals, and semivolatile organics. The contingency samples were acquired from these locations to verify the elevated results observed in the December 2006 results and to evaluate the variability noted in Table 2. Figure 10 provides the locations of contingency samples collected from Soil Pile I.

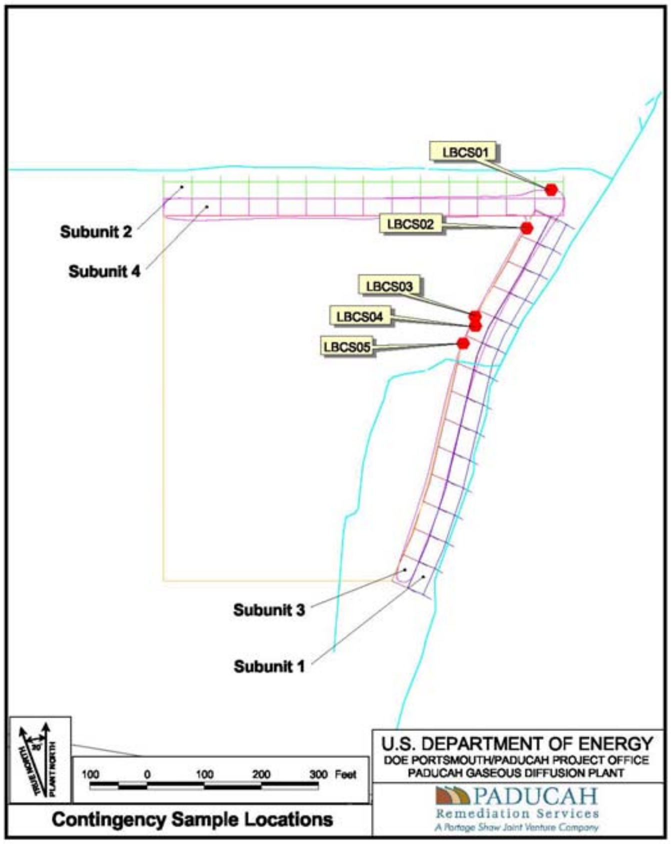


Figure 10. Soil Pile I Contingency Sample Locations

3.1.3 Tree Sampling

Soil Pile I is located in a densely vegetated area. Mature trees[5] and dense ground vegetation cover the expanse of the site with both established on top of the soil piles and in surrounding area. Sampling of tree tissue was conducted to (a) determine if trees contain contaminants at sufficiently high levels warranting their management as waste or (b) if trees can be segregated and managed on-site. To complete this effort, tissue samples were collected from five mature trees, one from each of the five investigative subunits. Figure 11 illustrates where each was located.

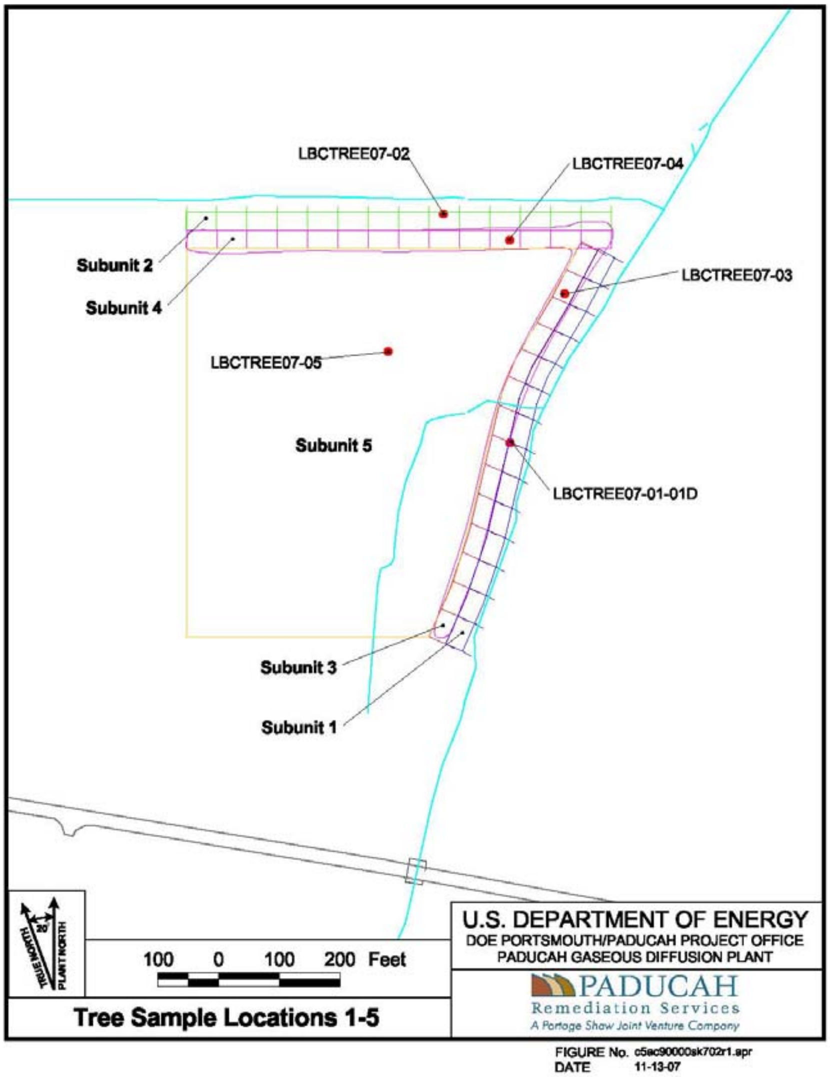


Figure 11. Soil Pile I Tree Sample Locations

---

[5] While acquiring tissue samples, trees were aged; these ranged from 14—30 years.

3.1.4 Sampling Summary

The following provides the planned sampling activities for Soil Pile I and an accounting of the actual number and types of samples collected. Addendum 1-A to the PGDP Soil Piles SAP specified the collection and analysis of the following:

- 98 surface samples to undergo field measurements and fixed laboratory analysis
- 577 surface samples to undergo field measurements only
- 106 subsurface samples to undergo field measurements and fixed laboratory analysis
- 192 subsurface samples to undergo field analysis only
- 5 tree samples for fixed laboratory analysis
- 16 soil samples for analysis to support engineering design of removal infrastructure (e.g., roads)
- Quantities of contingency samples were unspecified

During execution of Addendum 1-A, the total number of soil samples collected was as follows:

- 98 surface samples underwent field measurements and fixed laboratory analysis
- 646 surface samples underwent field measurements only
- 51 subsurface samples underwent field measurements and fixed laboratory analysis
- 117 subsurface samples underwent field analysis only
- 5 tree samples for fixed laboratory analysis
- 9 soil samples for analysis to support engineering design of removal infrastructure (e.g., roads)
- 5 contingency surface samples underwent field measurements and fixed laboratory analysis from 2006 biased locations

The observed differences between planned and actual sample numbers resulted from three factors.

First, the increase in surface field measurements during fieldwork was due to an omission in Table 1 of Addendum 1-A, which did not account for "*additional field measurement samples*" prescribed in the plan. During fieldwork, this omission was identified and these samples were collected to comply with the plan's intent.

Second, the observed differences in subsurface samples results entirely from variations in soil pile height. During planning, the height of Soil Pile I was based on a uniform estimate of 12 ft. Actual field conditions indicate the soil pile height ranges from 2 ft to 12 ft. Because the soil pile height, on average, was less than 8 ft, fewer subsurface samples were required to reach the natural grade. This does not represent a deficiency in the plan, rather it reflects actual field conditions.

Third, because there were so few PCB detections in the subsurface samples and none with significantly high levels, planned contingency samples at subsurface locations were not pursued. Instead, contingency samples were collected from the 2006 biased sample locations, as noted previously.

Fourth, the difference in the number of engineering samples was due to fewer required as discussed and agreed upon during scoping meetings held among DOE and its contractors, KDEP, and EPA during the summer of 2007.

Figure 12 provides a plan view of all soil sample locations as surveyed during execution of Addendum 1-A. The location symbols '+' are based on global positioning system (GPS) data acquired during the execution of fieldwork.[6]

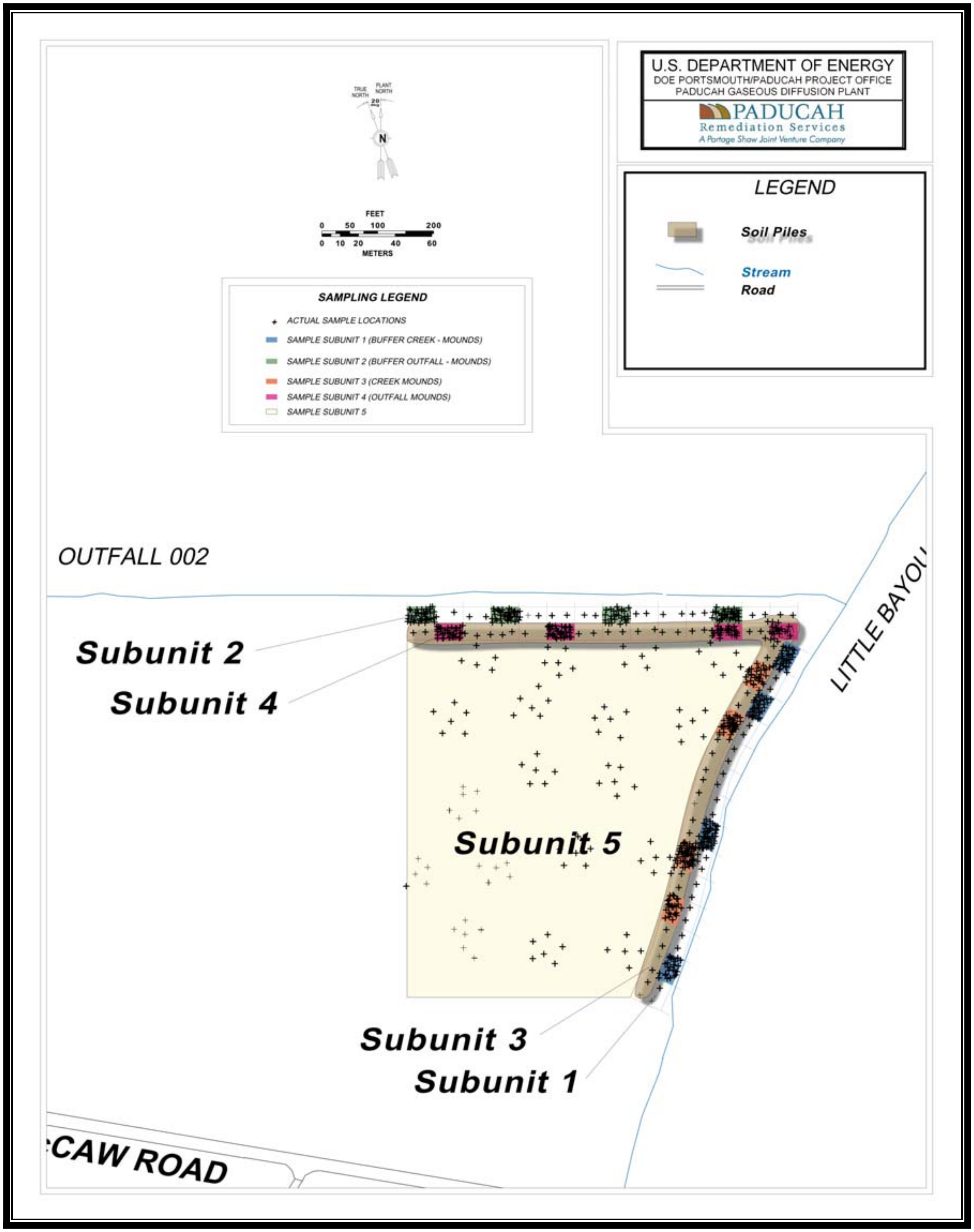


Figure 12. Soil Sample Locations - Soil Pile I

---

[6] Each location was surveyed using a Trimble GPS prior to sample collection.

3.1.5 Deviations from the SAP

In addition to issues discussed in Section 3.1.4, deviations from the SAP, Addendum 1-A, and associated work instructions included a change in the tree sampling method and changes in utilization of the contract laboratory from [Severn Trent Laboratory(STL)] to USEC.

The tree sampling procedure initially specified the use of a tree coring tool that extracts an approximate 1/8 inch diameter core from the tree. Because of the sampling volume required by the contract laboratory for sample analysis, it was determined in the field that sampling with the coring tool would require days to accomplish. As a result, an alternate method was adopted to save field time. This method involved use of an electric drill and spade bit to bore larger holes in the tree. The spade bit cuttings were collected directly into the sample containers. A new, precleaned spade bit was used for sample collection at each tree. This field change was documented in the Field Logbook.

The STL in St. Louis, Missouri, was selected as the contract laboratory to support Addendum 1-A implementation. As the project began, PRS noted this laboratory was issued a Priority 1 finding during their Department of Energy Consolidated Audit Program (DOECAP) audit completed in April 2007. This finding stated, "*The laboratory does not have a Technical Director with the appropriate educational and/or technical background to perform all radiochemistry tests for which the laboratory is accredited.*" DOECAP, along with the PGDP Sample Management Office, recommended that STL radiochemistry support for the Soil Pile I project be terminated. In order to keep the project on schedule, the decision was made to utilize the PGDP USEC laboratory for the radiochemistry portion of the project.

At the beginning of the Soil Pile I project, the STL laboratory was not able to perform the SW-3540/3541 extraction method for PCBs, which was requested by the EPA. STL had to expand the capability of their laboratory to perform this extraction method. In the interim, PCBs were sent to the PGDP USEC laboratory because they already utilized the extraction method and were able to meet the PCB detection limits in the laboratory statement of work (SOW). Once STL had achieved the extraction method capability, PCBs were redirected back to STL for the remainder of the project.

3.1.6 Fixed Laboratory Analysis

As noted, a total of 98 surface soil samples, 51 subsurface soil samples, 5 contingency surface soil samples, and 5 tree tissue samples underwent fixed laboratory analysis. Each was analyzed in accordance with the method requirements outlined in Table 3.

Addendum 1-A to the PGDP Soil Piles SAP also called for analysis of underlying hazardous constituents (UHC) in those samples exceeding toxicity characteristic leaching procedure (TCLP) criteria. To make this determination, constituents whose total concentration was measured at or near 20 times the TCLP maximum concentration limit[7] underwent TCLP analysis for that constituent. Addendum 1-A also called for measurement of waste disposal characteristics for any sample exceeding TCLP criteria. Samples requiring TCLP analysis because of elevated concentrations of key constituents are described in Table 4 and results are noted in Appendix S.

---

[7] As specified in 40 *CFR* § 261.24.

Table 3. Fixed Laboratory Analysis Requirements for Soils

Characterization Parameter	Analytical Method
VOC Target Compound List	EPA 8260
SVOC Target Compound List	EPA 8270
PCBs (Aroclors/Total)	EPA 3450/8082
Inorganic Target Analyte List (Total Metals)	EPA 6010 or EPA 6020
Americium-241	DOE EML HASL-300, Am-05-RC
Cobalt-60	EML HASL 300, 4.5.2.3.
Neptunium-237	DOE EML HASL 300
Plutonium-238	DOE EML HASL-300, Pu-11-RC
Plutonium-239/240	DOE EML HASL-300, Pu-11-RC
Radium- 226	EML HASL 300, 4.5.2.3.
Technetium-99	DOE EML HASL-300, Tc-02-RC
Thorium-228	DOE EML HASL-300, Th-01-RC
Thorium-230/232	DOE EML HASL-300, Th-01-RC
Total Uranium	DOE EML HASL-300, U-02-RC
Uranium-234	DOE EML HASL-300, U-02-RC
Uranium-235 radioactivity	DOE EML HASL-300, U-02-RC
Uranium-238	DOE EML HASL-300, U-02-RC

Table 4. TCLP Samples

Sample ID	Depth	Type
LBCSOSU1S4-01	0-1	Chromium
LBCSOSU3S1-01	0-1	Chromium
LBCSOSU3S1-03	0-1	Chromium
LBCSOSU3S2-05	0-1	Chromium
LBCSOSU3S3-04	0-1	Chromium
LBCSOSU3S4B1-01	1-4	TCLP VOA
LBCSOSU3S4B2-02	4-7	TCLP VOA
LBCSOSU4BF13FS-03	7-10	TCLP SVOA
LBCSOSU4S1B1-01	1-4	TCLP VOA
LBCSOSU4S1B3-01	1-4	TCLP VOA
LBCSOSU4S2B1-01	1-4	TCLP SVOA
LBCSOSU4S2B2-01	1-4	TCLP VOA
LBCSOSU4S2B3-02	4-7	TCLP SVOA
LBCSOSU4S3B2-01	1-4	TCLP VOA
LBCSOSU4S4-02	0-1	Chromium
LBCSOSU4S4B1-01	1-4	TCLP VOA
LBCSOSU4S4B3-01	1-4	TCLP VOA
LBCSOSU4S4B3-02	4-7	TCLP VOA
LBCSOSU4S4B3-03	7-10	TCLP SVOA

VOA = volatile organic analyte

3.1.7 Field Analysis

All of the discrete and composite samples collected at Soil Pile I underwent field analysis. Ninety-eight surface samples, 5 contingency surface samples, and 51 subsurface samples underwent fixed laboratory analysis in addition to field measurements. The total field analysis included 646 surface samples and 117 subsurface samples. Field measurements included the following:

- RCRA metals and uranium using a Niton® X-ray fluorescence (XRF) spectrometer
- Gamma radionuclides using a Canberra® *In situ* object counting system (ISOCS)
- PCBs using Hach® immunoassay sample extraction and colorimetric analysis methods

Both fixed laboratory and field results for the Soil Pile I Investigation are provided in Section 4.5 of this report.

3.1.8 Engineering Data

In the event a removal is deemed necessary for all or portions of Soil Pile I, basic engineering information was acquired to aid in the development of engineering specifications and design documents needed to support the development of removal infrastructure. To support this effort, Addendum 1-A called for the collection of eight samples along anticipated transportation routes. If needed, this information would be used to complete the necessary level of analysis for the design of haul roads. See Appendix T for results.

Addendum 1-A also called for one sample to be collected from Soil Pile I to allow for an evaluation of the physical characteristics of the soil piles should a removal be required. All of the planned samples were collected and analyzed in accordance with Table 5.

The difference in the number of engineering samples was due to fewer required, as discussed and agreed upon during scoping meetings held among DOE and its contractors, KDEP, and EPA during the summer of 2007.

Table 5. Engineering Data Requirements

Engineering Parameter	Analytical Method
Sieve analysis	ASTM D 422
Sieve analysis w/hydrometer	ASTM D 422
Atterberg limits	ASTM D 4318
Field moisture content	ASTM D 2216
Field moisture content/density	ASTM D 2937
Standard Proctor	ASTM D 698
Standard Proctor w/oversize material	ASTM D 698
Specific gravity	ASTM D 854

4. QUALITY ASSURANCE/QUALITY CONTROL

4.1 DATA QUALITY/DATA USABILITY

The following sections summarize the results of data verification, data validation, reconciliation of measurement quality objectives (MQOs), and the comparisons of field and laboratory data obtained from the Soil Pile I investigation.

4.1.1 Precision

Precision is the measure of agreement or reproducibility between individual measurements for the same property under the same analytical conditions. Precision is expressed as RPD for chemical analyses and absolute difference (AD) for radiochemistry.

Precision for Soil Pile I data was measured based on the performance of field and laboratory duplicate samples and laboratory matrix spike (MS) and matrix spike duplicate (MSD) pairs. The precision criteria used to evaluate the solid matrices for soil pile characterization was ± 35% RPD, AD ± 1.96, and 90% compliance to these criteria. Table 6 summarizes the results of this analysis.

Note: Precision does not affect the quality or usability of organic analyses whose precision is measured by MS/MSD pairs. As the SAP notes, precision results do not impact on PCBs, SVOCs, or VOCs in terms of data quality/data usability. Where performance criteria for precision are exceeded, there is less confidence in the reported result because of error introduced from sampling or analysis caused by unequal representation of target compounds or analytes between the two sample pairs.

Table 6. Summary of Precision Performance

Analysis Type	Total Number of Analytes	Number Duplicate Pairs	Average RPD (%)	Compliance to Precision Criteria (%)
Metals	5,040	47	18	99
PCBs	288	4	20	100
Radionuclides	684	24	34	92
SVOCs	2,376	132	NA[a]	100
VOCs	1,426	NA[b]	NA[b]	100

NA = Not Applicable.

[a] The statistic could not be calculated due to the high proportion of nondetects.

[b] Duplicates not sampled.

The SAP required that a minimum of 9 of 10 samples (90%) for each analysis type meet method prescribed precision criteria. As Table 6 illustrates, each analysis type met this goal.

4.1.2 Accuracy

Accuracy is the comparison of a known quantity of a reference standard to the value measured during analysis. Accuracy for Soil Pile I data was assessed by evaluating the performance of the following quality control standards designed to monitor accuracy during sample preparation and analysis.

- Laboratory control samples
- Radioactive tracers
- MS
- MSDs
- Surrogate compounds

Table 7 summarizes the accuracy for the Soil Pile I investigation.

Table 7. Summary of Accuracy Performance

Analysis Type	Total Number of Data Points	Compliance to Accuracy Criteria (%)
Metals	5,040	100
PCBs	288	100
Radionuclides	684	100
SVOCs	2,376	99
VOCs	1,426	99

The SAP required that a minimum of 9 of 10 samples (90%) for each analysis type meet method/PGDP prescribed accuracy criteria. As Table 7 illustrates, each analysis type met this goal.

4.1.3 Completeness

Completeness is defined as the number of valid data points obtained from a sampling effort, compared with the total number of data points obtained. Valid data are those generated when analytical systems and the resulting analytical data meet all of the quantitative measurement objectives for the project. The completeness for the Soil Pile I investigation is provided in Table 8.

Table 8. Summary of Soil Pile I Completeness

Analysis Type	Number of Data Points	Compliance to Precision Criteria (%)	Compliance to Accuracy Criteria (%)	Completeness (%)
Metals	5,040	99	100	99
PCBs	288	100	100	100
Radionuclides	684	92	100	96
SVOCs	2,376	100	99	100
VOCs	1,426	100	99	100

The SAP required that a minimum of 9 of 10 samples (90%) for each analysis type meet completeness criteria. As Table 8 illustrates, each analysis type met this goal. Sections 3.1.4 and 3.1.5 of this SER describe a comparison of planned activities with those executed during field work.

4.1.4 Detection Limits

To ensure the fixed laboratory data acquired from Soil Pile I supports the DQOs, method detection limits (MDLs) were preestablished for each analysis type and defined in the laboratory SOW. The MDLs were designed to ensure that sufficiently sensitive data were obtained from the contract laboratories, so nondetect results did not impact the evaluation of ARARs or human health risks.

For field analytical methods, method sensitivity was a variable determined during the project. Field MDLs were determined in accordance with laboratory analytical protocols, by performing seven nonconsecutive runs on a known standard. The results of these determinations then were used to compute a 99% upper confidence limit (UCL), which was applied to each analytical technique as the MDL. The field analytical methods do not achieve the same level of sensitivity as fixed-base laboratory methods. However, sufficient sensitivity was achieved for each method to support/direct field activities relating to clean up should actions be necessary at Soil Pile I. A complete discussion of field method sensitivity and comparisons of field to laboratory methods are provided in Appendix B [Data Quality Assessment (DQA)].

Reporting limits received from the laboratory were reviewed by project personnel and considered acceptable for meeting the DQOs for this project.

4.1.5 Comparability

Comparability is the degree to which one data set can be compared to another, when both are obtained from the same sample population. Comparability can be achieved only through the use of consistent sampling procedures, experienced sampling personnel, the same or comparable analytical methods, standard field and laboratory documentation, and traceable laboratory standards. To examine comparability, four sets of fixed laboratory data have been acquired from Soil Pile I:

(1) Biased samples collected in 2006 from investigative subunit 3 of Soil Pile I;
(2) Collocated field duplicates collected by KDEP from the 2006 biased locations in investigative subunit 3;
(3) Contingency samples collected in 2007 from the 2006 biased locations in investigative subunit 3; and
(4) Systematic random samples collected in 2007 from investigative subunits 1–5.

Due to the biased nature of the biased samples collected from subunit 3, they cannot be directly compared with results acquired using the randomized sample design. Because each of the biased sample sets was collected from the same locations, samplers employed similar sampling techniques, and similar analytical methods, their comparison provides a measure of variance for locations at Soil Pile I.

As Table 2 illustrates, the 2006 sampling effort provided very comparable results with the exception of values acquired for PCBs. The observed variation in the 2006 PCB results led to the collection of contingency samples in 2007 to verify the previous values. A comparison of the three sets of biased samples is provided in Table 9.

The results show similar variability in PCB results for all three events. While sampling and laboratory error contribute to the variation, the results provide data users with important information to be considered in formulating a decision for Soil Pile I, particularly with respect to PCBs. The results indicate that the soil matrix is heterogeneous in areas where localized contamination is found.

Table 9. Comparison of 2006 and 2007 Biased Samples – Soil Pile I

Sample Number	Analysis	2006 DOE Result	2006 KY Result	2007 DOE Contingency Result
LBCS0111-06	PCB, Total (µg/kg)	810	660	3,700
	Uranium-238 (pCi/g)	179	137	303
	Total Uranium (mg/kg)	205	156	344
	Chromium (mg/kg)	209	184	432
LBCS0211-06	PCB, Total (µg/kg)	23,900	12,700	2,800
	Uranium-238 (pCi/g)	511	730	253
	Total Uranium (mg/kg)	574	809	286
	Chromium (mg/kg)	127	176	132
LBCS0311-06	PCB, Total (µg/kg)	3,160	1,770	39
	Uranium-238 (pCi/g)	458	451	240
	Total Uranium (mg/kg)	516	505	270
	Chromium (mg/kg)	163	235	74.7
LBCS0411-06	PCB, Total (µg/kg)	4,630	6,200	14,000
	Uranium-238 (pCi/g)	172	187	176
	Total Uranium (mg/kg)	196	215.9	199
	Chromium (mg/kg)	932	1,370	1,140
LBCS0511-06	PCB, Total (µg/kg)	46,900	15,700	79,000
	Uranium-238 (pCi/g)	1,340	1,120	315
	Total Uranium (mg/kg)	1,490	1,247	353
	Chromium (mg/kg)	168	205	145

The results are based on samples biased toward locations exhibiting the highest concentrations of contaminants. For purposes of evaluating project data in this report, biased samples from 2006 and the corresponding contingency samples collected under Addendum 1-A in 2007 have not been included in summary statistics or in the assessment of human health risks.

4.1.6 Representativeness

The Soil Pile I investigation was to determine if the study area pose an imminent threat to public health or require immediate actions to mitigate threats. The overriding objectives were to obtain sufficient data to establish the nature and extent of contamination in Soil Pile I and adjacent soils and establish the mean concentrations of COPCs in each investigative subunit. The sampling effort at Soil Pile I has achieved these objectives. Data of known quality were acquired in sufficient quantities to support the development of mean contaminant concentrations in each investigative subunit. The computed mean concentrations were sufficient to support quantitative assessment of human health risks, to compare project data with chemical-specific ARARs and allow decision makers to formulate an informed decision as to the need for immediate actions at Soil Pile I.

The investigation supports an examination of contaminant distribution in both surface and subsurface soils, and it has identified those contaminants that must be considered in decision making going forward. The data bounds the concentrations of contaminants, identifying the minimum and maximum concentrations found at the site, and the sampling design has successfully identified where contamination is found, where it is not, and, for the majority of Soil Pile I, has delineated the boundaries of that contamination.

The investigation also was successful in identifying localized areas of contamination in the study area which must be considered in developing decisions concerning Soil Pile I. Finally, sufficient data have been acquired to inform decision makers concerning the levels and composition of the materials in Soil Pile I, such that, if an interim action is deemed necessary, a determination can be made as to where and how contaminated media should be dispositioned.

4.1.7 Field Quality Control Summary

Field quality control (QC) samples are independently generated samples from a pre-defined sampling scheme, designed to monitor the reproducibility, cleanliness, and accuracy of the sampling and analytical process. The following are the field QC samples prescribed for the Soil Pile I investigation:

- Field duplicates
- Field blanks
- Trip blanks
- Equipment rinseate blanks

QC samples were required by Addendum 1-A at a frequency of 1 QC sample for every 20 samples collected or 5%. With the exception of trip blanks, the collection frequency for QC samples applied to all samples whether undergoing field analysis or fixed laboratory analysis. Because trip blanks were required for VOC samples only, trip blanks are applicable only to fixed laboratory results for VOCs.

Field duplicates were collected and analyzed to evaluate the reproducibility (precision) of sampling techniques, laboratory methods, and to monitor the natural variability of the sample matrix. Field duplicates were co-located with the sample locations they were intended to mimic and were submitted as separate blind samples, with separate field identification numbers to the contract laboratory. The prescribed collection frequency was met with field duplicates collected and analyzed at a frequency of 6% for the Soil Pile I investigation. Field duplicate precision was met for the Soil Pile I investigation.

Field blanks were collected and analyzed to evaluate any cross contamination attributable to field methods including sample container handling. The prescribed frequency for field blanks was met with field blanks collected and analyzed at a frequency of 7% for the Soil Pile I investigation.

Addendum 1-A required that field rinseate blanks be collected and analyzed for those investigative subunits where subsurface samples were collected and sampling equipment was decontaminated and reused. Field rinseate blanks provide a measure of cross-contamination attributable to field equipment decontamination procedures. The prescribed frequency was met, with field rinseate blanks collected and analyzed at a frequency of 12%.

Trip blanks were prepared and analyzed to provide a measure of contamination to VOC samples from sample containers and sample shipment. The prescribed trip blank frequency was met with 1 trip blank submitted for every 20 samples or at a frequency of 5%.

In summary, field, trip, and rinseate blanks were analyzed to verify the cleanliness of the sampling, shipping, decontamination, and the overall analytical process. Each is designed to monitor at least one aspect of the process, with all providing meaningful information as to the reliability of low-level contaminant results.

4.1.8 Data Quality Summary/Fixed Laboratory Data

As stated, the primary DQO for the Soil Pile I investigation was to acquire sufficient data of known quality to support decision making. Experience and properly trained field personnel were utilized to execute the sampling and operating procedures. Project samples were collected, preserved, handled, and shipped in accordance with the SAP and industry and PGDP standard procedures. Reputable analytical laboratories using industry standard analytical procedures were utilized to generate sample data that complies with the requirements of the laboratory statements(s) of work and specified protocols.

Project data underwent a 10% Level C validation, with all data undergoing verification. This examination of the Soil Pile I data was completed in accordance with Section 3.2.7 of the SAP and the PGDP sitewide standard operating procedures for reviewing environmental data (Appendix B of the SAP). Precision, accuracy, and completeness criteria were met for all fixed-base laboratory data indicating the data set will support decision making. A complete examination of data quality is provided in Appendix B (DQA).

4.1.9 Data Quality Summary/Field Analytical Data

Each of the field techniques employed for the Soil Pile I investigation utilized QC measures to monitor the accuracy, precision, and drift of the method during use. The following summarizes the results of QC analysis.

4.1.9.1 XRF

To support field XRF analysis, three types of QC samples were analyzed with each batch of 20 samples. These included (1) blanks, (2) duplicates, and (3) standard reference materials (SRMs). The XRF blank was vendor-provided, consisting of silica-certified clean for use as a blank.

Blank results for XRF analysis showed no positive detections during execution of Addendum 1-A.

XRF duplicates were prepared from a field sample by taking a second volume of soil, placing it in the analysis cuvet, and analyzing it with the field samples. Precision for XRF duplicates was < 35% RPD for all field-laboratory duplicates.

Three SRMs were analyzed daily to monitor XRF accuracy. They represent low [National Institute of Standards and Technology (NIST) 2709], moderate (NIST 2711), and high (NIST 2710) level standards for soil analysis for metals. SRM performance was mixed for the three standards, with the low-level standard performing well for lead and barium, and moderately well for arsenic. The low concentrations for the remaining metals were outside the operating range of the XRF (below the

MDL).[8] The mid-range standard performed well for barium and lead, with moderate performance for arsenic, zinc, and cadmium. The high-end standard performed very well for arsenic, barium, uranium,[9] and lead. The remaining metals concentrations were below the MDL for the XRF.

4.1.9.2 Field PCBs

To support field PCB analysis, three types of QC samples were analyzed with each batch of 20 samples: (1) blanks, (2) duplicates, and (3) calibration verification standards. The following summarizes QC performance.

- No positive detections were noted in any of the PCB method blanks.
- Precision for PCB duplicates was < 35% RPD for all field-laboratory duplicates.
- All calibration verifications had recoveries within 90–110%.

4.1.9.3 ISOCS

To support field ISOCS analysis, two types of QC samples were analyzed daily. Daily checks included 1) a background and 2) a NIST traceable calibration/check source.

Background results for ISOCS analysis were all within acceptable limits (i.e., 2 sigma of weekly background). In addition to daily QC checks, a chamber background count was performed weekly for a predetermined count time. The predetermined background count time was equal to or greater than the sample count time. The weekly background count is used for background subtraction in the activity calculation. An accurate representation of the background for the detector is necessary to produce high quality sample results.

The NIST traceable calibration/check source consists of a mixed radionuclide with gamma peaks that cover the range (i.e., low, mid, high) of detections, generally 59 keV to 2,000 keV. All daily check source results for ISOCS analysis were within acceptable limits (i.e., 2 sigma).

4.1.10 Field Versus Laboratory Comparison

Another objective of the Soil Pile I investigation was to determine the efficacy of field analytical methods as a tool to support characterization and/or removal verification activities at PGDP. To make this determination, comparisons were completed between fixed laboratory and field data. Several techniques were employed to evaluate field data utility for future uses including the following:

- Direct comparison
- Correlation analysis
- UCL comparison

A complete evaluation of Soil Pile I data comparisons can be found in Appendix B (DQA).

4.1.10.1 Direct comparison

The first analysis applied to Soil Pile I field data was to compare individual sample concentrations directly to field and laboratory results. In addition to providing a direct measure of field data accuracy, direct comparison also provides both false negative and false positive rates for each field

---

[8] Selenium was not added to any of the standards.

[9] Chromium and uranium levels for the NIST SRMs are not certified values.

method employed. In this evaluation, field and fixed laboratory results were directly compared on a location-by-location basis to determine how well concentrations correspond between methods. Table 10 provides a summary of this analysis.

Table 10. Direct Comparison of Fixed Laboratory and Field Data

Analyte	# of Samples	% Detected Laboratory Data	% Detected Field Data	% Detected Field and Laboratory Data
Barium	98	100	100	100
Chromium	98	100	0	0
Lead	98	100	59	59
Uranium	98	100	18	18
PCB	60	45	13	8
Cesium-137	98	74	36	26
Uranium-238	95	100	1	1

4.1.10.2 Correlation analysis

The next analyses applied to Soil Pile I data were simple correlation analyses. They were employed to determine if a strong mathematical correlation exists between field and laboratory results. Table 11 provides a summary of this examination.

Table 11. Correlation of Field and Laboratory Data from Soil Pile I

Analyte	Correlation Coefficient
Cesium-137	0.50
Barium	0.25
Barium (Outliers Removed)	0.31
Chromium	NP
Lead, Uranium	0.80
PCBs	NP

NP = Correlation could not be performed due to insufficient number of detections.

Based on this analysis, the following observations emerge:

- **XRF:** Correlation for lead and uranium is strong. Limitations when making the comparison come when (ICP-MS) and XRF nondetects are included in this examination. This is primarily due to the difference in sensitivity between the two methods.

- **PCBs:** Correlation between laboratory and field PCB results is inconclusive due to the limited number of detections observed in each subunit and sitewide.

- **ISOCS:** Correlation between field and fixed laboratory data for cesium-137 is not very strong. For cesium-137, this is likely due to the relative insensitivity of the acquired data.

4.1.10.3 UCL comparison

The third technique applied to Soil Pile I data was comparisons of 95% UCLs determined by investigative subunit. This examination provides insight into data comparability, even when field and laboratory results do not correlate well on a sample-by-sample basis. Because UCL examinations employ summary statistics, a reasonably large number of detections are required in order to compute UCLs for both data sets.

To complete this evaluation, 95% UCLs were computed for both field and laboratory results. The following lists the outcome of these comparisons.

- UCLs computed for lead and uranium field results compare favorably with UCLs obtained from fixed laboratory data within the operating range of the XRF.

- The UCL analysis for ISOCS was inconclusive because of the large number of nondetects.

- The UCL analysis for PCBs was inconclusive because of the large number of nondetects.

Lead field data compared favorably with fixed laboratory data. Similarly, uranium and uranium-238 were detected in both field and fixed laboratory data concentrations when concentrations were above background.

When concentrations of PCBs were observed in the fixed laboratory data above 4 ppm, field PCB results also showed positive detections. The PCB field method does not accurately measure PCBs below 4 ppm. Additionally, the PCB field method was unable to reproduce results at the end of the concentration range (e.g., 79 ppm). Also worthy of note are the observed false positive and false negative rates. The PCB field method did not exhibit false negative results when PCBs were measured by the laboratory at concentrations greater than 4 ppm. Overall, the field method determined PCBs were present 6% of the time when the laboratory did not measure them above 4 ppm (false positive).

Field data concentrations of uranium-238 compared favorably with the fixed lab uranium-238 results when the fixed lab results were notably above background. If the fixed lab data were near or below background, the ISOCS was unable to detect uranium-238 in the soils. This is likely the result of abbreviated count times employed for ISOCS during the analysis of Soil Pile I samples.

4.1.11 Summary

Comparison of data obtained from the Soil Pile I investigation indicates field methods can be used to support investigation planning, to identify locations where contamination is present, and as a verification tool during remediation activities. Each of the methods is performed differently, with varying degrees of success in demonstrating their efficacy. The following summarizes the findings as they relate to each field method employed.

4.1.11.1 X-Ray florescence

An adequate sample population for both lead and uranium was available to examine the data statistically. The Soil Pile I investigation demonstrates that XRF is a quantitative tool that may be used for total uranium and lead during future investigations. It is suitable to deploy for characterization and removal verification at PGDP in the future, when lead and uranium action limits are greater than the instrument-specific MDL.

XRF should not serve as a substitute for radiochemistry data when little or no information is known for a given site. Once sufficient data is available to establish uranium and uranium daughter concentrations/ratios, XRF may be used effectively to determine uranium concentrations in PGDP soils and may be considered to estimate uranium daughter concentrations. Because it is relatively inexpensive and efficient, XRF is very useful in determining the distribution of uranium and lead. The method was relatively insensitive for the other RCRA metals and may have limited utility in examining these metals on future investigations.

XRF limitations are due to method insensitivity when compared with laboratory methods. To illustrate, method detection limits between XRF and inductively coupled plasma-mass spectrometer (ICP-MS) differ by two orders of magnitude (ICP-MS = 100 ppb; XRF = 18 ppm). Although this difference is numerically significant, the XRF accurately measures total uranium such that it can be used to estimate isotopic uranium below established PGDP risk-based benchmarks for uranium-238 (DOE 2001).

A complete examination of XRF utility is presented in Appendix B (DQA).

4.1.11.2 Field PCBs by immunoassay/colorimetric techniques

A limited population of positive PCB concentrations was available for comparison at Soil Pile I. To illustrate, when both field and laboratory PCB methods both showed measurable PCB concentrations, only four pairs of samples were available.

This method has demonstrated that it can reliably predict the presence of PCBs above 4 ppm; however, the method also exhibited a 6% false positive rate. For purposes of performing initial site screening to determine PCB presence or absence, these two factors together are positive, in that, the method will reliably predict PCBs when they are present at levels approaching Toxic Substances Control Act (TSCA) benchmarks of 25 ppm and 50 ppm. In addition, the method did not show false negative results when PCBs were present in laboratory derived results between 4 ppm and 72 ppm.

Based on the limited sample population available, the PCB test method did not accurately measure very low-level PCBs nor did it accurately measure PCBs at very high concentrations. Until additional information is available, the PCB method should not be used to support risk assessment nor as the sole basis for making regulatory related decisions. It can be used to inform decision making for PCB contamination, when a sufficient quantity of fixed laboratory data is available from corresponding locations.

A complete examination of PCB test kit utility is presented in Appendix B (DQA).

4.1.11.3 *In Situ* Object Counting System

The ISOCS used for the Soil Pile I investigation was employed in an *ex situ* manner, meaning it was deployed in a controlled environment, during sample analysis. ISOCS accurately measures gamma-emitting radioisotopes when they are present at levels within its operating range. Evaluation of the method comparing it with laboratory uranium-238 results indicates a strong correlation when laboratory data is detected above the ISOCS minimum detectable activity range.

Limitations on use of the ISOCS for Soil Pile I likely relate to its sensitivity for gamma emitting isotopes. This may be attributed to relatively short count times employed during quantitation of sample radioactivity for Soil Pile I. The short count times resulted in relatively high minimal detectable activities (MDAs) for the project, limiting its ability to measure mid- and low-level sample concentrations. Consequently, the ISOCS was only able to predict the presence of uranium-238 at relatively few locations for Soil Pile I.

Method accuracy is sound and the false positive rate is very low; however, method insensitivity for this project would allow the method to be used only as a screening tool. Until additional information is available, the ISOCS should not be used to support risk assessment nor as the sole basis for making regulatory related decisions. It can be used to evaluate uranium-238 distribution when a sufficient quantity of fixed laboratory data is available from corresponding locations.

A complete examination of ISOCs utility is presented in Appendix B (DQA).

THIS PAGE INTENTIONALLY LEFT BLANK

5. DISCUSSION AND RESULTS

The following section presents and evaluates the results for the Soil Pile I investigation. It includes a discussion of the conceptual site model (CSM) as it was defined for investigation planning and a discussion of contaminants identified at Soil Pile I. This section also provides data screening versus PGDP decision levels, describes contaminant distribution, examines contaminant concentrations versus chemical-specific ARARs, and discusses contaminant fate and transport. Summary statistics for all project data are presented in Appendix C. A complete set of project data can be found in Appendices D–T.

5.1 CONSTITUENTS ANALYZED FOR BUT NOT DETECTED

The following constituents were analyzed for but not detected in any samples at Soil Pile I. They are not considered further in evaluating site conditions.

- 1,1,1,2-Tetrachloroethane
- 1,1,1-Trichloroethane
- 1,1,2,2-Tetrachloroethane
- 1,1,2-Trichloroethane
- 1,1-Dichloroethane
- 1,1-Dichloroethene
- 1,2,3-Trichloropropane
- 1,2,4-Trichlorobenzene
- 1,2-Dibromoethane
- 1,2-Dichlorobenzene
- 1,2-Dichloroethane
- 1,2-Dichloropropane
- 1,3-Dichlorobenzene
- 1,4-Dichlorobenzene
- 2,4,5-Trichlorophenol
- 2,4,6-Trichlorophenol
- 2,4-Dichlorophenol
- 2,4-Dimethylphenol
- 2,4-Dinitrophenol
- 2,4-Dinitrotoluene
- 2,6-Dinitrotoluene
- 2-Chloroethyl vinyl ether
- 2-Chloronaphthalene
- 2-Chlorophenol
- 2-Hexanone
- 2-Methyl-4,6-dinitrophenol
- 2-Methylphenol
- 2-Nitroanaline
- 2-Nitrophenol
- 3,3-Dichlorobenzidine
- 3-Nitroanaline
- 4-Bromophenyl phenyl ether
- 4-Chloro-3-methylphenol
- 4-Chloroanaline
- 4-Chlorophenyl phenyl ether
- 4-Methyl-2-pentanone
- 4-Methylphenol
- 4-Nitroanaline
- 4-Nitrophenol
- Acenaphthylene
- Benzene
- Benzyl alcohol
- Bis(2-chloroethoxy)methane
- Bis(2-chloroethyl) ether
- Bis(2-chloroisopropyl) ether
- Bromodichloromethane
- Bromoform
- Bromomethane
- Carbon disulfide
- Carbon tetrachloride
- Chlorobenzene
- Chloroethane
- Chloroform
- Chloromethane
- *cis*-1,2-Dichloroethene
- *cis*-1,3-Dichloropropene
- Cobalt-60
- Dibromochloromethane
- Dibromomethane
- Dichlorodifluoromethane
- Dimethyl phthalate
- Di-n-octylphthalate
- Ethyl methacrylate
- Hexachlorobenzene
- Hexachlorobutadiene
- Hexachlorocyclopentadiene
- Hexachloroethane
- Iodomethane
- Isophorone
- Nitrobenzene
- N-Nitroso-di-n-propylamine
- N-Nitrosodi-n-propylamine
- N-Nitrosodiphenylamine
- o-Xylene
- Paint Filter Test
- Aroclor-1016
- Aroclor-1221
- Aroclor-1232
- Aroclor-1242
- Aroclor-1268
- Pentachlorophenol
- Phenol
- Pyridine
- Reactive Cyanide
- Reactive Sulfide
- Styrene
- Tetrachloroethene
- *trans*-1,2-Dichloroethene
- *trans*-1,3-Dichloropropene
- *trans*-1,4-Dichloro-2-butene
- Trichloroethene
- Trichlorofluoromethane
- Vinyl acetate
- Vinyl chloride.

5.2 CONCEPTUAL SITE MODEL

The following description of the CSM is taken from the PGDP soil piles SAP (DOE 2007a). It summarizes the expected receptors and exposures. The screening level risk assessment (SLRA) in Section 6 further refines the CSM for Soil Pile I.

Recreational activities known to take place in and around the PGDP soil piles include the following:

- Bow hunting
- Field trials (horses and dogs)
- Other recreational uses (e.g., hiking)

Recreational user exposure to surface soils is the primary exposure pathway. The recreational user could be exposed to contaminants through contact with surface soils through the following exposure routes:

- External exposure to ionizing radiation
- Dermal contact
- Incidental ingestion
- Inhalation

Recreational user exposure to surface soils through the dermal contact, incidental ingestion, and inhalation is likely limited given that most soil piles and soils in the adjoining areas are covered by continuous vegetation. Industrial worker exposure would be similar for nonintrusive activities.

Soil Pile I is located adjacent to Little Bayou Creek. This proximity to surface water drainage areas could result in several potential secondary exposure routes that could impact human health and the environment. The majority of the secondary routes assume the soils or contaminants they contain have been released to adjacent waterways or moved through the food chain.

Precipitation could result in contaminant migration from the soil piles; however, PGDP historical monitoring data indicate little migration is occurring (Section 2.6). Further, data presented in this SER indicate contaminants are not migrating away from Soil Pile I.

The majority of the contaminants at Soil Pile I do not bioaccumulate in plants to a great degree. As a result, plant uptake and corresponding accumulation in animal tissue is unlikely, but soil ingestion as part of normal feeding activities is likely a complete pathway. Ecological receptors also may be exposed to on-site contaminants; however, the primary focus of the characterization effort is to determine risks to human health.

5.3 EXAMINATION OF SAMPLE POPULATIONS

As part of project planning, the Soil Pile I operating hypothesis for investigative subunits was that each subunit likely represents a unique population, in terms of contaminant type, concentrations, and distribution. This coupled with their relative size and the physical setting at each, led initially to establishing each subunit as an exposure unit (EU). To examine this hypothesis and to determine how individual EUs correspond to individual subunits, the data from each subunit was examined to determine if individual sample populations were present. Following this examination, each subunit was compared with all the other subunits to determine if any/all were the same population. The complete evaluation of individual subunit populations and comparisons among subunits is provided in the DQA in Appendix B.

The comparison indicates subunits 1, 2, 4, and 5 are similar populations when considered individually and all are statistically similar to one another when compared to one other. While statistically similar, due to their size and geographic separation, these four subunits have been retained as separate EUs in evaluating site conditions. Additional detail concerning EUs is provided in Section 6.1.4.

Per Addendum 1-A, subunit 5 was evaluated specifically to determine if multiple contaminant populations were present. If multiple contaminant populations were identified, subunit 5 would be divided into individual EUs to correspond with the various populations. The statistical comparison for subunit 5 indicates it contains a single population. While some variation in the project data exists, dividing subunit 5 into multiple 0.5 acre EUs will not change the outcome of the screening risk assessment or the evaluation of chemical-specific ARARs. Therefore, subunit 5 has been considered a single EU for evaluating conditions at Soil Pile I.

Subunit 3 was found to be significantly different from all the other subunits based on contaminant concentrations and distribution. Subunit 3 has been treated as an individual EU for purposes of examining environmental conditions.

5.4 SURFACE DISTRIBUTION OF CONTAMINANTS

The initial step in examining project data from Soil Pile I was to perform a series of data screening steps, designed to establish which constituents must be retained for further consideration as chemicals of potential concern (COPCs). The data screening steps employed for Soil Pile I include the following:

- Comparison of maximum contaminant concentrations to PGDP background levels for soils (where applicable);
- Comparison of contaminant concentrations to established teen recreational user no action levels (NALs); [10]
- Evaluation of frequency of detection for each contaminant.

Those contaminants whose concentrations exceed PGDP background levels, exceed PGDP NALs for the teen recreational receptor, and were detected at a frequency greater than 5% were retained as COPCs. Those contaminants found to be less than either were not retained for further consideration.

Following data screening, the distribution of COPCs is examined for each subunit. The presentation of results is organized as follows:

- Subunit 1
- Subunit 2
- Subunit 5
- Subunit 3
- Subunit 4

---

[10] No Action Levels were taken from the PGDP Risk Methods Document (DOE 2001).

5.4.1 Subunit 1

Subunit 1 is the “buffer area” that joins Little Bayou Creek to Soil Pile I (Figure 6). A total of 21 composite surface soil samples,[11] created from 100 discrete locations, was collected and submitted for a full suite of fixed laboratory analyses. Tables 6-9 in Appendix C provide summary statistics for subunit 1 surface soils acquired from fixed laboratory analysis.

A total of 136 discrete and composite surface samples was collected in subunit 1 for field analyses. Of these, 116 were discrete samples collected for field measurements only. Each field sample was analyzed for RCRA metals and uranium, radionuclides, and PCBs in accordance with the prescribed field methods. Tables 10 through 12 in Appendix C provide summary statistics for constituents measured using field methods for subunit 1 surface samples.

To support data screening for subunit 1 soils, maximum fixed laboratory results are presented in Table 12. Constituents appearing as bold are those whose maximum concentrations exceed background (where applicable) and NALs for the teen recreational receptor.[12]

Benzo(a)pyrene was measured at a concentration greater than the teen recreator NAL. However, the PAH compounds (including benzo(a)pyrene) were detected in only 1 of 20 surface soil samples. Based on limited detection frequency, they are not considered COPCs for subunit 1. Based on the screening of subunit 1 data, the following are retained as COPCs: antimony, arsenic, beryllium, manganese, uranium and vanadium, cesium-137, uranium-238, and Aroclor-1260.[13]

As Table 12 illustrates, metals were detected in nearly all fixed laboratory data acquired from subunit 1 surface soils. With the exception of plutonium-239, technetium-99, and uranium-235, the radionuclides also were measured in nearly all of the subunit 1 surface soils. Total PCBs and PAHs were detected in only a fraction of the samples, with all of the measured values at or near the method detection limit.

Field analytical results for subunit 1 mirror those for the fixed laboratory data, noting metal detections in nearly all surface samples and PCBs noted in only a fraction of samples. When the laboratory, field, and GWS results are considered, the results indicate COPC distribution is at its highest in the middle 1/3 of subunit 1 adjacent to subunit 3 and at the northern end of the subunit near the confluence of Little Bayou Creek and Outfall 002 (Figure 5). Locations exhibiting elevated concentrations correspond with the location of contamination identified in subunit 3 (see Section 5.4.3).

5.4.2 Subunit 2

Subunit 2 is the “buffer area” that joins Outfall 002 to Soil Pile I (Figure 7). A total of 20 composite surface soil samples[14] was collected and submitted for a full suite of fixed laboratory analyses. Tables 13–14 in Appendix C provide summary statistics for subunit 2 surface soils acquired from fixed laboratory analysis.

A total of 136 discrete and composite surface soil samples was collected in subunit 2 for field analysis. Of these, 116 were discrete samples collected for field measurements only. Each was analyzed for RCRA metals and uranium, radionuclides, and PCBs in accordance with the prescribed

---

[11] In accordance with Addendum 1-A, subsurface samples were not collected in subunit 1.

[12] NALs for the teen recreational receptor were used for screening as it is the most likely, most conservative current land user.

[13] Organic compounds are not naturally occurring constituents; therefore, there are no established background concentrations.

[14] In accordance with Addendum 1-A, subsurface samples were not collected in subunit 2.

field methods. Tables 15–17 in Appendix C provide summary statistics for constituents measured using field methods for subunit 2 surface soils.

Table 12. Examination of Subunit 1 Results

Analyte	Maximum Concentration	Surface Background	Units	Exceed Background	NAL	Units	Exceed NAL	Detection Frequency
Aluminum	8,940	13,000	mg/kg	NO	3,010	mg/kg	Yes	21/21
Antimony	**0.45**	**0.21**	**mg/kg**	**YES**	**0.242**	**mg/kg**	**Yes**	**21/21**
Arsenic	**22.2**	**12**	**mg/kg**	**YES**	**0.346**	**mg/kg**	**Yes**	**21/21**
Barium	117	200	mg/kg	NO	148	mg/kg	No	21/21
Beryllium	**0.87**	**0.67**	**mg/kg**	**YES**	**0.606**	**mg/kg**	**Yes**	**21/21**
Cadmium	0.23	0.21	mg/kg	YES	14.7	mg/kg	No	21/21
Chromium	180	16	mg/kg	YES	227	mg/kg	No	21/21
Cobalt	31	14	mg/kg	YES	1,390	mg/kg	No	21/21
Copper	12.3	19	mg/kg	NO	331	mg/kg	No	21/21
Iron	26,000	28,000	mg/kg	NO	1,350	mg/kg	Yes	21/21
Lead	36.4	36	mg/kg	YES	50	mg/kg	No	21/21
Magnesium	1,060	7,700	mg/kg	NO	0	mg/kg	NA	21/21
Manganese	**2,230**	**1,500**	**mg/kg**	**YES**	**29**	**mg/kg**	**Yes**	**20/21**
Mercury	0.06	0.20	mg/kg	NO	0.634	mg/kg	No	21/21
Molybdenum	1.2	NA	mg/kg	NO	56.4	mg/kg	No	21/21
Nickel	11.5	21	mg/kg	NO	161	mg/kg	No	21/21
Selenium	0.57	0.80	mg/kg	NO	65	mg/kg	No	21/21
Silver	0.12	2.30	mg/kg	NO	27	mg/kg	No	21/21
Thallium	0.26	0.34	mg/kg	NO	0.539	mg/kg	No	21/21
Uranium	**82.4**	**4.90**	**mg/kg**	**YES**	**14.7**	**mg/kg**	**Yes**	**21/21**
Vanadium	**40.5**	**38**	**mg/kg**	**YES**	**2.12**	**mg/kg**	**Yes**	**21/21**
Zinc	140	65	mg/kg	YES	1,800	mg/kg	No	21/21
Total PCB	**0.36**	**NA**	**mg/kg**	**NA**	**0.127**	**mg/kg**	**Yes**	**8/22**
Total PAH	**0.09889**	**NA**	**mg/kg**	**NA**	**0.0133**	**mg/kg**	**Yes**	**1/21**
Cesium-137	**0.56**	**0.49**	**pCi/g**	**YES**	**0.178**	**pCi/g**	**Yes**	**20/21**
Plutonium-239	0.018	0.03	pCi/g	NO	30.3	pCi/g	No	1/21
Radium-226	0.956	1.50	pCi/g	NO	0.0534	pCi/g	Yes	21/21
Technetium-99	1.4	2.50	pCi/g	NO	926	pCi/g	No	4/21
Thorium-230	0.335	1.50	pCi/g	NO	39	pCi/g	No	21/21
Uranium-234	1.45	2.50	pCi/g	NO	52.2	pCi/g	No	21/21
Uranium-235	0.257	0.14	pCi/g	YES	0.826	pCi/g	No	10/31
Uranium-238	**13.7**	**1.20**	**pCi/g**	**YES**	**3.64**	**pCi/g**	**Yes**	**21/21**

[1] NA = information is not available or not applicable.

[2] Background values for surface soils are provisional values taken from Table A-12 of the 2000 revision of *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2001).

[3] The value for lead is regulatory based, not risk based.

[4] The table does not include essential human nutrients. The nutrients detected but not shown are calcium, magnesium, potassium, and sodium. All essential nutrients were below background.

To support data screening for subunit 2 soils, maximum fixed laboratory results are presented in Table 13. Constituents appearing as bold, are those whose maximum concentrations exceed background (where applicable) and NALs for the teen recreational receptor.

Based on the screening of subunit 2 results, the following have been retained as COPCs: antimony, arsenic, beryllium, lead, manganese, and vanadium. The remaining constituents were either less than background or the teen recreational NAL.

All of the metal COPCs were detected in each surface location for fixed laboratory analysis. Radionuclides were detected at low levels, all of which were below background. None of the organic constituents evaluated were detected in subunit 2 fixed laboratory data.

Field analytical results for subunit 2 mirror those for the fixed laboratory data, noting metal detections in nearly all surface samples. ISOCS also measured cesium-137 in approximately 40% of the surface samples, which corresponds well with fixed laboratory results; however, cesium-137 was less than the published PGDP background level.

Field results differed from fixed laboratory results in that low-levels of Total PCBs were noted in 4 of 116 samples. However, the reported PCB concentrations were less than 2x the MDL, indicating they are false positive values.

When all subunit 2 data are considered, the results indicate COPC distribution is relatively uniform throughout subunit 2. Differences in reported concentrations are likely due to the natural variability of the site and the soil media.

5.4.3 Subunit 5

Subunit 5 is the large open area west and south of Soil Pile I (Figure 7). A total of 19 composite surface soil samples[15] was collected and submitted for a full suite of fixed laboratory analyses. Tables 40–41 in Appendix C provide summary statistics for subunit 5 surface soils acquired from fixed laboratory analysis.

A total of 102 discrete and composite surface soil samples was collected in subunit 5 for field analysis. Of these, 84 were discrete samples collected for field measurements only. Each was analyzed for RCRA metals and uranium, radionuclides, and PCBs in accordance with the prescribed field methods. Tables 42–44 in Appendix C provide summary statistics for field measurements of subunit 5 surface soils.

To support data screening for subunit 5 soils, maximum fixed laboratory results are presented in Table 14. Constituents appearing as bold are those whose maximum concentrations exceed background (where applicable) and NALs for the teen recreational receptor.

Based on the screening of subunit 5 results, the following have been retained as COPCs: aluminum, antimony, arsenic, barium, beryllium, lead, manganese, vanadium, and cesium-137. The remaining constituents either were less than background or the teen recreational NAL.

Each of the metal COPCs was detected in all of the surface locations for fixed laboratory analysis. Similarly, cesium-137 was detected at all locations. None of the organic constituents evaluated were detected in subunit 5 fixed laboratory data.

---

[15] In accordance with Addendum 1-A, subsurface samples were not collected in subunit 5.

Table 13. Examination of Subunit 2 Results

Analyte	Maximum Concentration	Surface Background	Units	Exceed Background	NAL	Units	Exceed NAL	Detection Frequency
Aluminum	12,600	13,000	mg/kg	No	3,010	mg/kg	Yes	20/20
Antimony	**0.59**	**0.21**	**mg/kg**	**Yes**	**0.242**	**mg/kg**	**Yes**	**20/20**
Arsenic	**33.1**	**12**	**mg/kg**	**Yes**	**0.346**	**mg/kg**	**Yes**	**20/20**
Barium	**438**	**200**	**mg/kg**	**Yes**	**148**	**mg/kg**	**Yes**	**20/20**
Beryllium	**0.83**	**0.67**	**mg/kg**	**Yes**	**0.606**	**mg/kg**	**Yes**	**20/20**
Cadmium	0.12	0.21	mg/kg	No	14.7	mg/kg	No	20/20
Chromium	22	16	mg/kg	Yes	227	mg/kg	No	20/20
Cobalt	30.9	14	mg/kg	Yes	1,390	mg/kg	No	20/20
Copper	13	19	mg/kg	No	331	mg/kg	No	20/20
Iron	26,500	28,000	mg/kg	No	1,350	mg/kg	Yes	20/20
Lead	**71.1**	**36**	**mg/kg**	**Yes**	**50**	**mg/kg**	**Yes**	**20/20**
Magnesium	1,880	7,700	mg/kg	No	NA	mg/kg	NA	20/20
Manganese	**5,230**	**1,500**	**mg/kg**	**Yes**	**29**	**mg/kg**	**Yes**	**20/20**
Mercury	0.0656	0.20	mg/kg	No	0.634	mg/kg	No	19/20
Molybdenum	2	NA	mg/kg	No	56.4	mg/kg	No	20/20
Nickel	14.2	21.00	mg/kg	No	161	mg/kg	No	20/20
Selenium	0.7	0.80	mg/kg	No	65	mg/kg	No	20/20
Silver	0.068	2.30	mg/kg	No	27	mg/kg	No	20/20
Thallium	0.52	0.34	mg/kg	Yes	0.539	mg/kg	No	20/20
Uranium	2.6	4.90	mg/kg	No	14.7	mg/kg	No	20/20
Vanadium	**50**	**38**	**mg/kg**	**Yes**	**2.12**	**mg/kg**	**Yes**	**20/20**
Zinc	36	65	mg/kg	No	1,800	mg/kg	No	20/20
Americium-241	0.019	NA	pCi/g	NA	11.6	pCi/g	No	1/20
Cesium-137	0.38	0.49	pCi/g	No	0.178	pCi/g	Yes	11/20
Plutonium-238	0.031	0.073	pCi/g	No	31	pCi/g	No	1/20
Radium-226	1.4	1.500	pCi/g	No	0.0534	pCi/g	Yes	20/20
Technetium-99	1.31	2.50	pCi/g	No	926	pCi/g	No	10/20
Thorium-230	1.14	1.50	pCi/g	No	39	pCi/g	No	20/20
Uranium-234	1.1	2.50	pCi/g	No	52.2	pCi/g	No	20/20
Uranium-235	0.069	0.14	pCi/g	No	0.826	pCi/g	No	20/20
Uranium-238	1.25	1.20	pCi/g	Yes	3.64	pCi/g	No	20/20

[1] NA = information is not available or not applicable.

[2] Background values for surface soil are provisional values taken from Table A-12 of the 2000 revision of *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2000).

[3] The value for lead is regulatory based not risk based.

[4] The table does not include essential human nutrients. The nutrients detected but not shown are calcium, magnesium, potassium, and sodium. All essential nutrients were below background.

Table 14. Examination of Subunit 5 Results

Analyte	Maximum Concentration	Surface Background	Unit	Exceed Background	NAL	Unit	Exceed NAL	Detection Frequency
Aluminum	**13,800**	**13,000**	**mg/kg**	**Yes**	**3,010**	**mg/kg**	**Yes**	**19/19**
Antimony	**0.49**	**0.21**	**mg/kg**	**Yes**	**0.242**	**mg/kg**	**Yes**	**19/19**
Arsenic	**47**	**12**	**mg/kg**	**Yes**	**0.346**	**mg/kg**	**Yes**	**19/19**
Barium	**327**	**200**	**mg/kg**	**Yes**	**148**	**mg/kg**	**Yes**	**19/19**
Beryllium	**1.4**	**0.67**	**mg/kg**	**Yes**	**0.606**	**mg/kg**	**Yes**	**19/19**
Cadmium	0.19	0.21	mg/kg	No	14.7	mg/kg	No	19/19
Chromium	17.8	16	mg/kg	Yes	227	mg/kg	No	19/19
Cobalt	32	14	mg/kg	Yes	1,390	mg/kg	No	19/19
Copper	27.1	19	mg/kg	Yes	331	mg/kg	No	19/19
Iron	24,200	28,000	mg/kg	No	1,350	mg/kg	NA	19/19
Lead	**115**	**36**	**mg/kg**	**Yes**	**50**	**mg/kg**	**Yes**	**19/19**
Magnesium	1,980	7,700	mg/kg	No	0	mg/kg	Yes	19/19
Manganese	**8,340**	**1,500**	**mg/kg**	**Yes**	**29**	**mg/kg**	**Yes**	**19/19**
Mercury	0.0735	0.2	mg/kg	No	0.634	mg/kg	No	18/19
Molybdenum	2.3	NA	mg/kg	No	56.4	mg/kg	No	19/19
Nickel	14.9	21	mg/kg	No	161	mg/kg	No	19/19
Selenium	0.73	0.8	mg/kg	No	65	mg/kg	No	14/19
Silver	0.12	2.3	mg/kg	No	27	mg/kg	No	19/19
Thallium	0.44	0.34	mg/kg	Yes	0.539	mg/kg	No	19/19
Uranium	2.3	4.9	mg/kg	No	14.7	mg/kg	No	19/19
Vanadium	**48.4**	**38**	**mg/kg**	**Yes**	**2.12**	**mg/kg**	**Yes**	**19/19**
Zinc	40.3	65	mg/kg	No	1,800	mg/kg	No	19/19
Cesium-137	**0.555**	**0.49**	**pCi/g**	**Yes**	**0.178**	**pCi/g**	**Yes**	**19/19**
Americium-241	0.034	NA	pCi/g	NA	11.6	pCi/g	No	1/19
Technetium-99	3.65	2.5	pCi/g	Yes	926	pCi/g	No	1/19
Plutonium-239	0.0141	0.025	pCi/g	No	30.3	pCi/g	No	4/19
Radium-226	0.999	1.5	pCi/g	No	0.0534	pCi/g	Yes	18/18
Thorium-230	0.476	1.5	pCi/g	No	35.7	pCi/g	No	19/19
Thorium-232	0.528	1.5	pCi/g	No	35.7	pCi/g	No	19/19
Uranium-234	0.441	2.5	pCi/g	No	52.2	pCi/g	No	19/19
Uranium-235	0.0442	0.14	pCi/g	No	0.826	pCi/g	No	13/19
Uranium-238	1.16	1.2	pCi/g	No	3.64	pCi/g	No	19/19

[1] NA = information is not available or not applicable.

[2] Background values for subsurface soil are provisional values taken from Table A-12 of the 2000 revision of *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2001).

[3] The value for lead is regulatory based not risk based.

[4] The table does not include essential human nutrients. The nutrients detected but not shown are calcium, magnesium, potassium, and sodium. All essential nutrients were below background.

Table 15. Examination of Subunit 3 Results

Analyte	Maximum Concentration	Surface Background	Unit	Exceed Background	NAL	Unit	Exceed NAL	Detection Frequency
Aluminum	7,480	13,000	mg/kg	No	3,010	mg/kg	Yes	51/51
Antimony	0.21	0.21	mg/kg	No	0.242	mg/kg	No	51/51
Arsenic	**15.4**	**12**	**mg/kg**	**Yes**	**0.346**	**mg/kg**	**Yes**	**51/51**
Barium	89.4	200	mg/kg	No	148	mg/kg	No	51/51
Beryllium	**0.78**	**0.67**	**mg/kg**	**Yes**	**0.606**	**mg/kg**	**Yes**	**51/51**
Cadmium	1.2	0.21	mg/kg	Yes	14.7	mg/kg	No	21/21
Chromium	189	16	mg/kg	Yes	227	mg/kg	No	21/21
Cobalt	12	14	mg/kg	No	1,390	mg/kg	No	21/21
Copper	17	19	mg/kg	No	331	mg/kg	No	21/21
Iron	20,000	28,000	mg/kg	No	1,350	mg/kg	Yes	21/21
Lead	36.1	36	mg/kg	Yes	50	mg/kg	No	21/21
Magnesium	1,030	7,700	mg/kg	No	NA	mg/kg	NA	21/21
Manganese	1,070	1,500	mg/kg	No	29	mg/kg	Yes	21/21
Mercury	0.0679	0.2	mg/kg	No	0.634	mg/kg	No	21/21
Molybdenum	0.9	NA	mg/kg	No	56.4	mg/kg	No	21/21
Nickel	12.2	21	mg/kg	No	161	mg/kg	No	21/21
Selenium	0.62	0.8	mg/kg	No	65	mg/kg	No	21/21
Silver	0.065	2.3	mg/kg	No	27	mg/kg	No	21/21
Thallium	0.19	0.34	mg/kg	No	0.539	mg/kg	No	21/21
Uranium	**266**	**4.9**	**mg/kg**	**Yes**	**14.7**	**mg/kg**	**Yes**	**21/21**
Vanadium	**49.1**	**38**	**mg/kg**	**Yes**	**2.12**	**mg/kg**	**Yes**	**21/21**
Zinc	179	65	mg/kg	Yes	1,800	mg/kg	No	21/21
Total PCB	**0.18**	**NA**	**mg/kg**	**NA**	**0.127**	**mg/kg**	**Yes**	**7/21**
Total PAH	**0.46**	**NA**	**mg/kg**	**NA**	**0.0133**	**mg/kg**	**Yes**	**1/21**
Bis(2-ethylhexyl)phthalate	0.052	NA	mg/kg	NA	5.53	mg/kg	No	2/21
Diethyl phthalate	0.072	NA	mg/kg	NA	10,600	mg/kg	No	1/21
Cesium-137	0.323	0.49	pCi/g	No	0.178	pCi/g	Yes	12/21
Plutonium-239	0.0135	2.5	pCi/g	No	30.3	pCi/g	No	2/21
Radium-226	0.943	1.5	pCi/g	No	0.0534	pCi/g	Yes	21/21
Technetium-99	8.38	0.025	pCi/g	Yes	926	pCi/g	No	17/21
Thorium-230	0.283	0.1	pCi/g	Yes	39	pCi/g	No	21/21
Uranium-234	4.7	2.5	pCi/g	Yes	52.2	pCi/g	No	21/21
Uranium-235	0.701	0.14	pCi/g	Yes	0.826	pCi/g	No	21/21
Uranium-238	**48.2**	**1.2**	**pCi/g**	**Yes**	**3.64**	**pCi/g**	**Yes**	**21/21**

[1] NA = information is not available or not applicable.

[2] Background values for subsurface soil are provisional values taken from Table A-12 of the 2000 revision of *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2001).

[3] The value for lead is regulatory based, not risk based.

[4] The table does not include essential human nutrients. The nutrients detected but not shown are calcium, magnesium, potassium, and sodium. All essential nutrients were below background.

Field analytical results for subunit 5 mirror those for the fixed laboratory data, noting metal detections in nearly all surface samples. ISOCS also measured cesium-137 and uranium-238 in approximately 10% of the surface samples. Field results differed from the fixed laboratory data in that low-levels of Total PCBs were noted in 2 of 84 discrete samples for field PCB analysis. However, the reported PCB concentrations were less than two times the MDL, indicating they are false positive values.

When all subunit 5 data are considered together, the results indicate COPC distribution is relatively uniform throughout subunit 5. Differences in reported concentrations are likely due to the natural variability of the site and the soil media.

5.4.4 Subunit 3

Subunit 3 is the axis of Soil Pile I that parallels Little Bayou Creek (Figure 7). A total of 20 composite surface soil samples and a total of 23 subsurface soil samples was collected from randomly selected segments and were submitted for a full suite of laboratory analyses. Tables 18-24 in Appendix C provide summary statistics for subunit 3 surface and subsurface soils. Discussion of subsurface contaminant distribution is provided in Section 5.5.

A total of 136 discrete and composite surface soils and 57 subsurface samples were collected in subunit 3 for field analysis. Of these, 116 were discrete samples collected for field measurements only. Each was analyzed for RCRA metals and uranium, radionuclides, and PCBs in accordance with the prescribed field methods. Tables 25-28 in Appendix C provide summary statistics for subunit 3 surface and subsurface soils.

Surface contingency samples were collected from locations previously sampled in December 2006 from subunit 3 and at the confluence of subunits 3 and 4 (Figure 9). Previously sampled locations were located by retracing GPS locations and pin-flagging placed at each location in December 2006. A total of 5 discrete surface samples was collected from subunits 3 and 4, and these were submitted for a full suite of laboratory and field analyses. Tables 45-49 in Appendix C provide summary statistics for subunit 3 contingency samples. Each contingency sample also underwent field analysis. Appendix C summarizes these results.

To support data screening for subunit 3 surface soils, maximum fixed laboratory results from the random sample locations are presented in Table 15. Constituents appearing as bold are those whose maximum concentrations exceed background (where applicable) and NALs for the teen recreational receptor. Benzo(a)pyrene was measured at a concentration greater than the teen recreator NAL. However, the PAH compounds (including benzo(a)pyrene) were detected in only 1 of 21 surface soil samples. Based on limited detection frequency, they are not considered COPCs for subunit 3. The following have been retained as COPCs for subunit 3: arsenic, beryllium, uranium, vanadium, Total PCBs, and uranium-238. The remaining constituents were either were less than background or the teen recreational NAL.

As Section 5.3 notes, subunit 3 represents a unique sample population at Soil Pile I. While the COPCs and COPC distribution are similar to those identified in other subunits, the mean COPC concentrations are higher for uranium, uranium daughters, and Total PCBs. Uranium and an uranium 238 are elevated in surface soils throughout subunit 3, with localized areas of contamination identified in the northern half of the soil pile and at the confluence of Little Bayou Creek and Outfall 002.[16] Figures 13–16 illustrate uranium and uranium-238 distribution for Soil Pile I for both fixed laboratory and field uranium results.[17] Figures 17–18 illustrate the distribution of PCBs in subunit 3 and at its confluence with subunit 4.

---

[16] Benchmark values appearing on Figures 14–19 are action and no action levels taken from the PGDP Risk Methods Document (DOE 2001).

[17] Field uranium results are represented by more sample locations in subunit 3 based on the sampling design.

Note: Results for fixed laboratory and field data are presented together to illustrate the qualitative relationships observed between the field and laboratory methods.

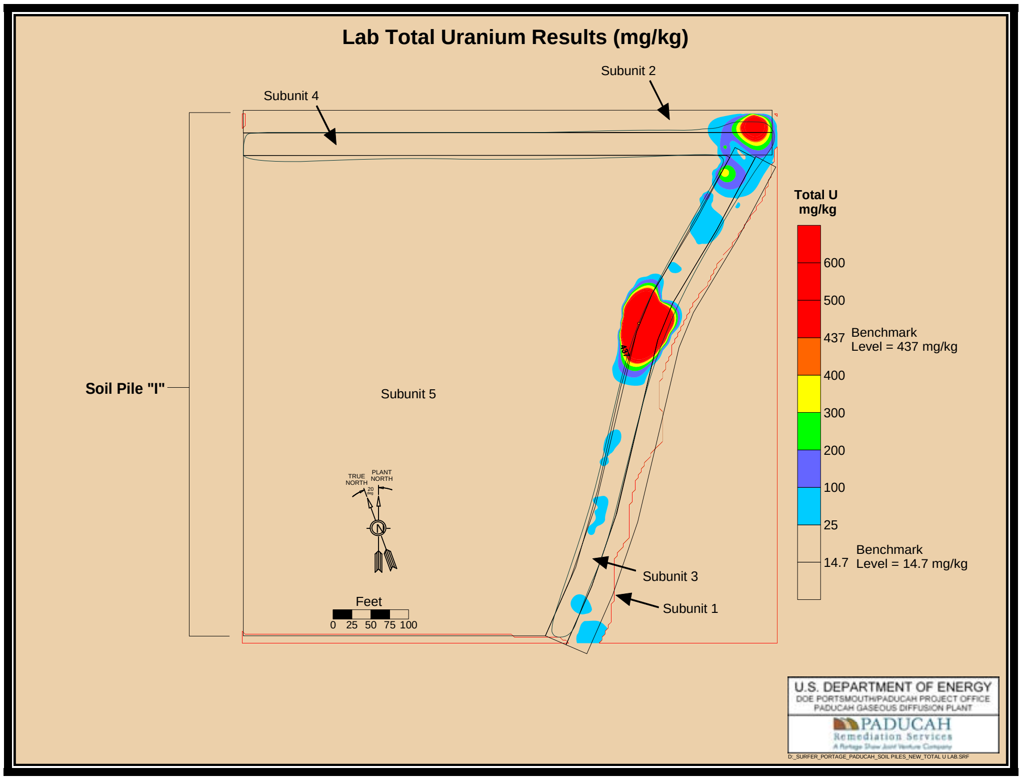


Figure 13. Surface Distribution of Total Uranium in Soil Pile I (Laboratory Data)

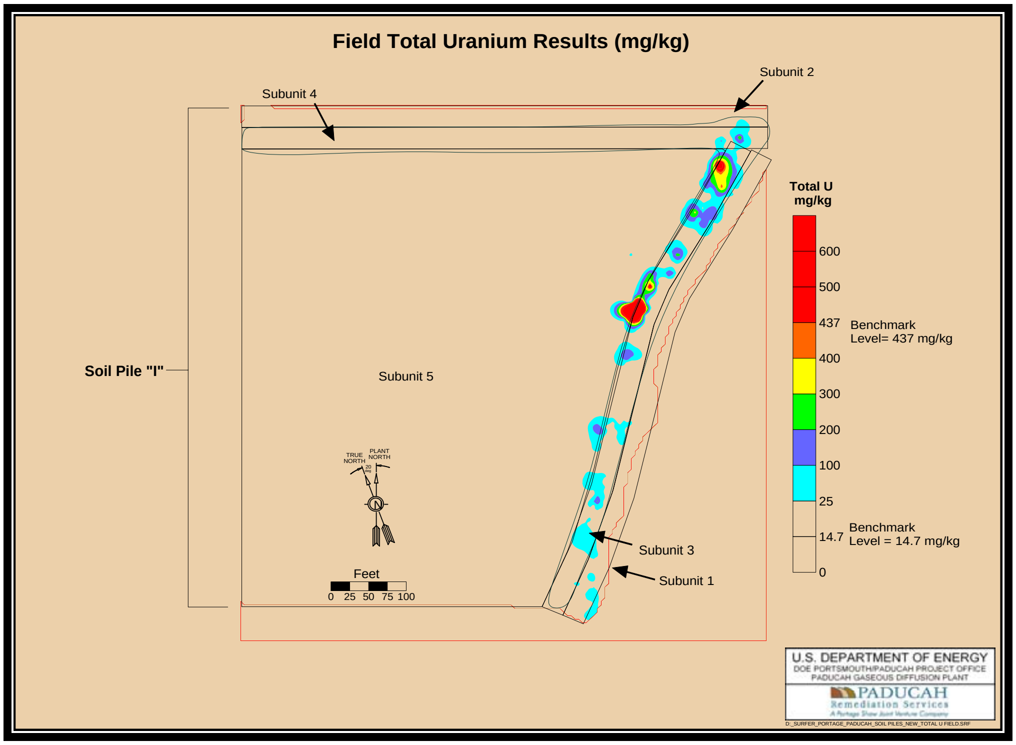


Figure 14. Surface Distribution of Total Uranium in Soil Pile I (Field Data)

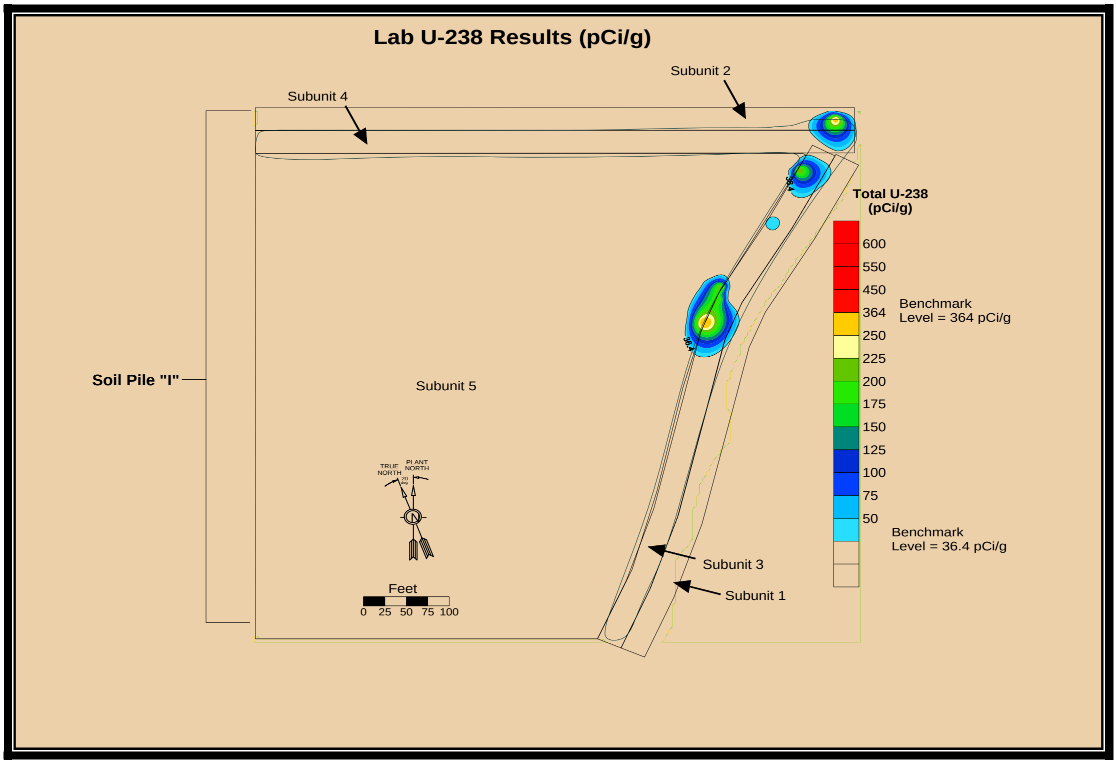


Figure 15. Surface Distribution of Uranium-238 in Soil Pile I (Laboratory Data)

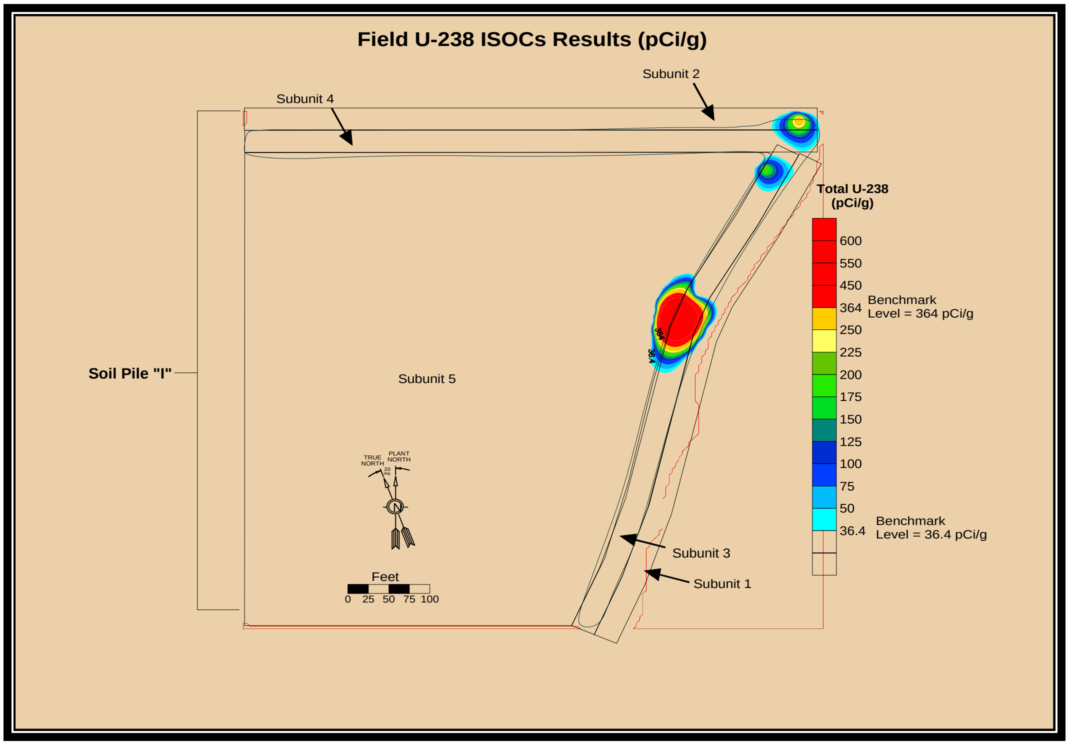


Figure 16. Surface Distribution of Uranium-238 in Soil Pile I (Field Data)

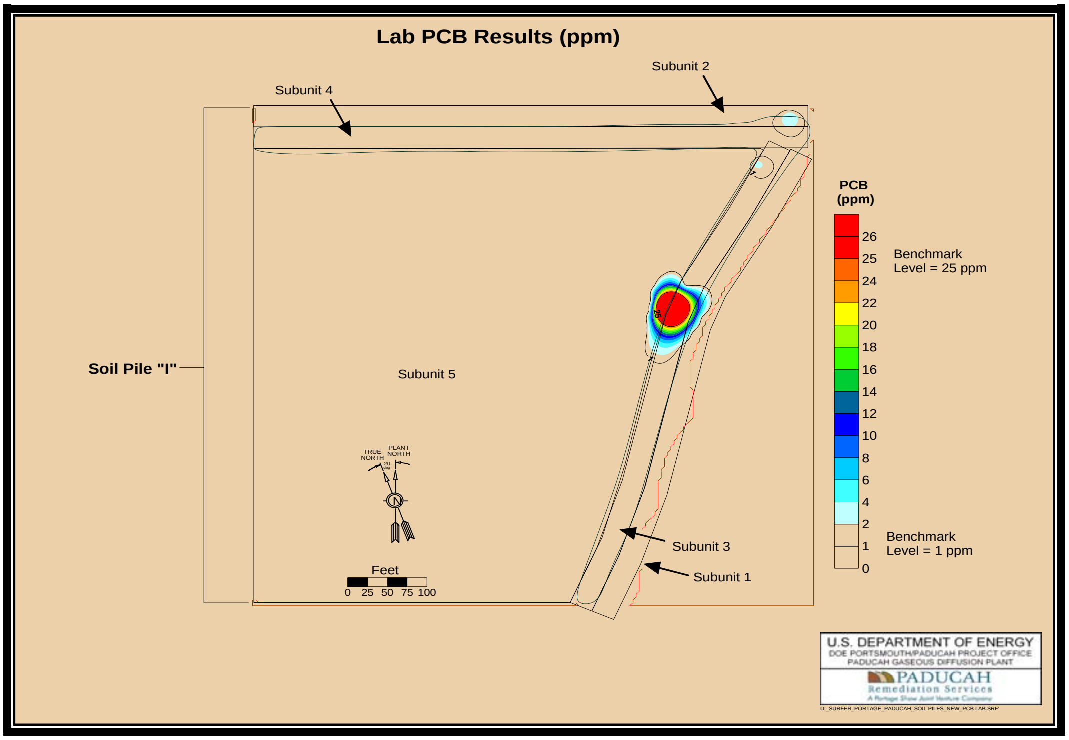


Figure 17. Surface Distribution of Total PCBs in Soil Pile I (Laboratory Data)

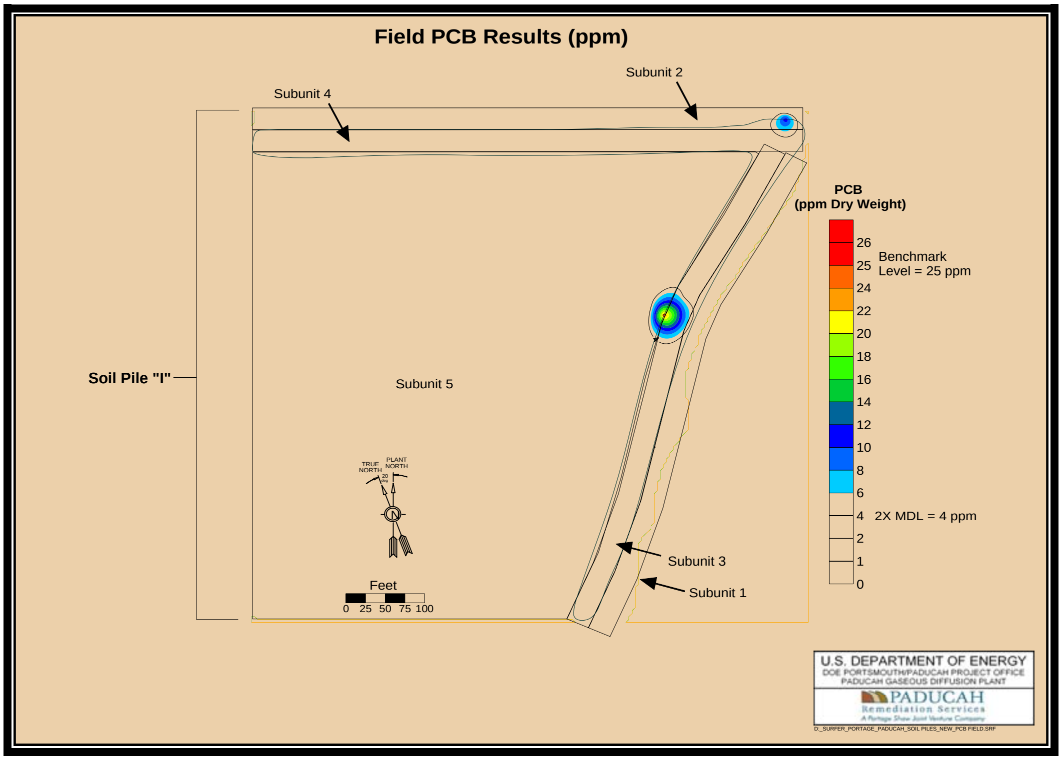


Figure 18. Surface Distribution of Total PCBs in Soil Pile I (Field Data)

Figures 13–19 demonstrate a key element of COPC distribution in Soil Pile I: with the exception of slightly elevated uranium near the southern terminus of subunit 3, contamination is confined to the soil pile along Little Bayou Creek. They also provide a visual representation of contamination in subunit 3. Figure 19 provides the locations of contingency samples collected as a means of confirming contamination concentrations identified in 2006 at Soil Pile I. The contingency sample locations are presented with the distribution of total uranium to provide context.

Figures 13–19 also highlight a qualitative correlation between PCBs, uranium, and uranium daughters. In all cases, when PCBs were detected above benchmark values, total uranium and uranium-238 also were detected. The number of samples available for mathematical comparison is relatively small; however, there is a relationship between the two contaminants in the soils in Soil Pile I. Similarly, the plots illustrate a qualitative correlation between the field and laboratory methods used to quantify uranium, uranium daughters, and PCBs. However, the reverse relationship is not true: PCBs were not always detected when uranium and uranium daughters were detected. Since the correlation is unilateral (i.e., uranium only in the presence of PCBs), the most logical source would be PCBs that are contaminated with uranium and its daughters. More detail concerning these relationships is provided in Section 2.6 and in Appendix B (DQA).

Also worthy of note is the relationship observed between the GWS results (Figure 5) and the total uranium results acquired using both field and laboratory methods. Not surprisingly, the GWS was a solid predictor of where elevated levels of uranium and uranium daughters would be found during the Soil Pile I investigation. This, coupled with the previous discussion (uranium predicting PCBs), may increase the utility of the GWS results for future efforts at PGDP.

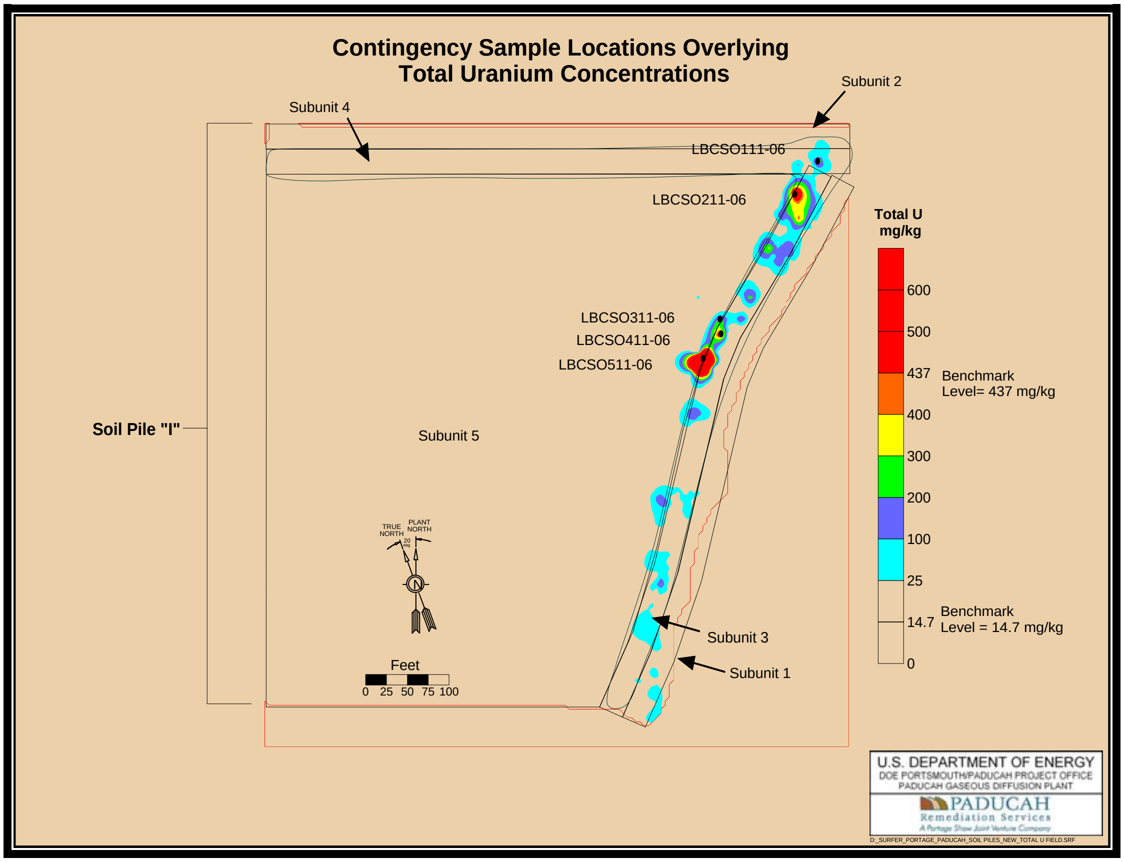


Figure 19. Soil Pile Contingency Sample Locations

5.4.5 Subunit 4

Subunit 4 is the axis of Soil Pile I that parallels Outfall 002 (Figure 6). A total of 20 surface composites and 28 subsurface soils was collected and submitted for a full suite of laboratory analyses. Tables 29-35 in Appendix C provide summary statistics for subunit 4 surface soils. Discussion of subsurface soils is proved in Section 5.5.

A total of 136 discrete and composite surface and 60 subsurface soil samples was collected in subunit 4 for field analysis. Each was analyzed for RCRA metals and uranium, radionuclides, and PCBs in accordance with the prescribed field methods. Tables 36–39 in Appendix C provide summary statistics for field measurements collected for subunit 4 soils.

To support data screening for subunit 4 surface soils, maximum fixed laboratory results from the random sample set are presented in Table 16. Constituents appearing as bold are those whose maximum concentrations exceed background (where applicable) and NALs for the teen recreational receptor. The PAH compounds were detected in only 1 of 21 surface soil samples; therefore, they were not retained as COPCs for subunit 4. The following have been retained as COPCs: antimony, arsenic, beryllium, iron, uranium, vanadium, Total PCBs, and uranium-238. The remaining constituents either were less than background or the teen recreational NAL.

As Figures 13-19 illustrate, although detected throughout subunit 4, elevated COPC concentrations are not widespread. In fact, with the exception of the contamination located at the northeastern corner of Soil Pile I, where subunits 3 and 4 converge, both maximum and mean COPC concentrations are generally below background and/or risk-based comparison benchmarks in the balance of subunit 4 surface soils. Field and laboratory data coincide very well, identifying metals, uranium, and uranium-238 throughout the site, cesium-137 in a portion of the samples, and PCBs in a fraction of the locations.

GWS results further support the fixed laboratory and field data and corresponding COPC distributions. As Figure 5 shows, slightly elevated gamma activity indicative of uranium-238 is noted along the subunit 4 axis.

Table 16. Examination of Subunit 4 Results

Analyte	Maximum Concentration	Surface Background	Exceed Background	Unit	NAL	Unit	Exceed NAL	Detection Frequency
Aluminum	10,100	13,000	No	mg/kg	3,010	mg/kg	Yes	21/21
Antimony	**0.84**	**0.21**	**Yes**	**mg/kg**	**0.242**	**mg/kg**	**Yes**	**21/21**
Arsenic	**23.3**	**12**	**Yes**	**mg/kg**	**0.346**	**mg/kg**	**Yes**	**21/21**
Barium	144	200	No	mg/kg	148	mg/kg	No	21/21
Beryllium	**1.5**	**0.67**	**Yes**	**mg/kg**	**0.606**	**mg/kg**	**Yes**	**21/21**
Cadmium	0.1	0.21	No	mg/kg	14.7	mg/kg	No	21/21
Chromium	158	16	Yes	mg/kg	227	mg/kg	No	21/21
Cobalt	11.3	14	No	mg/kg	1,390	mg/kg	No	21/21
Copper	29.1	19	Yes	mg/kg	331	mg/kg	No	21/21
Iron	**48,500**	**28,000**	**Yes**	**mg/kg**	**1,350**	**mg/kg**	**Yes**	**21/21**
Lead	32.9	36	No	mg/kg	50	mg/kg	No	21/21
Magnesium	1,460	7,700	No	mg/kg	0	mg/kg	Yes	21/21
Manganese	775	1,500	No	mg/kg	29	mg/kg	Yes	21/21
Mercury	0.0442	0.2	No	mg/kg	0.634	mg/kg	No	9/21
Molybdenum	2.4	NA	No	mg/kg	56.4	mg/kg	No	21/21
Nickel	20.7	21	No	mg/kg	161	mg/kg	No	21/21
Selenium	0.62	0.8	No	mg/kg	65	mg/kg	No	14/21
Silver	0.085	2.3	No	mg/kg	27	mg/kg	No	21/21
Thallium	0.3	0.34	No	mg/kg	0.539	mg/kg	No	21/21
Uranium	**269**	**4.9**	**Yes**	**mg/kg**	**14.7**	**mg/kg**	**Yes**	**21/21**
Vanadium	**86.9**	**38**	**Yes**	**mg/kg**	**2.12**	**mg/kg**	**Yes**	**21/21**
Zinc	77.7	65	Yes	mg/kg	1,800	mg/kg	No	21/21
Total PCB	**0.49**	**NA**	**NA**	**mg/kg**	**0.127**	**mg/kg**	**Yes**	**11/21**
Total PAH	**0.44**	**NA**	**NA**	**mg/kg**	**0.0133**	**mg/kg**	**Yes**	**1/21**
Cesium-137	0.371	0.49	No	pCi/g	0.178	pCi/g	Yes	18/21
Radium-226	0.974	1.5	No	pCi/g	0.0534	pCi/g	Yes	21/21
Thorium-230	0.412	1.5	No	pCi/g	39	pCi/g	No	21/21
Uranium-234	0.866	2.5	No	pCi/g	52.2	pCi/g	No	21/21
Uranium-235	0.244	0.14	Yes	pCi/g	0.826	pCi/g	No	6/21
Uranium-238	**9.67**	**1.2**	**Yes**	**pCi/g**	**3.64**	**pCi/g**	**Yes**	**21/21**

[1] NA = information is not available or not applicable.

[2] Background values for subsurface soil are provisional values taken from Table A-12 of the 2000 revision of *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2001).

[3] The value for lead is regulatory based, not risk based.

[4] The table does not include essential human nutrients. The nutrients detected but not shown are calcium, magnesium, potassium, and sodium. All essential nutrients were below background.

5.4.6 Results of Tree Sampling

Five tree samples were collected from subunits 1–5 to determine if tree tissue contains hazardous constituents. The trees were selected at random, one from each investigative subunit, in accordance with Addendum 1-A. The tissue samples were submitted for a full suite of fixed laboratory analyses. Tables 50–52 in Appendix C provide summary statistics for tree tissue results. The following summarizes the results of tree sampling.

- Two of the RCRA metals were detected in tree tissue samples: cadmium and lead. Total cadmium and lead concentrations were below TCLP maximum concentration limits in all samples.

- No other UHC were detected in tree tissue samples.

Figure 20 provides the location of trees sampled during the investigation. They are overlaying total uranium concentrations to illustrate the proximity of trees to elevated COPC concentrations.

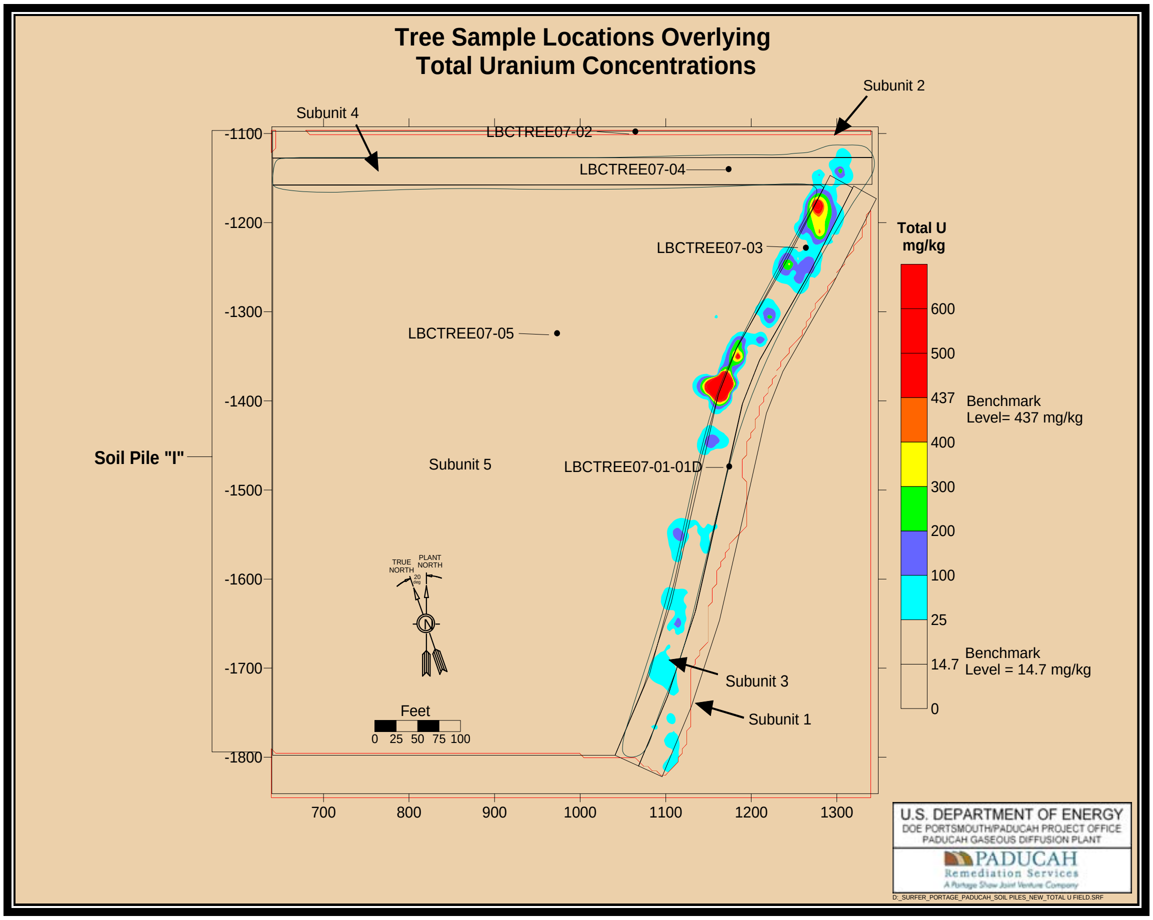


Figure 20. Tree Sample Locations

5.4.7 Results of TCLP Analysis

As required by the provisions of Addendum 1-A, samples exhibiting total concentrations of UHCs exceeding the TCLP maximum concentration limit were submitted for TCLP analysis. Because very few samples exhibited elevated concentrations, all soil samples containing total chromium greater than 65 mg/kg were submitted for TCLP analysis. None of the samples undergoing TCLP extraction and analysis, exceeded the maximum concentration limits.

Table 4 provides a summary of those samples submitted for TCLP analysis. Appendix S provides a complete listing of TCLP results.

5.5 SUBSURFACE DISTRIBUTION OF CONTAMINANTS

Another key consideration in determining the nature and extent of contamination is how contaminants are distributed with depth in Soil Pile I (surface » downward). The following sections examine the distribution of COPCs identified for Soil Pile I.

5.5.1 Metals

To begin this process, the distribution of metals in Soil Pile I has been examined. As Figures 21–24 illustrate, subsurface soils[18] exhibit very little variation over all depths sampled and for virtually all metals detected at Soil Pile I, with the exception of chromium.

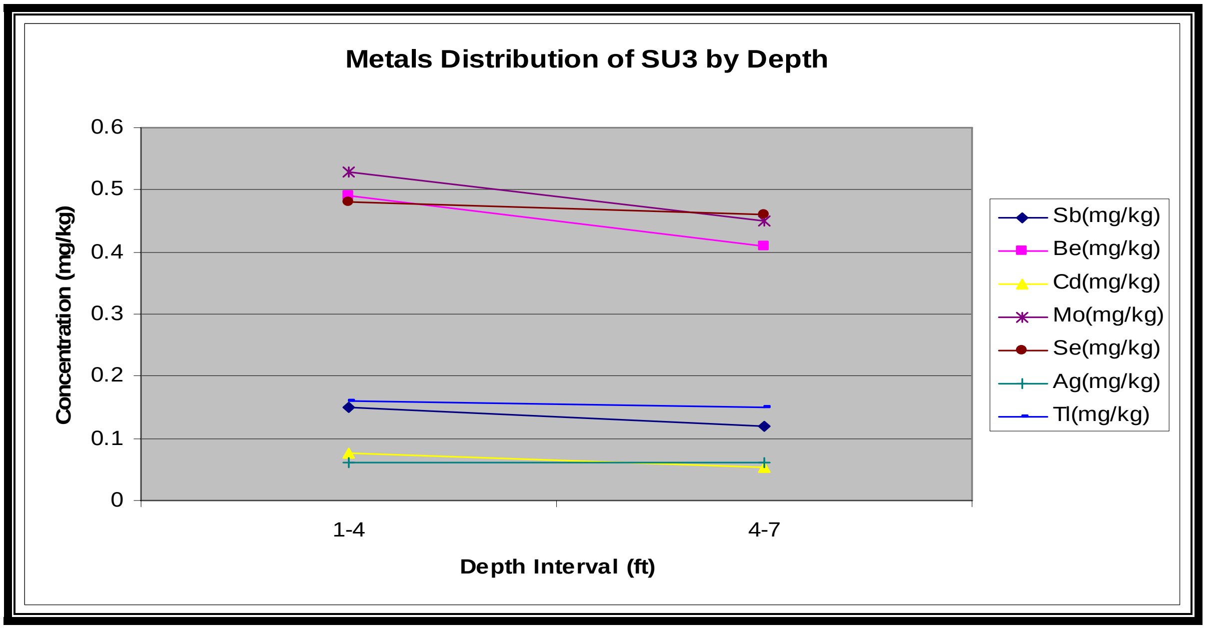


Figure 21. Distribution of Metals by Depth in Subunit 3

---

[18] Subsurface soils are those collected at depths greater than 1 ft.

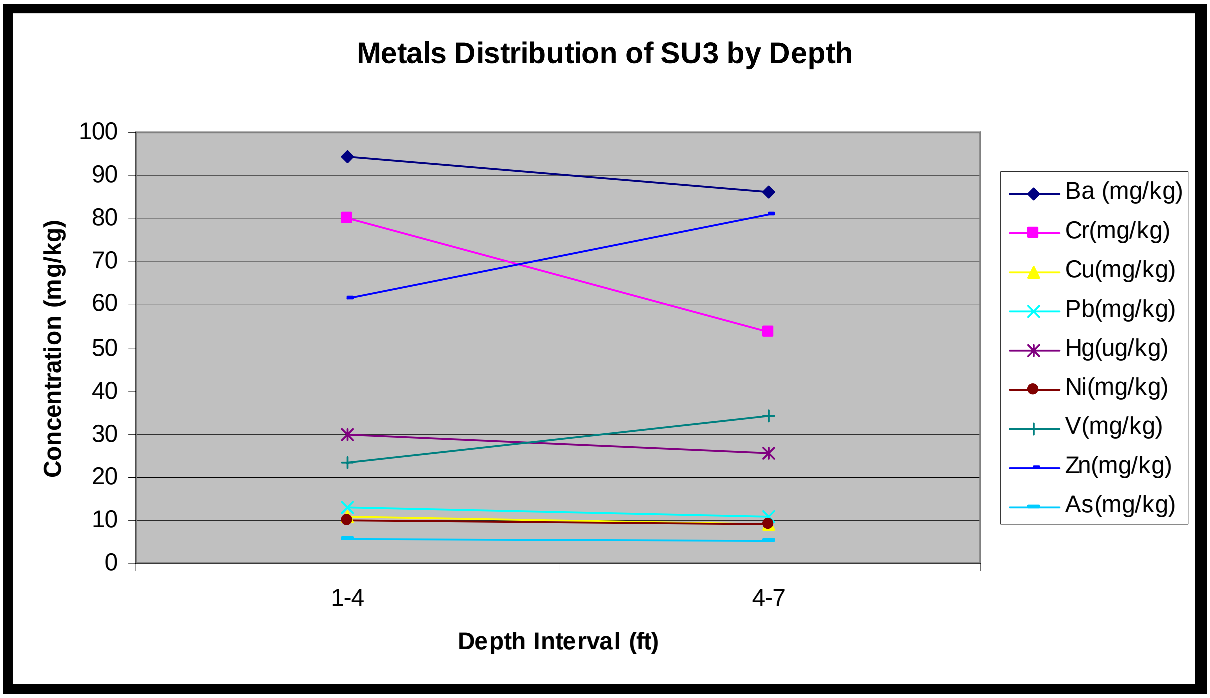


Figure 22. Distribution of Metals by Depth in Subunit 3

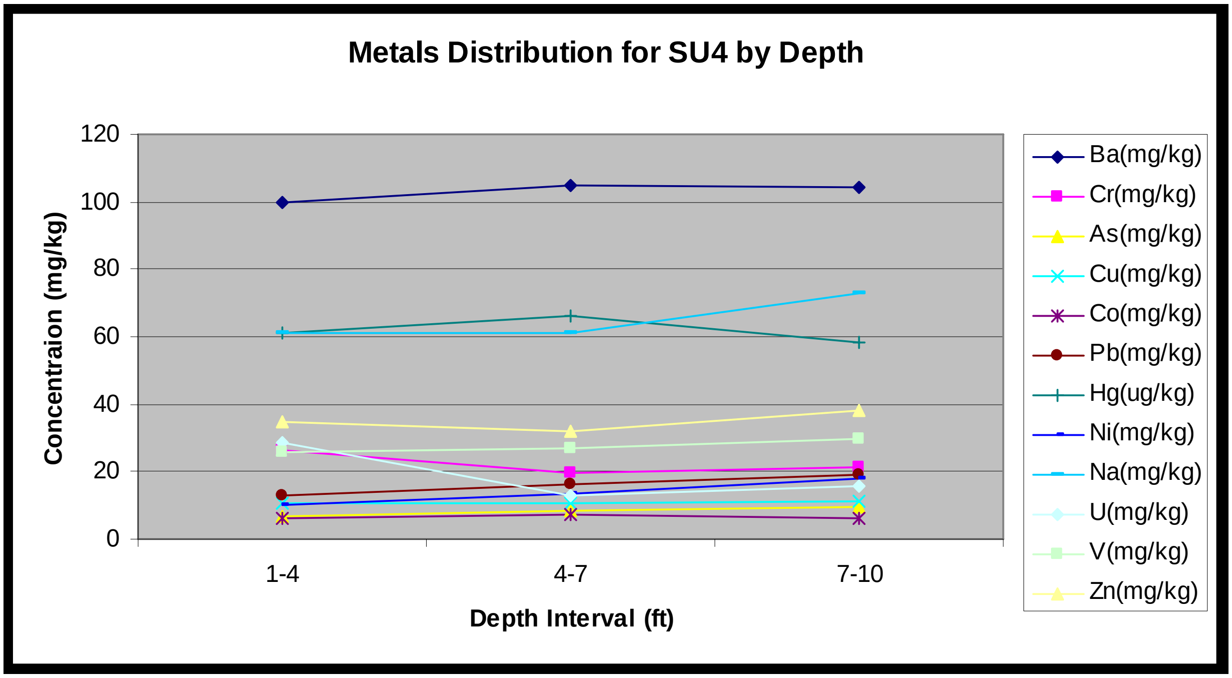


Figure 23. Distribution of Metals by Depth in Subunit 3

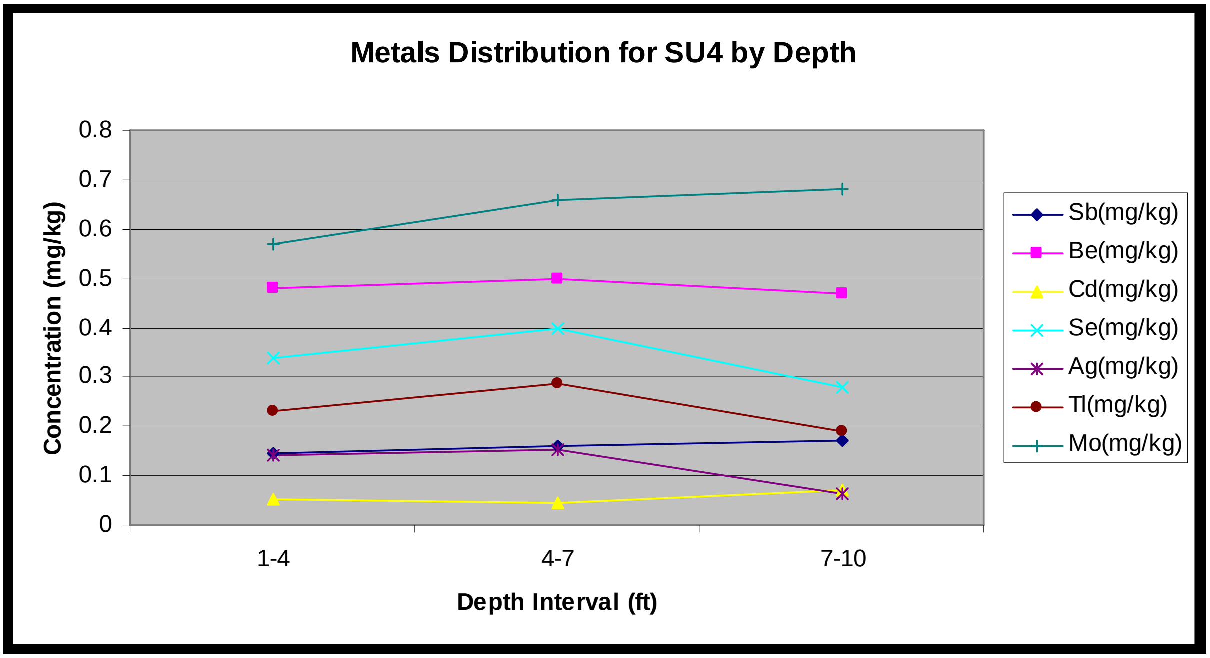


Figure 24. Distribution of Metals by Depth in Subunit 4

While the source of chromium is not clear, increased concentrations are observed in the soil pile fraction of the site with maximum values approximately 10 times background. This is also true for the maximum value in subunit 1 (Table 15).

For the remaining metals, similar concentrations are observed in soils sitewide, including investigative subunits containing little or no evidence of soil pile contact (e.g., subunits 1, 2, and 5) and those containing the highest COPCs concentrations (e.g., subunits 3 and 4). Table 17 provides a comparison of mean values for metals COPCs found in Soil Pile I.

Table 17. Summary for Metals by Depth for Subunit 3 Subsurface Samples

Metal	Depth (ft)	Mean Value (mg/kg)
Arsenic – SU5	0-1	17
Arsenic – SU3	1–4	5.8
Arsenic – SU3	4–7	5.1
Manganese – SU5	0-1	1,187
Manganese – SU3	1–4	429
Manganese – SU3	4–7	462
Vanadium – SU5	0-1	27.7
Vanadium – SU3	1–4	23.5
Vanadium – SU3	4–7	19.3

The comparison shows that Soil Pile I exhibits variability from subunit to subunit for metals. The comparison also illustrates that metals concentrations in the relatively undisturbed soil of subunit 5 are very similar if not higher than metals concentrations found in the most contaminated subunit on the site, subunit 3. Arsenic, manganese, and vanadium are examined here, because they are COPCs for Soil Pile I and contribute to human health risks as described in the SLRA, Section 6.

5.5.2 PCBs and Radionuclides

The data summary provided in Section 5.4 indicates other than metals, the remaining COPCs at Soil Pile I consist of PCBs, uranium, uranium daughters, and cesium-137.[19] As noted, with the exception of slightly elevated uranium near the southern terminus of subunit 1, elevated COPC concentrations are almost entirely confined to the axis of Soil Pile I paralleling Little Bayou Creek (subunit 3). Because of the way in which the soil pile was divided during investigation planning, elevated results are found in both subunits 3 and at the confluence of subunits 3 and 4.

To examine the vertical distribution of COPCs in subunits 3 and 4, uranium, uranium-238, and PCBs have been plotted. Figures 25–28 provide the distribution for average concentrations over depth.

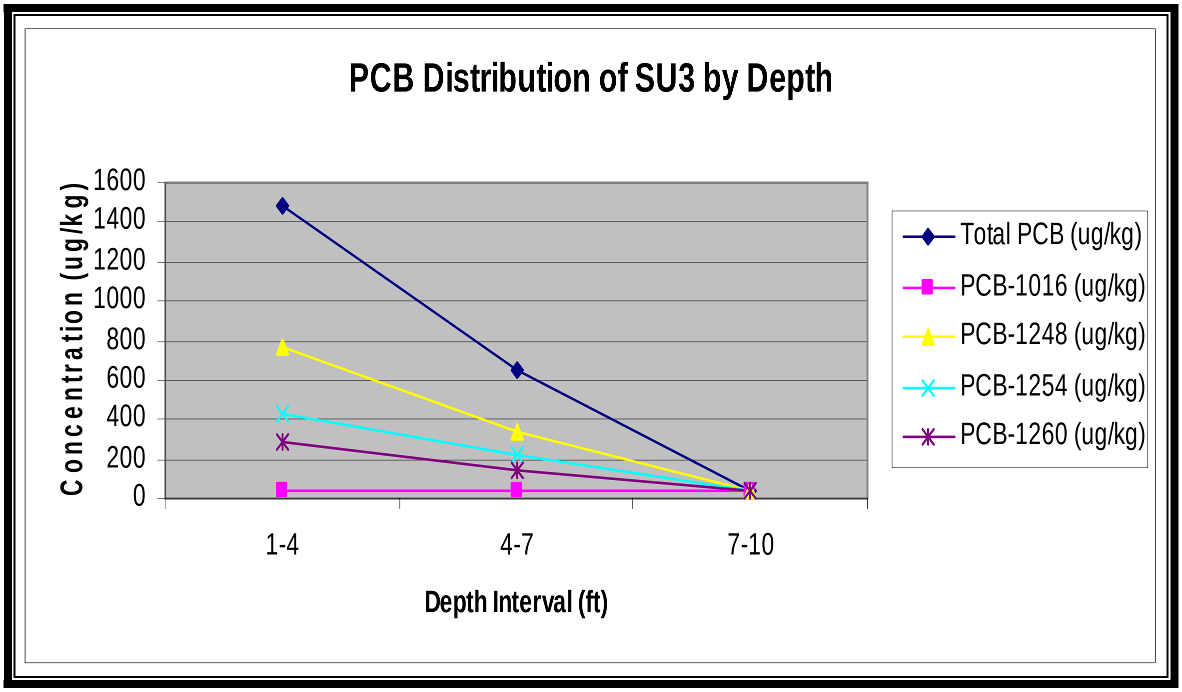


Figure 25. Subsurface Distribution of Total PCBs and PCB Aroclors in Subunit 3[20]

---

[19] Cesium-137 is not part of the PGDP uranium enrichment process. Its presence at Soil Pile I is likely due to radioactive fallout.

[20] PCB detection limit is 360 µg/kg.

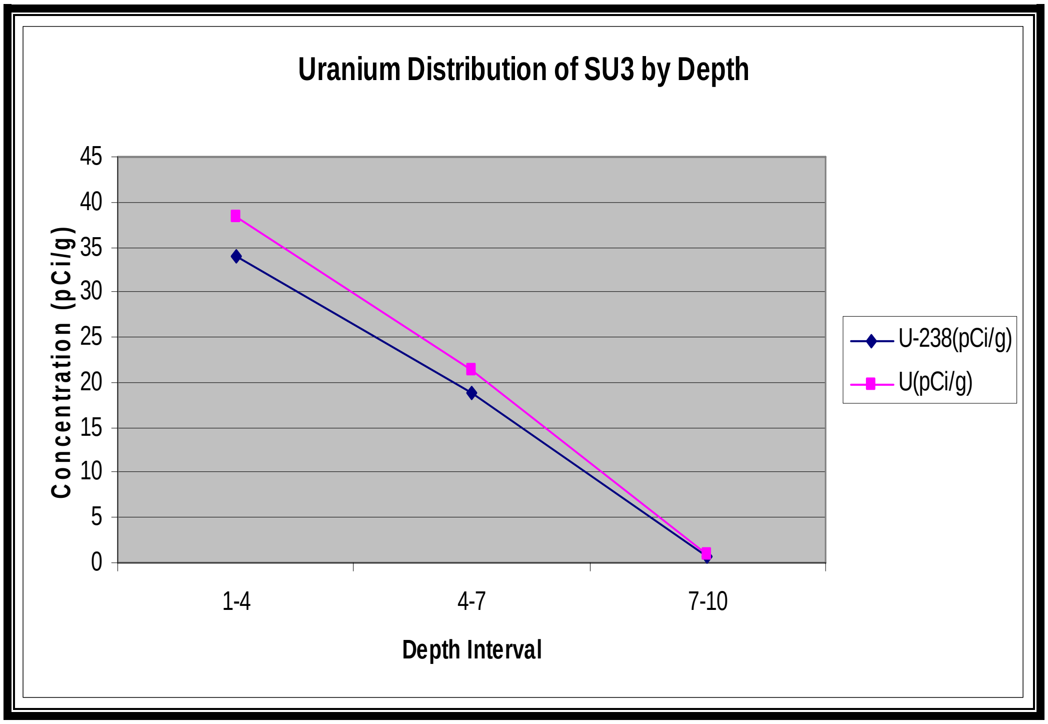


Figure 26. Subsurface Distribution of Radionuclides in Subunit 3

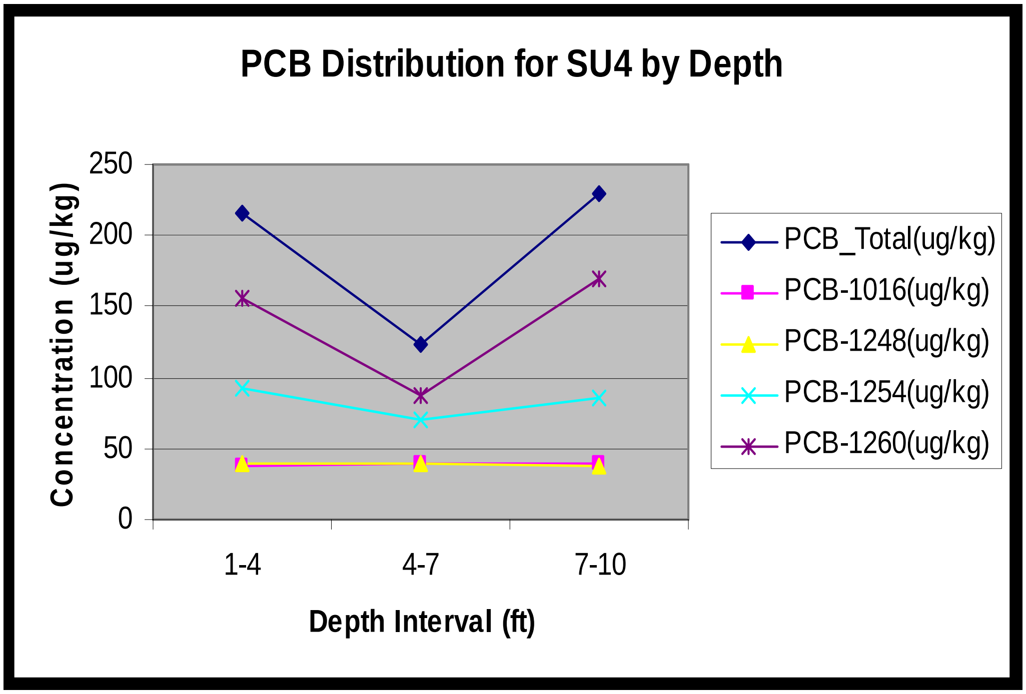


Figure 27. Subsurface Distribution of Total PCBs and PCB Aroclors in Subunit 4[21]

---

[21] PCBs were not detected above the MDL of 360 µg/kg.

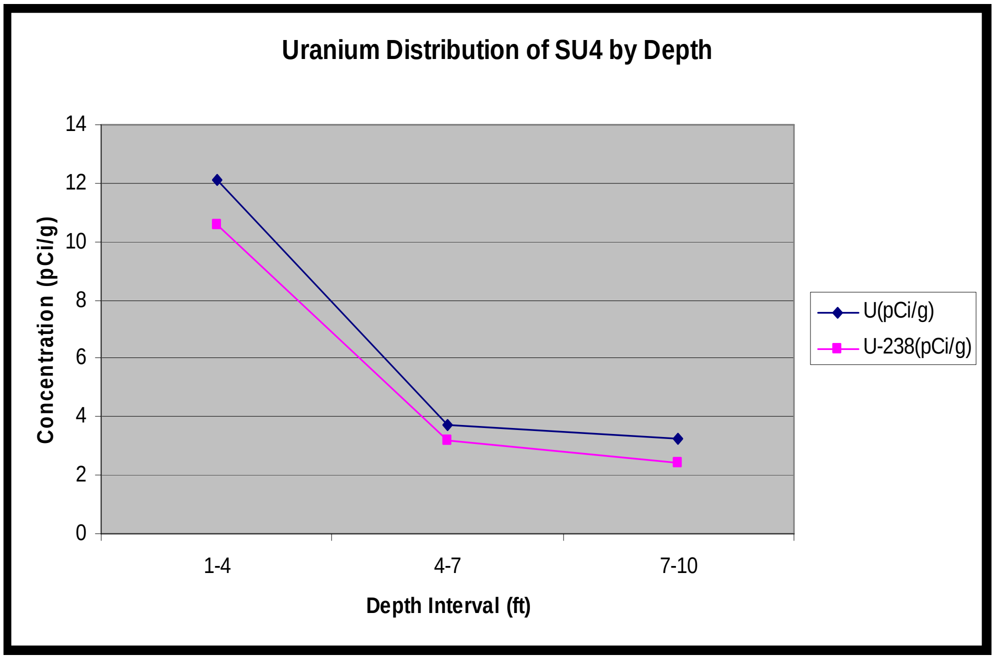


Figure 28. Subsurface Distribution of Radionuclides in Subunit 4

These plots illustrate a decrease in contaminants with depth over the vertical horizon of the soil pile, with concentrations decreasing below risk-based benchmark levels below the 4 ft interval. Samples collected at depth were extended to 2 ft below the natural grade at all locations. The figures also show a significant decrease in concentrations between the 1–4 ft and 4–7 ft intervals, indicating contamination in the soil pile is most prevalent at the surface and decreases with depth.

There are exceptions to this trend and include the following observations.

- Both benzo(a)pyrene and dibenz(a,h)anthracene exceeded the teen recreator action level in the 4–7 ft soil interval of subunit 4 in sample LBC4L050. However, due to limited detections of these compounds in subunit 4 and in soils sitewide, PAHs are not considered COPCs.

- Uranium metal was detected at 140 mg/kg in the action level in the 4–7 ft in sample LBC3F10 in subunit 3. This result is significantly below the uranium PGDP action level for the teen recreational receptor of 437 mg/kg.

- Uranium was detected in two depth intervals near the southern terminus of subunit 3. Here it was detected at 169 mg/kg in the 4–7 ft interval and at 349 mg/kg in the 7–10 ft interval. Both occurrences were observed in a single sample: LBC3F16. These results are significantly below the uranium PGDP action level for the teen recreational receptor of 437 mg/kg.

Figure 29 is a cross-section of subunit 3, illustrating the vertical distribution of uranium, the most widely distributed COPC at Soil Pile I.

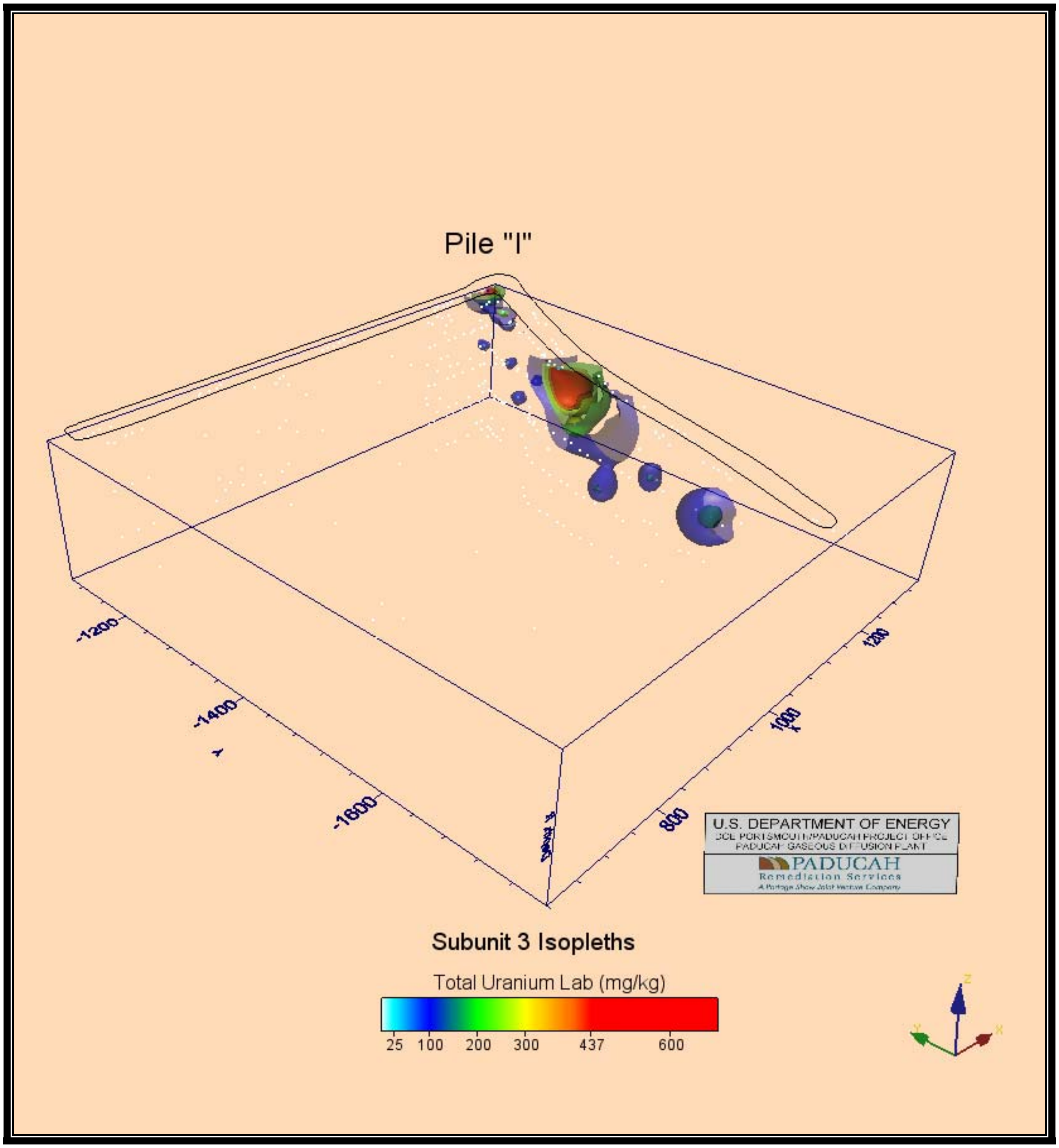


Figure 29. Subsurface Distribution of Total Uranium at Soil Pile I

5.6 CHEMICAL-SPECIFIC ARARs

Chemical-specific ARARs provide health or risk-based concentration limits or discharge limitations in various environmental media (i.e., surface water, groundwater, soil, or air) for specific hazardous substances, pollutants, or contaminants. ARARs include federal and state regulations. Additionally, per 40 *CFR* § 300.405(g)(3), other advisories, criteria, or guidance may be considered in determining remedies [to be considered (TBC) category].

Based on the scope of this SER, the following chemical specific ARARs from the *CFR*, *KAR*,[22] and TBC requirements in DOE Order 5400, "Radiation Protection of the Public and the Environment," were evaluated for contamination in Soil Pile I:

- Radiation dose limits for protection of individual members of the public;

- Risk-based or self-implementing standards for PCB remediation waste;

- Standards with respect to hazardous substances, pollutants, contaminants, petroleum, or petroleum products.

The applicability of chemical-specific ARARs and TBC criteria to contamination detected in Soil Pile I is discussed below:

5.6.1 Radiation Dose Limits

In accordance with 10 *CFR* § 20.1301, Dose limits for Individual Members of the Public, exposure to individual members of the public from radiation shall not exceed a total estimated dose equivalent (EDE) of 0.1 rem/year (100 mrem/year), exclusive of other state or federal provisions. In addition, federal requirements for radiation programs (10 *CFR* § 20.1101, Radiation Protection Programs) require that radiation exposure to the public be maintained as low as is reasonably achievable (ALARA). The TBC criteria in DOE Order 5400.5, Radiation Protection of the Public and the Environment, Chapter II indicates that, except under unusual circumstances, the exposure of members of the public to radiation sources as a consequence of all routine DOE activities shall not cause, in a year, an EDE greater than 100 mrem (0.1 rem/year). The Commonwealth of Kentucky promulgated dose and ALARA standards that are equally stringent as the federal requirements and, therefore, are not considered ARAR for CERCLA actions.

The 10 *CFR* § 20.1402, Radiological Criteria for Unrestricted Use, provides that a Nuclear Regulatory Commission (NRC) license site would be considered acceptable for unrestricted use (and the license terminated) if the residual radioactivity that is distinguishable from background radiation results in a total EDE to an average member of the critical group that does not exceed 25 mrem/year, including that from groundwater sources of drinking water, and that the residual radioactivity has been reduced to levels that are ALARA.

The TBC criteria in DOE Order 5400.5, Chapter IV provide radiological protection requirements and guidelines for cleanup of residual radioactive material and unrestricted release of property. The Order provides generic guideline values for radium and thorium and procedures for developing release values for other radionuclides that are derived from basic dose limits and specific property models and data. These are the generic guidelines for residual concentrations of thorium-230 and thorium-232:

- 5 pCi/g, averaged over the first 15 cm of soil below the surface; and
- 15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface.

The PGDP Risk Methods Document provides radionuclide screening concentrations derived for human health protection from target doses of 1, 15, and 25 mrem/year. Of the two known receptors (recreational user and wildlife worker) at Soil Pile I, screening concentrations for the recreational user are considered for this ARAR analysis since recreational user is the more sensitive receptor. The target dose of 25 mrem/year is based on TBC criteria in DOE Order 5400.5, Chapter II, which indicates that to the extent

---

[22] *KAR* values were evaluated in lieu of federal requirements, when the *KAR* values were lower.

required by 40 *CFR* Part 191, the exposure of members of the public to direct radiation or radioactive material released from DOE management and storage activities at a disposal facility for spent nuclear material or for high-level or transuranic radioactive wastes that are not regulated by the NRC shall not cause members of the public to receive a dose equivalent greater than 25 mrem/year. The target dose of 15 mrem/year is based on the U.S. EPA memorandum dated August 22, 1997, that provides guidance for establishing protective cleanup levels for radioactive contamination at CERCLA sites. The PGDP Risk Methods Document describes a screening level from the target dose of 1 mrem/year as the "walk away" level.

Table 18 shows the 95% UCL concentration for cesium-137, thorium-230, thorium-232, uranium-234, and uranium-238 detected at Soil Pile I. The UCL concentrations are below the individual recreational user screening levels for a 1 mrem/year dose and, therefore, below the "walk away" level in the PGDP Risk Methods Document. Further dose assessment will need to be considered if specific areas have concentrations above the 1 mrem/year dose. Concentrations of thorium-230 and thorium-232 also are below generic guidelines for release of DOE property in DOE Order 5400.5. The resulting total EDE from these radionuclides below the 0.1 rem/year, plus ALARA, is required for protection of individual members of the public pursuant to 10 *CFR* § 20.1301 and 20.1101 and DOE Order 5400.5.

Table 18. Comparison of Soil Pile I Radionuclide Concentrations and Radiation Dose/Concentration Limits

Radionuclide	Range of 95% UCL Concentration (pCi/g)[a]	Screening Level (pCi/g)[b]			Residual Concentration Limit for Release of DOE Property (pCi/g)
		1 mrem/year	15 mrem/year	25 mrem/year	
Cesium-137	0.13 – 0.35	1.07E+01	1.60E+02	2.67E+02	
Thorium-230	0.22 – 0.67	1.38E+03	2.07E+04	3.44E+04	5 / 15[c]
Thorium-232	0.32 – 0.69	2.88E+02	4.33E+03	7.21E+03	5 / 15[c]
Uranium-234	0.31 – 2.00	2.72E+03	4.07E+04	6.79E+04	
Uranium-238	0.45 – 17.6	2.44E+02	3.67E+03	6.11E+03	

[a] Range of 95% UCL concentrations of Subunits 1–5.

[b] From the PGDP Risk Methods Document.

[c] 5 pCi/g, averaged over the first 15 cm of soil below the surface; 14 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface.

5.6.2 PCB Remediation Waste

In the *Federal Register* Notice for the 1998 PCB Disposal Amendment, EPA stated: "EPA anticipates that today's rule will be a potential ARAR at CERCLA sites where PCBs are present. EPA would expect that CERCLA cleanups typically comply with one of the three options [self-implementing, performance-based or risk-based] provided by 761.61, upon completion of the cleanups." Self-implementing cleanup levels depend on the occupancy status of the contaminated area and the PCB concentrations. As defined in 40 *CFR* § 761.3, Soil Pile I would be categorized as a low-occupancy area. Such areas require no additional cleanup when PCB concentrations are < 25 mg/kg, unless otherwise specified. EPA also may approve a risk-based cleanup if it finds that the method will not pose an unreasonable risk of injury to health or the environment.

The results of fixed laboratory analysis of PCBs, for random surface samples are compared with the TSCA benchmark values in Table 19. Subunits 2 and 5 show no detection of PCBs. The 95% UCL and maximum concentrations of Total PCB in randomly collected surface samples from subunits 1, 3 and 4 do not exceed the high occupancy (no restriction) TSCA limit of 1 ppm.

Table 19. Comparison of Fixed Laboratory PCB Concentrations with TSCA Benchmark Values

Subunit	Description	Depth	95% UCL PCB Concentration (mg/kg)	Maximum PCB Concentration (mg/kg)	TSCA Action Limit (ppm)	Low Occupancy TSCA Limit (ppm)	High Occupancy, No Restrictions TSCA Limit (ppm)
SU1	Surface	0-1 ft	0.0816	0.36	50	25	1
SU2	Surface	0-1 ft	ND	ND			
SU3	Surface	0-1 ft	0.093	0.18			
SU4	Surface	0-1 ft	0.097	0.49			
SU5	Surface	0-1 ft	ND	ND			

ND = not detected

Several discrete locations exceeded TSCA benchmark values. These include the contingency samples collected in subunits 3 and 4. Table 20 lists locations where PCB concentrations exceeded at least one TSCA benchmark value. Figure 30 illustrates the location of the corresponding samples.

Table 20. Comparison of Fixed Laboratory PCB Concentrations with TSCA Benchmark Values

Sample Location	Subunit	Description	Depth (ft)	PCB Concentration (mg/kg)	> TSCA Action Limit (50 ppm)	> Low Occupancy TSCA Limit (25 ppm)	> High Occupancy, No Restrictions TSCA Limit (1 ppm)
LBCS01	SU3	Contingency	0-1	2.2	No	No	**Yes**
LBCS02	SU3	Contingency	0-1	2.8	No	No	**Yes**
LBCS04	SU3	Contingency	0-1	14	No	No	**Yes**
LBCS05	SU3	Contingency	0-1	79	**Yes**	**Yes**	**Yes**
LBC3F02	SU3	Subsurface	4-7	2.6	No	No	**Yes**
LBC3F06	SU3	Subsurface	1-4	5.7	No	No	**Yes**
LBC3F10	SU3	Subsurface	4-7	2.5	No	No	**Yes**
LBC3L05	SU3	Subsurface	1-4	2.9	No	No	**Yes**
LBC3L05	SU3	Subsurface	4-7	1.4	No	No	**Yes**
LBC3L25	SU3	Subsurface	1-4	1.5	No	No	**Yes**
LBC3L80	SU3	Subsurface	1-4	1.2	No	No	**Yes**
LBC3L90	SU3	Subsurface	1-4	1.9	No	No	**Yes**
LBC4L100	SU4	Subsurface	1-4	1.2	No	No	**Yes**

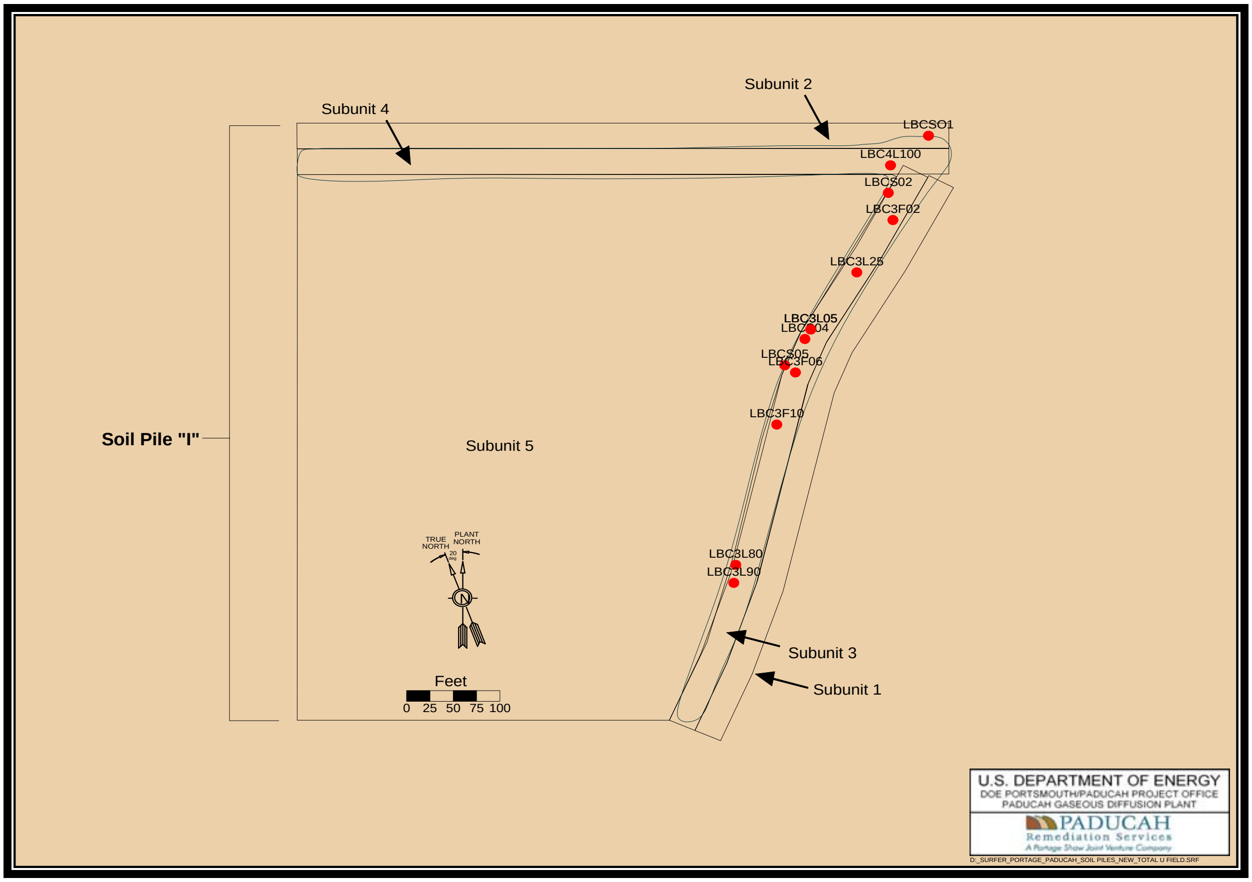


Figure 30. Location of PCB Detections above TSCA Benchmarks

5.6.3 Hazardous Substances, Pollutants, Contaminants, Petroleum, or Petroleum Products

The 401 *KAR* 100:030 establish the Commonwealth of Kentucky standards with respect to releases of hazardous substances, pollutants, contaminants, petroleum, or petroleum products. Commonwealth of Kentucky standards are based on EPA Region 9 Preliminary Remediation Goals (PRGs) and are used as initial site screening values. Contamination on a property that does not exceed the residential Region 9 PRG values and does not otherwise require action shall not rise to a level of concern. Contamination that exceeds the residential but not industrial value and does not otherwise require action does not rise to concern if the property is restricted by a recorded deed.

Comparisons of the 95% UCL concentration or maximum detected concentrations for surface soils, surface contingency samples, and subsurface samples completed using Region 9 industrial direct contact PRGs. Region 9 PRGs were not available for the teen recreator. Industrial use values were selected over residential values as they more closely resemble the recreational use scenario.

In surface samples, arsenic and benzo(a)pyrene exceeded the industrial Region 9 PRGs. The 95% UCL concentrations of arsenic exceeded the Region 9 PRG of 1.6 mg/kg in all subunits. Only subunits 2 and 5 with 95% UCL concentrations of 18 mg/kg and 23 mg/kg, respectively, also exceeded the PGDP provisional surface background concentration for arsenic (12 mg/kg) in the PGDP Risk Methods Document. In the case of organic compounds, the maximum detected concentration of benzo(a)pyrene (0.46 mg/kg) in subunit 3 exceeded the Region 9 PRG value of 0.21 mg/kg.

In contingency surface samples, the Region 9 PRGs for arsenic and uranium (200 mg/kg) were exceeded in all samples. The PRG for benzo(a)pyrene was exceeded in 2 of 5 samples and the PRG for Aroclor-1254 (0.74 mg/kg) was exceeded in 4 of 5 contingency samples. The PRG for total chromium (450 mg/kg) was exceeded in 1 of 5 samples. Table 21 shows a summary comparison of the detected surface samples and Region 9 direct contact soil PRGs for industrial worker.

In subsurface samples, arsenic exceeded the Region 9 PRG in all samples collected. Uranium exceeded the Region 9 PRG of 200 mg/kg in 4 of 52 samples: 2 samples collected from subunit 3 at a soil pile depth of 1 to 4 ft, 1 sample collected from subunit 3 at a depth of 4 to 7 ft, and 1 sample collected from subunit 4 at a depth of 1 to 4 ft. Aroclor-1254 was detected in 19 of 52 samples and exceeded the Region 9 PRG of 0.74 mg/kg in 3 samples from subunit 3; 2 samples collected at a depth of 1 to 4 ft and 1 sample collected at 4 to 7 ft. Benzo(a)pyrene was detected in 4 of 52 subsurface samples and exceeded the PRG of 0.21 mg/kg in 1 sample from subunit 4, collected at a depth of 4 to 7 ft. Dibenz(a,h)anthracene was detected in 1 of 52 samples and exceeded the PRG of 0.21 mg/kg in subunit 4, collected at a depth of 4 to 7 ft. Arsenic, chromium, uranium, Aroclor-1254, benzo(a)pyrene and dibenz(a,h)anthracene were further evaluated in the SLRA provided in Section 6.

The results of sampling completed at Soil Pile I show detections for two VOCs: ethylbenzene (0.9 µg/kg) and m,p-xylene (1.6 µg/kg). Each compound is well below the allowable soil levels in excavated materials to be used for unrestricted off-site purposes as indicated in the KDWM *Underground Storage Tank Classification Outline* (KDWM 2006): ethylbenzene = 900 µg/kg and total xylene = 5,000 µg/kg, respectively. Both also are several orders of magnitude below published PGDP NALs for child recreator contact with soil/sediment: ethylbenzene = 23,400 µg/kg and total xylene = 2,540,000 µg/kg, respectively (DOE 2001).

Table 21. Comparison of Soil Pile I Detected Hazardous Constituents in Surface Samples and the Commonwealth of Kentucky Standards of 401 *KAR* 100:030

Analytes	Sampling Area	Maximum Concentration (mg/kg)	UCL 95% or Mean Concentration (mg/kg)	Region 9 PRG, Industrial Soil[a] (mg/kg)	Background Concentration[b] (mg/kg)
Arsenic	Subunit 1	22.2	7.67 (UCL 95%)	1.6	12
	Subunit 2	33.1	18.02 (UCL 95%)		
	Subunit 3	15.4	7.6 (UCL 95%)		
	Subunit 4	23.3	9.04 (UCL 95%)		
	Subunit 5	47	23.4 (UCL 95%)		
	Contingency	40	13 (mean)		
Chromium	Contingency	1,140	385 (mean)	450	16[c]
Uranium	Contingency	6,410	1,912 (mean)	200	4.9
Aroclor-1254	Contingency	16	4.56 (mean)	0.74	None
Benzo(a)pyrene	Subunit 3	0.46	NA	0.21	None

NA = Not available.
[a] The 401 *KAR* 100:300 Standards are based on 2002 EPA Region 9 PRGs and used as initial site screening values.
[b] From the PGDP Risk Methods Document.
[c] From the PGDP Risk Methods Document, value for chromium (III).

5.7 CONTAMINANT FATE AND TRANSPORT

Another consideration at Soil Pile I is the potential for contaminants to be transported from the site vertically to groundwater in the RGA. The following provides an examination of COPCS and how they may contribute to degradation of groundwater in and around PGDP.[23]

The seepage velocity and travel time for water percolating downward through the unsaturated zone provides insight for the significance of contamination with respect to the groundwater transport pathway; therefore, the travel time to the RGA via the unsaturated zone was evaluated to determine the significance of the groundwater pathway. Soil Pile I COPCs evaluated include Aroclor-1254, Aroclor-1262, and uranium-238.

The seepage velocity in the portion of a soil column with constant capillary pressure (i.e., above the capillary fringe under conditions of constant infiltration) can be calculated assuming the infiltration rate is related to the vertical hydraulic gradient and unsaturated hydraulic conductivity at the water content of the vadose zone soil. Unsaturated hydraulic conductivity is commonly expressed as the product of the saturated hydraulic conductivity and the relative permeability, yielding the following vertical flow equation for annual average infiltration:

$$I = K_s \; K_{rw} \; i \quad ; \quad K_s < I \qquad (1)$$

where

- K_s is the saturated hydraulic conductivity (m/year),
- K_{rw} is the relative permeability of the soil (unitless),
- i is the hydraulic gradient (m/m), and
- I is the infiltration rate (m/year).

The infiltration rate can be estimated from a simple water balance equation:

$$I = P - ET - R \qquad (2)$$

where

- P is the precipitation,
- ET is the evapotranspiration rate, and
- R is the runoff.

By assuming the infiltration occurs under an average unit hydraulic gradient and solving for the relative permeability, the following relationship results:

$$K_{rw} = I \; K_s \qquad (3)$$

The relative permeability is a function of the volumetric water content. Using the Brooks and Corey (1964) soil-water characteristic model combined with the Burdine equation (1959) for the relative permeability, the relative permeability function is as follows:

---

[23] Air dispersion and surface water modeling were not performed as part of this investigation. If deemed necessary, these activities will be completed as part of the Soils OU.

$$K_{rw} = \frac{\left(\theta_w - \theta_r\right)}{\left(\theta_s - \theta_w\right)^{\varepsilon}} \qquad (4)$$

where

- θ_w is the volumetric water content,
- θ_s is the total (saturated) soil porosity,
- θ_r is the residual water content,
- $\varepsilon = 3 + 2/\lambda$ and
- λ = pore size distribution index (unitless) (Brooks and Corey 1964).

Substituting equation 3 into equation 4 yields the following equation for volumetric water content as a function of annual average infiltration:

$$\theta_w = \theta_r + \left(\theta_s - \theta_r\right)\left(\frac{I}{K_s}\right)^{1/\varepsilon} \qquad (5)$$

The average seepage velocity can then be estimated through a simplification of Darcy's Law assuming a unit hydraulic gradient, and where below the upper soil zone the capillary pressure is nearly constant. Substituting equation 5 into the Darcy's Law equation results in the following equation for seepage velocity:

$$v = \frac{I}{\theta_w \theta_r + \left(\theta_s - \theta_w \theta_r\right)\left(\dfrac{I}{K_s}\right)^{\lambda/(3\lambda+2)}} \qquad (6)$$

The average seepage velocity, which conservatively is equal to the solute velocity, is provided for various U.S. Soil Conservation Service soil textural classifications and average annual recharges shown in Table 22, calculated by Charbeneau and Daniels (1993) using the above methodology.

Table 22. Average Seepage Velocities (cm/yr)

Soil Type	Average Annual Infiltration (cm/yr)			
	5	**10**	**25**	**50**
Clay	16	31	75	148
Clay loam	19	34	86	164
Loam	26	49	113	211
Loamy sand	53	99	225	416
Silt	21	39	88	164
Silt loam	22	41	93	174
Silty clay	16	30	74	145
Silty clay loam	16	30	72	137

Table 22. Average Seepage Velocities (cm/yr) (Continued)

Sand	68	127	286	527
Sandy clay	18	35	82	158
Sandy clay loam	25	48	112	212
Sandy loam	39	73	167	308

[from Charbeneau and Daniels 1993]

The average seepage velocity and travel time estimated using the referenced model is approximate as the annual seepage velocity in Table 23 is based on a homogeneous soil and an annual infiltration rate. The seepage velocity will vary as a consequence of the seasonal variation in the infiltration rate. The following parameters were used in the assessment of the travel time screening calculations:

Table 23. Parameter Values for Soil Pile Groundwater Screening

COC	Porosity[a] (unitless)	Organic Sorption Coefficient[b] K_{oc} (L/kg)	Organic Carbon Content[c] f_{oc} %	Sorption Coefficient[d, e] K_d (L/kg)	Soil Density[f] (kg/L)	Average Annual Infiltration Rate[g] (cm/yr)
PCB-1254	0.45	4.25E+04	0.08	34	1.46	10.5
PCB-1260	0.45	2.07E+05	0.08	165.6	1.46	10.5
Uranium-238	0.45	NA	0.08	66.8	1.46	10.5

[a] Porosity value taken from DOE (2006b)
[b] Organic Sorption Coefficients from Ohio EPA Division of Hazardous Waste Management (http://www.epa.state.oh.us/dhwm/pdf/Chem_Phys_Tox.PDF)
[c] Organic carbon content from DOE (2006b)
[d] The K_d was determined for PCBs using the following relationship $K_d = K_{oc} \times (f_{oc}/100)$
[e] Sorption coefficient for uranium from DOE (2003)
[f] Soil density from DOE (2006b)
[g] Average annual infiltration rate from DOE (2006b)

The annual infiltration rate of 10.5 cm/yr for a silty clay results in an average seepage velocity of 30 cm from Table 1. The following equation provides the travel time to the RGA water table:

$$Travel\ Time\ (yr) = \frac{Unsaturated\ \ Zone\ Thickness\ (cm)}{Average\ Seepage\ Velocity\ (cm/yr)} \qquad (7)$$

The travel time is further modified by multiplying by the retardation factor based on the sorption coefficient (K_d):

$$R_d = 1 + \frac{\rho_b}{\theta} K_d \qquad (8)$$

where

- R_d is the retardation factor,
- ρ_b is the bulk density,
- θ is the volumetric water content [assumed to be the porosity], and
- K_d is the sorption coefficient.

The travel times calculated for Aroclor-1254, Aroclor-1260, and uranium-238 are provided in Table 24.

Table 24. Travel Time to the RGA for Soil Pile I Chemicals of Potential Concern

COPC	Retardation Factor R_d (unitless)	Unsaturated Zone Solute Velocity (cm/yr)	Unsaturated Zone Depth[a] (cm)	Unsaturated Zone Travel Time (yr)
PCB-1254	111	30	304.8	1.13E+03
PCB-1260	538	30	304.8	5.47E+03
Uranium-238	218	30	304.8	2.21E+03

[a] Unsaturated zone depth obtained from the PGDP Sitewide Model developed in MODFLOW.

5.7.1 Fate and Transport Summary

The travel time calculations predict that none of the noted contaminants will reach the RGA within a 1,000 year period, when a conservative unsaturated zone thickness of 304.8 cm is assumed. Empirical data supports this conclusion. Based on the age of trees found on Soil Pile I, the soil pile has been at its present location, in its current state, for between 14 and 30 years.

Data presented in Section 5, indicate the areas adjoining the soil pile (subunits 1, 2, and 5) do not contain widespread contamination. Similarly, subsurface results for subunits 3 and 4 indicate contamination has not migrated into the subgrade. Together, the Soil Pile I data indicate that contamination at the site is confined generally to soils along Little Bayou Creek and has not migrated laterally or downward.

THIS PAGE INTENTIONALLY LEFT BLANK

6. SCREENING LEVEL RISK ASSESMENT - HUMAN HEALTH

This SLRA for human health uses data collected in the spring and summer 2007 from Soil Pile I. The principal objective of this SLRA is to inform risk managers in support of decision making for the site. Key considerations include the following:

- Determine whether all or portions of the study area may be eliminated from concern.
- Identify where risk characterization suggest actions may be needed.
- Determine whether additional data gathering and/or risk assessments are warranted.

The SLRA provides information to the stakeholders based on the Commonwealth of Kentucky and nationally accepted risk assessment methods. These objectives are consistent with the goals, objectives, and requirements identified in the *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant Paducah, Kentucky, Volume 1, Human Health* (DOE 2001).

The scope of the Soil Pile I SLRA is to assess risks to human receptors who, through use of the Soil Pile I area, may be exposed to chemicals or radionuclides through normal use of the site. This SLRA does not examine ecological risks.

6.1 METHODOLOGY

In developing quantitative risks for Soil Pile I, a phased approach was employed. The following describes the stepwise process used to develop the SLRA.

6.1.1 Phase 1—Data Screening

Phase 1 was performed, to identify those COPCs that are statistically present, that are present at levels greater than background levels, and those whose concentrations are derived from data of known quality. Section 5.4 of this SER, *Discussion of Results*, contains a complete screening of Soil Pile I data. The following reviews the steps completed in examining project data and data screening steps employed to identify COPCs.

Initially, sample data assigned an “R” data validation qualifiers were removed from consideration in the risk assessment, as these values are not considered data points of known quality. Once removed, a comparison was made between metal and radionuclide concentrations and documented background concentrations for PGDP surface soils.[24] To accomplish this, the maximum value from each subunit was compared directly with background values listed in Table A-12 of the 2000 revision of the Risk Methods Document.

Following background comparisons, those contaminants retained were evaluated for frequency of detection to determine if sufficient data was available to support an evaluation of risks. Frequency of detection criteria is commonly set at 5% detections (EPA 1989). That is, if a given analyte is detected at a frequency less than or equal to 1 detection in 20 samples, it is not considered representative of the site and is screened from the data set. The data for each investigative subunit were examined using this criterion to ensure that areas of elevated concentrations of contaminants were not overlooked.

---

[24] Based on the CSM for Soil Pile I, only data from surface soils were considered in examining receptor exposure and risk.

Note: Biased samples collected from investigative subunits 3 and 4 were not included in summary statistics or the evaluation of human health risks due to the biased nature of the samples. The biased samples have been examined in the discussion of results and as part of the chemical-specific ARARs evaluation.

6.1.2 Phase 2—Comparison to Health Guidelines

As part of the data screening process, maximum concentrations from each subunit were compared to health guidelines. This involved examination of site-specific exposure conditions and comparison of site-specific maximum concentrations with established risk-based values. To complete this evaluation, NALs for the teen recreational use scenario listed in Table A-17 of the Risk Methods Document (DOE 2001) were used for comparisons with Soil Pile I maximum concentrations. The basis for using the teen recreational user NALs is discussed in Section 6.1.4.

Following health guideline comparison, those constituents that (1) exceeded PGDP background concentrations, (2) exhibited concentrations in excess of the NALs, and (3) were detected in more than 5% of the samples for an investigative subunit were retained as COPCs for quantitative risk assessment. EPA allows any minerals considered to be essential nutrients, such as calcium or potassium, to be excluded from this screening (EPA 2007). These constituents were not retained as COPCs.

6.1.3 Phase 3—Quantitative Risk Assessment

To perform the Soil Pile I data screening, maximum values were used for comparison purposes. In computing quantitative risks, the SLRA employs both 95% UCLs of the mean and maximum concentrations as the exposure point concentration (EPC). The following are the considerations defined in the PGDP Risk Methods Document (DOE 2001) in determining which values were used for each COPC:

(1) If results from fewer than 10 samples were available, the maximum concentration was used as the EPC.

(2) If results from ten or more samples were available, a distribution check was performed; the EPC for quantitative risk assessment was established by selecting the lesser of the maximum and the 95% UCL of the mean.

To ensure both efficiency and consistency, comparison values were used to assess the Soil Pile I data. The comparison values used are the PGDP NALs from the PGDP Risk Methods Document (DOE 2001). Use of NALs enabled identification of COPCs that do not result in adverse health effects (i.e., substances detected below comparison values) and substances requiring further evaluation (i.e., substances detected above comparison values).

The SLRA was performed by calculating risk and hazard for each EU, not the entire Soil Pile I study area. Risks were assessed in this way so as not to dilute the risk or hazard contribution from each EU or from areas of higher concentration within the EU. The following defines the EUs for Soil Pile I.

6.1.4 Exposure Units

Before quantitative risks can be computed, an evaluation of contaminant distribution and potential contact with contaminants by likely receptors must be completed. To do so, individual EUs are defined. In Addendum 1-A to the PGDP Soil Piles SAP, the following discussion of EUs was provided. This SER, the DQA, and the SLRA provide additional detail defining the EUs for Soil Pile I.

An EU is an area where a receptor is assumed to move at random, contacting environmental media (e.g., soil) equally at all sublocations (DOE 2001). Because the EU is key in calculating the exposure point concentration, EU size has a significant effect on the risk estimate. The random nature of individual behavior within the EU is the single most important factor to consider in selecting exposure point(s). For example, if the population of concern consists of recreational users, the site typically is divided into a series of EUs based on the types of recreational use (DOE 2007).

To focus the planned characterization effort for Soil Pile I, the sampling approach identified five distinctive subunits within the study area (Figure 6). They are defined as follows:

- Subunit 1—Buffer Area along Little Bayou Creek
- Subunit 2—Buffer Area along Outfall 002
- Subunit 3—Soil Piles along Little Bayou Creek
- Subunit 4—Soil Piles along Outfall 002
- Subunit 5—Interior area, south and west of soil piles

The soil pile and buffer areas of Soil Pile I (along Little Bayou Creek and Outfall 002) contain topographic features and dense vegetation, which are likely to induce recreational users to move within a smaller portion of the area on a given visit; therefore, a smaller EU is appropriate. Initially, the approximate 0.5 acre subunits (soil piles and buffer areas) each will be considered EUs when evaluating risks. This is consistent with the PGDP Risk Methods Document and the unique characteristics of the study area (DOE 2007).

The seven-acre area near Little Bayou Creek (Subunit 5) is significantly larger than standard EUs at PGDP. While Subunit 5 does not contain unique features such that recreational users would preferentially select a particular location over another, the large area likely precludes its being established as a single EU. Initially, data evaluation for Subunit 5 will determine if multiple 0.5 acre subunits are present and, if so, evaluate possible exposures to recreational receptors by dividing Subunit 5 into several EUs. Should the project data indicate little or no contamination or clearly indicate that Subunit 5 is composed of a single sample population, deviations from the PGDP Risk Methods Document may be employed, expanding the standard EU size (DOE 2007).

6.1.5 Definition of Soil Pile I Receptors

Soil Pile I is part of the WKWMA. Access to the portion of the WKWMA adjoining PGDP is controlled to the public throughout the year. In order to legally access the site, members of the public must check in with the USEC security force at the main guard outpost to PGDP. Known uses of DOE lands included in the WKWMA are defined in the CSM and include a) recreational users and b) wildlife workers.[25]

Known recreational uses of Soil Pile I include field trials, which incorporate horseback riding and dog trials, bow hunting, and similar outdoor activities. Generally, the defined recreational uses will be engaged in by teens and adults; child participation in the major activities is unlikely. Wildlife workers

---

[25] The receptors for Soil Pile I SLRA are current use receptors only.

also periodically perform work in and around Soil Pile I. The estimated exposure time for a wildlife worker is approximately one-fourth of the exposure time for a teen recreational user, making the teen recreational user more conservative in terms of exposure. Based on this, the teen recreational user, which includes those users between the ages of 7 and 18 years of age, provides a reasonable maximum estimate (RME) of receptor risks.

The Soil Pile I CSM, as defined in the SAP, details the routes of exposure considered in the risk assessment and includes the following:

- Incidental ingestion of soil
- Inhalation of soil particles (i.e., dust)
- Inhalation of vapors emitted from soil
- Dermal contact with soil
- External exposure to ionizing radiation

Figure 31 further refines the CSM by defining specific receptors, potential exposure mechanisms, and potential exposure routes. This SLRA reviews only the current use of the Soil Pile I area. Future use scenarios, if deemed necessary, will be examined as part of the Comprehensive Site Operable Unit.

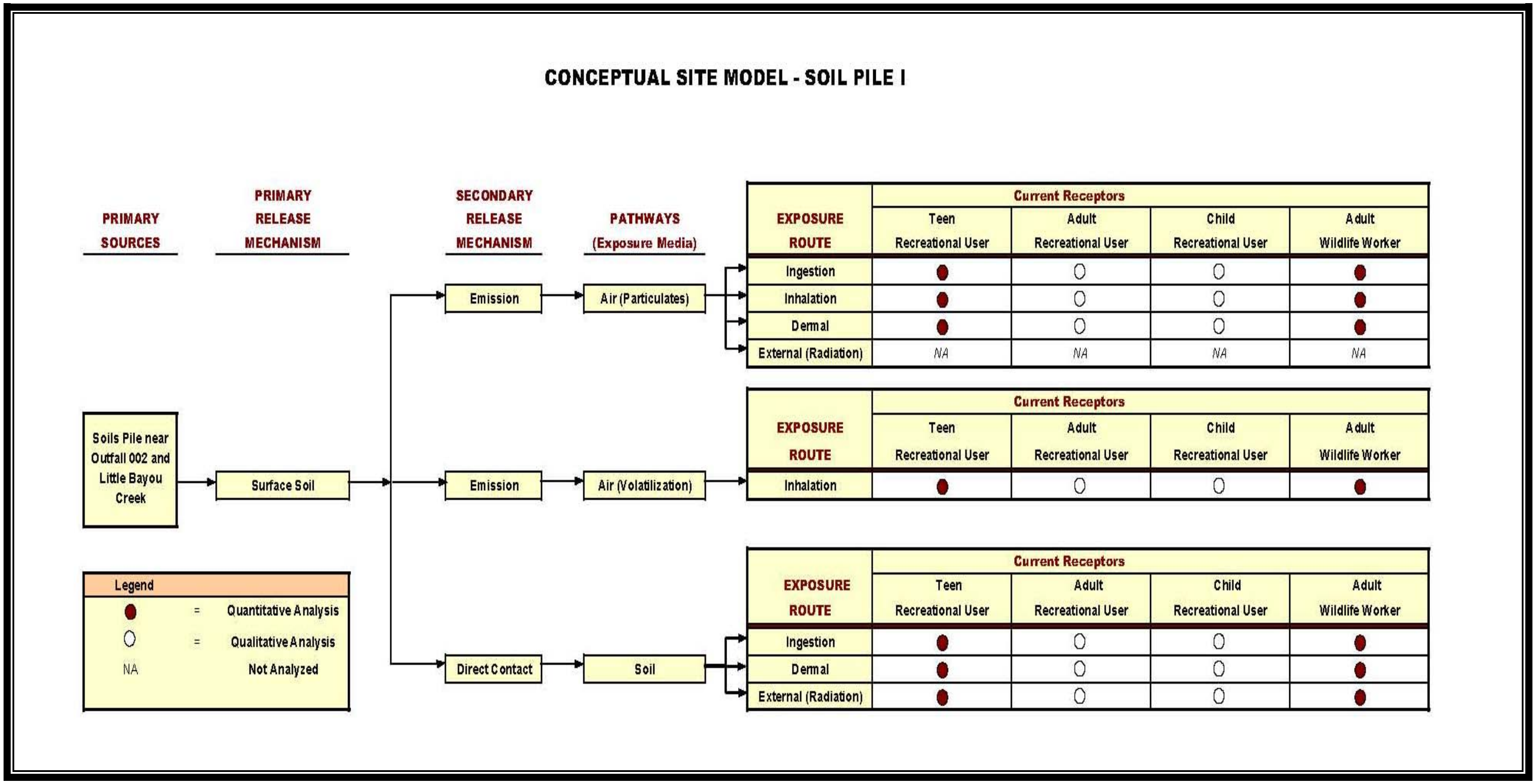
6.1.6 Evaluation of Risks and Hazards

Quantitative risks are presented as probabilities and are an expression of the potential for a given receptor to develop cancer through exposure to COPCS under a given set of exposure considerations. The NALs published in the Risk Methods Document employ an excess lifetime cancer risk (ELCR) value of 1E-6. This represents the lower end of EPA's generally acceptable risk range for site-related exposure. EPA considers risks in the range of 1E-4 to 1E-6 to be in the "acceptable" range (EPA 1989). In addition, the Risk Methods Document recommends that radionuclide COPCS be assessed against target doses of 1, 15 and 25 mrem/year for all exposure media except groundwater. Doses less than 1 mrem/year also are considered to be "acceptable," per the Risk Methods Document.

Hazard indices (HIs) express the potential for a receptor to develop a non-cancer, deleterious condition as a result of exposure to site-specific COPCS under a given set of exposure considerations. An HI less than 1 indicates it is unlikely that exposure will result in the development of a deleterious effect; however, a cumulative hazard value greater than 1 does not indicate that a deleterious effect will occur. The PGDP Risk Methods Document employs an HI of 0.1 when evaluating potential hazards to receptors. Because the effects of individual COPCS are not additive as presented in the Risk Methods Document, use of a HI of 0.1 provides a conservative estimate when predicting the likelihood that a deleterious effect will result from exposure.

The risk characterization parameters used in the Risk Methods Document are shown in Table 25. The teen receptor was used for risk characterization in this SLRA as it is more conservative than the wildlife worker (i.e., bounds risks for the wildlife worker). NALs used in the Soil Pile I SLRA were obtained from three sources:

- EPA's Integrated Risk Information System (IRIS)
- EPA's National Center for Exposure Assessment (NCEA)
- EPA's Health Effects Assessment Summary Tables (HEAST)



EXPOSURE ROUTE	Current Receptors			
	Teen Recreational User	Adult Recreational User	Child Recreational User	Adult Wildlife Worker
Ingestion	●	○	○	●
Inhalation	●	○	○	●
Dermal	●	○	○	●
External (Radiation)	*NA*	*NA*	*NA*	*NA*

EXPOSURE ROUTE	Current Receptors			
	Teen Recreational User	Adult Recreational User	Child Recreational User	Adult Wildlife Worker
Inhalation	●	○	○	●

EXPOSURE ROUTE	Current Receptors			
	Teen Recreational User	Adult Recreational User	Child Recreational User	Adult Wildlife Worker
Ingestion	●	○	○	●
Dermal	●	○	○	●
External (Radiation)	●	○	○	●

Figure 31. Conceptual Site Model for Soil Pile

Table 25. Risk Characterization Parameters

Parameter	Teen Recreational User
Adherence Factor	1 mg/cm2
Averaging Time (carcinogenic)	25,550 days
Averaging Time (non-carcinogenic)	365 x ED (4,380)
Body Weight	43 kg
Exposure Duration.(carcinogenic)	12 yr
Exposure Duration (non-carcinogenic)	12 yr
Exposure Frequency (carcinogenic)	140 d/yr
Exposure Frequency (non-carcinogenic)	140 d/yr
Exposure Time	5 hr/d
Fraction Ingested	1 (unitless)
Gamma Shielding Factor	0.2 (unitless)
Ingestion Rate	100 mg/d
Inhalation Rate	2.5 m3/hr
Particulate Emission Factor	3.21E+10 m3/kg
Surface Area	0.75 m2/d

[1] Teen recreational user values taken from Appendix B of the 2000 revision of *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2001).

6.1.7 Chemicals of Potential Concern

The data screening performed in Section 5.4 has identified COPCS for each investigative subunit. The following lists those chemicals and radionuclides retained for quantitative risk assessment at Soil Pile I.

- **Subunit 1:** antimony, arsenic, beryllium, manganese, uranium, vanadium, cesium-137, uranium-238, and Aroclor-1260.
- **Subunit 2:** antimony, arsenic, beryllium, lead, manganese, and vanadium.
- **Subunit 3:** arsenic, beryllium, uranium, vanadium, Total PCBs, and uranium-238.
- **Subunit 4:** antimony, arsenic, beryllium, iron, uranium, vanadium, Total PCBs, and uranium-238.
- **Subunit 5:** aluminum, antimony, arsenic, barium, beryllium, lead, manganese, vanadium, and cesium-137.

6.2 QUANTITATIVE RISK ASSESSMENT

Risk assessment provides one basis for determining whether actions should be taken at a site and identifies the contaminants and exposure pathways that need to be addressed. This SLRA consists of comparisons between the NALs described in the Risk Methods Document, Table A.17, and COPC concentrations.

Subsurface soils were collected in both EU 3 and EU 4; however, it is unlikely there is a scenario where either the teen recreational user or the wildlife worker would be exposed to the subsurface soils on a regular basis. In the interest of completeness, various scenarios were considered where the teen recreational user would experience exposure to subsurface soils. These included the following:

- Removal of soil to provide an area to unload horses from a trailer;

- Construction of a permanent tree stand for deer hunting involving digging of soil for support poles; and

- Digging in search of Native American artifacts.

One scenario was considered for the wildlife worker where the worker would be required to dig in the soil to install posts to be used to support signs associated with the WMWMA or artificial nests for birds.

In both sets of scenarios, each receptor would experience only brief periods of exposure to soils in the top 3 ft of soil pile horizon. The amount of soil removed would be minimal and exposure time would be less than 1 day. Because the exposure duration to subsurface soils is estimated to be very short, the associated risks also are unlikely to contribute significantly to surface soil pathways. Therefore, the use of the subsurface soil exposure pathway was not considered in the quantitative risk assessment.

Calculations performed to evaluate risks were performed for all EUs using the 95% UCL or maximum concentration observed surface samples (0-1 ft depth). A discussion of comparison techniques used to provide reference to RME estimates is provided in the uncertainty analysis.

Data acquired from XRF, PCB field measurements, and *in situ* gamma spectroscopy were not included in quantitative risk assessment. The data derived from the field methods, while useful in informing decision makers relative to contaminant distribution, are not sufficiently sensitive to support quantitative risk assessment. While XRF and ISOCS both are capable of acquiring quantitative results, their relatively high detection limits would inflate risk estimates for those analytes quantified using the field methods. PCB field methods are not accurate or sensitive enough to support risk characterization.

Quantitative risks for Soil Pile I were calculated by deriving cancer risk and hazard values utilizing the formulas shown here. For cancer risk posed by an individual chemical or radionuclide, the following formula was employed:

$$\text{Cancer Risk} = \frac{\text{Exposure Point Concentration}}{\text{Cancer - based Screening Level}} \times \text{Risk Target} \qquad (1)$$

where

- Cancer risk posed by a specific chemical, compound, or radionuclide
- EPC is the COPC concentration a receptor may be exposed to
- Teen recreational user NAL from Table A.17, PGDP Risk Methods Document
- Risk Target is 1×10^{-6}

For cancer risk posed over all COPCS, all exposure routes the following formula was used:

$$\text{Cumulative Cancer Risk} = \sum \text{Chemical - specific Cancer Risks} \qquad (2)$$

For hazard(s) posed by an individual chemical or compound:

$$\text{Hazard} = \frac{\text{Exposure Point Concentration}}{\text{Hazard - based Screening Level}} \times \text{Hazard Target} \qquad (3)$$

where

- Hazard is deleterious effect posed by a specific chemical
- EPC is the COPC concentration a receptor may be exposed to
- Hazard-based Screening Level is the value selected from Table A.17 of the PGDP Risk Methods Document
- Hazard Target is the hazard value used for the screening levels. A value of 0.1 was used in quantifying hazards for Soil Pile I

For hazard(s) posed over all COCs, all exposure routes the following formula was used:

$$\text{Cumulative Hazard} = \sum \text{Chemical - specific Hazards} \qquad (4)$$

Quantitative risks for each EU are provided in Tables 26–30.

6.2.1 Summary

Contaminants of concern (COCs) are those constituents whose concentrations under the defined exposure scenario(s) contribute to hazards and risks. The following lists the COCs for Soil Pile I by individual EU and describes their contributions to conditions at the site.

6.2.1.1 Subunit/EU 1

COCs identified for EU 1 based on their contributions to risk are arsenic, Aroclor-1260, and uranium-238. Arsenic contributes 79% to the risk estimate, with Aroclor-1260 and uranium-238 contributing 10% and 5%, respectively. The remaining constituents showed comparison risk values less than 1E-06.

COCs for EU 1 based on their contributions to hazard are arsenic, manganese, uranium, and vanadium. Manganese contributes 70% to the HIs for EU 1, with arsenic, uranium, and vanadium contributing 3%, 4%, and 20%, respectively. The remaining constituents showed comparison values less than 0.1.

6.2.1.2 Subunit/EU 2

Arsenic is the lone COC for EU 2, contributing 100% to the risk of 5.21E-05. The remaining constituents showed comparison risk values less than 1E-06.

COCs for EU 2 based on their contributions to hazard are antimony, arsenic, manganese, and vanadium. Manganese contributes 63% to the HIs for EU 1, with antimony, arsenic, and vanadium contributing 2%, 6%, and 27%, respectively. The remaining constituents showed comparison values less than 0.1.

Table 26. Quantitative Risks: Subunit 1/Exposure Unit 1

EU 1 COCs		**Teen No Action Value**	**Teen No Action Value**	**Target Risk**	**Cancer Risk**	**Percentage**	**Target Hazard Index**	**Hazard**	**Percentage**
	EPC	**Carcinogen**	**Hazard**	1.00E-06			0.1		
Antimony	1.92E-01		0.242					0.08	2%
Arsenic	7.67E+00	**0.346**	**5.98**		**2.22E-05**	**82%**		0.13	3%
Beryllium	4.97E-01	60,200	0.606		8.26E-12	0%		0.08	2%
Manganese	9.61E+02		**29**					**3.31**	**69%**
Uranium	2.98E+01		14.7					0.20	4%
Vanadium	2.02E+01		**2.12**					**0.95**	**20%**
Total PCB *	3.60E-01	0.127			2.83E-06	10%			
Cesium-137	1.57E-01	0.18			8.82E-07	3%			
Uranium-238	4.67E+00	3.64			1.28E-06	5%			
* Only Aroclor-1260 was detected.				**Total**	**2.72E-05**	100%	**Total**	**4.5**	100%

Table 27. Quantitative Risks: Subunit 2/Exposure Unit 2

EU 2 COCs		**Teen No Action Value**	**Teen No Action Value**	**Target Risk**	**Cancer Risk**	**Percentage**	**Target Hazard Index**	**Hazard**	**Percentage**
	EPC	**Carcinogen**	**Hazard**	1.00E-06			0.1		
Antimony	2.76E-01		2.42E-01					0.11	2%
Arsenic	1.80E+01	**3.46E-01**	**5.98E+00**		**5.21E-05**	**100%**		0.30	**6%**
Beryllium	5.50E-01	**6.02E+04**	6.06E-01		9.14E-12	0%		0.09	2%
Lead	3.49E+01								
Manganese	9.47E+02		**2.90E+01**					**3.27**	**63%**
Vanadium	2.96E+01		**2.12E+00**					**1.40**	**27%**
				Total	**5.21E-05**	**100%**	**Total**	**5.17**	**100%**

Table 28. Quantitative Risks: Subunit 3/Exposure Unit 3

EU 3 COCs		**Teen No Action Value**	**Teen No Action Value**	**Target Risk**	**Cancer Risk**	**Percentage**	**Target Hazard Index**	**Hazard**	**Percentage**
	EPC	**Carcinogen**	**Hazard**	1.00E-06			0.1		
Arsenic	7.60E+00	**3.46E-01**	**5.98E+00**		**2.20E-05**	**78%**		0.13	7%
Beryllium	5.36E-01	6.02E+04	6.06E-01		8.91E-12	0%		0.09	5%
Uranium	7.38E+01		**1.47E+01**					0.50	**27%**
Vanadium	2.23E+01		**2.12E+00**					1.05	**56%**
Total PCB*	1.80E-01	1.27E-01	1.91E-01		1.42E-06	5%		0.09	5%
Uranium-238	17.61	3.64E+00			4.84E-06	17%			
				Total	**2.82E-05**	**100%**	**Total**	**1.86**	**100%**

Table 29. Quantitative Risks: Subunit 4/Exposure Unit 4

EU 4 COCs		Teen No Action Value	Teen No Action Value	Target Risk	Cancer Risk	Percentage	Target Hazard Index	Hazard	Percentage
	EPC	**Carcinogen**	**Hazard**	1.00E-06			0.1		
Antimony	2.12E-01		0.242					0.09	3%
Arsenic	9.04E+00	**0.346**	**5.98**		**2.61E-05**	**95%**		0.15	5%
Beryllium	5.82E-01	60,200	0.606		9.67E-12	0%		0.10	3%
Iron	1.57E+04		**1,350**					**1.16**	**40%**
Uranium	2.16E+01		14.7					0.15	5%
Vanadium	2.74E+01		**2.12**					**1.29**	**44%**
Total PCB*	9.71E-02	0.127			7.64E-07	3%			
Uranium-238	1.77E+00	3.64			4.88E-07	2%			
				Total	**2.74E-05**	**100%**	**Total**	**2.94**	**100%**

Table 30. Quantitative Risks: Subunit 5/Exposure Unit 5

EU 5 contaminants		Teen No Action Value	Teen No Action Value	Target Risk	Cancer Risk	Percentage	Target Hazard Index	Hazard	Percentage
	EPC	**Carcinogen**	**Hazard**	1.00E-06			0.1		
Aluminum	1.03E+04		3,010					0.34	3%
Antimony	2.98E-01		0.242					0.12	1%
Arsenic	2.34E+01	**0.346**	**5.98**		**6.76E-05**	**97%**		0.39	4%
Barium	1.30E+02		148					0.09	1%
Beryllium	7.16E-01	60,200	0.606		1.19E-11	0%		0.12	1%
Lead	7.53E+01								
Manganese	2.50E+03		**29**					**8.61**	**77%**
Vanadium	3.13E+01		**2.12**					**1.48**	**13%**
Cesium-137	3.51E-01	0.178			1.97E-06	3%			
				Total	**6.95E-05**	**100%**	**Total**	**11.15**	**100%**

6.2.1.3 Subunit/EU 3

COCs identified for EU 3 based on their contributions to risk are arsenic, PCBs, and uranium-238. Arsenic contributes 78% to the risk estimate, with PCBs and uranium-238 contributing 5% and 17%, respectively. The remaining constituents showed comparison risk values less than 1E-06.

COCs for EU 3 based on their contributions to hazard are: arsenic, uranium, and vanadium. Vanadium contributes 56% to the HIs for EU 3, with arsenic and uranium contributing 27% and 7%. The remaining constituents showed comparison values less than 0.1.

6.2.1.4 Subunit/EU 4

Arsenic is the lone COC for EU 2, contributing 97% to the risk of 2.61E-05. The remaining constituents showed comparison risk values less than 1E-06.

COCs for EU 4 based on their contributions to hazard are arsenic, beryllium, iron, uranium, and vanadium. Iron and vanadium contribute equally to the hazard indices for EU 3, at 40% and 44%, respectively. Arsenic, beryllium, and uranium contribute fractionally to the hazards at 5%, 3% and 5%. The remaining constituents showed comparison values less than 0.1.

6.2.1.5 Subunit/EU 5

COCs identified for EU 5 based on their contributions to risk are arsenic and cesium-137. Arsenic contributes 97% to the risk estimate, with cesium-137 contributing the remaining 3%. None of the other constituents showed comparison risk values greater than 1E-06.

COCs for EU 5 based on their contributions to hazard are aluminum, antimony, arsenic, beryllium, and vanadium. Vanadium contributes 77% to the HIs for EU 5, with aluminum, antimony, arsenic, and beryllium contributing 3%, 1%, 4% and 1%, respectively. The remaining constituents showed comparison values less than 0.1.

6.2.2 Uncertainty Assessment

This section briefly summarizes the uncertainties in the screening human health risk assessment and their effect on risk characterization. All were considered when developing the site-specific NALs provided in Tables 36–42. Uncertainties are categorized as low, moderate, and high. As outlined in the Risk Methods Document, low uncertainties should not cause risk to vary more than one order of magnitude, moderate uncertainties are those that may cause the risk to vary between one and two orders of magnitude, and high uncertainties may cause risk to vary by more than two orders of magnitude.

6.2.2.1 Data screening—background

Maximum Soil Pile I data were compared with published PGDP background concentrations as a means of identifying COPCS. Because maximum values were used to perform the comparison, some constituents that are actually less than background may have been retained for quantitative risk assessment. In the interest of being protective of human health, the comparison to maximum values ensured that chemicals/radiochemicals were not excluded from the assessment. Conversely, although some inorganic chemicals and radionuclides were retained as COPCs due to levels greater than background concentrations, this does not indicate the source of contamination was necessarily due to site-related activities. The uncertainty related to background comparisons is considered low.

6.2.2.2 Data screening—frequency of detection

Constituents detected in less than 5% of the Soil Pile I samples were not retained for risk assessment. This was appropriate based on the lack of PAH detection in 3 of 5 EUs; in 2 of the EUs, it was detected at a frequency of 5%. The most notable of these were the PAH compounds. To illustrate, for EU 1, the total risk without PAHs is 2.8E-5; with the maximum benzo(a)pyrene value included, the corresponding risk would be 5.2E-5. Similarly in EU 3, the maximum PAH detections results in a risk estimate of 7.86E-05. This uncertainty is assumed to have a moderate effect on the risk characterization.

6.2.2.3 Risk contributions—metals

The presence of large contributors to both risk and hazards including arsenic, manganese, and vanadium requires special consideration in evaluating Soil Pile I. The concentrations and distributions of these metals is uniform throughout the site. Conversely, concentrations and distributions of non-metal COPC (e.g., uranium, uranium daughters, and PCBs) vary widely from subunit to subunit, with contamination confined primarily to the axis of Soil Pile I along Little Bayou Creek. While the maximum values for each of the metals exceeded PGDP background concentrations, their uniformity throughout the site suggests the measured levels may be reflective of background conditions. Consider how arsenic values compare in disturbed and undisturbed areas. When this comparison is made, the maximum concentrations are found in relatively undisturbed areas (subunit 5). Because background concentrations were not determined specifically for Soil Pile I, this remains an uncertainty in evaluating metal COPCS and the need for actions to address them. The effect of metals concentrations on risk and hazard estimates is considered high.

Note: Arsenic is the most significant contributor to risks in each of the EUs; however, its EPC is less than background in 3 of 5 subunits (EU 1, EU 3 and EU 4). For comparison purposes, it is worth noting the contribution to overall risks from arsenic at background for the teen recreational user is 3.5×10^{-5}. Similarly, manganese and vanadium contribute the majority of observed hazards.

6.2.2.4 Toxicity information

Some chemicals do not have available toxicity values; consequently, screening levels are not available. For purposes of the Soil Pile I SLRA, lead is the pertinent example. The absence of toxicity information does not increase the uncertainty in any single risk or hazard value, but it does lower the cumulative risk or hazard estimate and prevents the development of risk-based cleanup levels. The uncertainty associated with this is low, as lead was found to be a contaminant in only EU 2.

6.2.2.5 Gamma shielding factor

The gamma shielding factor is the ratio of the external gamma radiation level indoors to the radiation level outdoors. It is based on the fact that a building provides shielding against penetration of gamma radiation. The shielding factors represent reduction factors of 0.4 to 0.2 and are recommended as representative values for aboveground lightly constructed (wood frame) and heavily constructed (block and brick) homes, respectively.

The use of a gamma shielding factor in the calculation of risk for receptors that work or recreate outdoors results in a reduced risk when compared with risks calculated without the shielding factor. The gamma shielding factor only impacts gamma emitting radionuclides through the external exposure pathway. As the main radionuclide contributing to on-site risk is uranium-238, the overall impact of the gamma shielding factor is low.

6.2.2.6 Statistical outliers

During development of the DQA, statistical outliers were identified in each subunit. The risk assessment incorporated all data points, including statistical outliers. The 95% UCLs of the mean may be slightly over estimated using this technique, potentially increasing risk and hazard estimates. The effect of including outliers in the SLRA is moderate.

Site-specific no action values were not used in the calculation of risk, but are included here to provide perspective. The no action and action values were calculated for a teen recreational user and a wildlife worker using the set of input parameters listed in Table 31. The no action and action values both for the teen recreational user and wildlife worker will be compared to the values in the Risk Methods Document.

6.2.2.7 Default exposure parameters

Uncertainty associated with using default exposure parameters increases the risk and HI. Site specific no action values were not used in the calculation of risk, but are included in this section to establish the uncertainty of the risks calculated using default values. The no action and action values have been calculated for a teen recreational user and a wildlife worker using the set of input parameters listed in Table 31. The no action and action values for the teen recreational user were compared to the values in the Risk Methods Document. The wildlife worker action levels are presented without context. Table 32 shows the default dermal absorption factors listed in the Risk Methods Document used for calculation of the site specific values.

Tables 33–34 show the risk assessment results using the site specific no action values. The risk and hazard associated with each EU are significantly lower than those calculated using the default no action limits. The shorter exposure duration of the site-specific receptors and the use of lower dermal absorption factors contribute to the differences in risk and hazard. When comparing the teen recreational user site-specific risk to the wildlife worker site-specific risk again the risk and hazard are significantly lower because of the shorter exposure duration of the wildlife worker and the ingestion rate is half of the teen rate and surface area exposed (dermal contact) is slightly greater than half of the teen parameter. Tables 35–36 show the calculated site-specific no action values for both receptors.

Table 31. Site-Specific Exposure Parameters

Parameter	Teen Recreational User[1,2]	Wildlife Worker[1,2]
Adherence Factor	1 mg/cm2	1 mg/cm2
Averaging Time (carcinogenic)	25,550 days	25,550 days
Averaging Time (noncarcinogenic)	365 x ED (4,380)	365 x ED (9,125)
Body Weight	43 kg	70 kg
Exposure Duration.(carcinogenic)	12 yr	25 yr
Exposure Duration (noncarcinogenic)	12 yr	25 yr
Exposure Frequency (carcinogenic)	60 d/yr	15 d/yr
Exposure Frequency (noncarcinogenic)	60 d/yr	15 d/yr
Exposure Time	5 hr/d	8 hr/d
Fraction Ingested	1 (unitless)	1 (unitless)

Parameter	**Teen Recreational User[1,2]**	**Wildlife Worker[1,2]**
Gamma Shielding Factor	0.2 (unitless)	0.2 (unitless)
Ingestion Rate	100 mg/d	50 mg/d
Inhalation Rate	2.5 m3/hr	2.5 m3/hr
Particulate Emission Factor	3.21E+10 m3/kg	3.21E+10 m3/kg
Surface Area	0.75 m2/d	0.43 m2/d

[1] All factors except exposure frequency taken from Appendix D of the 2000 revision of *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2001).

[2] Exposure frequency factors from USEC (2007b).

Table 32. Site-Specific Absorption Factors

Absorption Factors[1] for Chemicals	
PCBs	0.14
PAH	0.13
Cadmium	0.001
Arsenic	3.00E-02
Other Metals	0.001
SVOCs	0.1

[1] Dermal absorption factors are default values taken from Table B.5 of the 2000 revision of *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2001).

Using the site specific risk parameters, arsenic contributes significantly to risk and hazard in all EUs. Arsenic dominates the risk in all EUs with the exception of EU 3 where uranium-238 also contributes significantly to the risk. Arsenic is not as dominant a contributor to the HI for the EUs. Uranium contributes significantly to the HI in 3 of 5 EUs. Arsenic is likely a significant contributor to the HI in the site-specific scenarios because of the dermal absorption factors of metals. The metals other than arsenic use a dermal absorption factor of 0.001, while arsenic has a dermal absorption factor of 0.03.

The site-specific risk results are a reasonable benchmark for the risk results that use the default exposure factors as described in the Risk Methods Document (DOE 2001) for developing NALs. The exposure duration of 60 days per year for the teen recreational user is a conservative estimate of the central tendency. The members of the public entering all the areas around PDGP were recorded by the USEC Security Force. Both the security fencing surrounding PGDP and USEC Security Force prevent members of the public from entering without documentation. In the period from January 1, 2007, to August 31, 2007, 114 entries were made in the areas immediately surrounding PDGP. Many of these individuals did not enter the area near Soil Pile I. Of the 114 entries, 35 individuals entered multiple times, and 11 individuals entered 3 or more times. The record shows that 3 people entered the WKWMA 5 times. While these results do not represent a definitive study, they do indicate 60 days per year is a conservative estimate of central tendency and may be near the reasonable maximum exposure duration (USEC 2007b).

The other significant difference between the default and the site-specific exposure parameters is the use of EPA recommended dermal absorption values. The EPA recommended dermal absorption values for arsenic and cadmium are taken from *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) OSWER 9285.7-02EP PB99-963312 July 2004* (EPA 2004). This guidance recommends the dermal absorption factors mentioned herein and generally recommends that other metals be treated qualitatively for dermal exposure. EPA Region 4 recommends a 0.001 or 0.1% dermal absorption factor in the Human Health Bulletin as shown on the EPA Region 4 website (http://epa.gov/region4/waste/ots/healtbul.htm).

Table 33. Comparison of Site-Specific Teen and Wildlife Worker NALs and PGDP Risk Methods NALs

		Site-Specific Teen Recreational User NALs			PGDP Teen Recreational User NALs			Multiple of the Site Specific Value
Contaminants	**Units**	**Hazard**	**Carcinogen**	**NAL**	**Hazard**	**Carcinogen**	**NAL**	
Aluminum	mg/kg	100,000		100,000	3,010		3,010	33
Antimony	mg/kg	26.4		26.4	0.242		0.242	109
Arsenic	mg/kg	13.8	1.79	1.79	5.98	0.346	0.346	5
Barium	mg/kg	40,707		40,707	148		148	275
Beryllium	mg/kg	67.9	466,490	67.9	0.606	60,200	0.606	112
Iron	mg/kg	100,000		100,000	1,350		1,350	74
Lead	mg/kg	NA	NA	NA			50	
Manganese	mg/kg	17,263		17,263	29.0		29.0	595
Uranium	mg/kg	529		529	14.7		14.7	36
Vanadium	mg/kg	4,036		4,036	2.12		2.12	1,904
Total PCB	mg/kg	0.436	0.636	0.436	0.191	0.127	0.127	3
Total PAH	mg/kg		0.066	0.066		0.0133	0.0133	5
Cesium-137	pCi/g		1.19	1.19		0.178	0.178	7
Plutonium-239	pCi/g		237	237		30.3	30.3	8
Thorium-230	pCi/g		302	302		39.0	39.0	8
Uranium-234	pCi/g		407	407		52.2	52.2	8
Uranium-235	pCi/g		5.53	5.53		0.826	0.826	7
Uranium-238	pCi/g		24.6	24.6		3.64	3.64	7

[1] No action values are based on a risk of 1E-6 and a HI of 0.1.

[2] The value for lead is a regulatory value provided by the Commonwealth of Kentucky Risk Assessment Branch.

Table 34. Comparison of Site-Specific Action Levels and PGDP Risk Methods Action Levels

		Site-Specific Teen Recreational User ALs			PGDP Teen Recreational User ALs			
Contaminants	**Units**	**Hazard**	**Carcinogen**	**Action**	**Hazard**	**Carcinogen**	**Action**	**Multiple of the Site Specific Value**
Aluminum	mg/kg	100,000		100,000	100,000		100,000	1
Antimony	mg/kg	793		793	344		344	2
Arsenic	mg/kg	413	179	179	2,590	314	314	0.57
Barium	mg/kg	100,000		100,000	100,000		100,000	1
Beryllium	mg/kg	2,036	46,649,028	2,036	884	100,000	884	2
Iron	mg/kg	100,000		100,000	100,000		100,000	1
Lead	mg/kg			400			400	1
Manganese	mg/kg	100,000		100,000	39,100		39,100	3
Uranium	mg/kg	15,877		15,877	6,830		6,830	2
Vanadium	mg/kg	121,076		121,076	3,090		3,090	39
Total PCB	mg/kg	13.1	63.6	13.1	2.02	10.5	2.02	6
Total PAH	mg/kg		6.60	6.60		4.24	4.24	2
Cesium-137	pCi/g		119	119		1.28	1.28	93
Plutonium-239	pCi/g		23,724	23,724		222	222	107
Thorium-230	pCi/g		30,237	30,237		285	285	106
Uranium-234	pCi/g		40,716	40,716		381	381	107
Uranium-235	pCi/g		553	553		5.91	5.91	93
Uranium-238	pCi/g		2,461	2,461		26.1	26.1	94

[1] The action levels (Als) are based on a risk of 1E-4 and a hazard index of 3.

[2] The value for lead is a regulatory value provided by the Commonwealth of Kentucky Risk Assessment Branch.

[3] Toxicity values for radionuclides account for short-lived daughter products, where applicable.

Table 35. Site-Specific NALs for the Wildlife Worker

		Site-Specific Wildlife Worker NALs		
Contaminants	**Units**	**Hazard**	**Carcinogen**	**NAL**
Aluminum	mg/kg	100,000		100,000
Antimony	mg/kg	98.0		98.0
Arsenic	mg/kg	64.3	8.22	8.22
Barium	mg/kg	62,819		62,819
Beryllium	mg/kg	374	976,375	374
Iron	mg/kg	100,000		100,000
Lead	mg/kg			50
Manganese	mg/kg	40,173		40,173
Uranium	mg/kg	211		211
Vanadium	mg/kg	3,057		3,057
Total PCB	mg/kg	11,789	3.24	3.24
Total PAH	mg/kg		0.368	0.368
Cesium-137	pCi/g		1.53	1.53
Plutonium-239	pCi/g		103	103
Thorium-230	pCi/g		137	137
Uranium-234	pCi/g		179	179
Uranium-235	pCi/g		6.93	6.93
Uranium-238	pCi/g		29.3	29.3

NAL = no action level
AL = action level

Table 36. Site-Specific Action Levels for the Wildlife Worker

		Site-Specific Wildlife Worker ALs		
Contaminants	Units	Hazard	Carcinogen	AL
Aluminum	mg/kg	9,762,422		9,762,422
Antimony	mg/kg	2,941		2,941
Arsenic	mg/kg	1,929	822	822
Barium	mg/kg	100,000		100,000
Beryllium	mg/kg	11,228	100,000	11,228
Iron	mg/kg	100,000		100,000
Lead	mg/kg	NA		NA
Manganese	mg/kg	100,000		100,000
Uranium	mg/kg	6,321		6,321
Vanadium	mg/kg	91,705		91,705
Total PCB	mg/kg	100,000	324	324
Total PAH	mg/kg		36.8	36.8
Cesium-137	pCi/g		153	153
Plutonium-239	pCi/g		10,290	10,290
Thorium-230	pCi/g		13,726	13,726
Uranium-234	pCi/g		17,867	17,867
Uranium-235	pCi/g		693	693
Uranium-238	pCi/g		2,928	2,928

Table 37. Site-Specific Teen Recreational User NALs Used in the Risk Assessment

EU 1 COCs		**Teen NAL**	**Teen NAL**	**Target Risk**	**Cancer Risk**	**Percentage**	**Target Hazard Index**	**Hazard**	**Percentage**
	EPC	**Carcinogen**	**Hazard**	1.00E-06			0.1		
Antimony	1.92E-01		26.4					0.00	1%
Arsenic	7.67E+00	1.79E+00	13.8		4.29E-06	83%		0.06	81%
Beryllium	4.97E-01	4.66E+05	67.9		1.07E-12	0%		0.001	1%
Manganese	9.61E+02		17,300					0.006	8%
Uranium	2.98E+01		529					0.006	8%
Vanadium	2.02E+01		4,040					0.0005	1%
Total PCB *	3.60E-01	6.36E-01			5.66E-07	11%			
Cesium-137	1.57E-01	1.19E+00			1.32E-07	25%			
Uranium-238	4.67E+00	2.46E+01			1.90E-07	35%			
				Total	**5.18E-06**	100%	**Total**	**0.07**	100%

* Only Aroclor-1260 was detected.

Table 38. Site-Specific Teen Recreational User NALs Used in the Risk Assessment

EU 2 COCs		**Teen NAL**	**Teen NAL**	**Target Risk**	**Cancer Risk**	**Percentage**	**Target Hazard Index**	**Hazard**	**Percentage**
	EPC	**Carcinogen**	**Hazard**	1.00E-06			0.1		
Antimony	2.80E-01		26.4					0.001	1%
Arsenic	1.80E+01	1.79E+00	13.8		1.01E-05	100%		0.13	93%
Beryllium	5.50E-01	4.66E+05	67.9		1.18E-12	0%		0.001	1%
Lead	3.49E+01								
Manganese	9.47E+02		17,300					0.01	4%
Vanadium	2.96E+01		4,040					0.001	1%
				Total	**1.01E-05**	**100%**	**Total**	**0.14**	**100%**

Table 39. Site-Specific Teen Recreational User NALs Used in the Risk Assessment

EU 3 COCs		**Teen NAL**	**Teen NAL**	**Target Risk**	**Cancer Risk**	**Percentage**	**Target Hazard Index**	**Hazard**	**Percentage**
	EPC	**Carcinogen**	**Hazard**	1.00E-06			0.1		
Arsenic	7.60E+00	1.79E+00	13.8		4.25E-06	81%		0.06	49%
Beryllium	5.36E-01	4.66E+05	67.9		1.15E-12	0%		0.00	1%
Uranium	**7.38E+01**		529					0.01	12%
Vanadium	**2.23E+01**		4,040					0.001	0%
Total PCB*	1.80E-01	6.36E-01	0.436		2.83E-07	5%		0.04	37%
Uranium-238	17.61	2.46E+01			7.16E-07	14%			
				Total	**5.25E-06**	**100%**	**Total**	**0.11**	**100%**

* Aroclor-1260, -1254 and -1248 were detected.

Table 40. Site-Specific Teen Recreational User NALs Used in the Risk Assessment

EU 4 COCs		**Teen NAL**	**Teen NAL**	**Target Risk**	**Cancer Risk**	**Percentage**	**Target Hazard Index**	**Hazard**	**Percentage**
	EPC	**Carcinogen**	**Hazard**	1.00E-06			0.1		
Antimony	2.12E-01		26.4					0.001	1%
Arsenic	9.04E+00	1.79E+00	13.8		5.06E-06	96%		0.07	75%
Beryllium	5.82E-01	4.66E+05	67.9		1.25E-12	0%		0.001	1%
Iron	1.57E+04		100,000					0.02	18%
Uranium	2.16E+01		529					0.004	5%
Vanadium	2.74E+01		4,040					0.001	1%
Total PCB*	9.71E-02	6.36E-01			1.53E-07	3%			
Uranium-238	1.77E+00	24.61			7.21E-08	1%			
				Total	**5.29E-06**	**100.00%**	**Total**	**0.1**	**100%**

* Only Aroclor-1260 was detected

Table 41. Site-Specific Teen Recreational User NALs Used in the Risk Assessment

EU 5 COCs		**Teen NAL**	**Teen NAL**	**Target Risk**	**Cancer Risk**	**Percentage**	**Target Hazard Index**	**Hazard**	**Percentage**
	EPC	**Carcinogen**	**Hazard**	1.00E-06			0.1		
Aluminum	1.03E+04		100,000					0.01	5%
Antimony	2.98E-01		26.4					0.001	1%
Arsenic	2.34E+01	1.79E+00	13.8		**1.31E-05**	98%		0.17	86%
Barium	1.30E+02		40,700					0.0003	0%
Beryllium	7.16E-01	4.66E+05	67.9		1.53E-12	0%		0.001	1%
Lead	7.53E+01								
Manganese	2.50E+03		17,300					0.014	7%
Vanadium	3.13E+01		4,040					0.001	0%
Cesium-137	3.51E-01	1.19E+00			2.94E-07	2%			
				Total	**1.34E-05**	**100%**	**Total**	**0.2**	**100%**

7. CONCLUSIONS

The following provides a summary of the major findings and conclusions for the Soil Pile I investigation. The discussion reconciles the DQOs with the MQOs and the balance of the investigation results. The following lists the objectives of the Soil Pile I investigation:

- Establish the nature and extent of contamination in Soil Pile I and adjacent soils.
- Establish the mean concentrations of contaminants in soils.
- Determine if soils pose imminent risks to human health.
- Determine if soils contamination exceeds regulatory thresholds.
- If contaminated, determine waste disposition alternatives.

In addition to supporting characterization at Soil Pile I, two objectives were included to aid in evaluating investigative techniques to determine if they might support future investigations at PGDP. These objectives are as follows:

- Evaluate the performance of field measurement techniques to determine their viability for use at other locales at PGDP, and

- Determine if there are chemicals at Soil Pile I that will serve as indicators for other chemicals.

7.1 NATURE AND EXTENT OF CONTAMINATION

Subunits 1-4 were divided into 14 evenly spaced segments, with the collection of comprehensive fixed laboratory and field data from surface composites in 4 of 14 segments, or over ~30% of the linear extent of these subunits. A random sample grid was placed over the entirety of subunit 5 where fixed laboratory and field data were acquired from 79 discrete locations. The CSM for the PGDP soil piles indicates that current land uses include part-time recreational and occupational activities; therefore, to examine the potential threats to public health, data acquired from surface soils (0–1 ft) were required to develop quantitative risk estimates.

Field measurements were collected from discrete surface locations to augment the understanding of contaminant distribution throughout the site and to identify localized areas of contamination if areas were present. In subunits 1–4, surface samples were collected every 30 ft and were analyzed for radioactivity, metals, and PCBs.

Subsurface soils also were collected. Samples were acquired over 3 ft intervals beginning at 1 ft below the top of the soil pile, extending to 2 ft below the natural grade. Subsurface data were acquired from three locations within each random segment where comprehensive sampling occurred and from locations spaced every 30 ft along the axis of the soil portion of the study area in the remaining segments. Those subsurface samples collected in the random segments underwent both fixed laboratory analysis and field measurements, while the samples collected in the remaining segments underwent field measurements only.

The sampling effort at Soil Pile I has achieved the identified objectives. The data review performed in conjunction with this study indicates that all objectives for data quality and completeness were met; therefore, data of known quality were acquired in sufficient quantities to support the development of mean contaminant concentrations in each investigative subunit. The computed mean concentrations are sufficient to support quantitative assessment of human health risks, to compare project data with chemical-specific ARARs, and to allow decision makers to formulate an informed decision as to the need for immediate or future actions at Soil Pile I.

The investigation supports an examination of contaminant distribution in both surface and subsurface soils, and it has identified those contaminants that must be considered in decision making going forward. The data bounds the concentrations of contaminants, identifying the minimum and maximum concentrations found at the site and in each subunit; and the sampling design has successfully identified where contamination is found and has delineated the boundaries of that contamination.

The investigation also was successful in identifying localized areas of contamination in the study area that must be considered in developing decisions concerning Soil Pile I. Finally, sufficient data has been acquired to inform decision makers concerning the levels and composition of the materials in Soil Pile I, such that, if an interim action is deemed necessary, a determination can be made as to where contaminated media should be disposed.

7.2 HUMAN HEALTH RISKS

The SLRA examines the current use of Soil Pile I and the risks to human health. The defined receptors are the teen recreational user and an adult wildlife worker. Conclusions concerning potential human health risks at Soil Pile I were derived from the summary tables provided in Section 5.3.

For all Soil Pile I EUs, the cumulative human health systemic toxicity and ELCR exceeded the acceptable risk standards as defined by KDEP and EPA.[26] The results of the risk assessment indicate that metals were the most important contributors to risk and the HI. EPCs used for metals to quantify risks and hazards were segregated by EU; often the risk and HI were due to concentrations less than or equal to published background levels.

Notes:

(1) The EPC for all metals was the calculated as a 95% UCL of the mean.

(2) The EPC for arsenic was below background in 3 of 5 of the EUs.

(3) In EU 3, the contingency location containing the highest levels of process related COCs (i.e., PCBs, uranium, and uranium daughters) had an arsenic concentration less than background.

(4) The maximum concentration of arsenic detected in subunit 3/EU 3 was 15 mg/kg, slightly above background.

(5) Risks from arsenic for the teen recreational user at the published background level for PGDP soils (12 mg/kg) is 3.5E-5.

7.3 REGULATORY THRESHOLDS

The following summarizes comparisons of observed Soil Pile I contaminant concentrations to chemical-specific ARARS.

---

[26] Tabulated EPCs do not include the biased contingency samples collected in subunit 3 and subunit 4.

7.3.1 Radiation Dose Limits

UCL concentrations of contaminants detected in Soil Pile I are below recreational user screening levels for a 1 mrem/year dose and, therefore, below the "walk away" level in the PGDP Risk Methods Document. Concentrations of thorium-230 and thorium-232 also are below generic guidelines for release of DOE property in DOE Order 5400.5. The resulting total EDE from these radionuclides below the 0.1 rem/year, plus ALARA, is required for protection of individual members of the public pursuant to 10 *CFR* §§20.1301 and 20.1101 and DOE Order 5400.5.

7.3.2 PCB Remediation Waste

When PCB results of randomly collected surface samples for PCBs are compared with TSCA benchmark values, the 95% UCL and maximum concentrations for subunits 1, 3, and 4 are less than the high occupancy (no restriction) TSCA limit of 1 ppm. Subunits 2 and 5 show no detection of PCBs.

Several discrete locations exceeded TSCA benchmark values. These include the contingency samples collected in subunits 3 and 4. Table 42 lists locations where PCB concentrations exceeded at least one TSCA benchmark value. Figure 30 provides the location of the corresponding samples.

Table 42. Comparison of Fixed Laboratory PCB Concentrations with TSCA Benchmark Values

Sample Location:	Subunit:	Description:	Depth:	PCB Concentration (mg/kg)	> TSCA Action Limit (50 ppm)	> Low Occupancy TSCA Limit (25 ppm)	> High Occupancy, No Restrictions TSCA Limit (1 ppm)
LBCS01	SU3	Contingency	0-1 ft	2.2	No	No	**Yes**
LBCS02	SU3	Contingency	0-1 ft	2.8	No	No	**Yes**
LBCS04	SU3	Contingency	0-1 ft	14	No	No	**Yes**
LBCS05	SU3	Contingency	0-1 ft	79	**Yes**	**Yes**	**Yes**
LBC3F02	SU3	Subsurface	4-7 ft	2.6	No	No	**Yes**
LBC3F06	SU3	Subsurface	1-4 ft	5.7	No	No	**Yes**
LBC3F10	SU3	Subsurface	4-7 ft	2.5	No	No	**Yes**
LBC3L05	SU3	Subsurface	1-4 ft	2.9	No	No	**Yes**
LBC3L05	SU3	Subsurface	4-7 ft	1.4	No	No	**Yes**
LBC3L25	SU3	Subsurface	1-4 ft	1.5	No	No	**Yes**
LBC3L80	SU3	Subsurface	1-4 ft	1.2	No	No	**Yes**
LBC3L90	SU3	Subsurface	1-4 ft	1.9	No	No	**Yes**
LBC4L100	SU4	Subsurface	1-4 ft	1.2	No	No	**Yes**

7.3.3 Hazardous Substances, Pollutants, Contaminants, Petroleum, or Petroleum Products

In surface samples, arsenic and benzo(a)pyrene exceeded the industrial Region 9 PRGs. The 95% UCL concentrations of arsenic exceeded the Region 9 PRG of 1.6 mg/kg in all subunits. Only subunits 2 and 5 with 95% UCL concentrations of 18 mg/kg and 23 mg/kg, respectively, also exceeded the PGDP provisional surface background concentration for arsenic (12 mg/kg) in the PGDP Risk Methods Document. In the case of organic compounds, the maximum detected concentration of benzo(a)pyrene (0.46 mg/kg) in subunit 3 exceeded the Region 9 PRG value of 0.21 mg/kg.

In contingency surface samples, the Region 9 PRGs for arsenic and uranium (200 mg/kg) were exceeded in all samples. The PRG for benzo(a)pyrene was exceeded in 2 of 5 samples, and the PRG for Aroclor-1254 (0.74 mg/kg) was exceeded in 4 of 5 contingency samples. The PRG for total chromium (450 mg/kg) was exceeded in 1 of 5 samples.

In subsurface samples, arsenic exceeded the Region 9 PRGs in all samples collected. Uranium exceeded the Region 9 PRG of 200 mg/kg in 4 of 52 samples: 2 samples collected from subunit 3 at a soil pile depth of 1 to 4 ft, 1 sample collected from subunit 3 at a depth of 4 to 7 ft, and 1 sample collected from subunit 4 at a depth of 1 to 4 ft. Aroclor-1254 was detected in 19 of 52 samples and exceeded the Region 9 PRG of 0.74 mg/kg in 3 samples from subunit 3; 2 samples collected at a depth of 1 to 4 ft and 1 sample collected at 4 to 7 ft. Benzo(a)pyrene was detected in 4 of 52 subsurface samples and exceeded the PRG of 0.21 mg/kg in 1 sample from subunit 4, collected at a depth of 4 to 7 ft. Dibenz(a,h)anthracene was detected in 1 of 52 samples and exceeded the PRG of 0.21 mg/kg in subunit 4, collected at a depth of 4 to 7 ft. Arsenic, chromium, uranium, Aroclor-1254, benzo(a)pyrene, and dibenz(a,h)anthracene were further evaluated in the SLRA provided in Section 6.

The results of sampling completed at Soil Pile I show detections for two VOCs: ethylbenzene (0.9 µg/kg) and m,p-xylene (1.6 µg/kg). Each compound is well below the allowable soil levels in excavated materials to be used for unrestricted off-site purposes: ethylbenzene = 900 µg/kg and total xylene = 5,000 µg/kg, respectively (KDWM 2006). Both also are several orders of magnitude below published PGDP NALs for child recreator contact with soil/sediment: ethylbenzene = 23,400 µg/kg and total xylene = 2,540,000 µg/kg, respectively (DOE 2001).

7.4 FIELD METHOD PERFORMANCE

Comparison of data obtained from the Soil Pile I investigation, indicates field methods can be used to support investigation planning, to identify locations where contamination is present, and as a verification tool during remediation activities. Each of the methods performed differently, with varying degrees of success in demonstrating their efficacy. The following summarizes the findings as they relate to each field method employed.

7.4.1 X-Ray Florescence

A large enough sample population for both lead and uranium was available to examine the data statistically. The Soil Pile I investigation demonstrates that XRF is a quantitative tool that may be used for total uranium and lead during future investigations. It is suitable to deploy for characterization and removal verification at PGDP in the future, when lead and uranium action limits are greater than the instrument-specific MDL.

XRF should not serve as a substitute for radiochemistry data when little or no information is known for a given site; however, once sufficient data is available to establish uranium and uranium daughter concentrations/ratios, XRF may be used effectively for determining uranium concentrations in PGDP soils and may be considered for estimating uranium daughter concentrations. Because it is relatively inexpensive and efficient, XRF is very useful in determining the distribution of uranium and lead. The method was relatively insensitive for the other RCRA metals and may have limited utility in examining these metals on future investigations.

A complete examination of XRF utility is presented in Appendix B (DQA).

7.4.2 Field PCBs by Immunoassay/Colorimetric Techniques

A limited population of positive PCB concentrations was available for comparison at Soil Pile I. To illustrate, when both field and laboratory PCB methods both showed measurable PCB concentrations, only four pairs of samples were available.

This method has demonstrated that it can reliably predict the presence of PCBs above 4 ppm; however, the method also exhibited a 6% false positive rate. For purposes of performing initial site screening to determine PCB presence or absence, these two factors together are positive, in that, the method will reliably predict PCBs when they are present at levels approaching TSCA benchmarks of 25 and 50 ppm. In addition, the method did not show false negative results when PCBs were present in laboratory-derived results between 4 and 72 ppm. Periodically, the method predicts PCBs are present when they are not 6% of the time.

Based on the limited sample population available, the PCB test method did not accurately measure very low-level PCBs nor did it accurately measure PCBs at very high concentrations. Until additional information is available, the PCB method should not be used to support risk assessment nor as the sole basis for making regulatory related decisions. It can be used to inform decision making for PCB contamination, when a sufficient quantity of fixed laboratory data is available from corresponding locations.

A complete examination of the PCB field method is presented in Appendix B (DQA).

7.4.3 *In Situ* Object Counting System

The ISOCS used for the Soil Pile I investigation was employed in an *ex situ* manner, meaning it was deployed in a controlled environment during sample analysis. ISOCS accurately measures gamma emitting radioisotopes when they are present at levels within its operating range. Evaluation of the method comparing it with laboratory uranium-238 results indicates a strong correlation when laboratory data is detected above the ISOCS minimum detectable activity range.

Limitations on use of the ISOCS for Soil Pile I likely relate to its sensitivity for gamma emitting isotopes. This may be attributed to relatively short count times employed during quantitation of sample radioactivity for Soil Pile I. The short count times resulted in relatively high MDAs for the project, limiting its ability to measure mid- and low-level sample concentrations. Consequently, the ISOCS was only able to predict the presence of uranium-238 under a portion of the conditions observed at Soil Pile I.

Method accuracy is sound and the false positive rate is very low; however, method insensitivity for this project would allow the method to be used only as a screening tool. Until additional information is available, the ISOCS should not be used to support risk assessment nor as the sole basis for making regulatory related decisions. It can be used to evaluate uranium-238 distribution when a sufficient quantity of fixed laboratory data is available from corresponding locations.

A complete examination of ISOCS utility is presented in Appendix B (DQA).

7.4.4 Sodium Iodide Detector

Also worthy of note is the relationship observed between the GWS results (Figure 5) and the total uranium results acquired using both field and laboratory methods. Not surprisingly, the GWS was a solid predictor of where elevated levels of uranium and uranium daughters would be found during the Soil Pile I investigation. This may increase the utility of the GWS results for future efforts at PGDP. Although the method will remain a qualitative (gross) method for measuring field radioactivity, should future field surveys indicate a similar relationship, the GWS will have a high degree of utility in support of investigation planning.

7.5 INDICATOR CHEMICALS

Correlation analysis was performed on several chemicals found at Soil Pile I.

If the correlation between two analytes was close to one, then one may be considered an indicator chemical for the other. None of the relationships found with correlation analysis were useful in guiding future sampling efforts in neighboring areas.

Figures 13–19 highlight a qualitative correlation between PCBs, uranium, and uranium daughters. In all cases, when PCBs were detected above benchmark values, total uranium and uranium-238 also were detected. The number of samples available for mathematical comparison is relatively small; however, there is a clear relationship between the two contaminants. Similarly, the plots illustrate a qualitative correlation between the field and laboratory methods used to quantify uranium, uranium daughters, and PCBs. The reverse relationship is not true; PCBs were not always detected when uranium and uranium daughters were detected. In this instance, the relationship indicates that the uranium and PCBs are from a common source (e.g., PCBs contaminated with uranium). More detail concerning these relationships is provided in Appendix B (DQA).

8. RECOMMENDATIONS

The following provides recommendations for future activities at Soil Pile I. The recommendations are based on the findings of the investigation and lessons learned during the planning and execution of study efforts at Soil Pile I.

8.1 FUTURE ACTIVITIES

The following are recommendations based on the findings of the Soil Pile I investigation.

8.1.1 Arsenic Risks

ELCRs for the Soil Pile I subunits range from 2.7E-05 to 7.0E-05. Risks in each of the subunits are dominated by arsenic with its contributions to overall subunit risks ranging from 78% to 100%. While the maximum values for arsenic exceed published PGDP upper tolerance limits (UTLs) for background, estimates of the arsenic mean are consistent with background concentrations. Risks in the investigative subunits when considered without arsenic range from 8.0E-07 to 1.90E-06. Although arsenic is a known carcinogen, its presence at or near background levels is not indicative of contamination; therefore, it is recommended that arsenic not be considered as a COPC at Soil Pile I.

8.1.2 Manganese and Vanadium Hazards

Similarly, detections of manganese and vanadium in each of the subunits do not represent contamination. While maximum results exceed PGDP UTLs for background in soils, sitewide estimates of the mean for both metals do not. It is recommended that manganese and vanadium not be considered as a COPC at Soil Pile I.

8.1.3 PAH Compounds

PAH compounds were detected in only five samples at Soil Pile I. Because the carcinogenic PAHs have high toxicity values, particularly benzo(a)pyrene and dibenz(a,h)anthracene, maximum concentrations for these compounds tend to increase risk estimates significantly. Because so few samples showed measurable concentrations of these compounds, samples containing them are not indicative of contamination in individual subunits or sitewide. Based on this, it is recommended PAH compounds not be considered as a COPC at Soil Pile I.

8.1.4 Cesium-137

Cesium-137 was detected in all subunits, at uniform levels in all surface soils. The 95% UCL values 0.16 to 0.18 pCi/g are both below the published PGDP 95% UCL background levels for cesium-137. Despite this, it was retained as a COC in subunits 1 and 5. When considered with background levels, it is recommended that cesium-137 not be considered as a COPC at Soil Pile I.

8.1.5 Uranium, Uranium Daughters, and PCBs

Uranium and uranium daughters were detected in all subunits, but were retained as COCs only in subunits 1, 4, and 5. Risks and hazards relating to both total uranium and uranium-238 are relatively low in these subunits; risks resulting from uranium-238 range from 4.88E-07 to 4.84E-06, and hazards for total uranium range from 0.15 to 0.50. Similarly, PCBs were retained as COCs only in subunits 1, 4, and 5. PCB risks also are relatively low, ranging from 7.64E-07 to 2.83E-06.

Discrete locations exhibit uranium, uranium daughter, and PCB concentrations in excess of chemical-specific ARARs. These locations occur along the Little Bayou Creek axis of Soil Pile I to the confluence with Outfall 002. Slightly elevated levels also are identified in the southern half of Subunit 1. Because observed conditions indicate localized areas of contamination, it is recommended that an engineering evaluation/cost analysis be completed to evaluate further the need for actions at Soil Pile I and, if deemed necessary, evaluate alternatives and costs, and recommend a path forward to address these impacts.

8.2 LESSONS LEARNED – SOIL PILE I

The following provides a summary of lessons learned from sampling completed at Soil Pile I. Because Soil Pile I was the first of a series of future soil pile investigations, these should be considered and incorporated into future planning efforts for PGDP soil pile characterization to the extent practicable.

8.2.1 Initial Decision Making

During initial planning for Soil Pile I characterization, the use of December 2006 biased sample data (data collected from locations with highest contaminant concentrations) were used to direct activities for soil pile related efforts. Based on the complete data set for Soil Pile I, the biased samples were not fully representative of conditions at Soil Pile I. In retrospect, a combined review of the gamma survey, the initial laboratory results, and a second field effort with limited sampling may have reduced or better focused data collection planning for Soil Pile I. Overall, the lesson learned is that incremental data gathering likely will result in more informed planning and decision making in the future.

8.2.2 Portable Sampler

Portable sampling equipment, particularly the portable direct push technology (DPT) sampler employed for Soil Pile I, proved to be both very cost effective and likely minimized potential safety and health issues when compared with vehicle-mounted DPT. The economics of the portable equipment prevented the need to site, design, and build a road suitable for vehicle mounted DPT units, resulting in significant cost savings to the government. This will prove to be more significant for future field activities, as soil piles in future study areas are spread over a wider geographic area.

The portable sampler also allowed minimal clearing and grubbing efforts to accommodate equipment and personnel, resulting in both cost savings and minimizing environmental impact to the surrounding area. While the portable equipment has affiliated work planning requirements for safety and health, the small size and relatively light weight minimized the potential for personal injury due to increased visibility of all field personnel during work efforts, lack of heavy equipment, mobilization/demobilization activities, and most pronounced access to the soil piles.

8.2.3 XRF Utility

The use of field grade/portable XRF has a high degree of utility and can be used to support future applications at PGDP. Comparisons of XRF uranium to laboratory results indicate relatively strong comparability within the operating range of the XRF. Because uranium and associated daughters are common contaminants at PGDP, this technology is likely to have broad applications in the future, including for Addendum 2 and Addendum 1-B field activities.

8.2.4 Seasonal Fieldwork

Completion of field work during the late spring and summer months at the PGDP resulted in potential heat stress to members of the field team, exposure to ticks and other biting insects, exposure to potentially venomous snakes, and increased standby time during heavy rainfall events. Scheduling field work for the fall and early winter seasons would mitigate these field issues and enhance field team productivity.

THIS PAGE INTENTIONALLY LEFT BLANK

9. REFERENCES

Brooks, R.H. and A.T. Corey 1964. *Hydraulic properties of porous media*, Hydrology Paper 3, Colorado State University, Fort Collins, CO.

Burdine, N.T. 1959. “Relative permeability calculations from pore size distribution data.” Trans. AIME, Vol. 198, pp. 71-77.

Charbeneau, R.J. and Daniel, D.E. 1993. “Contaminant Transport in the Unsaturated Zone” (Chapter 15), *Handbook of Hydrology*, David Maidment, Editor in Chief, McGraw Hill, New York.

DOE 2001. *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky Volume 1, Human He*alth, DOE/OR/07-1506&D2, December.

DOE 2003. *Risk and Performance Evaluation of the C-746-U Landfill at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky.* DOE/OR/07-2041&D2R1. U.S. Department of Energy, Paducah, KY, September.

DOE 2006a. *Surface Water Operable Unit (On-site) Site Investigation and the Baseline Risk Assessment Report at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/LX/07-0001&D1, November.

DOE 2006b. *Site Investigation Report for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*. DOE/OR/07-2180&D2, U.S. Department of Energy, Paducah, KY, May.

DOE 2007a. *Sampling and analysis Plan for Soil Piles at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/LX/07-0015&D2/R1, U. S. Department of Energy, Paducah, KY, September.

DOE 2007b. *Site Management Plan, Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-0009&D2, U. S. Department of Energy, Paducah, KY, October.

EPA 1998. *Federal Facility Agreement for the Paducah Gaseous Diffusion Plant,* DOE/OR/07-1707, U.S. Environmental Protection Agency, Atlanta, GA, February.

EPA 1989. *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual, Part A*, EPA/540/1-89/002, U. S. Environmental Protection Agency, Washington, DC, July.

EPA 2000. *Multi-Agency Radiation Survey and Site Investigation Manual*, EPA-402-R-97-016, Revision 1, U. S. Environmental Protection Agency, Washington, DC, August.

EPA 2004 *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)*, OSWER 9285.7-02EP PB99-963312, July.

KDWM 2006, *Underground Storage Tank Classification Outline,* Kentucky Department of Waste Management, Environmental and Public Protection Cabinet, Division of Waste Management, Underground Storage Branch, August.

PRS (Paducah Remediation Services, LLC) 2007. *Paducah Gaseous Diffusion Plant Building Directory, Primary Processes, and Possible Release Pathways*, Internal Document, Paducah Remediation Services, LLC, July 17.

USDA 1976. *Soil Survey of Ballard and McCracken Counties, Kentucky*, Soil Conservation Service, U. S. Department of Agriculture, Paducah, KY, February.

USEC 2007a. Personal Communication, Chris Travis, USEC Environmental Monitoring and Jennifer Blewett, PRS, December 6.

USEC 2007b. Personal Communication, Mike Banks, USEC Security and Aric Cowne, PRS, September.

APPENDIX A

SWMU ASSESSMENT REPORT

THIS PAGE INTENTIONALLY LEFT BLANK

SOIL PILE I
Solid Waste Management Unit (SWMU) Assessment Report

SWMU/AOC NUMBER: 561

DATE OF ORIGINAL SAR: 6/05/08

DATE OF REVISED SAR: NA

REGULATORY STATUS: SWMU

LOCATION: This SWMU is located outside the PGDP fenced, industrialized area, east of the PGDP fence and is adjacent to Little Bayou Creek between McCaw Road and Outfall 002 ditch.

APPROXIMATE DIMENSION OR CAPACITY: The SWMU covers approximately 7 acres. Soil piles within the 7 acre area are approximately 30 ft wide x 700 ft long by an average of 8 ft tall along Outfall 002 ditch and 30 ft wide x 700 ft long by an average of 8 ft tall along Little Bayou Creek.

FUNCTION: None.

BRIEF HISTORY: Interviews with PGDP employees indicated that historically it was an intermittent practice to dredge the outfall ditches and creeks to remove build-up of sediments and natural debris to enhance surface water flow. These piles were identified on November 2, 2006, and subsequently posted by November 22, 2006.

PRESENT OPERATIONAL STATUS: Inactive

DATES OPERATED: Approximately the 1950s to the 1980s, as noted in the response to the 3007 request.

SITE/PROCESS DESCRIPTION: This SWMU encompasses a 7 acre area, mostly wooded, flat or gently sloped with soil pile areas located along Outfall 002 ditch and Little Bayou Creek. Soil pile areas vary in size and range from approximately 12-30 ft in width and 2-12 ft high, with the majority averaging 8 ft high.

WASTE DESCRIPTION: Sediment, soil and vegetative debris. Radiological contamination above background concentrations and PCB contamination is present in portions of these soil piles.

WASTE QUANTITY: Approximately 10,000 yds^3 of soil.

SUMMARY OF ENVIRONMENTAL SAMPLING DATA: The following is a summary of samples collected from the soil piles and nearby areas within the SWMU boundaries:

98 samples underwent fixed laboratory analysis,
646 surface samples underwent field measurements only,
51 subsurface samples underwent field measurements and fixed laboratory analysis,
117 subsurface samples underwent field analysis only,
5 tree samples for fixed laboratory analysis, and
9 soil samples for analysis to support engineering design of possible removal/remedial action.

Field analyses included metals, PCBs, and radiological parameters. A gamma walkover survey was performed prior to any physical sample collection, with indications in a few areas of between 2 and 7 times background. Fixed laboratory analyses included metals, PCBs, radiological parameters, and volatile and semivolatile organics. Radiological contamination (uranium isotopes) was detected in 3 small areas at concentrations up to three times greater than background. PCB contamination was present in these same areas with metals also present above background.

DESCRIPTION OF RELEASE AND MEDIA AFFECTED:

GROUNDWATER:	None known
SURFACE WATER:	None known
SOIL:	See below
ECOLOGY AFFECTED:	None known

DOCUMENTATION OF NO RELEASE: As reflected by sampling data, some of the soil piles along Little Bayou Creek contain uranium and PCB contamination above background. Based upon the data collected from the soil, there does not appear to be any migration to groundwater or surface water from the soil piles. Ecological media do not appear to be impacted based upon the limited data collected (tree samples).

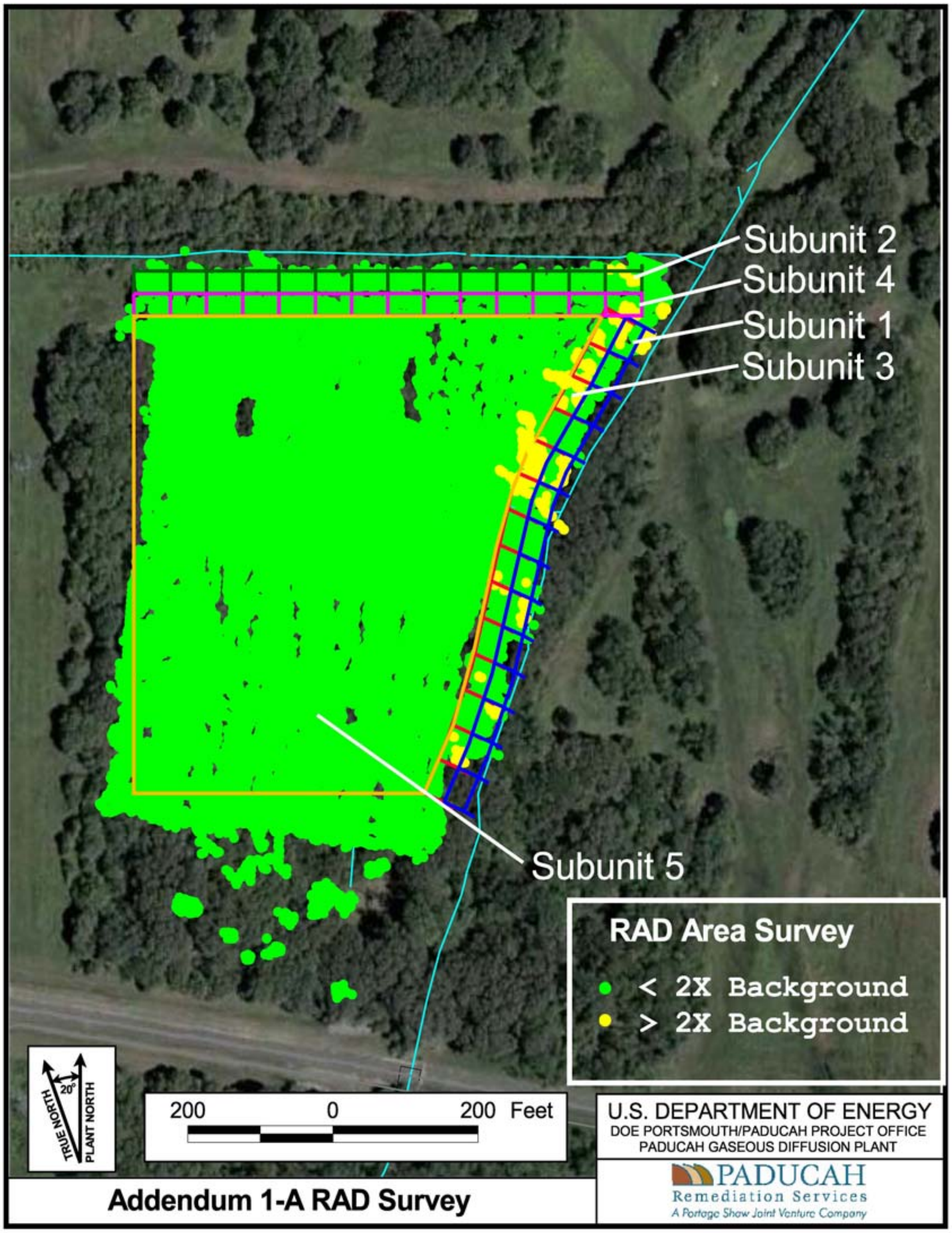
IMPACT ON OR BY OTHER SWMUS OR AOCS: There is no evidence that this SWMU impacts or is impacted by other SWMUs.

PRG COMPARISON: Benzo(a)pyrene and dibenz(a,h)anthracene exceeded the preliminary remediation goal (PRG) of 0.21 mg/kg at soil interval 4-7 ft in one sample. This occurred in sample LBC4L050 located in subunit 4.

Uranium was above the U.S. Environmental Protection Agency (EPA) Region 9 PRG of 200 mg/kg at soil interval 7-10 ft (349 mg/kg) in sample LBC3F16 (located on the southern terminus of subunit 3).

RFI NECESSARY: Yes, as identified in the Hazardous Waste Facility Permit (KY8-890-008-982).

OPERABLE UNIT ASSIGNMENT: Soils Operable Unit



Addendum 1-A RAD Survey

U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

PADUCAH
Remediation Services
A Portage Shaw Joint Venture Company

FIGURE No. c5ac90000sk643r2.apr
DATE 08-10-07

APPENDIX B

DATA QUALITY ASSESSMENT FOR SOIL PILE I

THIS PAGE INTENTIONALLY LEFT BLANK

PREFACE

This report documents the assessment of data obtained from soil samples associated with the Little Bayou Creek (LBC) Study Area of the Paducah Gaseous Diffusion Plant (PGDP), in Paducah Kentucky. The data assessed and summarized in this report were generated from the sample analysis of soil piles located outside the PGDP industrialized area identified in November 2006 along LBC between McCaw Road and Outfall 002 Ditch. Characterization will focus on the portion of the LBC originating at the confluence of PGDP Outfall 002 and LBC. Data were collected from surface soils in five subunits and subsurface soils in two of the subunits of interest to determine (1) the risk to human health as determined by a risk assessment, (2) the nature and extent of contamination, (3) the effectiveness of field data for decision making purposes, and (4) whether indicator variables can be identified in the area. The risk assessment is not presented in this document; rather, the data are carefully analyzed and the input parameters required for the risk assessment are computed.

CONTENTS

THIS PAGE INTENTIONALLY LEFT BLANK

TABLES

FIGURES

ACRONYMS

AD	absolute difference
AL	Analytical Laboratory
ANOVA	analysis of variance
ARAR	applicable or relevant and appropriate requirement
CV	coefficient of variation
DOE	U.S. Department of Energy
DQA	data quality assessment
DQO	data quality objectives
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
EU	exposure unit
HSD	honestly significant difference
ISOCS	*In Situ* Object Counting System
LBC	Little Bayou Creek
MANOVA	multivariable analysis of variance
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
NA	not applicable
ND	not detected
PCB	polychlorinated biphenyl
PGDP	Paducah Gaseous Diffusion Plant
RPD	relative percent difference
SAP	sampling and analysis plan
SER	Site Evaluation Report
SVOC	semivolatile organic compound
UCL	upper confidence limit
VOC	volatile organic compound
XRF	X-ray fluorescence

THIS PAGE INTENTIONALLY LEFT BLANK

B.1 INTRODUCTION

This report assesses the quality and summarizes data generated from soil samples associated with the Paducah Gaseous Diffusion Plant (PGDP) in Paducah, Kentucky. Soils associated with the Little Bayou Creek (LBC) Study Area of PGDP were sampled in accordance with the associated *Addendum 1-A to Sampling and Analysis Plan at the Paducah Gaseous Diffusion Plant Paducah, Kentucky,* DOE/LX-07-0015/A1&D2/R1 (DOE 2007a).

The purpose of this Data Quality Assessment (DQA) report is to analyze the data used to compute upper confidence limits (UCLs) of contaminants of concern to examine nature and extent of contamination, for use in a risk assessment, to compare field and fixed laboratory analysis methods, and to assess the presence of indicator chemicals.

In general, a DQA provides a scientific and statistical evaluation of data to determine if the collected data are of the right type, quality, and quantity to support their intended use. The DQA process is designed around the key idea that data quality, as a concept, is only meaningful when it directly relates to the intended use of the data (EPA 2006a). Two primary questions can be answered using the DQA process:

(1) Does the quality of the data permit decisions to be made with the desired degree of certainty?

(2) How well can the sampling design be expected to perform over a wide range of possible outcomes? Can the sampling design strategy be expected to perform well in a similar study with the same degree of confidence even if the actual measurements are different than those obtained in the present study?

The first question addresses the immediate needs of the study. If the assessment shows that the data are of sufficient quality, then the decision maker can make decisions using unambiguous data with the desired level of confidence. If the data do not provide sufficiently strong evidence to support one decision over another, then appropriate data analysis can alert the decision maker to the degree of ambiguity in the data. If this is the case, an informed decision can be made about how to proceed. For example, based on the data obtained, more data may be collected or the decision maker may make a decision knowing there is a greater-than-desirable uncertainty in the decision.

The second question addresses the potential future needs of the study. After the DQA is completed, personnel can determine how well the sampling design may perform at a different location given that different environmental conditions and outcomes may exist. Because environmental conditions vary from location to location, it is important to examine the sampling design over a large range of possible settings to ensure that the design will be adequate in other scenarios.

The data life cycle consists of three steps: planning, implementation, and assessment. The planning phase consists of documenting the data needs and plans for data collection using the data quality objective (DQO) process (EPA 2006b). The DQOs define the qualitative and quantitative criteria for specifying the sampling procedure and establish the desired level of confidence for decision making. The DQOs for this project are documented in the associated sampling and analysis plan (SAP) (DOE 2007b). The implementation phase consists of collecting the necessary data according to Addendum 1-A to the associated SAP (DOE 2007b). Data assessment consists of both data verification (to make sure that all sampling and analysis protocols were followed) and data validation (to determine if the data quality is satisfactory for making the decisions specified in the SAP). Following the SAP, Addendum 1-A, and PGDP validation protocols, 10% of laboratory analytical data underwent formal data validation.

The steps of the DQA process are as follows:

(1) Review the DQOs and sampling design
(2) Conduct a preliminary data review
(3) Select a statistical test or method
(4) Verify the assumptions of the selected test or method
(5) Draw conclusions from the data

The DQA process is iterative in nature in that characteristics of the data that are identified during one step may indicate that changes are needed on other steps. The steps of the DQA are discussed in greater detail Sections 2-12.

The LBC soils have not been characterized previously; therefore, sampling was necessary to gather data to allow DOE to define nature and extent of any contaminants in the soil piles and fully assess any potential risks to human health posed by the piles. Data from Soil Pile I were evaluated to determine whether regulatory thresholds were exceeded. Data also were collected to assess the extent to which field data can be used in characterizing other sites in the general vicinity and to examine the presence of indicator variables.

The geography of the area indicated that it was reasonable to divide the area into five subunits. The Soil Pile I area consists of two long, thin piles, the soils between the piles and LBC and Outfall 002 ditch, and the area between the two piles (See Figure B.1 in Section 10). Each subunit was selected to represent a separate exposure unit (EU). Data obtained from each of the subunits is examined in this document to determine whether subunits should be considered one EU or whether any of the subunits should be separated into more than one EU.

Samples were collected from surface and subsurface soils to fulfill the objectives of this study. Soils were analyzed using both fixed laboratory data and field measurement techniques. Both fixed laboratory and field data were used to determine nature and extent of contamination and to determine the extent that field sampling can be used for decision making in the neighboring sites. Field data were collected in between segments to determine the nature and extent of contamination in areas not sampled for fixed laboratory analysis. Field data also were compared to fixed laboratory data to determine how closely the results coincide. Fixed laboratory data were used to determine the potential risk to human health. These data are analyzed in this DQA report, and the results from a risk assessment are presented in the Site Evaluation Report (SER), to which this is appended.

Fixed laboratory data were analyzed using inductively coupled plasma-matrix spike. Field data were collected at the site using *In Situ* Object Counting System (ISOCS), X-ray fluorescence (XRF), and polychlorinated biphenyl (PCB) test kits.

Prior to this sampling effort, five samples were collected from the Soil Pile I area. These sample sites are the locations with the five highest instrument readings measured by radiological control technicians; therefore, these samples were collected using judgment sampling techniques and are therefore not comparable with samples collected from the rest of the site. These biased locations were resampled during the recent sampling event, and the resampling data are compared to the results from other samples collected in the area to determine if the sampling locations are different from the rest of the Soil Pile I region. These five samples are referred to as contingency samples in this document.

It also is of interest to determine whether any indicator chemicals are present in the site (whether there any chemicals that may indicate the presence of other chemicals that may be of primary importance in the same area). If an indicator chemical in the area can be identified, then sampling efforts at surrounding sites may be streamlined using this information.

THIS PAGE INTENTIONALLY LEFT BLANK

B.2 REVIEW OF THE DATA QUALITY OBJECTIVES AND SAMPLING DESIGN

The DQOs specify the problem being addressed and the approach that will be taken to address that problem. The DQOs consist of developing a problem statement and principal study questions, defining the decision inputs, defining study boundaries, developing a decision rule, establishing decision error limits, and optimizing the design. Although the soils associated with the entire soil piles area are mentioned in the DQOs, this DQA addresses only aspects of the DQOs pertaining to Soil Pile I. Note that some of the details that are mentioned in the following DQO summary were not included in the SAP.

- Problem Statement: To determine the nature and extent of contamination and potential risks to human health at Soil Pile I.

- Principal Study Questions: (1) Do the soil piles and/or adjoining soils pose risks to human health? (2) Do contaminants in the soil piles and/or in adjoining soils exceed regulatory thresholds? (3) If actions are required, what are the appropriate remedies to address elevated contaminant concentrations? (4) Can field methods acquire data of adequate quality, under site-specific conditions, to support characterization/decision making? (5) Are chemicals present that will predict the occurrence of other chemicals so that they can be used to support future decision making?

  Decision Rules: Do the data indicate that Soil Pile I does not pose a risk to human health or is additional sampling required to determine the extent of contamination.

- Decision Inputs: The identification and quantification of those contaminants that, based on historical site information and preliminary sampling, satisfy these criteria (1) are likely to be present, (2) could contribute to unacceptable human health risks, and (3) must be quantified to support decision making.

- Study Boundaries: the U.S. Department of Energy (DOE) Reservation area (1-A), which is LBC between McCaw Road and Outfall 002 Ditch (identified as Soil Pile I).

- Decision Rule: The data obtained from Soil Pile I will be used to determine nature and extent of contamination, to produce exposure point concentrations (EPCs) to be used in a risk assessment to determine if the soils pose a risk to human health, determine if field data can be used for decision making, and to determine if indicator chemicals are present in the area.

- Decision Error Limits: The primary tool for assessing the degree of contamination at Soil Pile I is a risk assessment. This is not a statistical test so it is not appropriate to define statistical hypotheses or error rates; however, a confidence level of 0.95 (alpha = 0.05) was determined to produce the UCLs that are used for risk assessment calculations.

- Design Optimization: Design optimization is an iterative process. A discussion of the rationale behind the design optimization is too lengthy for this summary. A summary of the selected design is stated here. The reader is referred to the SAP (DOE 2007b) and Addendum 1-A (DOE 2007a) for a full discussion of the optimization process. The Soil Pile I area was divided into five subunits for sampling. Samples for both field and laboratory analyses were collected from all five subunits. The primary sampling design for subunits 1 through 4 is a randomized, composited cluster, sampling design. Four segments, or clusters, were randomly selected from each of the subunits. Each of these segments was divided into five “slices.” Five samples were systematically collected from each of the “slices” and composited together. This was done for each slice, which produced a total of five composite samples per segment (20 per subunit).

Each composited sample was split; one split was analyzed using fixed laboratory analysis and the other split was analyzed with field methods. This was done to so that field and fixed laboratory methods could be compared. Field data also were collected from each of the samples prior to compositing and also from randomly selected locations between the segments so that nature and extent could be determined between segments.

Systematic random sampling was used for subunit 5. Both field and laboratory samples were collected from subunit 5. None of the samples from this subunit were composited.

Subsurface samples were collected from five randomly selected locations from each of the segments in subunits 3 and 4 for a total of 20 areal sampling locations per subunit. Grab samples were collected from three randomly selected depths down to 2 ft below grade level. All subsurface soils were analyzed both with fixed laboratory analysis and field methods.

B.3 PRELIMINARY DATA REVIEW

The purpose of the preliminary data review is to examine the data using graphical methods and numerical summaries to gain familiarity with the data and achieve an understanding of the “structure” of the data. A preliminary data review should be performed whenever data are used, regardless of the purpose of the data. This type of examination allows for identification of suitable approaches for further analysis and limitations of the data. The two main approaches to a preliminary data review are (1) calculation of basic statistical quantities (or summary statistics) and (2) graphical representations of the data. Appendix C, Attachments C1–C4 of the SER provide the graphical representations of soil data from Soil Pile I. The calculated summary statistics and explanation of the graphics are discussed in this section.

The summary statistics that were calculated for the detected constituents are measures of center (mean and median) and measures of spread (standard deviation and coefficient of variation [CV]). One measure of primary interest is the center of the data. The average ($\bar{x}$), or the mean, is the most commonly used measure of the central tendency of the data; however, it can be heavily influenced by outliers and by asymmetric data. The mean is calculated using Equation (1):

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \tag{1}$$

where

$\bar{x}$ = mean
n = number of observations
x_i = i^{th} observation.

Many of the analytes in the soils were reported as “undetected,” with concentrations below the corresponding detection limit. Undetected data provide some information, but that information is incomplete. When undetected, the concentration of an analyte in a sample is less than a known detection limit, but the exact concentration is unknown. Because the exact value of the concentration cannot be determined, a mathematical technique must be implemented to properly use this information to compute a mean and standard deviation. Kaplan-Meier is the method used in this document to compute the appropriate mean and standard deviation for analytes that contain between approximately 70% or fewer undetected results. Kaplan-Meier is a nonparametric technique that assesses the information from the detected data and takes the information of the undetected data into account to determine an appropriate mean and standard deviation of the data. Further information on the use of Kaplan-Meier on undetected data can be found in *Nondetects and Data Analysis* (Helsel 2004) and in the *ProUCL Version 4.0 Technical Guide* (EPA 2007).

The median is the preferred measure of the center of the data if outliers are present in the data or if the data have a skewed distribution. The median is the observation such that 50% of the data lie below the median and 50% of the data lie above the median. If the data are symmetric, the mean and the median will be equal to each other.

Another quantity of interest is the spread of the data. The standard deviation (s) is the most commonly used measure of spread. One reason for this is that it is fairly easy to interpret and is used in many other statistical methods. Because it is calculated using the average, it also is sensitive to outliers and affected by the data that are not symmetric. Kaplan-Meier was used to compute a more accurate estimate of the population standard deviation for contaminants whose analytical data consist of approximately 70% or fewer nondetects. The standard deviation is calculated using Equation (2) for the field grab samples and subunit 5 fixed laboratory and composited field samples. The standard deviation for fixed- laboratory data and from composited field data from subunit 1-4 was computed using Equation (5) defined in Section 4:

$$s = \sqrt{\frac{\sum_{i=1}^{n} \left(x_i - \bar{x}\right)^2}{n-1}} \tag{2}$$

where

s = standard deviation
n = number of observations
x_i = i^{th} observation
$\bar{x}$ = mean of the observations.

Data were composited; therefore, the computed standard deviation is not representative of the actual variance in the soils. However, the primary purpose of the standard deviation computations is to compute a UCL for the mean to be used in a risk assessment. The UCL uses the standard error, which is not affected by compositing.

The CV also was calculated for each detected analyte. The CV is a relative measure of variation. That is, it is a measure of the standard deviation relative to the mean expressed as a percentage. This measure provides a way to compare more directly the standard deviations of two different data sets that otherwise may not be directly comparable. It is important to note that the mean of the data may be very close or very far away from zero and the spread may be independent from the distance of the mean from zero; therefore, no firm guidelines have been established for interpreting the CV. It does provide useful information about the magnitude of the standard deviation when examined with the other summary statistics. The CV is calculated using Equation (3):

$$CV = \frac{s}{\bar{X}} \times 100\% \tag{3}$$

It often is difficult to read a table of numerical summary statistics and identify the degree of symmetry or normality of the data; therefore, the graphical representations for the subunit 5 fixed laboratory data and for the field data are shown in Appendix C, Attachments C1–C4 of the SER to aid the data user in assessing the symmetry and normality of the data collected. Graphical representations of the data include histograms, box plots, and normal-quantile plots. Plots are not presented for the subunits 1 through 4 data because the cluster analysis design produces patterns in the plots that can make the distribution appear multi-modal when, in fact, it is not.

Histograms show the overall distribution of the data. Histograms are effective for determining if the data have a skewed distribution or if the data are bimodal (clusters into two or more distinct groups). They also can be used to identify outliers or other irregularities in the data.

Box plots are a way of graphically viewing the symmetry of the data. The plot consists of a central box with a line or other mark inside of the box. Two lines come out of the ends of the box in either direction. The line, or mark, inside the box represents the median, the edges of the box represent the two quartiles, and the extreme ends of the lines represent the largest and smallest observations within 1.5 interquartile ranges of the box. This type of plot allows for a quick and comprehensive analysis of the symmetry of the data. It can be easily determined if the data are symmetric, right-skewed, or left-skewed. Right-skewed data have a lengthened tail on the larger values of the distribution. This tail pulls the mean toward it, causing the mean to be large relative to the center of the data. This makes the UCL high-biased if normality is assumed when running calculations. Left-skewed data have a lengthened tail on the lower values of the distribution. This tail pulls the mean toward it causing the mean to be lower than the center of the data. Left-skewed data will cause the UCL to be low-biased when normality is assumed in the calculations. Box plots also can be used to compare different sets of data. They are used in this document to compare the contingency data with the data obtained from the rest of the subunit.

The normal-quantile plot is a plot that is used to assess the normality of the data. If the data follow a normal distribution, then the points on the graph will lie along a straight line. Any deviations from a straight line are indicative of deviations from normality. If the tails bend away from the line at both of the ends of the line, then tails of the distribution are either too heavy or too light to assume a normal distribution. If the data veer away from the line at only one end, then the data are asymmetric. It is important to note that no real world data set is perfectly normal, so a certain amount of deviation from the line is to be expected, even in data that are sufficiently normal to construct a reliable UCL.

Both the field and fixed laboratory data from all five subunits were examined for outliers. It is essential to identify outliers that exist in the data because outliers can indicate several potential issues with the data that must be addressed. An outlier can indicate a value that was reported incorrectly or in the wrong units or was a result of a laboratory error. An outlier also can be indicative of a hotspot or an elevated area. Outliers can have a large or small impact on quantities computed using the data such as UCLs. If a large outlier is present in a data set, an UCL computed with the data containing the outlier can lead the data user to conclude that an entire subunit is contaminated when only a small location is problematic. All analytes are examined for outliers and the effect of the outliers on UCLs is examined. Statistical tests are available that can alert the data user to potential outliers; however, implementation of these tests identified “outliers” that were very close to the rest of the data. Outliers were identified by visual inspection using histograms and normal-quantile plots to ensure that identified outliers were truly different from the rest of the data for that analyte and not just the end values for a skewed distribution. Identified outliers are statistical outliers. That is, identified outliers may affect the statistical quantities that are computed, but they are not necessarily indicative of areas that are problematic from a regulatory perspective.

Sections 6 through 11 provide an overall analysis of the data pertaining to the samples collected from the soils associated with Soil Pile I. Samples collected from soils were analyzed for metals, semivolatile organic compounds (SVOCs), PCBs, and radionuclides. Specific soil samples also were analyzed for volatile organic compounds (VOCs) and wet chemistry or physical parameters.

Statistical analysis was performed using the R statistical package (R Development Core Team 2006) and Statistica (Statsoft 2006). All plots were generated using Statistica with the exception of the bubble plots and scatter plots that were generated using R.

THIS PAGE INTENTIONALLY LEFT BLANK

B.4 STATISTICAL TEST SELECTION

Once the preliminary data review has been completed, an appropriate statistical hypothesis test or method may be selected to answer the question(s) for which the data were collected. The data are analyzed to determine whether the data meet the assumptions of the desired test(s) and method(s).

One of the primary requirements of many statistical tests and methods is that the sample mean follows a normal distribution. Methods that require the assumption of normality are generally more efficient than either nonparametric methods or methods that do not have a distributional assumption. That is, a method that requires the sample mean to be normally distributed can provide more accurate and reliable information with fewer data points than a method that does not require the data to conform to a specific distribution. The most common way to verify if the sample mean follows a normal distribution is to determine if the data follow a normal distribution. If the data follow a normal distribution, then the sample mean follows a normal distribution; however, if the data do not follow a normal distribution, the sample mean may still follow a normal distribution. The Central-Limit Theorem states that the sample mean will have a normal distribution, regardless of the distribution of the data, if the sample size is sufficiently large. The more the distribution of the data deviates from the normal distribution, the larger the sample size must be to ensure that the sample mean has a normal distribution.

Nonparametric methods are appropriate if the sample mean does not follow a normal distribution. Although they do not require the data to exhibit a normal distribution, most nonparametric methods have assumptions that must be met. For example, one of the most common assumptions for a one-sample nonparametric test is that the data are symmetric in distribution. The assumptions of a selected hypothesis method, whether parametric or nonparametric, must be verified before the test is performed on the data.

The four main objectives for the Soil Pile I data investigation include the following:

(1) Determine nature and extent of contamination in the area
(2) Assess the risk to human health
(3) Determine to what extent field data can be used for decision making
(4) Identify indicator chemicals that may be present in the data

Each of the different objectives requires a different statistical analysis technique to assess the data. One of the first objectives that needs to be addressed is nature and extent of contamination. Once nature and extent of contamination is determined, the data can be properly analyzed to address the other objectives. The area of concern has been divided into five subunits. These subunits are examined to determine if it is reasonable to classify each subunit as an EU or if data should be aggregated differently to account for contaminant distribution. This is accomplished by performing multivariable analysis of variance (MANOVA) first on the subunits and then on the segments within each subunit. MANOVA assumes that the data are normal. It is a test of sample means, so if the sample size is sufficiently large, then the sample mean will be normally distributed even if the data are not normally distributed. The sample size is large enough that the normality assumption is sufficiently met. Bubble plots also are examined to determine if divisions exist within the subunits that warrant division into two or more EUs.

Once the EUs have been appropriately determined, EPCs can be computed for each EU for use in a risk assessment. The risk assessment is not part of the DQA, but information included in the DQA is used for the risk assessment. The data are examined to determine the presence of outliers and the distribution of the data. Once this is completed, then the appropriate set of EPCs can be determined for each EU. It is preferred to compute an UCL as an estimate of the EPC when possible. The UCL provides a maximum expected value for the true mean concentration of a particular analyte. For example, a 95% UCL provides a value such that the UCL is greater than the true population mean with 95% confidence. That means that if all possible samples of the specified size could be collected and analyzed and have a sample mean computed for each set of samples, 95% of the UCLs calculated with these sample means would be greater than the true population mean; therefore, the 95% UCL is a conservatively high estimate of the mean. The distribution of the data and the sampling design dictates the appropriate UCL that should be computed for the EPC.

Field data from subunits 1-5 and fixed laboratory data from subunit five were collected using a systematic random sampling design. These data are analyzed for outliers and then the distributional qualities of the data were used to determine the appropriate methods for computing an UCL. ProUCL Version 4.0.0.01 (EPA 2007) was used to analyze the distribution of the data and other data characteristics to determine the appropriate method for computing the UCL. ProUCL also was used to make the UCL calculations.

The fixed laboratory data from subunits 1 through 4 were obtained by a randomized cluster design. In this case, if a simple random sampling design is assumed when the standard deviation is computed for subunits 1-4, the standard deviation will be underestimated. This means that the computed UCL will be less than what the actual UCL should be. A modification must be made to the standard deviation equation for these data to ensure that the UCL computed for the data has 95% confidence and not a lesser degree of confidence. ProUCL assumes that the data are obtained from simple random sampling or a very close method; therefore, ProUCL cannot be used to compute the UCLs for these data. A UCL equation specifically designed for data obtained from a clustered design is used to obtain UCLs from these data. Equations (4) and (5) provide an appropriate UCL for clustered data (Alf and Lohr 2007). These equations are used to compute UCLs for clustered data in this DQA.

$$\bar{x} + t_{1-\alpha,df}\sqrt{\frac{s_c^2}{n}} \qquad (4)$$

where

$$s_c^2 = \frac{1}{n-1}\sum_{i=1}^{k}(\bar{x}_i - \bar{x})^2 \qquad (5)$$

$\bar{x}$ = sample mean computed from all of the samples
$\bar{x}_i$ = sample mean for the i^{th} cluster (or segments)
$t_{1-\alpha,df}$ = t-statistic with $(1 - \alpha)*100\%$ confidence and df (degrees of freedom)
n = total number of samples
k = number of clusters (or segments)
s_c = the standard deviation of the clusters (or segments).

Equation (4) assumes a certain degree of normality in the data; however, unless notable outliers exist, the means of the data should be sufficiently normal to provide adequate UCLs for the data due to the Central-Limit Theorem. Data that are not normally distributed are nearly always right skewed. Data that are right skewed tend to have a mean that is high biased. This means that if the data for an analyte are not normally distributed, the UCL computed using equations (4) and (5) will be conservative (i.e., the UCL has a level of confidence that exceeds 95%). If outliers are observed in the data, they are identified and

UCLs are computed both with and without the outliers. UCLs computed with the outliers or nonnormal data are conservative because the mean and standard deviation are overestimated; therefore, the computed 95% UCL has an actual level of confidence that exceeds 95%.

Fixed-base laboratory and field analytical results from split samples were analyzed to determine the extent that field data can be used for decision making. These data are initially compared using correlations because if the field and fixed laboratory data are highly correlated, then field data may be used extensively in all phases of the decision making process. If the data are not highly correlated, the field data still may be an effective part of decision making. Other statistical quantities such as false negative and false positive detection rates and behavior around the background levels and action limits are examined, UCLs computed from field and fixed laboratory data are compared to determine the accuracy of UCLs computed using field data, and plots are examined to determine the correspondence between the field and fixed laboratory results in the different regions of the Soil Pile I area. All of these statistical analyses can aid in determining the role that field data may play in decision making in surrounding sites.

The fourth objective is to determine if indicator chemicals can be identified in the data. If it can be shown that at least one chemical is present in the area that closely corresponds to another chemical of interest, information obtained from the indicator chemical may be used to obtain more cost-effective information about the chemicals of interest in neighboring sites. An indicator chemical must closely correspond to the chemical(s) of interest to be used effectively; therefore, correlations were computed between the analytes measured in the soils. If a high correlation between two chemicals is determined, it is possible that one chemical may be an indicator of the other. Other methods are used to determine if two chemicals correspond even if the correlation is low.

THIS PAGE INTENTIONALLY LEFT BLANK

B.5 REVIEW OF MEASUREMENT PERFORMANCE CRITERIA

The quality assurance objectives are the quantitative and qualitative measures used to evaluate the quality of fixed laboratory measurements and the usability of parameter-specific data for decision making. The following discussion applies only to validated data.

B.5.1 PRECISION

Precision is the measure of agreement or reproducibility between individual measurements for the same property under the same analytical conditions. Precision is expressed as relative percent difference (RPD) for chemical analyses and absolute difference (AD) for radiochemistry.

Precision for Soil Pile I data was measured based on the performance of field and laboratory duplicate samples and laboratory matrix spike (MS) and matrix spike duplicate (MSD) pairs. The precision criteria used to evaluate the solid matrices for soil pile characterization was ± 35% RPD, AD ± 1.96, and 90% compliance to these criteria. Table B.1 summarizes the results of this analysis.

Note: Precision does not affect the overall quality or usability of organic analyses whose precision is measured by MS/MSD pairs. As the SAP notes, precision results do not impact on PCBs, SVOCs, or VOCs in terms of data quality/data usability. Where performance criteria for precision are exceeded, there is less confidence in the reported result because of error introduced from sampling or analysis caused by unequal representation of target compounds or analtyes between the two sample pairs.

Table B.1. Summary of Precision Performance

Analysis Type:	**Total Number of Analytes**	**Number Duplicate Pairs**	**Average RPD (%)**	**Compliance to Precision Criteria (%)**
Metals	5,040	47	18	99
PCBs	288	4	20	100
Radionuclides	684	24	34	92
SVOCs	2,376	132	NA[a]	100
VOCs	1,426	NA[b]	NA[b]	100

NA = Not Applicable.

[a] The statistic could not be calculated due the high proportion of nondetects.

[b] Duplicates not sampled.

The SAP required that a minimum of 9 of 10 samples (90%) for each analysis type meet method prescribed precision criteria. As Table B.1 illustrates, each analysis type met this goal.

B.5.2 ACCURACY

Accuracy is the comparison of a known quantity of a reference standard to the value measured during analysis. Accuracy for Soil Pile I data was assessed by evaluating the performance of the following quality control standards designed to monitor accuracy during sample preparation and analysis.

- Laboratory control samples
- Radioactive tracers
- MS
- MSDs
- Surrogate compounds

Table B.2 summarizes the accuracy for the Soil Pile I investigation.

Table B.2. Summary of Accuracy Performance

Analysis Type	Total Number of Data Points	Compliance to Accuracy Criteria (%)
Metals	5,040	100
PCBs	288	100
Radionuclides	684	100
SVOCs	2,376	99
VOCs	1,426	99

The SAP required that a minimum of 9 of 10 samples (90%) for each analysis type meet method-/PGDP-prescribed accuracy criteria. As Table B.2 illustrates, each analysis type met this goal.

B.5.3 COMPLETENESS

Completeness is defined as the number of valid data points obtained from a sampling effort, compared with the total number of data points obtained. Valid data are those generated when analytical systems and the resulting analytical data meet all of the quantitative measurement objectives for the project. The completeness for the Soil Pile I investigation is provided in Table B.3.

Table B.3. Summary of Soil Pile I Completeness

Analysis Type	Number of Data Points	Compliance to Precision Criteria (%)	Compliance to Accuracy Criteria (%)	Completeness (%)
Metals	5,040	99	100	99
PCBs	288	100	100	100
Radionuclides	684	92	100	96
SVOCs	2,376	100	99	100
VOCs	1,426	100	99	100

The SAP required that a minimum of 9 of 10 samples (90%) for each analysis type meet completeness criteria. As Table B.3 illustrates, each analysis type met this goal. Sections 3.1.4 and 3.1.5 of the SER describe a comparison of planned activities with those executed during field work.

B.5.4 DETECTION LIMITS

To ensure the fixed laboratory data acquired from Soil Pile I support the DQOs, method detection limits (MDLs) were preestablished for each analysis type and defined in the laboratory statement of work. The MDLs were designed to ensure that sufficiently sensitive data were obtained from the contract laboratories, such that nondetect results did not impact the evaluation of applicable or relevant and appropriate requirements (ARARs) or human health risks.

For field analytical methods, method sensitivity was a variable determined during the project. Field MDLs were determined in accordance with laboratory analytical protocols, by performing seven nonconsecutive runs on a known standard. The results of these determinations were then used to compute a 99% UCL which was applied to each analytical technique as the MDL. The field analytical methods do not achieve the same level of sensitivity as fixed-base laboratory methods; however, sufficient sensitivity was achieved for each method to support/direct field activities relating to clean up should actions be necessary at Soil Pile I.

Reporting limits received from the laboratory were reviewed by project personnel and considered acceptable for meeting the DQOs for this project.

B.5.5 COMPARABILITY

Comparability is the degree to which one data set can be compared to another, when both are obtained from the same sample population. Comparability can be achieved only through the use of consistent sampling procedures, experienced sampling personnel, the same or comparable analytical methods, standard field and laboratory documentation, and traceable laboratory standards. To examine comparability, four sets of fixed laboratory data have been acquired from Soil Pile I:

(1) Judgmental samples collected in 2006 from investigative subunit 3 of Soil Pile I;

(2) Collocated field duplicates collected by Kentucky Department for Environmental Protection from the 2006 judgmental locations in investigative subunit 3;

(3) Contingency samples collected in 2007 from the 2006 judgmental locations in investigative subunit 3; and

(4) Systematic random samples collected in 2007 from investigative subunits 1–5.

As noted, due to the biased nature of the judgmental samples collected from subunit 3, they cannot be directly compared with results acquired using the randomized sample design. Because each of the judgmental sample sets was collected from the same locations, employed similar sampling techniques, and similar analytical methods, their comparison provides a measure of variance for contamination locations at Soil Pile I.

As Table 2 of the SER illustrates, the 2006 sampling effort provided very comparable results with the exception of values acquired for PCBs. The observed variation in the 2006 PCB results led to the collection of contingency samples in 2007 to verify the previous values. A comparison of the three sets of judgmental samples is provided in Table 9 of the SER.

The results show similar variability in PCB results for all three events. Data validation results for PCBs indicate that laboratory accuracy and precision were acceptable; therefore, sampling errors or heterogeneity is believed to contribute to the variation. The observed variability in the results provides data users with important information to be considered in formulating a decision for Soil Pile I, particularly with respect to PCBs. The results indicate that the soil matrix is heterogeneous in areas where localized contamination is found. The spread in the data from the same locations should be used to evaluate the uncertainty and bound concentrations when considering what levels of contaminants are present.

While the judgmental samples denote contamination at Soil Pile I, it is important for data users also to consider the results are based on samples biased toward locations exhibiting the highest concentrations of contaminants. Understanding the maximum concentration at Soil Pile I is important; however, these results do not represent sitewide conditions at Soil Pile I. Instead, they represent locations containing the highest levels of PCBs, radionuclides, and metals (see Section 5 of the SER, Discussion and Results).

While contamination deserves consideration in developing a final strategy for Soil Pile I, judgmental sample results should be used with some caution, given they are biased toward areas containing the highest levels of contaminants. For purposes of evaluating project data in this report, judgmental samples from 2006 and the corresponding contingency samples collected under Addendum 1-A in 2007 have not been included in summary statistics or in the assessment of human health risks.

It should be noted that incremental sampling provides more accurate estimates of the mean concentrations, but may not accurately identify small areas of contamination. The positive feature of this approach is the confidence that is provided for establishing mean concentrations, which supports recommendations made regarding arsenic, manganese, and vanadium because the mean concentrations of these contaminants fall within established levels for background.

B.5.6 REPRESENTATIVENESS

Representativeness is a measure of the degree to which data accurately and precisely represent the characteristics of a population at a sampling point, process condition, or environmental condition. It is a term used to explain if the data appropriately reflect the population parameter of interest as well as the media and phenomenon measured.

The principal backdrop of the Soil Pile I investigation was to determine if conditions in the study area pose an imminent threat to public health or are sufficiently contaminated, necessitating immediate actions to mitigate threats. The overriding objectives were to obtain sufficient data to establish the nature and extent of contamination in Soil Pile I, adjacent soils, and establish the mean concentrations of chemicals of potential concern in each investigative subunit. The sampling effort at Soil Pile I has achieved these objectives. Data of known quality were acquired in sufficient quantities to support the development of mean contaminant concentrations in each investigative subunit. The computed mean concentrations were sufficient to support quantitative assessment of human health risks, to compare project data with chemical-specific ARARs, and allow decision makers to formulate an informed decision as to the need for immediate actions at Soil Pile I.

The investigation supports an examination of contaminant distribution in both surface and subsurface soils, and it has identified those contaminants that must be considered in decision making going forward. The data bound the concentrations of contaminants, identifying the minimum and maximum concentrations found at the site, and the sampling design has successfully identified where contamination is found, where it is not, and, for the majority of Soil Pile I, has delineated the boundaries of that contamination.

The investigation also was successful in identifying existing localized areas of contamination in the study area that must be considered in developing decisions concerning Soil Pile I. Finally, sufficient data have been acquired to inform decision makers concerning the levels and composition of the materials in Soil Pile I, such that, if an interim action is deemed necessary, a determination can be made as to where contaminated media should be dispositioned.

The Soil Pile I data set was representative of the physical sample location, population, and media of interest. The combination of compliance to all precision, accuracy, and completeness criteria as well as the use of a statistically sound random sampling design and thorough analysis of the data confirm that the location, media, and population are well represented by this data set.

B.5.7 DISCUSSION OF DATA QUALITY

Five grab contingency samples collected from the Soil Pile I subunits under investigation were analyzed for metals, PCBs, and SVOCs by Test America Laboratories, Inc., (formerly STL) and for radionuclides by PGDP Analytical Laboratory (AL). Field analyses also were performed using XRF for metals determination, ISOCS for radionuclide measurements, and field immunoassay test kits for Total PCB concentrations. Ten percent (10%) of the fixed laboratory data underwent formal validation in accordance with approved, technical procedures. The data were assigned validation qualifying flags based on the laboratory performance in the associated quality control analyses. The results generated for the contingency samples for all analysis types from the fixed laboratories, the associated qualification flags, and the flag definitions are included in Appendix P of the SER. The field data are shown in Appendices I–M of the SER.

Test America Laboratories, Inc., analyzed the contingency soil samples for metals in accordance with SW-846 methods 7471A, *Mercury in Solid or Semisolid Waste (Manual Cold-Vapor Technique)*, and 6020, *Inductively Coupled Plasma-Mass Spectrometry.* The data underwent a Level C formal data validation in accordance with PA-5107, *Inorganic Data Verification & Validation.* During validation (Shaw 2007a), the positive results reported for sodium in four samples were assigned a "U" flag (undetected) to denote that the values are considered to be false positives based on sodium concentrations in the corresponding method and field blank analyses. The remaining qualifications made during validation are "J" flags to reflect an estimated quantitation. The potential bias in the estimated data does not negatively impact the data usability, and the validated data are used in this DQA.

The contingency samples were analyzed for PCBs by Test America Laboratories, Inc., in accordance with SW-846 8082, *Polychlorinated Biphenyls (PCBs) by Gas Chromatography.* The PCB data underwent Level C data validation in accordance with ES-B-0811. The concentrations reported for Aroclor-1248, Aroclor-1254, and Aroclor-1260 in samples LBCSOSU3C-04 and LBCSOSU3C-05 exceeded the corresponding calibration range and required a dilution analysis. During validation (Shaw 2007a), the concentrations determined from the dilution analysis for these Aroclors were determined to be more accurate than concentrations reported from the original analyses. For purposes of this DQA, the Total PCB concentration was determined as the sum of the positive Aroclor concentrations reported within the calibration range from the original analysis and the dilution analysis concentrations of Aroclor-1248, Aroclor-1254, and Aroclor-1260. When all Aroclors were undetected, the Total PCB concentration in this DQA reflects the maximum quantitation limit of the individual Aroclors.

The contingency samples were analyzed for SVOCs by Test America Laboratories, Inc., in accordance with SW-846 method 8270C, *Semivolatile Organics by GC/MS*. The data underwent a Level C data validation in accordance with PA-5105, *Volatile and Semivolatile Data Verification & Validation*. During validation (Shaw 2007a), all sample results reported for the compound 2,4-dinitrophenol were qualified "R" (rejected) based on low recovery for this compound during analysis of the laboratory control sample.

Although low recovery for 2,4-dinitrophenol was low in the laboratory control sample analysis, the recovery for this compound met the acceptance criteria in the associated MS and MSD analyses, demonstrating acceptable method accuracy; therefore, the data quality is adequate for the intended purpose with minimal impact on data usability, and the validated data are used in this DQA.

The contingency soil samples were analyzed by PGDP AL for radionuclides in accordance with the following procedures: *Gross Alpha/Beta,* RL-7111; *Alpha Spectrometry*, RL-7128; *Gamma Spectrometry*, RL-7124; and *Tc-99,* RL-7100. The data underwent a Level C validation in accordance with PA-5102, *Radiochemical Data Verification and Validation*. Validation efforts noted low tracer recovery yields for five radiochemical analyses in the five contingency samples and negative values associated with undetected sample results for three isotopes in more than one of the contingency samples (Shaw 2007b). Affected data have been qualified as estimated values with either a "J" (estimated positive value) or a "UJ" (undetected, estimated result) validation flag, respectively. The impact on data usability is negligible, and the validated data are used in this DQA.

B.5.8 DATA QUALITY

The primary DQO for the Soil Pile I investigation was to acquire sufficient data of known quality to support decision making. Experienced and properly trained field personnel were utilized to execute the sampling and operating procedures. Project samples were collected, preserved, handled, and shipped in accordance with the SAP and industry and PGDP standard procedures. Reputable analytical laboratories using industry standard analytical procedures were utilized to generate sample data that complies with the requirements of the laboratory statement (s) of work and specified protocols.

All of the data underwent data verification and 10% of the project data underwent a Level C validation of all analysis types. In evaluating project data, precision results do not give an indication of widespread, serious variability or matrix issues that would impact data quality based on the results in the tables herein. The accuracy results provide evidence of data within acceptable levels of control. This combination of acceptable precision and accuracy information results in completeness of performance compliance for the Soil Pile I project.

Precision, accuracy, and completeness compliance of 90%, as specified in the SAP, were met for all analysis types for the Soil Pile I project.

B.6 COMPARISON OF SUBUNITS AND SEGMENTS

The area comprising Soil Pile I was separated into five subunits as outlined in Section 1. The exposure unit is defined based on the receptor, exposure medium, and nature of the receptor's contact with the medium. Sections 2 and 3 of this DQA report address EUs in more detail.

Subunits 3 and 4 each consist of one long, thin soil pile. Subunits 1 and 2 are the long, thin areas between the piles and LBC and Outfall 002 ditch. Subunit 5 consists of the area between the two piles. Although these subunits make sense geographically, it is important to use available data to verify that each subunit comprises a reasonable EU. Data obtained from the area are examined to determine the relationship between the subunits numerically.

Subunits 1 through 4 were divided into segments, four of which were selected randomly for sampling. Data from these four segments were examined to determine if any of the subunits consist of multiple populations and should be divided into two or more EUs.

Surface soil samples were analyzed for metals, PCBs, SVOCs, and radionuclides. Each of the analytes can provide some insight about how the area should be divided for analysis. Statistical methods such as MANOVA can examine the distribution of several analytes among subunits and segments. If too many analytes are examined, statistical tests may show differences by chance even if the subunits and segments come from the same populations; therefore, a small subset of analytes that are of particular interest in Soil Pile I have been selected for this analysis based on of plant operations. The selected analytes are total uranium, Total PCBs, and uranium-238. Although these analytes were measured using both fixed laboratory and field methods, only the fixed laboratory data are used for this analysis.

MANOVA was selected for the analysis performed in the following subsections. MANOVA is a multivariable method that can be used to determine if a difference in concentrations of total uranium, PCBs, and/or uranium-238 between subunits or segments exists. MANOVA produces a table that contains the results of the statistical test. These tables are listed in the following subsections. Although all of the pieces of the table are important, the value that is used to determine a difference between subunits, or segments, is the *p*-value. It was determined that a chance of committing Type I error (determining there is a difference in the means when, in fact, there is no difference) of 0.05, as is common in statistical analysis, is appropriate for the tests performed in this section; therefore, if the *p*-value is greater than or equal to 0.05, then it can be assumed that the subunits come from the same population. If the *p*-value is less than 0.05, then at least one of the subunits is different than the other subunits for at least one analyte. MANOVA results do not indicate which subunits are different or for which analytes they differ. If MANOVA results indicate some type of difference ($p < 0.05$), then analysis of variance (ANOVA) is done for each of the analytes to determine which of the analyte concentrations differs from subunit to subunit. Nondetects were present in the PCB and uranium-238 data. Detection limits were used in place of the nondetected values in order to perform calculations on the data. It is important to note that the fixed laboratory data were obtained from composited samples. Although the population variance cannot be estimated from composited data, the variance of the sample mean, or standard error, can be obtained from these data (Gilbert 1987). Therefore, the fact that the data came from composited samples does not affect the results of the tests presented in this section.

As with MANOVA, ANOVA produces a table with a *p*-value. If the *p*-value is less than 0.05 for an analyte (e.g., PCBs), it indicates that the concentration of PCBs for at least one of the subunits is different than the concentration of PCBs for at least one other subunit. ANOVA will indicate which analytes have differences across subunits; however, ANOVA does not indicate which subunits differ from one other. If the *p*-value for ANOVA is less than 0.05, multiple means comparison testing is done on the data to determine which subunits are different from one other. The means comparison test used in this section is Tukey's honestly significant difference (HSD), or Tukey HSD test. This test performs a means test between each pair of subunits or segments. MANOVA, ANOVA, and Tukey's HSD test were performed using R version 2.1.3 (R Development Core Team 2006).

This multitiered approach is necessary to preserve the reliability of the statistical method. Because the data are multivariable in nature, use of ANOVA, a univariate method, without first performing MANOVA can produce "false positives." That is, ANOVA can indicate differences between subunits by chance where no differences exist because so many tests must be performed to make the comparisons. The same is true for multiple means comparison testing.

It is important to note that the area where subunits 3 and 4 meet does seem to have notably higher concentrations of total uranium, uranium isotopes, and PCBs; however, the area is too small to warrant being classified as its own EU. The area is referred to as an area of interest and is discussed further in Section B.7. MANOVA, ANOVA, and Tukey's HSD results all were computed using the R statistical software (R Development Core Team 2006).

B.6.1 COMPARISON OF SUBUNITS

Tables B.4–B.8 list the results of the subunit comparison. The *p*-value for MANOVA is considerably less than 0.05, indicating some difference between subunits. The ANOVA results show differences between subunits in concentrations of total uranium and uranium-238 and a small difference for PCBs. Tukey's HSD test shows that none of the subunits are different from one other with respect to PCBs, so PCBs are not included in Table B.8. Tukey's HSD test indicates that subunit 3 is different from all of the other subunits for both uranium and uranium-238, but none of the other subunits differ significantly from one another. Tukey's HSD test shows that none of the subunits are different for PCBs. This is possible because the p-value is so close to the 0.05 cut-off. Subunit 3 is statistically different from the other subunits for total uranium and uranium-238. Subunits 1 and 5 are separated by subunit 3, and subunits 2 and 4 have similar geography so each subunit is addressed as a separate EU in this document.

Table B.4. Results of MANOVA Test for Subunit Comparison

	Degrees of Freedom	**Approximate *f***	***p*-value**
Factor (Subunit)	4	6.7748	1.045E-10
Residuals	93		

Table B.5. Results of ANOVA Test for Total Uranium

	Degrees of Freedom	**Sum of Squares**	**Mean Squared**	***f*-value**	***p*-value**
Factor (Subunit)	4	60,966	15,242	10.828	2.995E–07
Residuals	93	130,905	1,408		

Table B.6. Results of ANOVA Test for PCBs

	Degrees of Freedom	Sum of Squares	Mean Squared	*f*-value	*p*-value
Factor (Subunit)	4	57,122	14,280	2.5282	0.0458
Residuals	93	525,303	5,648		

Table B.7. Results of ANOVA Test for Uranium-238

	Degrees of Freedom	Sum of Squares	Mean Squared	*f*-value	*p*-value
Factor (Subunit)	4	3,844.3	961.1	31.01	1.045E–10
Residuals	93	2,882.3	31.0		

Table B.8. Results of Tukey's HSD Test for Total Uranium and Uranium-238

Analyte	Subunit	Subunits that are Different
Total Uranium	1	3
	2	3
	3	1, 2, 4, and 5
	4	3
	5	3
Uranium-238	1	3
	2	3
	3	1, 2, 4, and 5
	4	3
	5	3

B.6.2 COMPARISON OF SEGMENTS FOR SUBUNIT 1

Tables B.9–B.13 list the results of the segment comparison of subunit 1. The *p*-value for MANOVA is less than 0.05, indicating some difference between segments. The ANOVA results show differences between segments in concentrations of total uranium and uranium-238, but no differences for PCBs. Tukey's HSD test indicates that segment 4 is different from all of the other segments with respect to total uranium and segments 1 and 2 differ with respect to uranium-238. Close investigation of the data shows an extreme outlier in the total uranium data in segment 4; however, because the total uranium difference is due to one outlier, it can be concluded that segment 4 does not come from a separate population than the other segments with respect to total uranium in subunit 1. The other total uranium results in segment 4 are similar to those seen in the other segments. Uranium-238 has one value in segment 1 that is notably larger than the other data values in the segment or in the rest of the subunit. Segment 2 has two values that are lower than many of the other data points in the subunit. These extremes would cause these two segments to be statistically different from each other. The fact that segments 1 and 2 are different from each other but not from the other segments indicates that the segments are not from a separate population than the other segments; therefore, it is reasonable to consider subunit 1 as a single population and as a single EU.

Table B.9. Results of MANOVA Test for Segment Comparison for Subunit 1

	Degrees of Freedom	Approximate *f*	*p*-value
Factor (Segment)	3	3.4333	0.002473
Residuals	16		

Table B.10. Results of ANOVA Test for Total Uranium in Subunit 1

	Degrees of Freedom	Sum of Squares	Mean Squared	*f*-value	*p*-value
Factor (Segment)	3	6,836.5	2,278.8	14.798	0.00007083
Residuals	16	2,464	154		

Table B.11. Results of ANOVA Test for PCBs in Subunit 1

	Degrees of Freedom	Sum of Squares	Mean Squared	*f*-value	*p*-value
Factor (Segment)	3	22,913	7,638	0.5694	0.6431
Residuals	16	214,608	13,413		

Table B.12. Results of ANOVA Test for Uranium-238 in Subunit 1

	Degrees of Freedom	Sum of Squares	Mean Squared	*f*-value	*p*-value
Factor (Segment)	3	92.275	30.758	4.058	0.02538
Residuals	16	121.274	7.58		

Table B.13. Results of Tukey's HSD Test for Total Uranium and Uranium-238 in Subunit 1

Analyte	Segment	Segments that are Different
Total Uranium	1	4
	2	4
	3	4
	4	1, 2, and 3
Uranium-238	1	2
	2	1
	3	None
	4	None

B.6.3 COMPARISON OF SEGMENTS FOR SUBUNIT 2

Tables B.14–B.16 list the results of the segment comparison for subunit 2. PCBs were not detected in subunit 2 and are not discussed further in this subsection; therefore, ANOVAs were computed only on the total uranium and uranium-238 data. ANOVA results show a difference between segments in concentrations of total uranium and uranium-238. Tukey's HSD test indicates that segment 1 is different from segments 2 and 4 for total uranium, but not from segment 3. Examination of the total uranium results shows that the values across the subunit are very similar to one another regardless of which segment they are in; however, four of the values in segment 4 are identical. Segment 1 has more variability and two values that are slightly higher than those seen in other segments.

Segment 1 is different from all of the other segments for uranium-238, but the other segments are not different from one other. All four uranium-238 observations from segment 1 are notably larger than the concentrations observed in the other segments.

Concentrations of total uranium and uranium-238 are small (close to or less than background) for all samples in the subunit and relative to subunit 4; therefore, it is recommended that subunit 2 should comprise its own EU rather than be divided into two EUs.

Table B.14. Results of ANOVA Test for Total Uranium in Subunit 2

	Degrees of Freedom	Sum of Squares	Mean Squared	*f*-value	*p*-value
Factor (Segment)	3	1.24138	0.41379	3.9692	0.002725
Residuals	16	1.66800	0.10425		

Table B.15. Results of ANOVA Test for Uranium-238 in Subunit 2

	Degrees of Freedom	Sum of Squares	Mean Squared	*f*-value	*p*-value
Factor (Segment)	3	3.4731	1.1577	23.581	4.09E-06
Residuals	16	0.7855	0.0491		

Table B.16. Results of Tukey's HSD Test for Total Uranium and Uranium-238 in Subunit 2

Analyte	Subunit	Segments that are Different
Total Uranium	1	2, 4
	2	1
	3	None
	4	1
Uranium-238	1	2, 3, and 4
	2	1
	3	1
	4	1

B.6.4 COMPARISON OF SEGMENTS FOR SUBUNIT 3

Table B.17 lists the results of the segment comparison. The *p*-value for MANOVA is greater than 0.05 so the segments appear to come from the same populations. ANOVA and Tukey's HSD test are not necessary or appropriate to verify this result.

Table B.17. Results of MANOVA Test for Segment Comparison for Subunit 3

	Degrees of Freedom	**Approximate *f***	***p*-value**
Factor (Segment)	3	1.53939	0.1615
Residuals	16		

B.6.5 COMPARISON OF SEGMENTS FOR SUBUNIT 4

Table B.18 lists the results of the segment comparison. The *p*-value for MANOVA is greater than 0.05 so the segments appear to come from the same populations. ANOVA and Tukey's HSD test are not necessary or appropriate to verify this result.

Table B.18. Results of MANOVA Test for Segment Comparison for Subunit 1

	Degrees of Freedom	**Approximate *f***	***p*-value**
Factor (Segment)	3	1.86281	0.08094
Residuals	16		

B.6.6 DISCUSSION OF SUBUNIT 5

Figures B.3–B.5 (in Section 10.4) show the concentrations of uranium, uranium-238, and PCBs. These plots show that concentrations are fairly evenly distributed in such a way that there are no regions of subunit 5 that should be separated into separate EUs.

B.7 ANALYSIS OF CONTINGENCY SAMPLES

Results from the five contingency samples collected from localized sections of subunits 3 and 4 are of particular interest because data from samples collected from this location November 9, 2006, indicate elevated levels of total uranium and PCBs. Sampled areas were flagged for the benefit of future sampling efforts; therefore, five contingency samples were collected from the flagged locations during the current sampling event to determine the current level of contamination.

Data obtained from contingency samples could not be compared to data obtained from subunits 3 and 4 using a statistical hypothesis test because samples from the subunit 3 and 4 data were composite samples and the contingency samples were grab samples. Side-by-side box plots comparing the fixed laboratory data for subunits 3 and 4 with the contingency data were generated and are located in Appendix C, Attachment C.4 of the SER. These box plots allow for direct comparison of the contingency data with the data obtained from subunits 3 and 4. The box plots indicate that the concentrations of total uranium, uranium isotopes, and PCBs are notably larger in the contingency samples than in either subunit 3 or 4; however, this does not necessarily indicate that the area is a hazard to human health. The contingency area is small enough that it should not be considered a separate EU, but rather should be considered an elevated area within subunits 3 and 4.

Tables B.19–B.21 list the summary statistics for the fixed laboratory data results for metals, PCBs, and radionuclides. Similarly, Tables B.22–B.24 list the summary for the field results for these analyses. The results for the metals include only barium, lead, and uranium because the other metals either were not detected in the soils or the results were not sufficiently reliable for analysis. SVOCs are not listed in the following tables because they were detected in no more than two samples for any one analyte and are not present in concentrations that indicate they need to be further investigated.

Tables B.25–B.27 compare the most recent samples collected from the contingency area with the historical sample from the contingency area. The mean and maximum values are compared in that table.

Table B.19. Summary Statistics for Metals Analytes from Fixed Laboratory Analysis of Contingency Soils Associated with Soil Pile I

Analyte	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Aluminum	5	5	6,090	6,500	7,500	6,724	579	8.6
Antimony	5	5	0.094	0.15	0.33	0.17	0.10	57
Arsenic	5	5	3.8	5.5	39.6	13	15	121
Barium	5	5	70.6	105	137	106	25	24
Beryllium	5	5	0.33	0.40	0.78	0.46	0.19	41
Cadmium	5	5	0.1	0.21	0.57	0.27	0.19	72
Calcium	5	5	1,120	1,420	1,470	1,344	144	11
Chromium	5	5	74.7	145	1,140	385	444	116
Cobalt	5	5	4.4	5.2	11.5	6.9	2.9	43
Copper	5	5	10.2	19.1	62.3	26.6	21.7	82
Iron	5	5	7,300	10,300	19,400	11,854	4,606	39
Lead	5	5	10.4	16.9	53.5	22.9	17.7	78

Table B.19. Summary Statistics for Metals Analytes from Fixed Laboratory Analysis of Contingency Soils Associated with Soil Pile I (Continued)

Analyte	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Magnesium	5	5	620	841	1,040	858	161	19
Manganese	5	5	170	452	666	392	216	55
Mercury	5	5	18.4	34.2	90.6	43.3	28.7	66
Molybdenum	5	5	0.31	0.67	1.3	0.70	0.38	54
Nickel	5	5	7.5	11	12.7	10	2.4	24
Selenium	2	5	<0.25	NA[b]	0.78	NA[b]	NA[b]	NA[b]
Silver	5	5	0.046	0.072	0.14	0.085	0.043	50
Sodium	5	5	<20.3[a]	21.5	103	39.5	35.8	91
Thallium	5	5	0.1	0.12	0.15	0.12	0.023	19
Uranium	5	5	322	1,030	6,410	1,912	2,551	133
Vanadium	5	5	13.1	16.8	41.9	22.5	11.8	52
Zinc	5	5	69.3	178	591	265	210	79

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the MDL.

[b] An insufficient number of positively detected results (<30%) were reported for this analyte in order to calculate this statistic.

Table B.20. Summary Statistics for PCB Analytes from Fixed Laboratory Analysis of Contingency Soils Associated With Soil Pile I

Analyte	# Positive Detections	# Data Points	Minimum (µg/kg)	Median (µg/kg)	Maximum (µg/kg)	Mean (µg/kg)	Standard Deviation (µg/kg)	Coefficient of Variation (%)
PCB, Total	4	5	<39[a]	3,700	79,000	19,908	33,455	168
PCB-1248	3	5	<39[a]	NA[b]	57,000	NA[b]	NA[b]	NA[b]
PCB-1254	4	5	<39[a]	1,500	16,000	4,562	6,615	145
PCB-1260	4	5	<39[a]	2,200	6,400	2,412	2,476	103

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the MDL.

[b] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

Table B.21. Summary Statistics for Radionuclides from Fixed Laboratory Analysis of Contingency Soils Associated with Soil Pile I

Analyte	# Positive Detections	# Data Points	Minimum (pCi/g)	Median (pCi/g)	Maximum (pCi/g)	Mean (pCi/g)	Standard Deviation (pCi/g)	Coefficient of Variation (%)
Uranium-235	5	5	3.17	4.33	5.81	4.44	0.959	22
Alpha Activity	5	5	92.3	168	356	198	101	51
Americium-241	1	5	<0.014[a]	NA[b]	0.0162	NA[b]	NA[b]	NA[b]
Beta Activity	5	5	266	411	773	487	197	41
Cesium-137	5	5	0.151	0.357	1.01	0.440	0.333	76
Neptunium-237	4	5	0.0232	0.0478[a]	0.0678	0.0425	0.0190	45
Plutonium-239/240	4	5	<0.0104[a]	0.014	0.046	0.0223	0.0154	69
Radium-226	5	5	0.547	0.865	0.976	0.833	0.166	20

Table B.21. Summary Statistics for Radionuclides from Fixed Laboratory Analysis of Contingency Soils Associated with Soil Pile I (Continued)

Analyte	# Positive Detections	# Data Points	Minimum (pCi/g)	Median (pCi/g)	Maximum (pCi/g)	Mean (pCi/g)	Standard Deviation (pCi/g)	Coefficient of Variation (%)
Technetium-99	5	5	0.984	1.88	2.42	1.79	0.554	31
Thorium-228	5	5	0.37	0.41	0.486	0.43	0.047	11
Thorium-230	5	5	0.282	0.300	0.532	0.368	0.111	30
Thorium-232	5	5	0.348	0.375	0.477	0.399	0.0580	15
Uranium-234	5	5	20.2	28.7	34.4	28.5	5.88	21
Uranium-235	5	5	0.234	0.269	0.297	0.269	0.0231	8.9
Uranium-238	5	5	176	253	315	257	55.6	22

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the MDL.

[b] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

Table B.22. Summary Statistics for the Contingency Field Data Results for Metals

Analyte	Minimum (mg/kg)	Maximum (mg/kg)	Median (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)
Uranium	325	3,799	658	1,228	1,446
Chromium[a]	<218	440	NA	NA	NA
Barium	294	500	401	403	74.6

[a] Chromium was detected in only one of the five samples.

Table B.23. Summary Statistics for the Contingency Field Data Results for PCBs

Analyte	Minimum (mg/kg)	Maximum (mg/kg)	Median (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)
PCBs	2.59	24.1	4.34	9.35	9.07

Table B.24. Summary Statistics for the Contingency Field Data Results for Radionuclides

Analyte	Minimum (pCi/g)	Maximum (pCi/g)	Median (pCi/g)	Mean (pCi/g)	Standard Deviation (pCi/g)
Cesium-137[a]	<0.0557	0.761	NA	NA	NA
Uranium-238	8.30	87.5	50.8	41.6	33.7

NA = Not Applicable.

[a] Cesium-137 was detected in only one of the five samples.

Table B.25. Comparison of Current and Historical Data for the Contingency Data Results for Metals

Analyte	Historical Contingency Mean (mg/kg)	Current Contingency Mean (mg/kg)	Historical Contingency Maximum (mg/kg)	Current Contingency Maximum (mg/kg)
Aluminum	6,736	6,724	8,930	7,500
Antimony	ND	0.1688	ND	0.33
Arsenic[a]	NA	12.56	26	39.6
Barium	68.46	105.56	88.4	137
Beryllium	ND	0.456	ND	0.78
Cadmium	ND	0.27	ND	0.57
Calcium	1,464	1,344	1,680	1,470
Chromium	319.8	384.74	932	1,140
Cobalt	5.568	6.88	11	11.5
Copper	22.22	26.56	45.3	62.5
Iron	10,138	11,854	15,900	19,400
Lead	NA	22.88	38.4	53.5
Magnesium	874.4	858.2	1,020	1,040
Manganese	293.06	392	515	666
Mercury	ND	43.28	ND	90.6
Molybdenum	ND	0.7	ND	1.3
Nickel	9.572	10.1	12.1	12.7
Potassium	452.4	ND	523	ND
Selenium[b]	ND	0.566	ND	0.78
Silver	2.54	0.0852	2.54	0.14
Sodium[c]	ND	NA	ND	103
Thallium	ND	0.122	ND	0.15
Uranium	ND	1,912	ND	6,410
Vanadium	56.26	22.46	71.6	41.9
Zinc	338.6	265.26	843	591

ND = Not detected.

NA = Not applicable.

[a] Only one of the five samples was detected in the field data.

[b] Selenium detected in only two of the five current samples.

[c] Sodium was detected in only one of the five current samples.

Table B.26. Comparison of Current and Historical Data for the Contingency Data Results for PCBs

Analyte	Historical Contingency Mean (mg/kg)	Historical Contingency Maximum (mg/kg)	Current Contingency Mean (pCi/g)	Current Contingency Maximum (pCi/g)
PCB, Total	15,880	46,900	NA	79,000
PCB-1248[a]	21,700	NA	NA	57,000
PCB-1254	5,602.5	11,500	NA	16,000
PCB-1260	2,712	6,000	NA	6,400

NA = Not applicable.

Note: None of the PCBs were detected in all five current contingency samples.

[a] Analyte was detected in only one of the five historical contingency samples.

Table B.27. Comparison of Current and Historical Data for the Contingency Data Results for Radionuclides

Analyte	Historical Contingency Mean (pCi/g)	Current Contingency Mean (pCi/g)	Historical Contingency Maximum (pCi/g)	Current Contingency Maximum (pCi/g)
Potassium-40[a]	NA	ND	9.25	ND
Thorium-230[b]	2.23	0.3676	2.23	0.532
Uranium	596.2	290.4	1,490	353
Uranium-234	56.46	28.5	136	34.4
Uranium-235	8.67	ND	19.6	ND
Uranium-238	532	257.4	1340	315

ND = Not detected.

[a] Potassium was detected in two of the historical samples.

[b] Thorium was detected in one of the historical samples.

THIS PAGE INTENTIONALLY LEFT BLANK

B.8 STATISTICAL ANALYSIS OF FIXED LABORATORY DATA COLLECTED FROM SOIL PILE I SAMPLES

This section contains the statistical analysis of fixed laboratory data collected from subunits 1 through 5. Detected analytes for each subunit are identified and summary statistics are computed for these detected analytes. Outliers are identified and UCLs are computed for the data.

Fixed laboratory data were generated from soil samples collected from subunits 1 through 5. Composite samples collected from subunits 1 through 4 were obtained using a randomized cluster design, and discrete samples from subunit 5 were collected via a systematic random sampling design. Because of the different sampling approaches explained in Section 4, different statistical methods are required to analyze the data from subunits 1 through 4 than for subunit 5. Equations (4) and (5) listed in Section 4 show how the standard deviation and UCLs were calculated for subunits 1 through 4. ProUCL (EPA 2007) was used to generate the mean, standard deviation, and UCL for subunit 5 data. Traditional mean and standard deviation equations were used to calculate the mean and standard deviation defined in Section B.3 for subunit 5 data that contained 100% detects. Kaplan-Meier was used to compute means and standard deviations for data that contained less than approximately 70% undetected results. Minimums and maximums are listed for data that contain less than 70% undetected results.

The contingency data are not included in UCL calculations because they are grab samples and subunit data are composited samples; therefore, the data cannot be combined. Even if the contingency data and the subunit data came from the same sampling design, they still should not be combined because the contingency data are conclusively different from the subunit data and combining the two sets of the data for analysis would produce UCLs that are not representative of the subunit as a whole. Data from the contingency area should be kept separate from the subunit data and are not included in any of the calculations in this section.

B.8.1 LABORATORY RESULTS REPORTED FOR SUBSURFACE SAMPLES IN SOIL PILES LBC SUBUNITS 3 AND 4

Fixed laboratory samples were collected from the subsurface of subunits 3 and 4. These data are not used in a risk assessment because it is beyond the scope of this project; therefore, this DQA report contains a discussion of data quality, but does not contain analysis of these data; however, the main body of the SER contains a complete analysis of the subsurface data. Reported results for the subsurface soil samples from subunits 3 and 4 can be found in Appendices N and O, respectively (found on CD) of the SER.

Ten percent of fixed laboratory data generated for 23 soil samples, two field blanks, four trip blanks, and two rinseate samples associated with the subsurface sampling activities in subunit 3 underwent a Level C validation in accordance with approved, technical procedures. The data were assigned validation qualifying flags based on the laboratory performance in the associated quality control analyses. The laboratory data reported for subsurface samples from subunit 3, associated qualifying flags, and corresponding flag definitions are included in Appendix N of the SER. Although 10% of the data were validated, all analyzed data were used for analysis.

B.8.1.1 Metals

The samples were analyzed by Test America Laboratories, Inc., for mercury in accordance with SW-846 methods 7470A, *Mercury in Liquid Waste (Manual Cold-Vapor Technique)*, and 7471A, *Mercury in Solid or Semisolid Waste (Manual Cold-Vapor Technique)*. Data for the remaining metals were generated in accordance with SW-846 Method 6020, *Inductively Coupled Plasma-Mass Spectrometry*. The metals data underwent a Level C validation in accordance with PA-5107, *Inorganic Data Verification & Validation*. During validation of the metals data (Shaw 2007b), six positive sample results reported for sodium were assigned the validation flag "U" (undetected) based on the corresponding concentration reported in the associated method and field blanks. The validated, undetected results for sodium are used in this DQA report. The remaining qualifications made during validation do not negatively impact the data usability.

B.8.1.2 PCBs

The samples were analyzed for PCBs by Test America Laboratories, Inc., in accordance with SW-846 Method 8082, *Polychlorinated Biphenyls (PCBs) by Gas Chromatography.* The PCB data underwent Level C data validation in accordance with ES-B-0811. The concentration reported for Aroclor-1248 in sample LBCSOSU3S1B1-01 exceeded the calibration range and required a dilution analysis. During validation of the PCB data (Shaw 2007b), the positive result reported for Aroclor-1248 from the dilution analysis of sample LBCSOSU3S1B1-01 was determined to be more accurate than the original analysis. For purposes of this DQA, the Total PCB concentration was determined as the sum of the positive Aroclor concentrations within the calibration range from the original analysis and the dilution analysis concentration of Aroclor-1248. When all Aroclors were undetected, the Total PCB concentration in this DQA report reflects the maximum quantitation limit of the individual Aroclors. The remaining qualifications made during validation are deemed to have minimal impact on data usability.

B.8.1.3 SVOCs

The samples were analyzed by Test America Laboratories, Inc., for SVOCs in accordance with SW-846 Method 8270C, *Semivolatile Organics by GC/MS*. The data underwent a Level C data validation in accordance with PA-5105, *Volatile and Semivolatile Data Verification &Validation*. During validation (Shaw 2007b), low recovery of the compound 2,4-dinitrophenol was noted in the laboratory control sample analysis. Consequently, undetected 2,4-dinitrophenol results reported in five samples were qualified with an "R" flag (rejected). Although low in the laboratory control sample analysis, the percent recovery for 2,4-dinitrophenol in the MS and MSD analyses is within the acceptance criteria demonstrating method accuracy; therefore, the impact on data usability is deemed minimal and the qualified undetected data are used in this DQA report. Also during validation, the positive results reported in two samples for the compound bis(2-ethyhexyl)phthalate were qualified with a "U" flag (undetected) based on laboratory contamination. The data as qualified for bis(2-ethyhexyl)phthalate are used in this DQA report. The remaining qualifications made during validation have minimal impact on the data usability.

B.8.1.4 VOCs

The samples were analyzed by Test America Laboratories, Inc., (formerly STL) for VOCs in accordance with SW-846 Method 8260B, *Volatile Organics by GC/MS*. The data underwent a Level C validation in accordance with PA-5105, *Volatile and Semivolatile Data Verification & Validation*. During validation of the VOC data (Shaw 2007b), the undetected results reported for the compound 2-chloroethyl vinyl ether in four subsurface soil samples were assigned an "R" flag (rejected), based on potential low bias noted in low relative response factors in the initial and/or continuing calibrations. In spite of the discrepancies noted during validation, the presence of 2-chloroethyl vinyl ether was detected by the instrumentation in the associated laboratory standards. Had this compound been present in the subunit 3 samples at similar concentrations, a detection would have been made. Therefore, the impact of the analytical discrepancies associated with the quantitation of 2-chloroethyl vinyl ether do not significantly impact the data usability, and the undetected results reported are deemed adequate for the intended use in the DQA report. Also, contamination in the method and field blanks was noted during validation of the VOC data. When positive results for the compounds methylene chloride, 2-butanone, toluene, and acetone were reported in samples associated with these blanks at levels that could not be distinguished from the corresponding blank contamination, the validation flag “U” (undetected) was assigned.

B.8.1.5 Radionuclides

The samples were analyzed by PGDP AL for radionuclides in accordance with the following procedures: *Gross Alpha/Beta,* RL-7111; *Alpha Spectrometry*, RL-7128; *Gamma Spectrometry*, RL-7124; and *Tc-99,* RL-7100. The data underwent a Level C validation in accordance with PA-5102, *Radiochemical Data Verification and Validation*. Validation efforts noted low tracer recovery yields in 14 samples and negative values associated with undetected sample results for six isotopes in multiple samples (Shaw 2007b). Affected data have been qualified as estimated values with either a “J” (estimated positive value) or a “UJ” (undetected estimated value) validation flag. The impact is on data usability is negligible.

B.8.1.6 Wet Chemistry and Physical Parameters

Wet chemistry data were generated in accordance with SW-846 Methods 1010A, *Pensky-Martens Closed-Cup Method for Determining Ignitability;* 9095B, *Paint Filter Liquids Test;* 7.3.3; *Reactive Cyanide*; 7.3.4, *Reactive Sulfide;* and MCAWW 160.3, *Percent Moisture*. The data underwent formal validation following the guidelines for a Level C validation in PRS-ENM-0026, *Wet Chemistry and Miscellaneous Analyses Data Verification and Validation*. No discrepancies were noted that would significantly impact the data usability (Shaw 2007b).

B.8.2 ANALYSIS OF SUBUNIT 1 SURFACE DATA

B.8.2.1 Metals Data Summary for Subunit 1

Table B.28 lists the metals that were detected in the laboratory data for subunit 1. Twenty-four metals were detected. Metals were detected in all 20 samples. Statistical outliers were identified for each of the metals except for aluminum, magnesium, mercury, selenium, silver, and thallium. Two outliers were identified for cobalt, lead, manganese, and molybdenum. Sixteen of the metals had outliers in the first composited sample of segment 4. This is consistent with what was seen in the results presented in Section B.5.2. All but one of the other six outliers were in segment 2. Summary statistics and UCLs were computed with and without these outliers and are listed in Tables B.29 and B.36, respectively. Laboratory results, associated validation flags, and flag definitions for fixed laboratory data for subunit 1 are listed in Appendix D of the SER.

Table B.28. Metals Detected in the Fixed Laboratory Composite Samples Associated with Subunit 1

Detected Metals

Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Calcium
Chromium
Cobalt
Copper
Iron
Lead
Magnesium
Manganese
Mercury
Molybdenum
Nickel
Selenium
Silver
Sodium
Thallium
Uranium
Vanadium
Zinc

Table B.29. Summary Statistics for Metals from Fixed Laboratory Analysis of Composite Soils Associated with Subunit 1

Analyte	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Aluminum	20	20	6,540	7,895	8,940	7,294	8,336	2.5
Antimony	20	20	0.12	0.17	0.45	0.13	0.22	9.1
Antimony (Outlier Removed)	19	19	0.12	0.16	0.36	0.13	0.16	9.1
Arsenic	20	20	3.9	6.0	22.2	4.6	8.3	12
Arsenic (Outlier Removed)	19	19	3.9	6.0	15	4.6	4.8	15
Barium	20	20	42.8	75.0	117	54.3	85.0	7.6
Barium (Outlier Removed)	19	19	42.8	75.0	103	54.3	77.1	7.3
Beryllium	20	20	0.31	0.47	0.87	0.36	0.48	8.0
Beryllium (Outlier Removed)	19	19	0.31	0.46	0.79	0.36	0.38	9.6
Cadmium	20	20	0.034	0.058	0.23	0.049	0.091	13
Cadmium (Outlier Removed)	19	19	0.034	0.055	0.091	0.049	0.056	9.4
Calcium	20	20	350	519	1,390	430	727	10
Calcium (Outlier Removed)	19	19	350	513	773	430	561	7.9
Chromium	20	20	10	17	180	17	64	33
Chromium (Outlier Removed)	19	19	10	17	40.8	17	35	20
Cobalt	20	20	4.5	6.3	31	5.0	6.1	17
Cobalt (Outlier Removed)	19	19	4.5	6.2	11.7	5.0	6.1	6.7
Cobalt (2 Outliers Removed)	18	18	4.5	5.9	8.2	5.0	4.8	9.3

Table B.29. Summary Statistics for Metals from Fixed Laboratory Analysis of Composite Soils Associated with Subunit 1 (Continued)

Analyte	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Copper	20	20	6	7.6	12.3	7.0	8.8	3.8
Copper (Outlier Removed)	19	19	6	7.6	8.7	7.0	7.9	2.1
Iron	20	20	8,890	10,850	26,000	9,528	13,286	7.1
Iron (Outlier Removed)	19	19	8,890	10,800	22,000	9,528	10,108	7.9
Lead	20	20	9.8	14	36.4	11	18	12
Lead (Outlier Removed)	19	19	9.8	14	32.2	11	14	12
Lead (2 Outliers Removed)	18	18	10	14	22.5	11	14	8.9
Magnesium	20	20	655	906	1,060	749	958	4.4
Manganese	20	20	495	849	2,230	705	679	12
Manganese (2 Outliers Removed)	18	18	495	822	1,170	705	679	8.4
Mercury	20	20	0.0133	0.028	0.06	0.023	0.043	10
Molybdenum	20	20	0.37	0.53	1.2	0.45	0.65	7.7
Molybdenum (Outlier Removed)	19	19	0.37	0.51	1.1	0.45	0.52	8.2
Molybdenum (2 Outliers Removed)	18	18	0.37	0.51	0.73	0.45	0.52	5.6
Nickel	20	20	5.7	7.7	11.5	6.7	8.1	3.5
Nickel (Outlier Removed)	19	19	5.7	7.6	8.4	6.7	7.3	3.0
Selenium	20	20	0.24	0.34	0.57	0.282	0.35	8.3
Silver	20	20	0.032	0.042	0.12	0.036	0.078	16
Sodium	20	20	14.5	17.6	59.3	15.1	19.2	8.6
Sodium (Outlier Removed)	19	19	14.5	17.5	22.8	15.1	19.8	5.7
Thallium	20	20	0.17	0.21	0.26	0.19	0.23	3.8
Uranium	20	20	3.5	18	82	19	56	32
Uranium (Outlier Removed)	19	19	3.5	18	65.7	19	50	31
Vanadium	20	20	15	18	40.5	15	21	6.9
Vanadium (Outlier Removed)	19	19	15	18	31	15	16	8.0
Zinc	20	20	22.8	27.7	140	24.8	60.6	19
Zinc (Outlier Removed)	19	19	22.8	27.4	44	24.8	40.7	10

B.8.2.2 PCB Data Summary for Subunit 1

Table B.30 lists the PCBs that were detected in the laboratory data for subunit 1. Total PCBs was measured and Aroclor-1260 was detected in the soils. For purposes of this DQA, the Total PCB concentration reflects the sum of positively detected Aroclors. Two outliers were identified for each of the PCBs. These outliers were observed in segments 1 and 4. Summary statistics and UCLs were computed with and without these outliers and are listed in Tables B.31 and B.36, respectively. Laboratory results associated validation flags, and flag definitions for fixed laboratory data for subunit 1 are listed in Appendix D of the SER.

Table B.30. PCBs Detected in the Fixed Laboratory Composite Samples Associated with Subunit 1

Detected PCBs	
PCB, Total	PCB-1260

Table B.31. Summary Statistics for PCBs from Fixed Laboratory Analysis of Composite Soils Associated with Subunit 1

Analyte	# Positive Detections	# Data Points	Minimum (µg/kg)	Median (µg/kg)	Maximum (µg/kg)	Mean (µg/kg)	Standard Deviation (µg/kg)	Coefficient of Variation (%)
PCB, Total	8	20	<33.1[a]	<40[a]	360	75	18	23
PCB, Total (Outlier Removed)	7	19	<33.1[a]	<40[a]	290	60	10	16
PCB, Total (2 Outliers Removed)	6	18	<33.1[a]	<40[a]	140	47	8	16
PCB-1260	8	20	<33.1[a]	<40[a]	360	75	18	23
PCB-1260 (Outlier Removed)	7	19	<33.1[a]	<40[a]	290	60	10	16
PCB-1260 (2 Outliers Removed)	6	18	<33.1[a]	<40[a]	140	47	8	16

[a] The reported result was a nondetect. The value shown represents the MDL.

B.8.2.3 Radionuclide Data Summary for Subunit 1

Table B.32 lists the radionuclides that were detected in the laboratory data for subunit 1. Thirteen radionuclides were detected in the subunit 1 soils. One outlier was detected in the cesium-137 and uranium data. Two outliers were detected in both the uranium-234 and uranium-238 data. The outliers were observed in segments 1, 3, and 4. Summary statistics and UCLs were computed with and without these outliers and are listed in Tables B.33 and B.36, respectively. Laboratory results, associated validation flags, and flag definitions for fixed laboratory data for subunit 1 are listed in Appendix D of the SER.

Table B.32. Radionuclides Detected in the Fixed Laboratory Composite Samples Associated with Subunit 1

Detected Radionuclides		
Alpha Activity	Technetium-99	Uranium
Beta Activity	Thorium-228	Uranium-234
Cesium-137	Thorium-230	Uranium-235
Plutonium-239/240	Thorium-232	Uranium-238
Radium-226		

Table B.33. Summary Statistics for Radionuclides Analytes from Fixed Laboratory Analysis of Composite Soils Associated with Subunit 1

Analyte	# Positive Detections	# Data Points	Minimum (pCi/g)	Median (pCi/g)	Maximum (pCi/g)	Mean (pCi/g)	Standard Deviation (pCi/g)	Coefficient of Variation (%)
Uranium-235	20	20	0.0268	0.0870	0.257	0.0918	0.0175	19
Alpha Activity	20	20	4.72	10.7	25.7	13.4	1.66	12
Beta Activity	20	20	4.81	15.0	46.5	17.4	3.75	21
Cesium-137	15	20	0.0638[a]	0.093	0.56	0.14	0.039	28
Cesium-137 (Outlier Removed)	14	19	<0.0638[a]	0.0917	0.313	0.120	0.0268	22
Plutonium-239/240	1	20	<0.0103[a]	<0.012[a]	0.018	NA[b]	NA[b]	NA[b]
Radium-226	20	20	0.688	0.808	0.956	0.825	0.0172	2.1
Technetium-99	3	20	<0.868[a]	<0.92[a]	1.4	NA[b]	NA[b]	NA[b]
Thorium-228	20	20	0.19	0.32	0.396	0.32	0.017	5.3
Thorium-230	20	20	0.16	0.28	0.335	0.27	0.012	4.3
Thorium-232	20	20	0.229	0.358	0.405	0.341	0.0155	4.6
Uranium (mg/kg)	20	20	2.00	12	41.0	12.8	2.94	23
Uranium (mg/kg) (Outlier Removed)	19	19	2.00	11.5	30.8	11.3	2.44	22
Uranium-234	20	20	0.126	0.443	1.45	0.549	0.104	19
Uranium-234 (2 Outliers Removed)	18	18	0.126	0.44	0.92	0.45	0.086	19
Uranium-238	20	20	0.666	3.89	13.7	4.29	0.986	23
Uranium-238 (2 Outliers Removed)	18	18	0.666	3.84	7.22	3.43	0.796	23

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the MDL.

[b] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

B.8.2.4 Semivolatile Organic Data Summary for Subunit 1

Table B.34 lists the organics that were detected in the laboratory data for subunit 1. Eleven organic compounds were detected in the subunit 1 soils. Each of the detected organics was detected in only one of the 20 samples. Each of the detected values was less than the detection limits so it was not possible to determine if there were outliers in the data or to compute UCLs. The detected values for all of the organics came from the fourth composite of segment 4. The detected values are reported in Table B.35. Laboratory results, associated validation flags, and flag definitions for fixed laboratory data for subunit 1 are listed in Appendix D of the SER.

Table B.34. SVOCs Detected in the Fixed Laboratory Composite Samples Associated with Subunit 1

Detected SVOCs		
Benzo(a)anthracene	Benzo(ghi)perylene	Fluoranthene
Benzo(a)pyrene	Benzo(k)fluoranthene	Phenanthrene
Benzo(b)fluoranthene	Chrysene	Pyrene

Table B.35. Summary Statistics for SVOCs from Fixed Laboratory Analysis of Composite Soils Associated with Subunit 1

Analyte	# Positive Detections	# Data Points	Minimum (µg/kg)	Median (µg/kg)	Maximum (µg/kg)	Mean (µg/kg)	Standard Deviation (µg/kg)	Coefficient of Variation (%)
Benzo(a)anthracene	1	20	NA[a]	NA[a]	66	NA[a]	NA[a]	NA[a]
Benzo(a)pyrene	1	20	NA[a]	NA[a]	82	NA[a]	NA[a]	NA[a]
Benzo(b)fluoranthene	1	20	NA[a]	NA[a]	95	NA[a]	NA[a]	NA[a]
Benzo(ghi)perylene	1	20	NA[a]	NA[a]	66	NA[a]	NA[a]	NA[a]
Benzo(k)fluoranthene	1	20	NA[a]	NA[a]	68	NA[a]	NA[a]	NA[a]
Chrysene	1	20	NA[a]	NA[a]	110	NA[a]	NA[a]	NA[a]
Fluoranthene	1	20	NA[a]	NA[a]	280	NA[a]	NA[a]	NA[a]
Phenanthrene	1	20	NA[a]	NA[a]	270	NA[a]	NA[a]	NA[a]
Pyrene	1	20	NA[a]	NA[a]	220	NA[a]	NA[a]	NA[a]

NA = Not Applicable.

[a] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

B.8.2.5 Upper Confidence Limits for Fixed Laboratory Analyses for Subunit 1

Table B.36 lists the UCLs for the metals, PCBs, radionuclides, and organics detected by the fixed laboratories in subunit 1. UCLs were calculated for data that had 70% or fewer nondetects. If more than 70% of the data were nondetects, the maximum detected value was reported in place of the UCL. Where one or more outliers were observed in the data, UCLs were computed with and without the outlier(s). If more than one outlier was present in the data, they were removed simultaneously if they were close in value; if the outliers were notably different from one another, they were removed separately. Removal of the outlier often did not cause significant changes in the UCL. Removal of the outliers for cadmium, calcium, chromium, cobalt, manganese, zinc, Total PCBs, Aroclor-1260, uranium-234, and uranium-238 made a large enough change in the UCL that the assessment of nature and extent or decision making may be notably impacted.

Table B.36. Upper Confidence Limits from Fixed Laboratory Analyses Associated with the Composite Soils from Subunit 1

Analyte	Mean Seg 1	Mean Seg 2	Mean Seg 3	Mean Seg 4	Mean	SD	UCL
Metals	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Aluminum	7,706	8,280	7,294	8,336	7,904	197	7,980
Antimony	0.17	0.22	0.13	0.22	0.19	0.017	0.19
Antimony (Outlier Removed)	0.17	0.22	0.13	0.16	0.17	0.016	0.18
Arsenic	6.5	9.9	4.6	8.3	7.3	0.91	7.7
Arsenic (Outlier Removed)	6.5	9.9	4.6	4.8	6.5	1.0	6.9
Barium	76.5	84.1	54.3	85.0	75.0	5.68	77.2
Barium (Outlier Removed)	76.5	84.1	54.3	77.1	72.8	5.28	74.9
Beryllium	0.50	0.59	0.36	0.48	0.48	0.038	0.50

Table B.36. Upper Confidence Limits from Fixed Laboratory Analyses Associated with the Composite Soils from Subunit 1 (Continued)

Analyte	Mean Seg 1	Mean Seg 2	Mean Seg 3	Mean Seg 4	Mean	SD	UCL
Metals	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Beryllium (Outlier Removed)	0.50	0.59	0.36	0.38	0.46	0.045	0.50
Cadmium	0.077	0.049	0.049	0.091	0.066	0.0083	0.069
Cadmium (Outlier Removed)	0.077	0.049	0.049	0.056	0.058	0.0054	0.060
Calcium	654	463	430	727	569	57.3	590
Calcium (Outlier Removed)	654	463	430	561	525	41.3	542
Chromium	20	13	17	64	29	9.5	32
Chromium (Outlier Removed)	20	13	17	35	21	4.0	22
Cobalt	6.8	12	5.0	6.1	7.5	1.3	8.0
Cobalt (Outlier Removed)	6.8	7.5	5.0	6.1	6.3	0.42	6.5
Cobalt (2 Outliers Removed)	6.8	7.5	5.0	4.8	6.0	0.56	6.2
Copper	7.6	7.7	7.0	8.8	7.8	0.30	7.9
Copper (Outlier Removed)	7.6	7.7	7.0	7.9	7.5	0.16	7.6
Iron	11,420	14,520	9,528	13,286	12,188	868	12,524
Iron (Outlier Removed)	11,420	14,520	9,528	10,107	11,461	911	11,824
Lead	14	22	11	18	16	1.9	17
Lead (Outlier Removed)	14	22	11	14	15	1.9	16
Lead (2 Outliers Removed)	14	18	11	14	14	1.3	15
Magnesium	875	955	749	958	884	39.0	899
Manganese	1,081	1,213	705	679	920	107	961
Manganese (2 Outliers Removed)	986	959	705	679	817	68.7	844
Mercury	0.033	0.030	0.023	0.043	0.032	0.0033	0.034
Molybdenum	0.56	0.71	0.45	0.65	0.59	0.046	0.61
Molybdenum (Outlier Removed)	0.56	0.71	0.45	0.52	0.56	0.046	0.58
Molybdenum (2 Outliers Removed)	0.56	0.61	0.45	0.52	0.53	0.030	0.54
Nickel	7.5	8.0	6.7	8.1	7.6	0.26	7.7
Nickel (Outlier Removed)	7.5	8.0	6.7	7.3	7.4	0.22	7.5
Selenium	0.34	0.46	0.28	0.35	0.36	0.030	0.37
Silver	0.040	0.040	0.036	0.078	0.049	0.0079	0.052
Sodium	21.1	25.7	15.1	19.2	20.3	1.74	20.9
Sodium	21.1	17.3	15.1	19.2	18.2	1.05	18.6

Table B.36. Upper Confidence Limits from Fixed Laboratory Analyses Associated with the Composite Soils from Subunit 1 (Continued)

Analyte	Mean Seg 1	Mean Seg 2	Mean Seg 3	Mean Seg 4	Mean	SD	UCL
Metals	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
(Outlier Removed)							
Thallium	0.20	0.21	0.19	0.23	0.21	0.0079	0.21
Uranium	25	5.9	19	56	26	8.5	30
Uranium (Outlier Removed)	25	5.9	19	50	24	7.5	27
Vanadium	19	23	15	21	20	1.4	20
Vanadium (Outlier Removed)	19	23	15	16	19	1.5	19
Zinc	31.9	25.5	24.8	60.6	35.7	6.71	38.3
Zinc (Outlier Removed)	31.9	25.5	24.8	40.7	30.2	3.02	31.4
Organics	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)
PCB, Total	87	40	40	132	75	18	82
PCB, Total (Outlier Removed)	87	40	40	75	60	9.9	64
PCB, Total (2 Outliers Removed)	37	40	40	75	47	7.6	50
PCB-1260	87	40	40	132	75	18	82
PCB-1260 (Outlier Removed)	87	40	40	75	60	9.9	64
PCB-1260 (2 Outliers Removed)	37	40	40	75	47	7.6	50
Benzo(a)anthracene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	66[b]
Benzo(a)pyrene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	82[b]
Benzo(b)fluoranthene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	95[b]
Benzo(ghi)perylene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	66[b]
Benzo(k)fluoranthene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	68[b]
Chrysene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	110[b]
Fluoranthene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	280[b]
Phenanthrene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	270[b]
Pyrene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	220[b]
Radionuclides	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)
Uranium-235	0.14	0.033	0.096	0.097	0.092	0.018	0.099
Alpha Activity	15	8.4	12	18	13	1.7	14
Beta Activity	20	6.1	15	29	17	3.8	19
Cesium-137	0.097	0.087	0.094	0.29	0.14	0.039	0.16
Cesium-137 (Outlier Removed)	0.097	0.087	0.094	0.22	0.12	0.027	0.13
Plutonium-239/240	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	0.018[b]
Radium-226	0.81	0.89	0.80	0.80	0.83	0.017	0.83
Technetium-99	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	1.4[b]
Thorium-228	0.33	0.35	0.25	0.33	0.32	0.017	0.32

Table B.36. Upper Confidence Limits from Fixed Laboratory Analyses Associated with the Composite Soils from Subunit 1 (Continued)

Analyte	Mean Seg 1	Mean Seg 2	Mean Seg 3	Mean Seg 4	Mean	SD	UCL
Metals	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Thorium-230	0.26	0.31	0.24	0.29	0.27	0.012	0.28
Thorium-232	0.36	0.38	0.29	0.35	0.34	0.016	0.35
Uranium (mg/kg)	20	2.6	14	14	13	2.9	14
Uranium (mg/kg) (Outlier Removed)	15	2.6	14	14	11	2.4	12
Uranium-234	0.80	0.18	0.62	0.59	0.55	0.10	0.59
Uranium-234 (Outlier Removed)	0.64	0.18	0.44	0.59	0.45	0.086	0.49
Uranium-238	6.8	0.87	4.8	4.7	4.3	0.99	4.7
Uranium-238 (Outlier Removed)	5.1	0.87	3.5	4.7	3.4	0.80	3.8

NA = Not Applicable.

[a] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

[b] An insufficient number of detections were recorded for this analyte in order to calculate the UCL. The value shown is the maximum reported value.

B.8.3 ANALYSIS OF SUBUNIT 2 SURFACE DATA

B.8.3.1 Metals Data Summary for Subunit 2

Table B.37 lists the metals that were detected in the fixed laboratory data for subunit 2. Twenty-four metals were detected in the composite soil samples. All metals were detected in all 20 results. Statistical outliers were identified for antimony, cobalt, manganese, molybdenum, nickel, and vanadium in composite 3 of segment 1. Another outlier was identified for cobalt in segment 4. No other outliers were observed. This is consistent with what was seen in the results presented in Section 5.3. All summary statistics and UCLs were computed with and without identified outliers and are listed in Tables B.38 and B.41, respectively. Laboratory results, associated validation flags, and flag definitions for fixed laboratory data for subunit 2 are listed in Appendix E of the SER.

Table B.37. Metals Detected in the Fixed Laboratory Composite Samples Associated with Subunit 2

Detected Metals		
Aluminum	Cobalt	Nickel
Antimony	Copper	Selenium
Arsenic	Iron	Silver
Barium	Lead	Sodium
Beryllium	Magnesium	Thallium
Cadmium	Manganese	Uranium
Calcium	Mercury	Vanadium
Chromium	Molybdenum	Zinc

Table B.38. Summary Statistics for Metals from Fixed Laboratory Analysis of Composite Soils Associated with Subunit 2

Analyte	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Aluminum	20	20	9,130	10,150	12,600	10,511	203	1.9
Antimony	20	20	0.16	0.24	0.59	0.27	0.017	6.4
Antimony (Outlier Removed)	19	19	0.16	0.24	0.37	0.25	0.018	7.1
Arsenic	20	20	6.8	17	33.1	17	2.3	13
Barium	20	20	76.2	97	438	117	18.4	16
Beryllium	20	20	0.42	0.54	0.83	0.55	0.014	2.5
Cadmium	20	20	0.03	0.047	0.12	0.051	0.0056	11
Calcium	20	20	381	642	791	625	12.1	1.9
Chromium	20	20	11.6	14	22	15	0.50	3.4
Cobalt	20	20	4.3	6.7	30.9	8.0	1.0	13
Cobalt (Outlier Removed)	19	19	4.3	6.6	16.4	6.8	0.39	5.7
Cobalt (2 Outliers Removed)	18	18	4.3	6.6	7.9	6.2	0.28	4.5
Copper	20	20	8.4	10	12.8	11	0.42	4.0
Iron	20	20	12,600	16,800	26,500	17,350	574	3.3
Lead	20	20	11.7	32	71.1	33.0	4.90	15
Magnesium	20	20	1,110	1,380	1,880	1,430	39	2.8
Manganese	20	20	279	520	5,230	871	197	23
Manganese (Outlier Removed)	19	19	279	517	2,230	642	56.5	8.8
Mercury	19	20	0.013	0.038	0.066	0.036	0.0027	7.6
Molybdenum	20	20	0.62	0.82	2	0.85	0.065	7.6
Molybdenum (Outlier Removed)	19	19	0.62	0.81	1	0.79	0.026	3.3
Nickel	20	20	8.2	10	14.2	10	0.22	2.2
Nickel (Outlier Removed)	19	19	8.2	10	11.6	10	0.27	2.8
Selenium	20	20	0.29	0.46	0.7	0.46	0.034	7.4
Silver	20	20	0.05	0.051	0.07	0.052	0.00069	1.3
Sodium	20	20	17	24	31	23	1.4	6.0
Thallium	20	20	0.17	0.43	0.52	0.38	0.042	11
Uranium	20	20	0.95	1.2	2.6	1.4	0.11	8.1
Vanadium	20	20	20.1	29	50	29	1.2	4.0
Vanadium (Outlier Removed)	19	19	20.1	29	35.9	28.1	1.46	5.2
Zinc	20	20	25	30	36	30	0.83	2.8

B.8.3.2 PCB Data Summary for Subunit 2

No PCBs were detected in the subunit 2 soils; therefore, no summary statistics or UCLs were calculated for PCBs in subunit 2. Laboratory results, associated validation flags, and flag definitions for fixed laboratory data for subunit 2 are listed in Appendix E of the SER.

B.8.3.3 Radionuclide Data Summary for Subunit 2

Table B.39 lists the radionuclides that were detected in the laboratory data for subunit 2. Fifteen radionuclides were detected in the subunit 2 soils. Statistical outliers were identified in the beta activity, cesium-137, thorium-228, thorium-230, thorium-232, uranium-234, and uranium-238 data. All of the outliers were observed in composite 1 of segment 2 with the exception of the cesium-137 outlier, which was observed in composite 4 of segment 1. Summary statistics and UCLs were computed with and without these outliers and are listed in Tables B.40 and B.41, respectively. Laboratory results, associated validation flags, and flag definitions for fixed laboratory data for subunit 2 are listed in Appendix E of the SER.

Table B.39. Radionuclides Detected in the Fixed Laboratory Composite Samples Associated with Subunit 2

Detected Radionuclides		
Uranium-235	Plutonium-238	Thorium-232
Alpha Activity	Radium-226	Uranium
Americium-241	Technetium-99	Uranium-234
Beta Activity	Thorium-228	Uranium-238
Cesium-137	Thorium-230	

Table B.40. Summary Statistics for Radionuclides Analytes from Fixed Laboratory Analysis of Composite Soils Associated with Subunit 2

Analyte	# Positive Detections	# Data Points	Minimum (pCi/g)	Median (pCi/g)	Maximum (pCi/g)	Mean (pCi/g)	Standard Deviation (pCi/g)	Coefficient of Variation (%)
Uranium-235	6	20	<0.0241[a]	<0.0246[a]	0.069	0.035	0.0074	21
Alpha Activity	20	20	5.02	8.9	30	13	3.2	24
Americium-241	1	20	<0.0098[a]	<0.014[a]	0.019[a]	NA[b]	NA[b]	NA[b]
Beta Activity	20	20	3.45	5.39	29.2	11.7	4.20	36
Beta Activity (Outlier Removed)	19	19	3.45	5.2	29	11	4.7	43
Cesium-137	10	19	<0.0636[a]	<0.091[a]	0.38	0.12	0.027	22
Cesium-137 (Outlier Removed)	9	18	<0.0636[a]	0.087	0.243	0.11	0.019	18
Plutonium-238	1	20	<0.00991[a]	<0.011[a]	0.031[a]	NA[b]	NA[b]	NA[b]
Radium-226	20	19	0.8	0.91	1.4	0.97	0.045	4.7
Technetium-99	10	20	<0.49[a]	0.77	1.31	0.79	0.065	8.2
Thorium-228	20	20	0.407	0.513	1.12	0.652	0.103	16
Thorium-228 (Outlier Removed)	19	19	0.407	0.513	1.12	0.634	0.11	18

Table B.40. Summary Statistics for Radionuclides Analytes from Fixed Laboratory Analysis of Composite Soils Associated with Subunit 2 (Continued)

Analyte	# Positive Detections	# Data Points	Minimum (pCi/g)	Median (pCi/g)	Maximum (pCi/g)	Mean (pCi/g)	Standard Deviation (pCi/g)	Coefficient of Variation (%)
Thorium-230	20	20	0.355	0.456	1.14	0.619	0.128	21
Thorium-230 (Outlier Removed)	19	19	0.355	0.453	1.14	0.601	0.137	23
Thorium-232	20	20	0.405	0.508	1.09	0.648	0.00998	15
Thorium-232 (Outlier Removed)	19	19	0.405	0.506	1.05	0.625	0.108	17
Uranium (mg/kg)	13	20	<0.194[a]	0.361	2.73	0.915	0.423	46
Uranium-234	20	20	0.109	0.16	1.1	0.41	0.17	41
Uranium-234 (Outlier Removed)	19	19	0.109	0.16	1.1	0.38	0.18	48
Uranium-238	17	17	0.122	0.184	1.25	0.355	0.230	65
Uranium-238 (Outlier Removed)	16	16	0.122	0.177	1.25	0.307	0.250	81

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the MDL.

[b] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

B.8.3.4 Organics Data Summary for Subunit 2

No organics were detected in subunit 2; therefore, no summary statistics or UCLs were calculated to report for organics in subunit 2. Laboratory results, associated validation flags, and flag definitions for fixed laboratory data for subunit 2 are listed in Appendix E of the SER.

B.8.3.5 Upper Confidence Limits for Fixed Laboratory Analyses for Subunit 2

Table B.41 lists the UCLs for the metals and radionuclides detected in subunit 2. UCLs were calculated for data that had 70% or fewer nondetects. If more than 70% of the data were nondetects, the maximum detected value was reported in place of the UCL. Where one or more outliers were observed in the data, UCLs were computed with and without the outlier(s). If more than one outlier was present in the data, they were removed simultaneously if close in value; if the outliers were notably different from one another, they were removed separately. Removal of the outlier typically did not cause significant changes in the UCL; however, removal of the outliers for cobalt and manganese made a large enough change in the UCL that assessment of nature and extent and decision making may be notably affected.

Table B.41. Upper Confidence Limits from Fixed Laboratory Analyses Associated with the Composite Soils from Subunit 2

Analyte	Mean Seg 1	Mean Seg 2	Mean Seg 3	Mean Seg 4	Mean	SD	UCL
Metals	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Aluminum	10,728	9,870	10,380	11,066	10,511	203	10,590
Antimony	0.30	0.21	0.30	0.27	0.27	0.017	0.28
Antimony (Outlier Removed)	0.22	0.21	0.30	0.27	0.25	0.018	0.26
Arsenic	11	16	25	18	17	2.3	18
Barium	186.7	96.1	92.6	94.1	117	18.4	124
Beryllium	0.56	0.50	0.54	0.58	0.55	0.014	0.55
Cadmium	0.072	0.043	0.044	0.044	0.051	0.0056	0.053
Calcium	660	597	642	603	625	12.1	630
Chromium	16	13	16	15	15	0.50	15
Cobalt	7.9	5.6	6.9	12	8.0	1.0	8.4
Cobalt (Outlier Removed)	7.9	5.6	6.9	6.7	6.8	0.39	6.9
Cobalt (2 Outliers Removed)	5.8	5.6	6.9	6.7	6.2	0.28	6.4
Copper	10	9.3	12	11	11	0.42	11
Iron	17,460	15,360	17,780	18,800	17,350	574	17,572
Lead	20.5	27.3	49.2	34.8	33.0	4.90	34.9
Magnesium	1,390	1,310	1,488	1,530	1,430	39	1,445
Manganese	1,587	508	568	823	871	197	947
Manganese (Outlier Removed)	676	508	568	823	642	56.5	664
Mercury	0.032	0.039	0.044	0.028	0.036	0.0027	0.037
Molybdenum	1.1	0.80	0.82	0.71	0.85	0.065	0.88
Molybdenum (Outlier Removed)	0.86	0.80	0.82	0.71	0.79	0.026	0.80
Nickel	10	9.2	9.9	11	10	0.22	10
Nickel (Outlier Removed)	9.1	9.2	9.9	11	10	0.27	9.8
Selenium	0.37	0.55	0.51	0.41	0.46	0.034	0.47
Silver	0.054	0.051	0.052	0.051	0.052	0.00069	0.052
Sodium	25	27	22	19	23	1.4	24
Thallium	0.23	0.43	0.46	0.42	0.38	0.042	0.40
Uranium	1.8	1.2	1.4	1.2	1.4	0.11	1.5
Vanadium	30	25	32	30	29	1.2	30
Vanadium (Outlier Removed)	24.9	24.9	31.6	30.4	28.1	1.46	28.7
Zinc	33	27	30	31	30	0.83	30

Table B.41. Upper Confidence Limits from Fixed Laboratory Analyses Associated with the Composite Soils from Subunit 2 (Continued)

Analyte	Mean Seg 1	Mean Seg 2	Mean Seg 3	Mean Seg 4	Mean	SD	UCL
Radionuclides	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)
Uranium-235	0.063	0.026	0.025	0.025	0.035	0.0074	0.038
Alpha Activity	25	11	8.1	8.2	13	3.2	14
Americium-241	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	0.019[b]
Beta activity	273	9.09	5.24	5.11	11.7	4.20	13.3
Beta Activity (Outlier Removed)	28	5.9	5.0	3.9	11	4.7	13
Cesium-137	0.22	0.076	0.10	0.082	0.12	0.027	0.13
Cesium-137 (Outlier Removed)	0.18	0.076	0.10	0.082	0.11	0.019	0.11
Plutonium-238	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	0.031[b]
Radium-226	1.1	0.99	0.87	0.92	0.97	0.045	0.99
Technetium-99	0.56	0.81	0.93	0.87	0.79	0.065	0.82
Thorium-228	1.04	0.555	0.474	0.542	0.652	0.103	0.691
Thorium-228 (Outlier Removed)	1.0	0.45	0.47	0.54	0.634	0.11	0.68
Thorium-230	1.10	0.535	0.408	0.439	0.619	0.128	0.669
Thorium-230 (Outlier Removed)	1.10	0.426	0.408	0.439	0.601	0.137	0.656
Thorium-232	1.01	0.609	0.469	0.501	0.648	0.00998	0.687
Thorium-232 (Outlier Removed)	1.01	0.489	0.469	0.501	0.625	0.108	0.668
Uranium (mg/kg)	2.50	0.541	0.311	0.302	0.915	0.423	1.08
Uranium-234	1.0	0.31	0.16	0.14	0.41	0.17	0.48
Uranium-234 (Outlier Removed)	1.0	0.14	0.16	0.14	0.38	0.18	0.46
Uranium-238	1.25	0.337	0.198	0.174	0.355	0.230	1.00
Uranium-238 (Outlier Removed)	1.25	0.143	0.198	0.174	0.307	0.250	0.453

NA = Not Applicable.

[a] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

[b] An insufficient number of detections were recorded for this analyte in order to calculate the UCL. The value shown is the maximum reported value.

B.8.4 ANALYSIS OF SUBUNIT 3 SURFACE DATA

B.8.4.1 Metals Data Summary for Subunit 3

Table B.42 lists the metals that were detected in the laboratory data for subunit 3. Twenty-four metals were detected. All detected metals were detected in all twenty results. Cadmium, lead, uranium, and vanadium data each had one outlier. Statistical outliers were identified in segments 1, 2, and 3; therefore, no pattern was apparent to the outliers. This is consistent with what was seen in the results presented in Section 5.3. Summary statistics and UCLs were computed with and without outliers and are listed in Tables B.43 and B.50, respectively. Laboratory results, associated validation flags, and flag definitions for fixed laboratory data for subunit 3 are listed in Appendix F of the SER.

Table B.42. Metals Detected in the Fixed Laboratory Composite Samples Associated with Subunit 3

Detected Metals		
Aluminum	Cobalt	Nickel
Antimony	Copper	Selenium
Arsenic	Iron	Silver
Barium	Lead	Sodium
Beryllium	Magnesium	Thallium
Cadmium	Manganese	Uranium
Calcium	Mercury	Vanadium
Chromium	Molybdenum	Zinc

Table B.43. Summary Statistics for Metals from Fixed Laboratory Analysis of Composite Soils Associated with Subunit 3

Analyte	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Aluminum	20	20	5,210	6,600	7,480	6,441	96	1.5
Antimony	20	20	0.084	0.15	0.21	0.14	0.0083	5.8
Arsenic	20	20	3.3	6.3	15.4	7.3	0.89	12
Barium	20	20	45.9	75.4	89.4	71.6	1.30	1.8
Beryllium	20	20	0.35	0.50	0.78	0.52	0.041	7.9
Cadmium	20	20	0.031	0.085	1.2	0.15	0.047	31
Cadmium (Outlier Removed)	19	19	0.031	0.079	0.32	0.10	0.010	10
Calcium	20	20	580	990	1,550	943	58	6.1
Chromium	20	20	11.9	43.7	189	56.4	10.8	19
Cobalt	20	20	3.8	6.4	12	6.5	0.38	5.9
Copper	20	20	5.2	8.8	17	9.2	0.19	2.1
Iron	20	20	9,200	11,800	20,000	13,028	707	5.4
Lead	20	20	8.5	14	36.1	16	2.0	12
Lead (Outlier Removed)	19	19	8.5	14	21.2	15	1.4	9.3
Magnesium	20	20	492	774	1,030	768	30	3.9
Manganese	20	20	193	475	1,070	528	86	16
Mercury	20	20	0.0195	0.0424	0.0679	0.0449	0.00426	9.5
Molybdenum	20	20	0.22	0.47	0.90	0.50	0.048	9.7
Nickel	20	20	5.9	7.7	12.2	7.8	0.14	1.9
Selenium	20	20	0.19	0.35	0.62	0.38	0.023	6.3
Silver	20	20	0.04	0.046	0.065	0.047	0.00080	1.7
Sodium	20	20	14.7	18.7	39.5	21.2	2.18	10
Thallium	20	20	0.11	0.14	0.19	0.15	0.0060	4.1

Table B.43. Summary Statistics for Metals from Fixed Laboratory Analysis of Composite Soils Associated with Subunit 3 (Continued)

Analyte	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Uranium	20	20	11.6	64.2	266	69.2	11.8	17
Uranium (Outlier Removed)	19	19	11.6	63.6	112	58.8	4.99	8.5
Vanadium	20	20	15	19	49.1	22	1.2	5.3
Vanadium (Outlier Removed)	19	19	15	19	30.2	20	0.72	3.5
Zinc	20	20	29.4	47.4	179	61.4	7.47	12

B.8.4.2 PCB Data Summary for Subunit 3

Table B.44 lists the PCBs that were detected in the laboratory data for subunit 3. Total PCBs were determined as the sum of the positively detected results reported for Aroclor-1248, Aroclor-1254, and Aroclor-1260. Aroclor-1248 and Aroclor-1260 each had one statistical outlier. These outliers were in segments 3 and 2, respectively. Summary statistics and UCLs were computed with and without outliers and are listed in Tables B.45 and B.50, respectively. Laboratory results, associated validation flags, and flag definitions for fixed laboratory data for subunit 3 are listed in Appendix F of the SER.

Table B.44. PCBs Detected in the Fixed Laboratory Composite Samples Associated with Subunit 3

Detected PCBs	
PCB, Total	PCB-1254
PCB-1248	PCB-1260

Table B.45. Summary Statistics for PCBs from Fixed Laboratory Analysis of Composite Soils Associated with Subunit 3

Analyte	# Positive Detections	# Data Points	Minimum (μg/kg)	Median (μg/kg)	Maximum (μg/kg)	Mean (μg/kg)	Standard Deviation (μg/kg)	Coefficient of Variation (%)
PCB, Total	9	20	<40[a]	<44[a]	180	86	17	20
PCB-1248	6	20	<40[a]	<42[a]	110	50	2.5	5.0
PCB-1248 (Outlier Removed)	5	19	<40[a]	<42[a]	89	47	1.9	4.0
PCB-1254	8	20	<40[a]	<42[a]	90	50	3.4	6.8
PCB-1260	6	20	<40[a]	<42[a]	110	47	2.9	6.2
PCB-1260 (Outlier Removed)	5	19	<40[a]	<42[a]	62	44	2.1	4.8

[a] The reported result was a nondetect. The value shown represents the MDL.

B.8.4.3 Radionuclide Data Summary for Subunit 3

Table B.46 lists the radionuclides that were detected in the laboratory data for subunit 3. Fourteen radionuclides were detected in the subunit 3 soils. The uranium-235 activity, alpha activity, beta activity, technetium-99, uranium-234, and uranium-238 data each had one outlier. Statistical outliers were identified in all four segments. Summary statistics and UCLs were computed with and without these outliers and are listed in Tables B.47 and B.50, respectively. Laboratory results, associated validation flags, and flag definitions for fixed laboratory data for subunit 3 are listed in Appendix F of the SER.

Table B.46. Radionuclides Detected in the Fixed Laboratory Composite Samples Associated with Subunit 3

Detected Radionuclides

- Uranium-235
- Alpha Activity
- Beta Activity
- Cesium-137
- Plutonium-239/240
- Radium-226
- Technetium-99
- Thorium-228
- Thorium-230
- Thorium-232
- Uranium
- Uranium-234
- Uranium-238

Table B.47. Summary Statistics for Radionuclides Analytes from Fixed Laboratory Analysis of Composite Soils Associated with Subunit 3

Analyte	# Positive Detections	# Data Points	Minimum (pCi/g)	Median (pCi/g)	Maximum (pCi/g)	Mean (pCi/g)	Standard Deviation (pCi/g)	Coefficient of Variation (%)
Uranium-235	20	20	0.0212	0.265	0.701	0.270	0.0267	9.9
Uranium-235 (Outlier Removed)	19	19	0.0212	0.256	0.551	0.247	0.0133	5.4
Alpha Activity	20	20	5.77	16.1	43.8	18.4	1.07	5.8
Alpha Activity (Outlier Removed)	19	19	5.77	16.1	32.3	17.1	1.88	11
Beta Activity	20	20	3.79	24	96	31	2.6	8.5
Beta Activity (Outlier Removed)	19	19	3.79	22	68	27	3.7	14
Cesium-137	11	20	<0.0683[a]	<0.105[a]	0.323	0.132	0.0217	16
Plutonium-239/240	3	20	<0.00954[a]	<0.0100[a]	0.0135	NA[b]	NA[b]	NA[b]
Radium-226	20	20	0.72	0.79	0.943	0.81	0.016	2.0
Technetium-99	15	20	<0.863[a]	1.11	8.38	1.52	0.278	18
Technetium-99 (Outlier Removed)	14	19	<0.863[a]	1.11	1.57	1.18	0.0346	3.0
Thorium-228	20	20	0.226	0.271	0.357	0.276	0.00566	2.0
Thorium-230	20	20	0.147	0.216	0.283	0.217	0.0113	5.2
Thorium-232	20	20	0.258	0.308	0.395	0.315	0.00692	2.2
Uranium (mg/kg)	20	20	1.01	18.2	53.5	19.0	2.23	12
Uranium-234	20	20	0.404	1.9	4.7	1.9	0.20	10
Uranium-234 (Outlier Removed)	19	19	0.404	1.7	4.7	1.9	0.18	9.7
Uranium-238	20	20	0.582	16.2	48.2	17.0	2.01	12
Uranium-238 (Outlier Removed)	19	19	0.582	15.2	34.6	15.2	1.06	7.0

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the MDL.

[b] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

B.8.4.4 Data Summary for Subunit 3

Table B.48 lists the organics that were detected in the laboratory data for subunit 3. Eleven organic compounds were detected in the subunit 3 soils. Each of the detected organics was detected in only one of the 20 samples. Each of the detected values was less than the detection limit so it was not possible to determine if outliers were present in the data or to compute UCLs. The detected values for each of the organics came from the third composite of the first segment. The detected values are reported in Tables B.49 and B.50. Laboratory results, associated validation flags, and flag definitions for fixed laboratory data for subunit 3 are listed in Appendix F of the SER.

Table B.48. SVOCs Detected in the Fixed Laboratory Composite Samples Associated with Subunit 3

Detected SVOCs		
Benzo(a)anthracene	Benzo(k)fluoranthene	Indeno(1,2,3-cd)pyrene
Benzo(a)pyrene	Chrysene	Phenanthrene
Benzo(b)fluoranthene	Dibenz(a,h)anthracene	Pyrene
Benzo(ghi)perylene	Fluoranthene	

Table B.49. Summary Statistics for SVOCs from Fixed Laboratory Analysis of Composite Soils Associated with Subunit 3

Analyte	# Positive Detections	# Data Points	Minimum (µg/kg)	Median (µg/kg)	Maximum (µg/kg)	Mean (µg/kg)	Standard Deviation (µg/kg)	Coefficient of Variation (%)
Benzo(a)anthracene	1	20	NA[a]	NA[a]	310	NA[a]	NA[a]	NA[a]
Benzo(a)pyrene	1	20	NA[a]	NA[a]	460	NA[a]	NA[a]	NA[a]
Benzo(b)fluoranthene	1	20	NA[a]	NA[a]	420	NA[a]	NA[a]	NA[a]
Benzo(ghi)perylene	1	20	NA[a]	NA[a]	390	NA[a]	NA[a]	NA[a]
Benzo(k)fluoranthene	1	20	NA[a]	NA[a]	450	NA[a]	NA[a]	NA[a]
Chrysene	1	20	NA[a]	NA[a]	340	NA[a]	NA[a]	NA[a]
Dibenz(a,h)anthracene	1	20	NA[a]	NA[a]	100	NA[a]	NA[a]	NA[a]
Fluoranthene	1	20	NA[a]	NA[a]	270	NA[a]	NA[a]	NA[a]
Indeno(1,2,3-cd)pyrene	1	20	NA[a]	NA[a]	340	NA[a]	NA[a]	NA[a]
Phenanthrene	1	20	NA[a]	NA[a]	110	NA[a]	NA[a]	NA[a]
Pyrene	1	20	NA[a]	NA[a]	270	NA[a]	NA[a]	NA[a]

NA = Not Applicable.

[a] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

B.8.4.5 Upper Confidence Limits for Fixed Laboratory Analyses for Subunit 3

Table B.50 lists the UCLs for the metals, PCBs, radionuclides, and organics detected in subunit 3. UCLs were calculated for data that had 70% or fewer nondetects. If more than 70% of the data were nondetects, the maximum detected value was reported in place of the UCL. If more than one outlier was present in the data, they were removed simultaneously if they were close in value; if the outliers were notably different from one another, they were removed separately. Removal of outliers usually did not cause significant changes in the UCL. Removal of outliers for cadmium and uranium made large enough changes in the UCLs that the risk assessment may be significantly impacted.

Table B.50. Upper Confidence Limits from Fixed Laboratory Analyses Associated with the Composite Soils from Subunit 3

Analyte	**Mean Seg 1**	**Mean Seg 2**	**Mean Seg 3**	**Mean Seg 4**	**Mean**	**SD**	**UCL**
Metals	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Aluminum	6,322	6,660	6,156	6,624	6,441	96	6,478
Antimony	0.14	0.17	0.13	0.12	0.14	0.0083	0.15
Arsenic	7.6	10	5.8	5.3	7.3	0.89	7.6
Barium	71.3	75.7	67.6	71.8	71.6	1.30	72.1
Beryllium	0.64	0.57	0.47	0.41	0.52	0.041	0.54
Cadmium	0.11	0.33	0.063	0.11	0.15	0.047	0.17
Cadmium (Outlier Removed)	0.11	0.11	0.063	0.11	0.10	0.010	0.10
Calcium	1,006	727	993	1,046	943	57.9	965
Chromium	95.1	38.0	55.5	36.9	56.4	10.8	60.6
Cobalt	6.6	7.8	5.9	5.8	6.5	0.38	6.7
Copper	9.5	9.4	9.4	8.4	9.2	0.19	9.2
Iron	14,620	14,260	12,472	10,760	13,028	707	13,301
Lead	14	23	13	14	16	2.0	17
Lead (Outlier Removed)	14	20	13	14	15	1.4	15
Magnesium	737	837	676	820	768	30	779
Manganese	360	797	347	607	528	86	561
Mercury	0.0541	0.0532	0.0405	0.0318	0.0449	0.00426	0.0466
Molybdenum	0.48	0.67	0.41	0.43	0.50	0.048	0.52
Nickel	7.6	8.0	8.1	7.4	7.8	0.14	7.8
Selenium	0.36	0.46	0.32	0.37	0.38	0.023	0.38
Silver	0.044	0.047	0.049	0.046	0.047	0.00080	0.047
Sodium	28.8	16.9	17.4	21.6	21.2	2.18	22.0
Thallium	0.15	0.16	0.13	0.14	0.15	0.0060	0.15
Uranium (mg/kg)	113	44.8	57.1	62.3	69.2	11.8	73.8
Uranium (Outlier Removed)	74.2	44.8	57.1	62.3	58.8	4.99	60.8
Vanadium	20	23	25	19	22	1.2	22
Vanadium (Outlier Removed)	20	23	20	19	20	0.72	21
Zinc	73.5	81.1	49.0	42.1	61.4	7.47	64.3
Organics	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)
PCB, Total	146	77	80	42	86	17	93
PCB-1248	50	51	57	42	50	2.5	51
PCB-1248 (Outlier Removed)	50	51	44	42	47	1.9	48
PCB-1254	62	46	48	42	50	3.4	51
PCB-1260	52	55	41	42	47	2.9	49

Table B.50. Upper Confidence Limits from Fixed Laboratory Analyses Associated with the Composite Soils from Subunit 3 (Continued)

Analyte	Mean Seg 1	Mean Seg 2	Mean Seg 3	Mean Seg 4	Mean	SD	UCL
Organics	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)
PCB-1260 (Outlier Removed)	52	42	41	42	44	2.1	45
Benzo(a)anthracene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	310[b]
Benzo(a)pyrene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	460[b]
Benzo(b)fluoranthene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	420[b]
Benzo(ghi)perylene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	390[b]
Benzo(k)fluoranthene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	450[b]
Chrysene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	340[b]
Dibenz(a,h)anthracene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	100[b]
Fluoranthene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	270[b]
Indeno(1,2,3-cd)pyrene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	340[b]
Phenanthrene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	110[b]
Pyrene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	270[b]
Radionuclides	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)
Uranium-235	0.363	0.203	0.252	0.261	0.270	0.0267	0.280
Uranium-235 (Outlier Removed)	0.279	0.203	0.252	0.261	0.247	0.0133	0.252
Alpha Activity	21.4	15.0	17.9	19.4	18.4	1.07	18.8
Alpha Activity (Outlier Removed)	21.4	15.0	11.4	19.4	17.1	1.88	17.8
Beta Activity	38	23	33	28	31	2.6	32
Beta Activity (Outlier Removed)	38	23	17	28	27	3.7	29
Cesium-137	0.117	0.211	0.0845	0.117	0.132	0.0217	0.141
Plutonium-239/240	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	0.014[a]
Radium-226	0.87	0.78	0.80	0.79	0.81	0.016	0.81
Technetium-99	1.25	2.57	1.07	1.21	1.52	0.278	1.63
Technetium-99 (Outlier Removed)	1.25	1.11	1.07	1.21	1.18	0.0346	1.17
Thorium-228	0.273	0.291	0.258	0.283	0.276	0.00566	0.279
Thorium-230	0.198	0.259	0.203	0.217	0.217	0.0113	0.221
Thorium-232	0.311	0.340	0.302	0.305	0.315	0.00692	0.317
Uranium (mg/kg)	26.7	13.6	16.7	19.1	19.0	2.23	19.9
Uranium-234	2.6	1.5	1.7	1.9	1.9	0.20	2.0
Uranium-234 (Outlier Removed)	2.5	1.5	1.7	1.9	1.9	0.18	1.9
Uranium-238	23.7	11.8	14.7	17.0	17.0	2.01	17.6
Uranium-238 (Outlier Removed)	17.6	11.8	14.7	17.0	15.2	1.06	15.6

NA = Not Applicable.

[a] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

[b] An insufficient number of detections were recorded for this analyte in order to calculate the UCL. The value shown is the maximum reported value.

B.8.5 ANALYSIS OF SUBUNIT 4 SURFACE DATA

B.8.5.1 Metals Data Summary for Subunit 4

Table B.51 lists the metals that were detected in the laboratory data for subunit 4. Twenty-four metals were detected. All detected metals were detected in all 20 results. The antimony, beryllium, cobalt, copper, iron, molybdenum, nickel, silver, sodium, uranium, and vanadium data each had one statistical outlier. All but two of the outliers were in the first composite of segment 3. The other two outliers were in different composites of segment 4. Summary statistics and UCLs were computed with and without outliers and are listed in Tables B.52 and B.59, respectively. Laboratory results, associated validation flags, and flag definitions for fixed laboratory data for subunit 4 are listed in Appendix G of the SER.

Table B.51. Metals Detected in the Fixed Laboratory Composite Samples Associated with Subunit 4

Detected Metals		
Aluminum	Cobalt	Nickel
Antimony	Copper	Selenium
Arsenic	Iron	Silver
Barium	Lead	Sodium
Beryllium	Magnesium	Thallium
Cadmium	Manganese	Uranium
Calcium	Mercury	Vanadium
Chromium	Molybdenum	Zinc

Table B.52. Summary Statistics for Metals from Fixed Laboratory Analysis of Composite Soils Associated with Subunit 4

Analyte	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Aluminum	20	20	6,150	8,495	10,100	8,490	349	4.1
Antimony	20	20	0.11	0.17	0.84	0.20	0.030	15
Antimony (Outlier Removed)	19	19	0.11	0.16	0.28	0.17	0.012	7.5
Arsenic	20	20	3.5	7.0	23	8.6	1.2	14
Barium	20	20	52	90	144	91	6.8	7.4
Beryllium	20	20	0.38	0.51	1.5	0.56	0.056	9.9
Beryllium (Outlier Removed)	19	19	0.38	0.50	0.66	0.51	0.027	5.3
Cadmium	20	20	0.027	0.063	0.10	0.063	0.0032	5.1
Calcium	20	20	691	922	1,210	935	31	3.3
Chromium	20	20	14	27	158	42	9.1	21
Cobalt	20	20	4.0	6.1	11	6.4	0.13	2.0
Cobalt (Outlier Removed)	19	19	4.0	6.1	8.3	6.1	0.14	2.3

Table B.52. Summary Statistics for Metals from Fixed Laboratory Analysis of Composite Soils Associated with Subunit 4 (Continued)

Analyte	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Copper	20	20	7.8	10	29	11	0.98	8.6
Copper (Outlier Removed)	19	19	7.8	10	17	10	0.83	7.9
Iron	20	20	8,150	13,600	48,500	15,053	1,688	11
Iron (Outlier Removed)	19	19	8,150	13,600	17,100	13,292	725	5.5
Lead	20	20	10	14	33	17	2.1	12
Magnesium	20	20	804	1,205	1,460	1,199	76	6.3
Manganese	20	20	212	379	775	412	38	9.2
Mercury	9	20	0.0086	0.040	0.044	0.031	0.0028	9.2
Molybdenum	20	20	0.30	0.65	2.40	0.71	0.084	12
Molybdenum (Outlier Removed)	19	19	0.30	0.64	1.1	0.62	0.064	10
Nickel	20	20	6.7	8.7	21	9.1	0.56	6.2
Nickel (Outlier Removed)	19	19	6.7	8.6	10	8.5	0.36	4.3
Selenium	20	20	0.16	0.38	0.62	0.41	0.041	10
Silver	20	20	0.042	0.057	0.085	0.057	0.0015	2.7
Silver (Outlier Removed)	19	19	0.042	0.056	0.075	0.056	0.0019	3.4
Sodium	20	20	18	23	35	23	1.1	4.5
Sodium (Outlier Removed)	19	19	18	23	30	23	0.95	4.2
Thallium	20	20	0.15	0.22	0.30	0.22	0.021	9.8
Uranium	20	20	1.3	2.7	269	17	11	66
Uranium (Outlier Removed)	19	19	1.3	2.2	17	4.0	1.1	29
Vanadium	20	20	14	23	87	26	3.1	12
Vanadium (Outlier Removed)	19	19	14	23	30	23	1.5	6.6
Zinc	20	20	28	35	78	42	4.1	9.9

B.8.5.2 PCB Data Summary for Subunit 4

Table B.53 lists the PCBs that were detected in the laboratory data for subunit 4. Total PCBs were measured and Aroclor-1260 was detected in the soils. Two statistical outliers were identified for each of the PCBs. These outliers were observed in segments 1 and 4. Summary statistics and UCLs were computed with and without these outliers and are listed in Tables B.54 and B.59, respectively. Laboratory results, associated validation flags, and flag definitions for fixed laboratory data for subunit 4 are listed in Appendix G of the SER.

Table B.53. PCBs Detected in the Fixed Laboratory Composite Samples Associated with Subunit 4

Detected PCBs	
PCB, Total	PCB-1260

Table B.54. Summary Statistics for PCBs from Fixed Laboratory Analysis of Composite Soils Associated with Subunit 4

Analyte	# Positive Detections	# Data Points	Minimum (μg/kg)	Median (μg/kg)	Maximum (μg/kg)	Mean (μg/kg)	Standard Deviation (μg/kg)	Coefficient of Variation (%)
PCB, Total	10	20	<39[a]	45	490	90	18	20
PCB, Total (Outlier Removed)	9	19	<39[a]	<44[a]	270	69	8.4	12
PCB, Total (2 Outliers Removed)	8	18	<39[a]	<44[a]	160	58	6.6	11
PCB-1260	10	20	<39[a]	45	490	90	18	20
PCB-1260 (Outlier Removed)	9	19	<39[a]	<44[a]	270	69	8.4	12
PCB-1260 (2 Outliers Removed)	8	18	<39[a]	<44[a]	160	58	6.6	11

[a] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

B.8.5.3 Radionuclide Data Summary for Subunit 4

Table B.55 lists the radionuclides that were detected in the laboratory data for subunit 4. Twelve radionuclides were detected in the subunit 4 soils. Alpha activity and beta activity data each had one statistical outlier. All three outliers were observed in composite 5 of segment 4. Summary statistics and UCLs were computed with and without outliers and are listed in Tables B.56 and B.59, respectively. Laboratory results and associated validation flags for fixed laboratory data for subunit 4 are listed in Appendix G of the SER.

Table B.55. Radionuclides Detected in the Fixed Laboratory Composite Samples Associated with Subunit 4

Detected Radionuclides		
Uranium-235	Radium-226	Uranium
Alpha Activity	Thorium-228	Uranium-234
Beta Activity	Thorium-230	Uranium-238
Cesium-137	Thorium-232	

Table B.56. Summary Statistics for Radionuclides Analytes from Fixed Laboratory Analysis of Composite Soils Associated with Subunit 4

Analyte	# Positive Detections	# Data Points	Minimum (pCi/g)	Median (pCi/g)	Maximum (pCi/g)	Mean (pCi/g)	Standard Deviation (pCi/g)	Coefficient of Variation (%)
Uranium-235	6	20	<0.024[a]	<0.025[a]	0.132	0.037	0.0094	25
Alpha Activity	20	20	2.6	6.3	106	12	4.7	40
Alpha Activity (Outlier Removed)	19	19	2.6	6.3	21	6.9	0.97	14
Beta Activity	20	20	3.3	4.6	203	16	9.1	58
Beta Activity (Outlier Removed)	19	19	3.3	4.5	28	6.0	1.6	27
Cesium-137	18	20	<0.049[a]	0.13	0.37	0.15	0.018	12
Radium-226	20	20	0.71	0.82	0.97	0.83	0.019	2.3
Thorium-228	20	20	0.25	0.35	0.48	0.36	0.016	4.5
Thorium-230	20	20	0.17	0.26	0.41	0.27	0.022	8.0
Thorium-232	20	20	0.27	0.37	0.47	0.36	0.020	5.5
Uranium	16	20	<0.18[a]	0.60	11	1.8	0.93	53
Uranium-234	20	20	0.13	0.25	0.87	0.34	0.071	21
Uranium-238	20	20	0.17	0.36	9.7	1.5	0.83	57

[a] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

B.8.5.4 Organics Data Summary for Subunit 4

Table B.57 lists the organic compounds that were detected in the laboratory data for subunit 4. Nine organic compounds were detected in the subunit 4 soils. Each of the detected organics was detected in only one of the 20 samples except for fluoranthene, which has six detects, and pyrene, which has four detects. Each of the detected values was less than the detection limit, so it was not possible to determine if there were outliers in the data or to compute UCLs for the organics with the exception of fluoranthene. All of the detected organics were detected in composite 4 of segment 1. The detected values and the UCL for fluoranthene are reported in Tables B.58 and B.59, respectively. Laboratory results, associated validation flags, and flag definitions for fixed laboratory data for subunit 4 are listed in Appendix G of the SER.

Table B.57. SVOCs Detected in the Fixed Laboratory Composite Samples Associated with Subunit 4

Detected SVOCs		
Benzo(a)anthracene	Benzo(k)fluoranthene	Indeno(1,2,3-cd)pyrene
Benzo(a)pyrene	Chrysene	Phenanthrene
Benzo(b)fluoranthene	Fluoranthene	Pyrene

Table B.58. Summary Statistics for SVOCs from Fixed Laboratory Analysis of Composite Soils Associated with Subunit 4

Analyte	# Positive Detections	# Data Points	Minimum (µg/kg)	Median (µg/kg)	Maximum (µg/kg)	Mean (µg/kg)	Standard Deviation (µg/kg)	Coefficient of Variation (%)
Benzo(a)anthracene	1	20	NA[a]	NA[a]	43	NA[a]	NA[a]	NA[a]
Benzo(a)pyrene	1	20	NA[a]	NA[a]	56	NA[a]	NA[a]	NA[a]
Benzo(b)fluoranthene	1	20	NA[a]	NA[a]	55	NA[a]	NA[a]	NA[a]
Benzo(k)fluoranthene	1	20	NA[a]	NA[a]	46	NA[a]	NA[a]	NA[a]
Chrysene	1	20	NA[a]	NA[a]	64	NA[a]	NA[a]	NA[a]
Fluoranthene	6	20	46	400	440	308	16	5.1
Indeno(1,2,3-cd)pyrene	1	20	NA[a]	NA[a]	440	NA[a]	NA[a]	NA[a]
Phenanthrene	1	20	NA[a]	NA[a]	120	NA[a]	NA[a]	NA[a]
Pyrene	4	20	NA[a]	NA[a]	110	NA[a]	NA[a]	NA[a]

NA = Not Applicable.

[a] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

B.8.5.5 Upper Confidence Limits for Fixed Laboratory Analyses for Subunit 4

Table B.59 lists the UCLs for the metals, PCBs, radionuclides, and organics detected in subunit 4. UCLs were calculated for data that had 70% or fewer nondetects. If more than 70% of the data were nondetects, the maximum detected value was reported in place of the UCL. Where one or more outliers were observed in the data, UCLs were computed with and without the outlier(s). If more than one outlier was present in the data, they were removed simultaneously if they were close in value; if the outliers were notably different from one another, they were removed separately. Removal of the outlier often did not cause significant changes in the UCL. Removal of the outliers for iron, molybdenum, nickel, uranium, Total PCBs, Aroclor-1260, alpha activity, beta activity, and perhaps beryllium made a large change in the UCLs. In fact, the UCL for uranium changes by a factor of 5 when the outlier was removed.

Table B.59. Upper Confidence Limits from Fixed Laboratory Analyses Associated with the Composite Soils from Subunit 4

Analyte	Mean Seg 1	Mean Seg 2	Mean Seg 3	Mean Seg 4	Mean	SD	UCL
Metals	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Aluminum	9,170	8,616	8,954	7,218	8,490	349	8,624
Antimony	0.16	0.20	0.30	0.13	0.20	0.030	0.21
Antimony (Outlier Removed)	0.16	0.20	0.17	0.13	0.17	0.012	0.17
Arsenic	6.9	10	12	5.3	8.6	1.2	9.0
Barium	107	105	81	72	91	6.8	94
Beryllium	0.46	0.58	0.75	0.46	0.56	0.056	0.58
Beryllium (Outlier Removed)	0.46	0.58	0.57	0.46	0.51	0.027	0.52
Cadmium	0.069	0.070	0.053	0.061	0.063	0.0032	0.064
Calcium	820	950	994	977	935	31	948
Chromium	17	29	58	66	42	9.1	46

Table B.59. Upper Confidence Limits from Fixed Laboratory Analyses Associated with the Composite Soils from Subunit 4 (Continued)

Analyte	Mean Seg 1	Mean Seg 2	Mean Seg 3	Mean Seg 4	Mean	SD	UCL
Metals	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Cobalt	6.2	6.4	6.8	6.0	6.4	0.13	6.4
Cobalt (Outlier Removed)	6.2	6.4	5.7	6.0	6.1	0.14	6.2
Copper	9.2	9.3	13	14	11	1.0	12
Copper (Outlier Removed)	9.2	9.3	13	9.7	10	0.83	11
Iron	13,700	14,860	20,880	10,770	15,053	1,688	15,705
Iron (Outlier Removed)	13,700	14,860	13,975	10,770	13,292	725	13,580
Lead	12	18	23	13	17	2.1	17
Magnesium	1,384	1,268	1,208	935	1,199	76	1,228
Manganese	364	555	372	358	412	38	427
Mercury	0.026	0.041	0.030	0.027	0.031	0.0028	0.032
Molybdenum	0.68	0.80	0.93	0.43	0.71	0.084	0.74
Molybdenum (Outlier Removed)	0.68	0.80	0.57	0.43	0.62	0.064	0.65
Nickel	9.4	8.9	11	7.3	9.1	0.56	9.3
Nickel (Outlier Removed)	9.4	8.9	8.3	7.3	8.5	0.36	8.6
Selenium	0.53	0.48	0.35	0.31	0.41	0.041	0.43
Silver	0.060	0.059	0.058	0.052	0.057	0.0015	0.058
Silver (Outlier Removed)	0.060	0.059	0.052	0.052	0.056	0.0019	0.057
Sodium	25	24	25	19	23	1.1	24
Sodium (Outlier Removed)	25	24	23	19	23	0.95	23
Thallium	0.28	0.23	0.19	0.16	0.22	0.021	0.22
Uranium	1.6	2.3	5.0	60	17	11	22
Uranium (Outlier Removed)	1.6	2.3	5.0	7.7	4.0	1.1	4.4
Vanadium	24	27	37	18	26	3.1	27
Vanadium (Out Removed)	24	27	24	18	23	1.5	24
Zinc	31	35	54	46	42	4.1	43
Organics	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)
PCB, Total	92	75	42	151	90	18	97
PCB, Total (Outlier Removed)	92	75	42	67	69	8	72
PCB, Total (2 Outliers Removed)	47	75	42	67	58	6.6	61
PCB-1260	92	75	42	151	90	18	97
PCB-1260 (Outlier Removed)	92	75	42	67	69	8.4	72

Table B.59. Upper Confidence Limits from Fixed Laboratory Analyses Associated with the Composite Soils from Subunit 4 (Continued)

Analyte	Mean Seg 1	Mean Seg 2	Mean Seg 3	Mean Seg 4	Mean	SD	UCL
Metals	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
PCB-1260 (2 Outliers Removed)	47	75	42	67	58	6.6	61
Benzo(a)anthracene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	43[b]
Benzo(a)pyrene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	56[b]
Benzo(b)fluoranthene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	55[b]
Benzo(k)fluoranthene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	46[b]
Chrysene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	64[b]
Fluoranthene	276	338	346	271	308	16	314
Indeno(1,2,3-cd)pyrene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	440[b]
Phenanthrene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	120[b]
Pyrene	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	NA[a]	110[b]
Radionuclides	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)
Uranium-235	0.068	0.026	0.026	0.073	0.048	0.010	0.052
Alpha Activity	6.2	6.3	5.2	30	11.8	4.7	14
Alpha Activity (Outlier Removed)	6.2	6.3	5.2	11	6.9	0.97	7.3
Beta Activity	4.0	4.4	4.7	50	15.9	9.1	19
Beta Activity (Outlier Removed)	4.0	4.4	4.7	12	6.0	1.6	6.6
Cesium-137	0.20	0.13	0.17	0.10	0.15	0.018	0.16
Radium-226	0.89	0.82	0.83	0.77	0.83	0.019	0.83
Thorium-228	0.39	0.36	0.38	0.30	0.36	0.016	0.36
Thorium-230	0.34	0.27	0.26	0.21	0.27	0.022	0.28
Thorium-232	0.40	0.38	0.38	0.29	0.36	0.020	0.37
Uranium (mg/kg)	0.36	0.59	0.85	5.3	1.8	0.93	2.1
Uranium-234	0.19	0.25	0.33	0.60	0.34	0.071	0.37
Uranium-238	0.27	0.36	0.59	4.6	1.5	0.83	1.8

B.8.6 ANALYSIS OF SUBUNIT 5 SURFACE DATA

B.8.6.1 Metals Data Summary for Subunit 5

Table B.60 lists the metals that were detected in the laboratory data for subunit 5. Twenty-four metals were detected. All detected metals were detected in all 20 results. The barium, beryllium, cobalt, manganese, molybdenum, and silver data each had one statistical outlier. All of the outliers except for the silver outlier were observed at the same sample identification number. Summary statistics and UCLs were computed with and without these outliers and are listed in Tables B.61 and B.64, respectively. Laboratory results and associated validation flags for fixed laboratory data for subunit 5 are listed in Appendix H of the SER.

Table B.60. Metals Detected in the Fixed Laboratory Composite Samples Associated with Subunit 5

Detected Metals

- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Calcium
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Magnesium
- Manganese
- Mercury
- Molybdenum
- Nickel
- Selenium
- Silver
- Sodium
- Thallium
- Uranium
- Vanadium
- Zinc

Table B.61. Summary Statistics for Metals from Fixed Laboratory Analysis of Composite Soils Associated with Subunit 5

Analyte	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Aluminum	18	18	5,650	8,620	13,800	9,293	2,423	26
Antimony	18	18	0.089	0.26	0.49	0.25	0.11	44
Arsenic	18	18	3.7	12	47	17	13	79
Barium	18	18	52	89	327	103	61	59
Barium (Outlier Removed)	17	17	52	87	168	90	25	27
Beryllium	18	18	0.26	0.59	1.4	0.61	0.25	42
Beryllium (Outlier Removed)	17	17	0.26	0.58	0.94	0.56	0.17	29
Cadmium	18	18	0.021	0.066	0.19	0.074	0.046	61
Calcium	18	18	137	479	1,230	547	331	60
Chromium	18	18	6.2	12	18	12	3.4	28
Cobalt	18	18	2.6	7	32	8.8	6.6	75
Cobalt (Outlier Removed)	17	17	2.6	6.7	14	7.5	3.2	43
Copper	18	18	4.8	11	27	12	6.9	58
Iron	18	18	6,690	16,850	24,200	15,498	5,268	34
Lead	18	18	9	20	115	38	36	94
Magnesium	18	18	610	1,035	1,980	1,206	474	39
Manganese	18	18	169	609	8,340	1,187	1,892	159
Manganese (Outlier Removed)	17	17	169	0.043	2,790	766	648	85
Mercury	17	18	0.0099	0.89	0.0735	0.043	0.016	36
Molybdenum	18	18	0.29	0.88	2.3	0.91	0.45	50
Molybdenum (Outlier Removed)	17	17	0.29	9.3	1.3	0.83	0.30	36

Table B.61. Summary Statistics for Metals from Fixed Laboratory Analysis of Composite Soils Associated with Subunit 5 (Continued)

Analyte	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Nickel	18	18	4.5	0.5	15	9.0	2.6	29
Selenium	13	18	0.22	0.046	0.73	0.48	0.18	37
Silver	18	18	0.035	0.046	0.12	0.051	0.019	37
Silver (Outlier Removed)	17	17	0.035	20	0.06	0.047	0.0078	17
Sodium	18	18	16	0.30	26	20	3.0	15
Thallium	18	18	0.23	1.7	0.44	0.31	0.053	17
Uranium	18	18	1.3	27	2.3	1.8	0.33	19
Vanadium	18	18	14	26	48	28	8.8	32
Zinc	18	18	18	8,620	40	28	6.7	23

B.8.6.2 PCB Data Summary for Subunit 5

No PCBs were detected in the subunit 5 soils; therefore, there were no summary statistics or UCLs for PCBs for subunit 5. Laboratory results, associated validation flags, and flag definitions for fixed laboratory data for subunit 5 are listed in Appendix H of the SER.

B.8.6.3 Radionuclide Data Summary for Subunit 5

Table B.62 lists the radionuclides that were detected in the laboratory data for subunit 5. Fifteen radionuclides were detected in the subunit 5 soils. The uranium-234 and uranium-238 data each had one statistical outlier. Neither of the outliers was in the same location. Summary statistics and UCLs were computed with and without outliers and are listed in Tables B.63 and B.64, respectively. Laboratory results, associated validation flags, and flag definitions for fixed laboratory data for subunit 5 are listed in Appendix H of the SER.

Table B.62. Radionuclides Detected in the Fixed Laboratory Composite Samples Associated with Subunit 5

Detected Radionuclides		
Uranium-235	Plutonium-239/240	Thorium-232
Alpha Activity	Radium-226	Uranium
Americium-241	Technetium-99	Uranium-234
Beta Activity	Thorium-228	Uranium-238
Cesium-137	Thorium-230	

Table B.63. Summary Statistics for Radionuclides Analytes from Fixed Laboratory Analysis of Composite Soils Associated with Subunit 5

Analyte	# Positive Detections	# Data Points	Minimum (pCi/g)	Median (pCi/g)	Maximum (pCi/g)	Mean (pCi/g)	Standard Deviation (pCi/g)	Coefficient of Variation (%)
Uranium-235	12	18	0.012	0.02	0.044	0.02	0.009	39
Alpha Activity	18	18	3.1	6.27	9.6	6.4	2.0	31
Americium-241	1	18	<0.013[a]	NA[b]	0.034	NA[b]	NA[b]	34
Beta Activity	18	18	3.2	5.18	7.6	5.3	1.3	25
Cesium-137	18	18	0.14	0.28	0.56	0.30	0.12	40
Plutonium-239/240	4	18	<0.010[a]	0.011	0.014	0.01	0.0013	11
Radium-226	18	18	0.64	0.81	1.0	0.82	0.11	13
Technetium-99	1	18	<0.88[a]	NA[b]	3.7	NA[b]	NA[b]	65
Thorium-228	18	18	0.21	0.31	0.49	0.32	0.078	24
Thorium-230	18	18	0.11	0.31	0.45	0.28	0.11	39
Thorium-232	18	18	0.27	0.35	0.51	0.36	0.074	20
Uranium (mg/kg)	18	18	0.35	0.65	1.5	0.73	0.28	39
Uranium (Outlier Removed)	17	17	0.35	0.63	1.1	0.69	0.20	30
Uranium-234	18	18	0.12	0.27	0.44	0.28	0.083	30
Uranium-238	18	18	0.22	0.37	1.2	0.43	0.22	51
Uranium-238 (Outlier Removed)	17	17	0.22	0.33	0.66	0.39	0.13	33

NA = Not Applicable

[a] The reported result was a nondetect. The value shown represents the MDL.

[b] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

B.8.6.4 Organics Data Summary for Subunit 5

No organics were detected in subunit 5; therefore, no summary statistics or UCLs are reported for organics in subunit 5. Laboratory results, associated validation flags, and flag definitions for fixed laboratory data for subunit 5 are listed in Appendix H of the SER.

B.8.6.5 Upper Confidence Limits for Fixed Laboratory Analyses for Subunit 5

Table B.64 lists the UCLs for the metals and radionuclides detected in subunit 5. UCLs were calculated for data that had 70% or fewer nondetects. If more than 70% of the data were nondetects, the maximum detected value was reported in place of the UCL. Where one or more outliers were observed in the data, UCLs were computed with and without the outlier(s). If more than one outlier was present in the data, they were removed simultaneously if they were close in value; if the outliers were notably different from one another, they were removed separately. Removal of the outlier sometimes did not cause significant changes in the UCL. Removal of the outliers for barium, beryllium, cobalt, silver, uranium, and uranium-238 made a large change in the UCLs. It also should be noted that ProUCL recommended the H-UCL for the manganese data. This particular UCL method was very unstable; therefore, this UCL also was listed for this analyte for the benefit of the data user. There is a large difference in the results produced by these two methods for the manganese data.

Table B.64. Upper Confidence Limits from Fixed Laboratory Analyses Associated with the Composite Soils from Subunit 5

Analyte	Mean	SD	Distribution	Method for Computing UCL	UCL
Metals	(mg/kg)	(mg/kg)			(mg/kg)
Aluminum	9,293	2,423	Normal	95% Student's-t	10,286
Antimony	0.25	0.11	Normal	95% Student's-t	0.30
Arsenic	17	13	Gamma	95% Approximate Gamma	23
Barium	103	61	Nonparametric	95% Modified-t	130
Barium (Outlier Removed)	90	25	Lognormal	95% Modified-t	101
Beryllium	0.61	0.25	Gamma	95% Approximate Gamma	0.72
Beryllium (Outlier Removed)	0.56	0.17	Normal	95% Student's-t	0.63
Cadmium	0.074	0.046	Normal	95% Student's-t	0.093
Calcium	547	331	Normal	95% Student's-t	683
Chromium	12	3.4	Normal	95% Student's-t	13
Cobalt	8.8	6.6	Gamma	95% Approximate Gamma	11
Cobalt (Outlier Removed)	7.5	3.2	Normal	95% Student's-t	8.8
Copper	12	6.9	Gamma	95% Approximate Gamma	15
Iron	15,498	5,268	Normal	95% Student's-t	17,658
Lead	38	36	Nonparametric	95% Chebyshev (Mean, Sd)	75
Magnesium	1,206	474	Gamma	95% Approximate Gamma	1,425
Manganese	1,187	1,892	Lognormal	Use 95% H-UCL	1,822
Manganese	1,187	1,892	Lognormal	95% BCA Bootstrap	2,498
Manganese (Outlier Removed)	766	648	Gamma	95% Approximate Gamma	1,051
Mercury	0.043	0.016	Normal	95% Student's-t	0.049
Molybdenum	0.91	0.45	Gamma	95% Approximate Gamma	1.1
Molybdenum (Outlier Removed)	0.83	0.30	Normal	95% Student's-t	1.0
Nickel	9.0	2.6	Normal	95% Student's-t	10
Selenium	0.48	0.18	Nonparametric	95% Modified-t	0.55
Silver	0.051	0.019	Nonparametric	95% Modified-t	0.059
Silver (Outlier Removed)	0.047	0.0078	Normal	95% Student's-t	0.050
Sodium	20	3.0	Normal	95% Student's-t	21
Thallium	0.31	0.053	Normal	95% Student's-t	0.34
Uranium	1.8	0.33	Normal	95% Student's-t	1.9
Vanadium	28	8.8	Normal	95% Student's-t	31
Zinc	28	6.7	Normal	95% Student's-t	31
Radionuclides	(pCi/g)	(pCi/g)			(pCi/g)
Uranium-235	0.019	0.0083	Gamma	95% KM (Percentile Bootstrap)	0.022

Table B.64. Upper Confidence Limits from Fixed Laboratory Analyses Associated with the Composite Soils from Subunit 5 (Continued)

Analyte	Mean	SD	Distribution	Method for Computing UCL	UCL
Metals	(mg/kg)	(mg/kg)			(mg/kg)
Alpha Activity	6.4	2.0	Normal	95% Student's t-UCL	7.2
Americium-241	NA[b]	NA[b]	NA	NA	0.034[b]
Beta Activity	5.3	1.3	Normal	95% Student's t-UCL	5.8
Cesium-137	0.30	0.12	Normal	95% Student's t-UCL	0.35
Plutonium-239/240	0.012	0.00062	Normal	95% KM (Percentile Bootstrap)	0.014
Radium-226	0.82	0.11	Normal	95% Student's t-UCL	0.87
Technetium-99	NA[b]	NA[b]	NA	NA	3.7[b]
Thorium-228	0.32	0.078	Normal	95% Student's t-UCL	0.36
Thorium-230	0.28	0.11	Normal	95% Student's t-UCL	0.33
Thorium-232	0.36	0.074	Normal	95% Student's t-UCL	0.39
Uranium (mg/kg)	0.73	0.28	Gamma	95% Approximate Gamma	0.86
Uranium (Outlier Removed)	0.69	0.20	Normal	95% Student's t-UCL	0.77
Uranium-234	0.28	0.083	Normal	95% Student's t-UCL	0.31
Uranium-238	0.43	0.22	Normal	95% Student's t-UCL	0.52
Uranium-238 (Outlier Removed)	0.39	0.13	Normal	95% Student's t-UCL	0.45

NA = Not Applicable.

[a] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

[b] An insufficient number of detections were recorded for this analyte in order to calculate the UCL. The value shown is the maximum reported value.

B.9 STATISTICAL ANALYSIS OF FIELD DATA COLLECTED FROM SURFACE SAMPLES FROM SOIL PILE I

This section contains the statistical analysis of field data collected from subunits 1 through 5. XRF, PCB, and ISOCS data were collected from all five subunits. Field data were collected using several different methods. One of the primary interests of this DQA is to determine the correspondence between field and fixed laboratory data so that it can be determined to what extent field data can be used for decision making in other projects in the area. Field data were collected from the same composited samples used in fixed laboratory analysis. Another key interest of the field data is to help characterize the areas that the segments do not cover and provide more data than could be obtained from fixed laboratory analysis. Noncomposited field samples were collected from each of the locations where fixed laboratory samples were collected and also from additional areas within each subunit. Composited data cannot be combined with noncomposited data, so this section examines only the field data obtained from noncomposited samples. Field data obtained from the composited field samples are analyzed and some summary statistics are listed in Section B.10.

Field data were collected using both a randomized clustered design and a systematic random sampling design. These data will be combined to perform a preliminary data analysis and compute UCLs where feasible. The data will be combined and analysis was done as if the data were obtained from a simple random sample. It is true that the data were not obtained from a true simple random sampling design and the clusters within the design cause the standard deviations to be underestimated to some extent. Because fixed laboratory data also were collected for UCL computation and the UCLs resulting from this analysis will be compared to both the fixed laboratory UCLs and the clustered field UCLs in Section 10, the effect of underestimating the standard deviation on UCL computation can be determined by the results in Section 10.

It should be noted that XRF sampling methods measured barium, chromium, lead, and uranium. The reliability of the data for other metals analyzed using XRF was very unreliable so results for the other metals are not addressed in this document. XRF methods detected chromium in only four samples in the entire Soil Pile I area. PCB field methods measured Total PCBs, and ISOCS methods measured cesium-137 and uranium-238.

Summary statistics and UCLs for the XRF and ISOCS data were computed using Kaplan-Meier techniques to account for nondetect and also were computed using the raw values reported by the lab in place of undetected values. Kaplan-Meier is the method recommended by EPA (Singh 2006). It was of interest to see how computations made using the raw reported values in place of undetected results compared to Kaplan-Meier methods. The results from the two methods are listed in separate tables in Section B.9.1-B.9.5.

B.9.1 ANALYSIS OF SUBUNIT 1 DATA

B.9.1.1 XRF Data Summary for Subunit 1

Table B.65 lists the metals detected in the XRF data for subunit 1. Three of the four possible metals were detected. Two statistical outliers were identified in the uranium data. Summary statistics and UCLs were computed with and without these outliers and are listed in Tables B.66 and B.67, respectively. Laboratory results for field data for subunit 1 are listed in Appendix I of the SER.

Table B.65. Metals Detected in the Field Analyses of Surface Samples Associated with Subunit 1

Detected Metals	
Barium	Uranium
Lead	

Table B.66. Summary Statistics for Metals Computed Using Kaplan-Meier from Field Analysis of Soils Associated with Subunit 1

Analyte	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Barium	116	116	203.82	407.33	545.63	404	59.1	15
Lead	54	116	<7[a]	<7[a]	31.03	16.2	3.44	21
Uranium	21	116	<13[a]	NA[b]	130.39	NA[b]	NA[b]	NA[b]
Uranium (Outlier Removed)	20	115	<13[a]	NA[b]	95.89	NA[b]	NA[b]	NA[b]
Uranium (2 Outliers Removed)	19	114	<13[a]	NA[b]	49.48	NA[b]	NA[b]	NA[b]

NA = Not Applicable.

[a] The value for this statistic is based on a nondetected result. The value shown represents the MDL.

[b] An insufficient number of positively detected results (<30%) were reported for this analyte in order to calculate this statistic. The value for this statistic is based on a nondetected result.

Table B.67. Summary Statistics Computed Using Raw XRF Values in Place of Nondetects for Metals from Field Analysis of Soils Associated with Subunit 1

Analyte	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Barium	203.82	407.33	545.63	404	59.1	14.6
Chromium	-101.19	-37.305	29.5	-39.4	25.7	-65.3
Lead	-1.5	13.93	31.03	14.3	5.29	37.1
Uranium	-5.64	8.57	130.39	13.4	17.9	134

B.9.1.2 PCB Data Summary for Subunit 1

Total PCBs were measured and detected in the subunit 1 soils. The two detected PCB values appear to be statistical outliers because they are approximately 0.8 mg/kg greater than the largest detection limit of 1.82 mg/kg. More than 70% of the data were nondetects, so no summary statistics or UCLs were calculated for the PCB data. The maximum detected value is listed in Tables B.68 and B.70. Laboratory results, associated validation flags, and flag definitions for field data for subunit 1 are listed in Appendix I of the SER.

Table B.68. Summary Statistics for PCBs from Field Analysis of Soils Associated with Subunit 1

Analyte	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
PCB, Total	2	116	<1.71[a]	1.75[b]	2.64	NA[b]	NA[b]	NA[b]

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the smallest MDL.

[b] An insufficient number of positively detected results (<30%) were reported for this analyte in order to calculate this statistic.

B.9.1.3 ISOCS Data Summary for Subunit 1

Table B.69 lists the radionuclides detected in the ISOCS data for subunit 1. One statistical outlier was identified in the cesium-137 data. The uranium-238 data has more than 70% nondetects, so summary statistics and an UCL cannot be computed for the data. Some statistics are listed in Table B.66. Summary statistics and UCLs were computed for cesium-137 and also are listed in Tables B.70 and B.71, respectively. Laboratory results, associated validation flags, and flag definitions for field data for subunit 1 are listed in Appendix I of the SER.

Table B.69. Radionuclides Detected in the Field Samples Associated with Subunit 1

Detected Radionuclides	
Cesium-137	Uranium-238

Table B.70. Summary Statistics for Radionuclides Analytes Computed Using Kaplan-Meier from Field Analysis of Soils Associated with Subunit 1

Analyte	# Positive Detections	# Data Points	Minimum (pCi/g)	Median (pCi/g)	Maximum (pCi/g)	Mean (pCi/g)	Standard Deviation (pCi/g)	Coefficient of Variation (%)
Cesium-137	42	116	<0.147[a]	0.234[a]	0.999	0.312	0.0981	31
Cesium-137 (Outlier Removed)	41	115	<0.147[a]	0.233	0.589	0.306	0.0746	24
Uranium-238	1	116	<3.270[a]	<20.9[a]	49.87	NA[b]	NA[b]	NA[b]

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the minimum detectable activity.

[b] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

Table B.71. Summary Statistics Computed Using Raw ISOCS Values in Place of Nondetects for Metals from Field Analysis of Soils Associated with Subunit 1

Analyte	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Cesium-137	-0.024	0.258	0.999	0.268	0.135	50.5
Uranium-238	-9.66	3.27	49.87	4.68	8.27	177

B.9.1.4 Upper Confidence Limits for Field Data Analysis for Subunit 1

Tables B.72 and B.73 list the UCLs for the XRF, PCB, and ISOCS data detected in subunit 1. UCLs were calculated for data that had 70% or fewer nondetects. If more than 70% of the data were nondetects, the maximum detected value was reported in place of the UCL. Where one or more outliers were observed in the data, UCLs were computed with and without the outlier(s). If more than one outlier was present in the data, they were removed simultaneously if they were close in value; if the outliers were notably different from one another, they were removed separately. Removal of the outlier did not cause a noteworthy change in the UCL for cesium-137, but the changes in the UCL for uranium were very large when each outlier was removed.

Table B.72. Upper Confidence Limits Computed Using Kaplan-Meier from Field Analyses Associated with the Soils from Subunit 1

Analyte	Mean	Standard Deviation	Distribution	UCL Method	UCL
Metals	(mg/kg)	(mg/kg)			(mg/kg)
Barium	404	59.1	Normal	95% Student's-t UCL	413
Lead	16.2	3.44	Nonparametric	95% KM (% Bootstrap) UCL	16.8
Uranium	NA[a]	NA[a]	NA	NA	130[b]
Uranium (Outlier Removed)	NA[a]	NA[a]	NA	NA	95.9[b]
Uranium (2 Outliers Removed)	NA[a]	NA[a]	NA	NA	49.5[b]
Organics	(mg/kg)	(mg/kg)			(mg/kg)
PCB, Total	NA[a]	NA[a]	NA[b]	NA[b]	2.64[b]
Radionuclides	(pCi/g)	(pCi/g)			(pCi/g)
Cesium-137	0.312	0.0981	Approximate Gamma	95% KM (t) UCL	0.327
Cesium-137 (Outlier Removed)	0.306	0.0746	Gamma	95% KM (t) UCL	0.318
Uranium-238	NA[a]	NA[a]	NA	NA	49.87[b]

NA = Not Applicable.

[a] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

[b] Analyte was not detected in enough samples to compute an UCL. Reported value is the maximum detected value.

Table B.73. Upper Confidence Intervals Computed Using Raw XRF and ISOCS Values in Place of Nondetects for Metals from Field Analysis of Soils Associated with Subunit 1

Analyte	Mean	Standard Deviation	Distribution	UCL Method	UCL
Metals	(mg/kg)	(mg/kg)			(mg/kg)
Barium	404	59.1	Normal	95% Student's-t UCL	413.4
Chromium	-39.4	25.7	Normal	95% Student's-t UCL	-35.42
Lead	14.3	5.29	Normal	95% Student's-t UCL	15.07
Uranium	13.4	17.9	Nonparametric	Use 95% Chebyshev (Mean, Sd) UCL	20.63
Radionuclides	(pCi/g)	(pCi/g)			(pCi/g)
Cesium-137	0.268	0.135	Nonparametric	Use 95% Chebyshev (Mean, Sd) UCL	0.323
Uranium-238	4.68	8.27	Nonparametric	Use 95% Chebyshev (Mean, Sd) UCL	8.03

B.9.2 ANALYSIS OF SUBUNIT 2 DATA

B.9.2.1 XRF Data Summary for Subunit 2

Table B.74 lists the metals detected in the XRF data for subunit 2. Two of the four possible metals were detected. Three statistical outliers were identified in the lead data. Summary statistics and UCLs were computed with and without these outliers and are listed in Tables B.75 and B.76, respectively. Laboratory results, associated validation flags, and flag definitions for field data for subunit 2 are listed in Appendix J of the SER.

Table B.74. Metals Detected in the Field Samples Associated with Subunit 2

Detected Metals	
Barium	Lead

Table B.75. Summary Statistics for Metals Computed Using Kaplan-Meier from Field Analysis of Soils Associated with Subunit 2

Analyte	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Barium	115	116	<183[a]	459	704	461	57.81	13
Lead	81	116	<7[a]	18.52	225.47	21.83	20.720	95
Lead (Outlier Removed)	80	115	<7[a]	18.43	84.01	20.06	8.319	41
Lead (2 Outliers Removed)	79	114	<7[a]	18.34	53.21	19.5	5.799	30
Lead (3 Outliers Removed)	78	113	<7[a]	18.24	37.41	19.2	4.876	25

[a]The reported result was a nondetect. The value shown represents the MDL.

Table B.76. Summary Statistics Computed Using Raw XRF Values in Place of Nondetects for Metals from Field Analysis of Soils Associated with Subunit 2

Analyte	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Barium	-25.06	458.775	704.48	458	72.8	15.9
Chromium	-132.55	-40.3	35.26	-39.0	31.8	-81.5
Lead	1.43	18.52	225.47	21.1	21.1	100
Uranium	-14.96	1.7	11.89	1.17	4.66	399

B.9.2.2 PCB Data Summary for Subunit 2

Total PCBs was measured and detected in the subunit 2 soils. Although only four of the samples were detects, it is not possible to determine if the detects are statistical outliers. The distribution of the detects indicates that it is possible that none of the detected values are outliers. More than 70% of the data were nondetects, so no summary statistics or UCLs could be calculated for the PCB data. The maximum detected value is listed in Table B.77. Laboratory results, associated validation flags, and flag definitions for field data for subunit 2 are listed in Appendix J of the SER.

Table B.77. Summary Statistics for PCBs Computed Using Kaplan-Meier from Field Analysis of Soils Associated with Subunit 2

Analyte	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
PCB, Total	4	116	<1.63[a]	<1.71[b]	2.47	NA[c]	NA[c]	NA[c]

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the smallest value reported for the minimum detectable activity.

[b] The reported result was a nondetect. The value shown represents the largest value reported for the minimum detectable activity.

[c] An insufficient number of positively detected results (<30%) were reported for this analyte in order to calculate this statistic.

B.9.2.3 ISOCS Data Summary for Subunit 2

Table B.78 lists the radionuclides detected in the ISOCS data for subunit 2. No outliers were identified in the data. The uranium-238 data has more than 70% nondetects, so summary statistics and an UCL cannot be computed for the data. Some statistics are listed in Table B.79. Summary statistics and UCLs were computed for cesium-137 and are listed in Tables B.79 and B.80, respectively. Laboratory results, associated validation flags, and flag definitions for field data for subunit 2 are listed in Appendix J of the SER.

Table B.78. Radionuclides Detected In the Field Samples Associated with Subunit 2

Detected Radionuclides	
Cesium-137	

Table B.79. Summary Statistics for Radionuclides Analytes Computed Using Kaplan-Meier from Field Analysis of Soils Associated with Subunit 2

Analyte	# Positive Detections	# Data Points	Minimum (pCi/g)	Median (pCi/g)	Maximum (pCi/g)	Mean (pCi/g)	Standard Deviation (pCi/g)	Coefficient of Variation (%)
Cesium-137	43	116	<0.058[a]	<0.225[a]	0.619	0.165	0.151	92

[a] The reported result was a nondetect. The value shown represents the minimum detection limit.

Table B.80. Summary Statistics Computed Using Raw ISOCS Values in Place of Nondetects for Metals from Field Analysis of Soils Associated with Subunit 2

Analyte	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Cesium-137	-0.0683	0.246	0.619	0.248	0.113	45.4
Uranium-238	-15.7	1.26	12.7	1.20	5.15	429

B.9.2.4 Upper Confidence Limits for Field Data Analysis for Subunit 2

Tables B.81 and B.82 list the UCLs for the XRF, PCB, and ISOCS data detected in subunit 2. UCLs were calculated for data that have 70% or fewer nondetects. If more than 70% of the data were nondetects, the maximum detected value was reported in place of the UCL. Where one or more outliers were observed in the data, UCLs were computed with and without the outlier(s). If more than one outlier was present in the data, they were removed simultaneously if they were close in value; if the outliers were notably different from one another, they were removed separately. Removal of outliers caused a notable but not excessive change in the lead data.

Table B.81. Upper Confidence Limits Computed Using Kaplan-Meier from Field Analyses Associated with the Soils from Subunit 2

Analyte	Mean	Standard Deviation	Distribution	UCL Method	UCL
Metals	(mg/kg)	(mg/kg)			(mg/kg)
Barium	461	57.81	Normal	95% KM (Percentile Bootstrap) UCL	470
Lead	21.83	20.720	Nonparametric	95% KM (BCA) UCL	25.8
Lead (Outlier Removed)	20.06	8.319	Nonparametric	95% KM (BCA) UCL	21.7
Lead (2 Outliers Removed)	19.5	5.799	Approximate Gamma	95% KM (Percentile Bootstrap) UCL	20.5
Lead (3 Outliers Removed)	19.2	4.876	Gamma	95% KM (Percentile Bootstrap) UCL	20.1
Organics	(mg/kg)	(mg/kg)			(mg/kg)
PCB, Total	NA[a]	NA[a]	NA	NA	2.47[b]
Radionuclides	(pCi/g)	(pCi/g)			(pCi/g)
Cesium-137	0.165	0.151	Nonparametric	95% KM (% Bootstrap) UCL	0.297

NA = Not Applicable.

[a] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

[b] Analyte was not detected in enough samples to compute an UCL. Reported value is the maximum detected value.

Table B.82. Upper Confidence Limits Computed Using Raw XRF and ISOCS Values in Place of Nondetects for Metals from Field Analysis of Soils Associated with Subunit 2

Analyte	Mean	Standard Deviation	Distribution	UCL Method	UCL
Metals	(mg/kg)	(mg/kg)			(mg/kg)
Barium	458	72.8	Nonparametric	Use 95% Chebyshev (Mean, Sd) UCL	487.2
Chromium	-39.0	31.8	Normal	95% Student's-t UCL	-34.07
Lead	21.1	21.1	Nonparametric	or 95% Modified-t UCL	24.61
Uranium	1.17	4.66	Normal	95% Student's-t UCL	1.884
Radionuclides	(pCi/g)	(pCi/g)			(pCi/g)
Cesium-137	0.248	0.113	Normal	95% Student's-t UCL	0.265
Uranium-238	1.20	5.15	Normal	95% Student's-t UCL	1.995

B.9.3 ANALYSIS OF SUBUNIT 3 DATA

B.9.3.1 XRF Data Summary for Subunit 3

Table B.83 lists the metals detected in the XRF data for subunit 3. All four possible metals were detected. An interesting phenomenon occurred in the XRF data in this subunit. Each of the metals had a value that was detected with a recorded value of zero. This value came from a sample that was collected but not analyzed; therefore, it was removed from each of the XRF metals prior to computing summary statistics and UCLs. The rest of the text and tables in this subsection address the data with the zero values removed. One statistical outlier was identified in the uranium data. Summary statistics and UCLs were computed with and without this outlier and are listed in Tables B.84 and B.85, respectively. Laboratory results, associated validation flags, and flag definitions for field data for subunit 3 are listed in Appendix K of the SER.

Table B.83. Metals Detected in the Field Samples Associated with Subunit 3

Detected Metals	
Barium	Lead
Chromium	Uranium

Table B.84. Summary Statistics for Metals Computed Using Kaplan-Meier from Field Analysis of Soils Associated with Subunit 3

Analyte	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Barium	115	115	108.9	336.25	537.26	344	87.3	25
Chromium	3	115	185	<218[a]	528.44	NA[b]	NA[b]	NA[b]
Lead	35	115	<7[a]	<7[a]	35.07	16.4	3.41	21
Uranium	61	115	<13[a]	25.17	473.19	62.9	80.1	127
Uranium (Outlier Removed)	60	114	<13[a]	25.055	373.72	59.3	70.6	119

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the minimum detection limit.

[b] An insufficient number of positively detected results (<30%) were reported for this analyte in order to calculate this statistic.

Table B.85. Summary Statistics Computed Using Raw XRF Values in Place of Nondetects for Metals from Field Analysis of Soils Associated with Subunit 3

Analyte	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Barium	108.92	336.25	537.26	344	87.3	25.4
Chromium	-119.84	-37.75	528.44	-26.5	70.7	-267
Lead	-26.95	12.34	35.07	11.1	9.69	87.0
Uranium	-7.84	25.17	473.19	56.4	84.0	149

B.9.3.2 PCB Data Summary for Subunit 3

Total PCBs were measured and detected in the subunit 3 soils. Two of the detected values appear to be statistical outliers. More than 70% of the data were nondetects, so no summary statistics or UCLs could be calculated for the PCB data. The maximum detected value is listed in Table B.86. Laboratory results, associated validation flags, and flag definitions for field data for subunit 3 are listed in Appendix K of the SER.

Table B.86. Summary Statistics for PCBs from Field Analysis of Soils Associated with Subunit 3

Analyte	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
PCB, Total	19	116	<1.63[a]	1.69[a]	4.30	NA[b]	NA[b]	NA[b]

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the MDL.

[b] An insufficient number of positively detected results (<30%) were reported for this analyte in order to calculate this statistic.

B.9.3.3 ISOCS Data Summary for Subunit 3

Table B.87 lists the radionuclides detected in the ISOCS data for subunit 3. No statistical outliers were identified in the data. The uranium-238 data contains more than 70% nondetects, so summary statistics and an UCL cannot be computed for the data. Some statistics are listed in Table B.88. Summary statistics and UCLs were computed for cesium-137 and are listed in Tables B.88 and B.89, respectively. Laboratory results, associated validation flags, and flag definitions for field data for subunit 3 are listed in Appendix K of the SER.

Table B.87. Radionuclides Detected in the Field Samples Associated with Subunit 3

Detected Radionuclides	
Cesium-137	Uranium-238

Table B.88. Summary Statistics for Radionuclides Analytes Computed Using Kaplan-Meier from Field Analysis of Soils Associated with Subunit 3

Analyte	# Positive Detections	# Data Points	Minimum (pCi/g)	Median (pCi/g)	Maximu m (pCi/g)	Mean (pCi/g)	Standard Deviation (pCi/g)	Coefficient of Variation (%)
Cesium-137	36	116	<0.0007[a]	<0.216[a]	0.659	0.277	0.0827	30
Uranium-238	6	116	<18.3[a]	<21.7[a]	140	NA[b]	NA[b]	NA[b]

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents a detection limit.

[b] An insufficient number of positively detected results (<30%) were reported for this analyte in order to calculate this statistic.

Table B.89. Summary Statistics Computed Using Raw ISOCS Values in Place of Nondetects for Metals from Field Analysis of Soils Associated with Subunit 3

Analyte	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Cesium-137	0.0763	0.248	0.659	0.263	0.104	39.5
Uranium-238	-6.54	8.19	140	16.0	23.9	149

B.9.3.4 Upper Confidence Limits for Field Data Analysis for Subunit 3

Tables B.90 and B.91 list the UCLs for the XRF, PCB, and ISOCS data detected in subunit 3. UCLs were calculated for data that had 70% or fewer nondetects. If more than 70% of the data were nondetects, the maximum detected value was reported in place of the UCLs. Where one or more outliers were observed in the data, UCLs were computed with and without the outlier(s). If more than one outlier was present in the data, they were removed simultaneously if they were close in value; if the outliers were notably different from one another, they were removed separately. Removal of the uranium outlier caused a notable but not excessive change in the UCL.

Table B.90. Upper Confidence Limits Computed Using Kaplan-Meier from Field Analyses Associated with the Soils from Subunit 3

Analyte	Mean	Standard Deviation	Distribution	UCL Method	UCL
Metals	(mg/kg)	(mg/kg)			(mg/kg)
Barium	344	87.3	Normal	95% Student's-t UCL	358
Chromium	NA[a]	NA[a]	NA	NA	528[b]
Lead	16.4	3.41	Approximate Gamma	95% KM (t) UCL	16.9
Uranium	62.9	80.1	Nonparametric	95% KM (% Bootstrap) UCL	76.1
Uranium (Outlier Removed)	59.3	70.6	Lognormal	95% KM (% Bootstrap) UCL	70.6
Organics	(mg/kg)	(mg/kg)			(mg/kg)
PCB, Total	NA[a]	NA[a]	NA	NA	4.30[b]
Radionuclides	(pCi/g)	(pCi/g)			(pCi/g)
Cesium-137	0.277	0.0827	Normal	95% KM (Percentile Bootstrap) UCL	0.306
Uranium-238	NA[a]	NA[a]	NA	NA	140[b]

NA = Not Applicable.

[a] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

[b] Analyte was not detected in enough samples to compute an UCL. Reported value is the maximum detected value.

Table B.91. Upper Confidence Limits Computed Using Raw XRF and ISOCS Values in Place of Nondetects for Metals from Field Analysis of Soils Associated with Subunit 3

Analyte	Mean	Standard Deviation	Distribution	UCL Method	UCL
Metals	(mg/kg)	(mg/kg)			(mg/kg)
Barium	344	87.3	Normal	95% Student's-t UCL	357.6
Chromium	-26.5	70.7	Nonparametric	Use 95% Chebyshev (Mean, Sd) UCL	2.251
Lead	11.1	9.69	Nonparametric	Use 95% Chebyshev (Mean, Sd) UCL	15.09
Uranium	56.4	84.0	Nonparametric	Use 95% Chebyshev (Mean, Sd) UCL	90.53
Radionuclides	(pCi/g)	(pCi/g)			(pCi/g)
Cesium-137	0.263	0.104	Gamma	95% Approximate Gamma UCL	0.28
Uranium-238	16.0	23.9	Nonparametric	Use 95% Chebyshev (Mean, Sd) UCL	25.76

B.9.4 ANALYSIS OF SUBUNIT 4 DATA

B.9.4.1 XRF Data Summary for Subunit 4

Table B.92 lists the metals detected in the XRF data for subunit 4. Three of the four possible metals were detected. Two statistical outliers were identified in the lead data. Summary statistics and UCLs were computed with and without outliers and are listed in Tables B.93 and B.94, respectively. Laboratory results, associated validation flags, and flag definitions for field data for subunit 4 are listed in Appendix L of the SER.

Table B.92. Metals Detected in the Field Samples Associated with Subunit 4

Detected Metals	
Barium	Uranium
Lead	

Table B.93. Summary Statistics for Metals Computed Using Kaplan-Meier from Field Analysis of Soils Associated with Subunit 4

Analyte	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Barium	116	116	182.76	380.24	606.17	374	80.3	21
Lead	62	116	<7[a]	15.09	58.36	17.7	6.15	35
Lead (2 Outliers Removed)	60	114	<7[a]	14.76	31.7	17.1	3.71	22
Uranium	6	116	<13[a]	NA[b]	321.36	NA[b]	NA[b]	NA[b]

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the minimum detection limit.

[b] An insufficient number of positively detected results (<30%) were reported for this analyte in order to calculate this statistic.

Table B.94. Summary Statistics Computed Using Raw XRF Values in Place of Nondetects for Metals from Field Analysis of Soils Associated with Subunit 4

Analyte	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Barium	182.76	380.24	606.17	374	80.2	21.4
Chromium	-106.88	-33.42	114.48	-32.7	36.2	-111
Lead	-22.47	15.43	58.36	16.3	7.97	48.9
Uranium	-10.31	3.21	321.36	8.58	34.3	400

B.9.4.2 PCB Data Summary for Subunit 4

Total PCBs were measured and detected in the subunit 4 soils. Two statistical outliers were identified in the data. More than 70% of the data were nondetects, so no summary statistics or UCLs could be calculated for the PCB data. The maximum detected value is listed in Table B.95. Laboratory results, associated validation flags, and flag definitions for field data for subunit 4 are listed in Appendix L of the SER.

Table B.95. Summary Statistics for PCBs from Field Analysis of Soils Associated with Subunit 4

Analyte	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
PCB, Total	26	116	<1.59[a]	<1.69[a]	5.77	NA[b]	NA[b]	NA[b]
PCB, Total (Outlier Removed)	25	115	<1.59[a]	<1.69[a]	4.56	NA[b]	NA[b]	NA[b]
PCB, Total (2 Outliers Removed)	24	114	<1.59[a]	<1.69[a]	3.71	NA[b]	NA[b]	NA[b]

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents a detection limit.

[b] An insufficient number of positively detected results (<30%) were reported for this analyte in order to calculate this statistic.

B.9.4.3 ISOCS Data Summary for Subunit 4

Table B.96 lists the radionuclides detected in the ISOCS data for subunit 4. No statistical outliers were identified in the data. The uranium-238 data has more than 70% nondetects, so summary statistics and an UCL cannot be computed for the data. Some statistics are listed in Table B.97. Summary statistics and UCLs were computed for cesium-137 and are listed in Tables B.97 and B.98, respectively. Laboratory results, associated validation flags, and flag definitions for field data for subunit 4 are listed in Appendix L of the SER.

Table B.96. Radionuclides Detected in the Field Samples Associated with Subunit 4

Detected Radionuclides	
Cesium-137	Uranium-238

Table B.97. Summary Statistics for Radionuclides Analytes Computed Using Kaplan-Meier from Field Analysis of Soils Associated with Subunit 4

Analyte	# Positive Detections	# Data Points	Minimum (pCi/g)	Median (pCi/g)	Maximum (pCi/g)	Mean (pCi/g)	Standard Deviation (pCi/g)	Coefficient of Variation (%)
Cesium-137	41	116	<0.0557[a]	0.262	0.693	0.346	0.0872	25
Uranium-238	2	116	<0[a]	NA[b]	201	NA[b]	NA[b]	NA[b]

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the minimum detection limit.

[b] An insufficient number of positively detected results (<30%) were reported for this analyte in order to calculate this statistic.

Table B.98. Summary Statistics Computed Using Raw ISOCS Values in Place of Nondetects for Metals from Field Analysis of Soils Associated with Subunit 4

Analyte	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Cesium-137	-0.0823	0.233	0.693	0.246	0.160	65.0
Uranium-238	-18.4	2.05	201	4.51	20.4	452

B.9.4.4 Upper Confidence Limits for Field Data Analysis for Subunit 4

Tables B.99 and B.100 list the UCLs for the XRF, PCB, and ISOCS data detected in subunit 4. UCLs were calculated for data that had 70% or fewer nondetects. If more than 70% of the data were nondetects, the maximum detected value was reported in place of the UCLs. Where one or more outliers were observed in the data, UCLs were computed with and without the outlier(s). If more than one outlier was present in the data, they were removed simultaneously if they were close in value; if the outliers were notably different from one another, they were removed separately. Removal of the lead outlier caused a minor change in the UCL.

Table B.99. Upper Confidence Limits Computed Using Kaplan-Meier from Field Analyses Associated with the Soils from Subunit 4

Analyte	Mean	Standard Deviation	Distribution	UCL Method	UCL
Metals	(mg/kg)	(mg/kg)			(mg/kg)
Barium	374	80.3	Normal	95% Student's-t UCL	387
Lead	17.7	6.15	Nonparametric	95% KM (% Bootstrap) UCL	18.7
Lead (2 Outliers Removed)	17.1	3.71	Approximate Gamma	95% KM (t) UCL	17.6
Uranium	NA[a]	NA[a]	NA	NA	321[b]
Organics	(mg/kg)	(mg/kg)			(mg/kg)
PCB, Total	NA[a]	NA[a]	NA	NA	5.77[b]
PCB, Total (Outlier Removed)	NA[a]	NA[a]	NA	NA	4.56[b]
PCB, Total (2 Outliers Removed)	NA[a]	NA[a]	NA	NA	3.71[b]

Table B.99. Upper Confidence Limits Computed Using Kaplan-Meier from Field Analyses Associated with the Soils from Subunit 4 (Continued)

Analyte	Mean	Standard Deviation	Distribution	UCL Method	UCL
Radionuclides	(pCi/g)	(pCi/g)			(pCi/g)
Cesium-137	0.346	0.0872	Nonparametric	95% KM (% Bootstrap) UCL	0.348
Uranium-238	NA[a]	NA[a]	NA	NA	201[b]

NA = Not Applicable.

[a] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

[b] Analyte was not detected in enough samples to compute an UCL. Reported value is the maximum detected value.

Table B.100. Upper Confidence Limits Computed Using Raw XRF and ISOCS Values in Place of Nondetects for Metals from Field Analysis of Soils Associated with Subunit 1

Analyte	Mean	Standard Deviation	Distribution	UCL Method	UCL
Metals	(mg/kg)	(mg/kg)			(mg/kg)
Barium	374	80.2	Normal	95% Student's-t UCL	386.8
Chromium	-32.7	36.2	Normal	95% Student's-t UCL	-27.15
Lead	16.3	7.97	Nonparametric	Use 95% Chebyshev (Mean, Sd) UCL	19.51
Uranium	8.58	34.3	Nonparametric	Use 95% Chebyshev (Mean, Sd) UCL	22.45
Radionuclides	(pCi/g)	(pCi/g)			(pCi/g)
Cesium-137	0.246	0.160	Normal	95% Student's-t UCL	0.27
Uranium-238	4.51	20.4	Nonparametric	Use 95% Chebyshev (Mean, Sd) UCL	12.77

B.9.5 ANALYSIS OF SUBUNIT 5 DATA

B.9.5.1 XRF Data Summary for Subunit 5

Table B.101 lists the metals detected in the XRF data for subunit 5. Three of the four possible metals were detected. Three statistical outliers were identified in the lead data. Summary statistics and UCLs were computed with and without these outliers and are listed in Tables B.102 and B.103, respectively. Laboratory results, associated validation flags, and flag definitions for field data for subunit 5 are listed in Appendix M of the SER.

Table B.101. Metals Detected in the Field Samples Associated with Subunit 5

Detected Metals	
Barium	Uranium
Lead	

Table B.102. Summary Statistics for Metals Computed Using Kaplan-Meier from Field Analysis of Soils Associated with Subunit 5

Analyte	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Barium	84	84	231.54	436.48	636.34	437	61.0	14
Lead	75	84	<7[a]	20.41	209.69	38.2	40.9	107
Lead (3 Outliers Removed)	72	81	<7[a]	19.95	114.08	32.1	26.4	82
Uranium	1	84	<13[a]	NA[b]	30.16	NA[b]	NA[b]	NA[b]

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the minimum detection limit.

[b] An insufficient number of positively detected results (<30%) were reported for this analyte in order to calculate this statistic.

Table B.103. Summary Statistics Computed Using Raw XRF Values in Place of Nondetects for Metals from Field Analysis of Soils Associated with Subunit 5

Analyte	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Barium	231.54	436.48	636.34	437	61.0	14.0
Chromium	-118.53	-39.71	22.07	-40.2	27.4	-68.3
Lead	8.77	20.42	209.69	38.0	41.2	109
Uranium	-10.3	2.23	30.16	2.34	5.47	234

B.9.5.2 PCB Data Summary for Subunit 5

Total PCBs were measured and detected in the subunit 5 soils. The two detected results are 1 and 2 mg/kg greater than the largest detection limit so they are possibly outliers. More than 70% of the data were nondetects, so no summary statistics or UCLs could be calculated for the PCB data. The maximum detected value is listed in Table B.104. Laboratory results, associated validation flags, and flag definitions for field data for subunit 5 are listed in Appendix M of the SER.

Table B.104. Summary Statistics for PCBs from Field Analysis of Soils Associated with Subunit 5

Analyte	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
PCB, Total	2	84	1.78[a]	1.78[b]	3.12	NA[c]	NA[c]	NA[c]

NA = Not Applicable.

aThe reported result was a nondetect. The value shown represents the minimum detection limit.

[b] The reported result was a nondetect. The value shown represents the maximum detection limit.

[c] An insufficient number of positively detected results (<30%) were reported for this analyte in order to calculate this statistic.

B.9.5.3 ISOCS Data Summary for Subunit 5

Table B.105 lists the radionuclides detected in the ISOCS data for subunit 5. None of the detected values were notably larger than the detection limit, so it cannot be determined if these points are outliers. The uranium-238 and cesium-137 data have more than 70% nondetects, so summary statistics and an UCL cannot be computed for the data. Some statistics are listed in Tables B.106 and B.107. Laboratory results, associated validation flags, and flag definitions for field data for subunit 5 are listed in Appendix M of the SER.

Table B.105. Radionuclides Detected in the Field Samples Associated with Subunit 5

Detected Radionuclides	
Cesium-137	Uranium-238

Table B.106. Summary Statistics for Radionuclides Analytes Computed Using Kaplan-Meier from Field Analysis of Soils Associated with Subunit 5

Analyte	# Positive Detections	# Data Points	Minimum (pCi/g)	Median (pCi/g)	Maximum (pCi/g)	Mean (pCi/g)	Standard Deviation (pCi/g)	Coefficient of Variation (%)
Cesium-137	9	84	<0.056[a]	<0.30[a]	0.67	NA[b]	NA[b]	NA[b]
Uranium-238	7	84	<5.28[a]	35.1[b]	18.4	NA[c]	NA[c]	NA[c]

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the minimum detection limit.

[b] The reported result was a nondetect. The value shown represents the maximum detection limit.

[c] An insufficient number of positively detected results (<30%) were reported for this analyte in order to calculate this statistic.

Table B.107. Summary Statistics Computed Using Raw ISOCS Values in Place of Nondetects for Metals from Field Analysis of Soils Associated with Subunit 5

Analyte	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	Coefficient of Variation (%)
Cesium-137	-0.110	0.211	0.670	0.220	0.163	74.4
Uranium-238	-20.9	3.07	18.4	2.32	7.20	310

B.9.5.4 Upper Confidence Limits for Field Data Analysis for Subunit 5

Tables B.108 and B.109 list the UCLs for the XRF, PCB, and ISOCS data detected in subunit 5. UCLs were calculated for data that had 70% or fewer nondetects. If more than 70% of the data were nondetects, the maximum detected value was reported in place of the UCLs. Where one or more outliers were observed in the data, UCLs were computed with and without the outlier(s). If more than one outlier was present in the data, they were removed simultaneously if they were close in value; if the outliers were notably different from one another, they were removed separately. Removal of the lead outliers caused a notable change in the UCL.

Table B.108. Upper Confidence Limits Computed Using Kaplan-Meier from Field Analyses Associated with the Soils from Subunit 5

Analyte	Mean	Standard Deviation	Distribution	UCL Method	UCL
Metals	(mg/kg)	(mg/kg)			(mg/kg)
Barium	437	61.0	Normal	95% Student's-t UCL	448
Lead	38.2	40.9	Nonparametric	95% KM (BCA) UCL	46.0
Lead (3 Outliers Removed)	32.1	26.4	Nonparametric	95% KM (BCA) UCL	37.3
Uranium	NA[a]	NA[a]	NA	NA	30.1[b]
Organics	(mg/kg)	(mg/kg)			(mg/kg)
PCB, Total	NA[a]	NA[a]	NA	NA	3.12[b]
Radionuclides	(pCi/g)	(pCi/g)			(pCi/g)
Cesium-137	NA[a]	NA[a]	NA	NA	0.67[b]
Uranium-238	NA[a]	NA[a]	NA	NA	18.4[b]

NA = Not Applicable.

[a] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

[b] Analyte was not detected in enough samples to compute a UCL. Reported value is the maximum detected value.

Table B.109. Upper Confidence Limits Computed Using Raw XRF and ISOCS Values in Place of Nondetects for Metals from Field Analysis of Soils Associated with Subunit 5

Analyte	Mean	Standard Deviation	Distribution	UCL Method	UCL
Metals	(mg/kg)	(mg/kg)			(mg/kg)
Barium	437	61.0	Normal	95% Student's-t UCL	448.3
Chromium	-40.2	27.4	Normal	95% Student's-t UCL	-35.2
Lead	38.0	41.2	Nonparametric	Use 95% Chebyshev (Mean, Sd) UCL	57.58
Uranium	2.34	5.47	Normal	95% Student's-t UCL	3.335
Radionuclides	(pCi/g)	(pCi/g)			(pCi/g)
Cesium-137	0.220	0.163	Normal	95% Student's-t UCL	0.249
Uranium-238	2.32	7.20	Normal	95% Student's-t UCL	3.63

B.9.6 CONCLUSIONS

The results for the XRF and ISOCS presented in the previous section compare two ways of handling nondetects in the data. Calculations were done using Kaplan-Meier, the EPA recommended method of handling nondetects (Singh 2006), and substituting the raw values reported from the field method in place of the nondetects. Many of the means and UCLs are very similar for both methods; however, there are some interesting differences. Chromium, which was undetected in all samples, always had a mean and a UCL that was negative when the raw values were used. Uranium, which had a large number of nondetects in all of the subunits, always had a UCL that was considerably less than the maximum detected value. For example, the UCL for uranium in subunit 5 was 3.33, but the maximum value was 30.1. The same phenomenon also was seen with uranium-238. There were no major discrepancies between the methods for lead and cesium-137 data; however, these two analytes had far fewer nondetects than the other analytes with the exception of barium, which had no nondetects. It appears that when the raw values are substituted for the undetected values for analytes with a high proportion of nondetects, the mean and UCL are grossly underestimated due to the large number of negative values that are present in the data. Thus, it is not recommended substituting the raw values in place of undetected values for computation of summary statistics and UCLs.

B.10 COMPARISON OF FIELD AND LABORATORY DATA

One of the objectives of this DQA is to determine the efficacy of field data in this area. This is done by comparing the results seen in the fixed laboratory data with the data obtained from field analysis of surface soil samples. In order for this comparison to be effective, it is important that the laboratory and field samples are directly comparable. Samples were collected from subunits 1 through 4. The laboratory samples were collected from four clusters (segments) in subunits 1 through 4, and data consisted of five random composited samples from each of the four segments. Each of these samples was split into two subsamples. One subsample from each was analyzed using field techniques and the other subsample was analyzed via fixed laboratory analysis.

Several different techniques were used to determine the efficacy of the field data. The first set of analyses consists of simple correlations. If it can be shown that there is strong correlation between the field and laboratory data for a particular analyte, then it follows that the field data is a good predictor of what will be seen in fixed laboratory data analysis. This is the most desirable relationship between the data.

The second analysis for the field data is to determine the ability of the field data to detect data that should be detected. Different measurements such as the false negative and false positive rates for the field data as well as the ability of the field data to determine if concentrations are above or below critical levels are reported.

The third set of comparisons is a UCL comparison. Even if the data do not correlate well on a sample-by-sample basis, it is possible that UCLs obtained from fixed laboratory and from field data may be comparable overall for a site. UCLs were computed for fixed laboratory data and for the field grab data and are presented in Sections B.8 and B.9 of this document. UCLs also were computed from the field composite data that were obtained from the same composites from which the fixed laboratory data were acquired. Such a comparison allows the data user to determine if the advantage of a large number of samples analyzed using field techniques can overcome the large variability of field methods to produce a UCL that is comparable to a UCL computed from a smaller number of samples.

The fourth comparison is a relationship comparison that is done by bubble plots. Bubbles representing field data and bubbles representing the fixed laboratory data are placed on the same graph in different colors so that the data user can see the relationship between the two sets of data. This type of comparison shows the efficacy of field data as a screening tool. If the field data can be shown to be effective as a screening method, it can be used as part of a two-stage sampling technique to direct fixed laboratory sampling at large sites.

B.10.1 CORRELATION ANALYSIS OF FIELD DATA TO FIXED LABORATORY DATA

Field and fixed laboratory results were directly compared point by point to determine how well values obtained from field analysis directly corresponded to concentrations obtained through fixed laboratory analysis. This was done by performing a correlation analysis on the measured analytes. The Pearson Product moment correlation coefficient (*r*) was computed for each pair of analytes that was detected. The correlation coefficient (*r*) is a number between -1 and 1 that indicates the strength of the relationship between two analytes. A correlation of 0 indicates no relationship and a correlation of 1, or -1, indicates a 1-to-1 relationship between the two analytes. If the correlation between two variables is equal to 1, then given the concentration of one variable, the concentration of the other variable can be precisely determined. The closer a correlation is to 1, or -1, the stronger the correlation between the analyte concentrations. If the correlation is positive, it indicates that the relationship is positive. Larger concentrations in the field data are associated with larger concentration in the fixed laboratory data. If the correlation is negative, then the relationship between the two analyte concentrations is negative, (larger concentrations in fixed laboratory data are associated with smaller concentrations in the field data). The correlation coefficient detects only linear relationships so it is possible that two variables can be highly correlated with a nonlinear relationship and have a correlation coefficient close to zero; therefore, scatter plots were made for each of the variables to determine if a nonlinear relationship exists. If a linear relationship exists or if the data can be transformed to have a high correlation, regression can be used to establish a predictive relationship between the field and fixed laboratory data. That is, a model could be created that would allow the data user to determine approximately what a fixed laboratory result would be from a result obtained via field methods. The strength of the correlation directly compares to the ability of a regression model to make such estimations (Hamilton 1993).

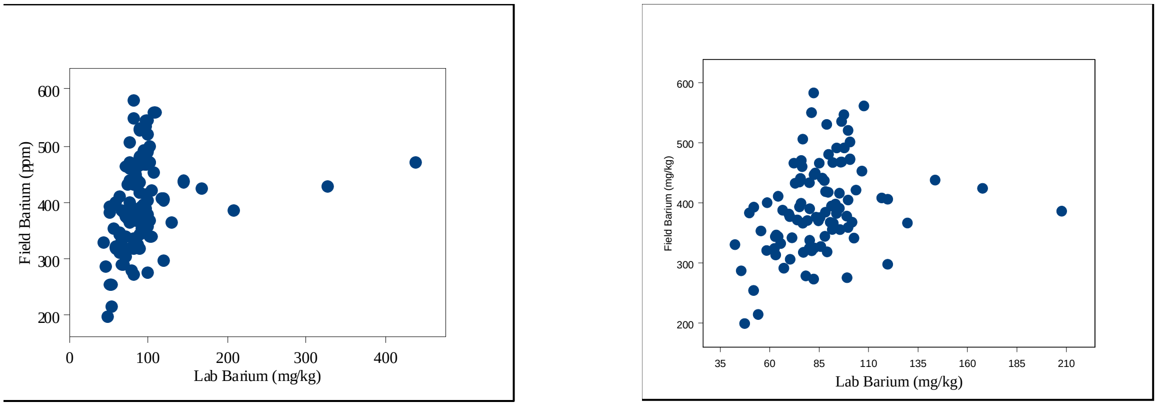
Table B.110 shows the correlations coefficients for the fixed laboratory and field data. Correlation coefficients were not calculated for chromium or uranium-238 because of the lack of detects in the field data. Correlations also were not calculated for uranium and PCBs because so few of the data were detected that the correlations could not be interpreted. Nondetects also were present in the cesium-137 and lead data, which makes the correlations coefficient unstable; however, the calculation still was performed using the undetected data to provide a rough estimate of the correlation between field and fixed laboratory data. Barium was detected in all of the field samples. Figure B.1 shows the scatter plots that compare the field and fixed laboratory data. Scatter plots include undetected results.

The correlation coefficients show that the correlation between field and fixed laboratory data for barium and cesium-137 is weak. The correlation for the lead data appears to be quite strong, but closer investigation of the data and the scatter plot shows that this *r*-value is inflated because of the large number of nondetects. None of the scatter plots show a clear nonlinear relationship. The scatter plots show that the barium data contains two clear statistical outliers. These were removed, a new scatter plot was made, and the correlation was recalculated. The scatter plot looks a little more linear and the correlation coefficient increases, but the correlation for the barium data is still weak; therefore, it appears that none of the correlations are very strong and the field data are not a good predictor of the actual values that will be observed in fixed laboratory analysis. The large number of nondetects in the data makes it difficult to interpret the correlation results for any of the analytes with the exception of barium.

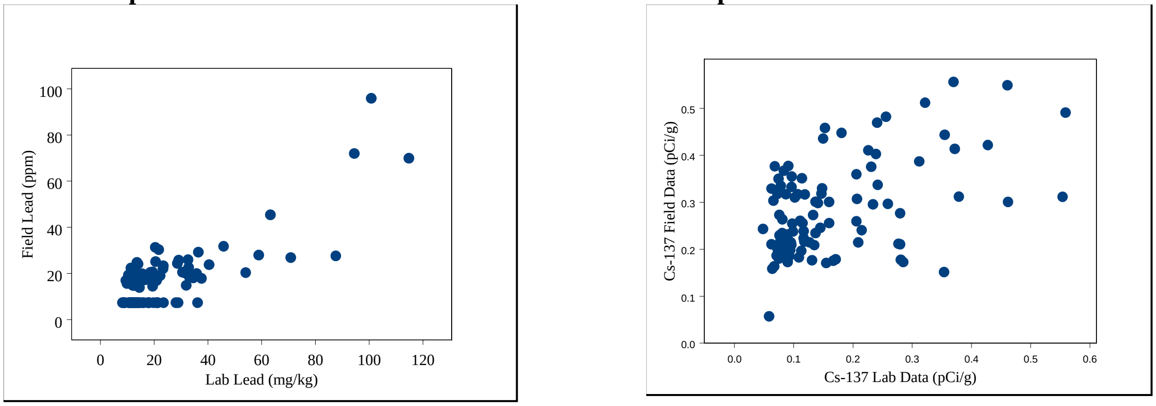
Table B.110. Correlation Analysis of Field Data Versus Fixed Laboratory Data

Analyte	Correlation Coefficient
Barium	0.25
Barium (Outliers Removed)	0.31
Chromium	ND
Lead	0.80
Uranium	NA
PCBs	NA
Cesium-137	0.50
Uranium-238	ND

ND = Not detected.



Scatter plot of barium data with outliers **Scatter plot of barium data with outliers removed**



Scatter plot of lead data **Scatter plot of cesium-137 data**

Figure B.1. Scatter Plots Showing the Relationship between Fixed Laboratory and Field Data

B.10.2 PERFORMANCE SUMMARY OF FIELD DATA

This section addresses the ability of the field data to determine concentrations of analytes around critical values such as detection limits, background levels (DOE 2001), and no action limits when compared with results concentrations measured with fixed laboratory methods. This type of analysis is helpful because of the large number of nondetects. Summaries in this section present the field data values that should not have been detected (false positive results) and the field data values that should have been detected (false negative results). It also is desirable to determine some level of performance of field methods away from the detection limit; thus, the data were compared to background levels (DOE 2001) and to the teen recreational user no action limits in the same manner to determine the type of information field methods potentially can provide in decision making. Table B.111 shows a summary of detection rates in the field and the fixed laboratory data. Table B.112 lists the no action limits and background levels for each analyte. These numbers are provided so the data user has a complete frame of reference when assessing the rates listed in Tables B.113 and B.114.

The rates of false positive and false negative results were determined for each of the analytes detected in the field data. These were determined by assuming that the numbers acquired from fixed laboratory methods reflected the true concentrations in a sample. If the fixed laboratory analysis determined that a the concentration of an analyte in the sample was greater than the critical value but the field method measured the concentration as less than the critical value, then that sample was considered a false negative. If the fixed laboratory analysis determined that a the concentration of an analyte in the sample was less than the critical value but the field method measured the concentration as greater than the critical value, then that sample was considered a false positive. The percentage of the field data that were false negatives and false positives for analytes with detected field results is reported in Table B.113.

Chromium and uranium-238 were not detected in any of the field samples; therefore, a different set of comparisons was used for these two analytes. The analysis for these analytes consisted of determining if the method was able to detect the analyte in levels that were less than the critical values. This was done by comparing the detection limit reported for each sample with each critical value. The percentage of fixed laboratory data that exceeded a critical value also is reported to provide the data user with a frame of reference for these numbers. Table B.114 lists the summary for chromium and uranium-238.

Results from Table B.113 show that lead and uranium have a large number of false negatives (40% and 16 % respectively). Large percentages of the barium and PCB field data exceeded the background values and no action limits when the fixed laboratory data indicated that the actual concentrations were less than background and the no action limits. The uranium field data indicate that the no action limit was not exceeded in 89% of the samples when fixed laboratory data show that the actual concentrations are greater than the no action limit. Results from Table B.114 show that the chromium and uranium-238 field detection limits were greater than background and the uranium-238 detection limit also was above the no action limit; therefore, chromium and uranium-238 field techniques are not effective in making decisions with respect to risk.

Table B.111. Summary of Detection Rates for Fixed Laboratory and Field Data

Analyte	Number of Samples	Percent Detected in Laboratory Data	Percent Detected in Field Data	Percent Detected in Both Field and Laboratory Data
Barium	98	100	100	100
Chromium	98	100	0	0
Lead	98	100	59	59
Uranium	98	100	18	18
PCB	60	45	13	8
Cesium-137	98	74	36	26
Uranium-238	95	100	1	1

Table B.112. No Action Limits and Background Levels for Field Data Analytes

Analyte	No Action Limit	Background Value	Detection Limit
	(mg/kg)	(mg/kg)	(mg/kg)
Barium	148	200	NA
Chromium	227	16	218
Lead	400	36	7
Uranium	14.7	4.9	13
PCBs (Low)	0.127	NA	1.59-1.82
	(pCi/g)	(pCi/g)	(pCi/g)
Cs-137	0.178	0.49	0.06-0.44
U-238	3.64	1.2	3.27-67.9

Table B.113. Performance of Field Data Around the Detection Limits, No Action Limits, and Background Levels

Analyte	Percent of False Positive Results	Percent of False Negative Results	Percent of False Positive Results	Percent of False Negative Results	Percent of False Positive Results	Percent of False Negative Results
	Field Detection Limit		No Action Limit		Background	
Barium	0	0	96	0	96	0
Lead	0	40	0	9	0	16
Uranium	0	16	0	89	0	0
	Field Detection Limit		High-Risk No Action Limit			
PCBs	5	0	50	0		
	Field Detection Limit		No Action Limit		Background	
Cesium-137	10	10	0	9	9	6

Table B.114. Performance of Field Data for Chromium, Uranium, and Uranium-238

Analyte	Percent Detected in Laboratory Data	Percent of Fixed Laboratory Data Detected Above Field Detection Limit (False Negative)	Percent of Field Detection Limits Above No Action Limit	Percent of Field Detection Limits Above Background	Percent Laboratory Data Above No Action Limit	Percent Laboratory Data Above Background
Chromium	100	0	0	100	0	58
Uranium-238	100	10	98	100	35	43

B.10.3 COMPARISON OF UPPER CONFIDENCE LIMITS FOR FIELD AND FIXED LABORATORY DATA

UCLs were calculated for the fixed laboratory data, the field grab samples, and for the composited field samples. The UCLs for the fixed laboratory data and the field grab samples were listed in Sections B.8 and B.9. These UCLs also are reported in this section along with the UCLs computed from the field composited data to determine the ability of the field data to produce usable UCLs. The UCLs computed from the composited field data are collected from the same locations as the fixed laboratory samples so they produce the most comparable means. One of the primary advantages of collecting field data is that more samples can be collected and analyzed than with fixed laboratory data. More field grab samples were collected than field composite samples, so if the field method produces unbiased results, more accurate sample means may be computed from the data than with the composited field data. This is because the sample mean has its own standard deviation called the standard error. The standard error is equal to the standard deviation divided by the square root of the number of samples collected, and it is an important quantity in calculating the UCL. The size of the standard error is directly related to the accuracy of the UCL (smaller standard error means a more accurate UCL that is closer to the true population mean). UCLs were computed using the 20 field and fixed laboratory samples, composited samples, and the 116 field grab samples collected from each of subunits 1-4. The 18 composited fixed laboratory and field and 84 field grab samples were collected from subunit 5 were used to compute the UCLs and summary statistics for that subunit.

It is known that field data do not provide the same level of precision as fixed laboratory data. Field data have greater variability than fixed laboratory data, as can be seen by the standard deviations reported in Tables B.115–B.119. The standard deviation reflects variability from all sources including sample heterogeneity, analytical error, and differences in sample support.

It also is possible that field data introduce a bias into the measurements and, therefore, a bias to the UCLs. That is, it is possible that field techniques can systematically overestimate or underestimate the true concentrations in the soil. This section determines if UCLs computed by field data are influenced by a bias or systematic over or under estimation in the field measurements or if the differences are due to increased variability in the field data. Tables B.115–B.119 list the UCLs for the fixed laboratory, composited field, and field grab samples, along with the means and standard deviations for each set of data. The means and standard deviations assist in determining if differences in the UCLs are due to a bias in measurements or just to the increased variability of the field methods. The means indicate that there is a large bias in the XRF barium results. Results for lead and uranium seem to coincide well. Uranium-238 and PCB results are not able to provide usable estimates of the data at the concentrations observed in the Soil Pile I soils. The relationship between field and fixed laboratory data for PCBs and uranium-238 should be reevaluated in an area with considerably higher concentrations of PCBs and uranium-238 than observed in these soils.

If the larger UCLs in the field data are not subject to a bias but are only different because of larger variability, this issue may be overcome by collecting large numbers of field data. If the UCLs differ because the field data regularly produce results that are in excess of the fixed laboratory data, the UCLs produced by field data are unreliable and unfit for use in decision making processes because expensive remediation may ensue where there is no real contamination. Conversely, if UCLs produced by field methods regularly produce results that are less than fixed laboratory methods, then contaminated sites may erroneously be declared clean. If there had been a strong correlation between the field and fixed laboratory data results, the field data could have been rescaled using regression to compute UCLs that would be close to UCLs obtained from fixed laboratory data; therefore, it might have been possible to use field UCLs for decision making. Strong correlations were not found, so bias in the field results cannot be accounted for properly. It is important to note that the none of the data presented in this document indicate that there is contamination in the Soil Pile I area.

Tables B.120–B.124 show the two types of field UCLs expressed as a percent of the UCL obtained from the laboratory data. These percentages were computed to enable the data user to decide if the results obtained from field methods are sufficiently comparable to fixed laboratory methods for their intended use. The tables show that the field lead and cesium-137 UCLs compare well (around a magnitude of 2 or less) with the fixed laboratory UCLs, and the uranium UCLs compare acceptably when there is sufficient detected data to compute a field UCL; otherwise, the field uranium data provided very unreliable estimates when compared with the fixed laboratory data. There is improvement in correspondence when the grab samples are examined, which indicates that the increased sample size produced more accurate field UCLs. Because none of the PCB or uranium-238 field data were detected in enough samples to compute an UCL, the estimates provided do not provide an informative picture of how accurately field data can compute UCLs for PCBs or uranium-238 when higher concentration of these analytes are present. Additional data would need to be collected from sites where a higher concentration of PCBs and uranium-238 are present in the soils to assess the relationship. Note that statistical testing cannot be performed to compare the means from the field grab samples and the composited fixed laboratory samples because the type of sample (grab vs. composite) does not allow for comparison in this way. Statistical testing would not tell the data user if the differences between the means or UCLs are detrimental to the intended use of the field data; only project needs and specifications can determine that.

It can be concluded that the variability in the field methods for both PCBs and uranium-238 makes it difficult to obtain reasonable estimates of contamination in the soils if there is a large number of nondetects in the field data. This is likely true for all of the field analyses; therefore, field data should not be used to compute UCLs unless it is known that concentrations of these analytes are large enough that field methods will be able to produce data with a minimum of 30% detects. Also, as noted above, further investigation is needed to determine if it is possible to obtain reliable UCLs from PCBs or uranium-238 field data.

Table B.115. Upper Confidence Limits for Fixed Laboratory, Composited Field, and Field Grab Samples for Subunit 1

Analyte	Laboratory Mean	Laboratory Standard Deviation	Laboratory Upper Confidence Limit	Composite Field Mean	Composite Field Standard Deviation	Composite Field Upper Confidence Limit	Grab Sample Field Mean	Grab Sample Field Standard Deviation	Grab Sample Field Upper Confidence Limit
Metals	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Barium	75.0	5.68	77.2	394	11.9	398	404.3	59.13	413.4
Chromium	28.5	9.54	32.2	ND	ND	218[a]	ND	ND	218[a]
Lead	16.2	1.91	16.9	11.7	1.11	12.1	16.2	3.44	16.81
Uranium	26.5	8.48	29.8	17.1	3.23	18.3	23.72	13.55	28.03
PCBs	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Total PCBs	ND	ND	ND	ND	ND	ND	NA	NA	2.47[b]
Radionuclides	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)
Cesium-137	0.142	0.0393	0.157	0.265	0.0255	0.275	0.312	0.0981	0.327
Uranium-238	4.29	0.986	4.67	ND	ND	31[a]	ND	ND	49.87[a]

NA = Not applicable.

ND = Not detected.

[a] Analyte was not detected in any of the samples. Reported value is the largest detection limit.

[b] There were not enough detected data to compute an UCL. Reported value is the largest detected value.

Table B.116. Upper Confidence Limits for Fixed Laboratory, Composited Field, and Field Grab Samples for Subunit 2

Analyte	Laboratory Mean	Laboratory Standard Deviation	Laboratory Upper Confidence Limit	Composite Field Mean	Composite Field Standard Deviation	Composite Field Upper Confidence Limit	Grab Sample Field Mean	Grab Sample Field Standard Deviation	Grab Sample Field Upper Confidence Limit
Metals	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Barium	117	18.4	124	475	15.1	481	461	57.81	470.3
Chromium	15.0	0.502	15.2	ND	ND	218[a]	ND	ND	218[a]
Lead	33.0	4.90	34.9	19.9	2.23	20.8	21.83	20.720	25.8
Uranium	1.41	0.114	1.46	ND	ND	13[a]	ND	ND	ND
PCBs	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Total PCBs	ND	ND	ND	ND	ND	ND	NA	NA	2.47[b]
Radionuclides	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)
Cesium-137	0.122	0.0270	0.132	0.244	0.0133	0.249	0.168	0.151	0.258
Uranium-238	0.355	0.230	0.453	ND	ND	30.6[a]	ND	ND	12.7[a]

NA = Not Applicable.

ND = Not Detected.

[a] Analyte was not detected in any of the samples. Reported value is the largest detection limit.

[b] There were not enough detected data to compute an UCL. Reported value is the largest detected value.

Table B.117. Upper Confidence Limits for Fixed Laboratory, Composited Field, and Field Grab Samples for Subunit 3

Analyte	Laboratory Mean	Laboratory Standard Deviation	Laboratory Upper Confidence Limit	Composite Field Mean	Composite Field Standard Deviation	Composite Field Upper Confidence Limit	Grab Sample Field Mean	Grab Sample Field Standard Deviation	Grab Sample Field Upper Confidence Limit
Metals	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Barium	71.6	1.30	72.1	340	22.2	349	344.1	87.31	357.6
Chromium	56.4	10.8	60.6	ND	ND	218[a]	NA	NA	528.4[a]
Lead	15.9	1.97	16.6	11.9	2.43	12.8	16.39	3.414	16.93
Uranium	69.2	11.8	73.8	32.4	4.96	34.4	62.89	80.110	76.07
PCBs	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Total PCBs	0.0864	0.0172	0.0931	1.78	0.0587	1.80	NA	NA	4.30[b]
Radionuclides	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)
Cesium-137	0.132	0.0217	0.141	0.275	0.00888	0.278	0.277	0.0826	0.308
Uranium-238	16.8	2.01	17.6	ND	ND	35[a]	ND	ND	140.2[a]

NA = Not Applicable.

ND = Not Detected.

[a] Analyte was not detected in any of the samples. Reported value is the largest detection limit.

[b] There were not enough detected data to compute an UCL. Reported value is the largest detected value.

Table B.118. Upper Confidence Limits for Fixed Laboratory, Composited Field, and Field Grab Samples for Subunit 4

Analyte	Laboratory Mean	Laboratory Standard Deviation	Laboratory Upper Confidence Limit	Composite Field Mean	Composite Field Standard Deviation	Composite Field Upper Confidence Limit	Grab Sample Field Mean	Grab Sample Field Standard Deviation	Grab Sample Field Upper Confidence Limit
Metals	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Barium	91.1	6.79	93.7	362.7945	15.8957839	368.940539	374.4	80.250	406.8
Chromium	42.4	9.07	45.9	ND	ND	218[a]	ND	ND	218[a]
Lead	16.6	2.05	17.4	13.4	2.32	14.3	17.71	6.150	18.71
Uranium	17.2	11.3	21.6	32.9	15.8	39.0	NA	NA	321.4[b]
PCBs	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Total PCBs	0.0901	0.0181	0.0971	1.79	0.098	1.83	NA	NA	5.769[b]
Radionuclides	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)
Cesium-137	0.149	0.0180	0.156	0.309	0.0221	0.318	0.332	0.087	0.383
Uranium-238	1.45	0.834	1.77	ND	ND	54.7[a]	NA	NA	201.1[b]

NA = Not Applicable.

ND = Not Detected.

[a] Analyte was not detected in any of the samples. Reported value is the largest detection limit.

[b] There were not enough detected data to compute an UCL. Reported value is the largest detected value.

Table B.119. Upper Confidence Limits for Fixed Laboratory, Composited Field, and Field Grab Samples for Subunit 5

Analyte	Laboratory Mean	Laboratory Standard Deviation	Laboratory Upper Confidence Limit	Composite Field Mean	Composite Field Standard Deviation	Composite Field Upper Confidence Limit	Grab Sample Field Mean	Grab Sample Field Standard Deviation	Grab Sample Field Upper Confidence Limit
Metals	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Barium	103	60.8	130	399	41.2	415			448
Chromium	12.0	3.36	13.4	ND	ND	218[a]	ND	ND	218[a]
Lead	38.3	36.1	75.3	29.8	22.9	39.6	38.2	40.9	46.0
Uranium	1.76	0.331	1.89	ND	ND	13[a]	NA	NA	30.2[b]
PCBs	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Total PCBs	ND	ND	ND	ND	ND	ND	NA	NA	3.12[b]
Radionuclides	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)
Cesium-137			0.351	NA	NA	0.55[a]	NA	NA	0.67[a]
Uranium-238			0.523	ND	ND	67.9[b]	NA	NA	18.41[a]

NA = Not Applicable.

ND = Not Detected.

[a] Analyte was not detected in any of the samples. Reported value is the largest detection limit.

[b] There were not enough detected data to compute an UCL. Reported value is the largest detected value.

Table B.120. Upper Confidence Limits for Field Data Expressed as a Percent of the Fixed Laboratory Upper Confidence Limit for Subunit 1

Analyte	Laboratory Upper Confidence Limit	Composite Field Upper Confidence Limit	Grab Sample Field Upper Confidence Limit	Ratio of Composite Field UCL to Laboratory UCL	Ratio of Grab Sample Field UCL to Laboratory UCL
Metals	(mg/kg)	(mg/kg)	(mg/kg)	(%)	(%)
Barium	77.2	398	413.4	516	535
Chromium	32.2	218	218	677	677
Lead	16.9	12.1	16.81	72	99
Uranium	29.8	18.3	28.03	62	94
PCBs	(mg/kg)	(mg/kg)	(mg/kg)	(%)	(%)
Total PCBs	0.0817	2.50	0.264	3,063	323
Radionuclides	(pCi/g)	(pCi/g)	(pCi/g)	(%)	(%)
Cesium-137	0.2	0.3	0.327	175	208
Uranium-238	4.7	31.0	49.87	664	1,068

Table B.121. Upper Confidence Limits for Field Data Expressed as a Percent of the Upper Confidence Limit for Subunit 2

Analyte	Laboratory Upper Confidence Limit	Composite Field Upper Confidence Limit	Grab Sample Field Upper Confidence Limit	Ratio of Composite Field UCL to Laboratory UCL	Ratio of Grab Sample Field UCL to Laboratory UCL
Metals	(mg/kg)	(mg/kg)	(mg/kg)	(%)	(%)
Barium	124	481	470.3	386	378
Chromium	15.2	218	218	1,436	1,436
Lead	34.9	20.8	25.8	60	74
Uranium	1.46	13	ND	892	ND
PCBs	(mg/kg)	(mg/kg)	(mg/kg)	(%)	(%)
Total PCBs	ND	ND	2.47	ND	ND
Radionuclides	(pCi/g)	(pCi/g)	(pCi/g)	(%)	(%)
Cesium-137	0.132	0.249	0.258	188	195
Uranium-238	0.453	30.6	12.7	6,761	2,806

ND = Not Detected.

Table B.122. Upper Confidence Limits for Field Data Expressed as a Percent of the Fixed Laboratory Upper Confidence Limit for Subunit 3

Analyte	Laboratory Upper Confidence Limit	Composite Field Upper Confidence Limit	Grab Sample Field Upper Confidence Limit	Ratio of Composite Field UCL to Laboratory UCL	Ratio of Grab Sample Field UCL to Laboratory UCL
Metals	(mg/kg)	(mg/kg)	(mg/kg)	(%)	(%)
Barium	72.1	349	357.6	483	496
Chromium	60.6	218	528.4	360	872
Lead	16.6	12.8	16.93	77	102
Uranium	73.8	34.4	76.07	47	103
PCBs	(mg/kg)	(mg/kg)	(mg/kg)	(%)	(%)
Total PCBs	0.0931	1.80	4.3	1,935	4,620
Radionuclides	(pCi/g)	(pCi/g)	(pCi/g)	(%)	(%)
Cesium-137	0.141	0.278	0.308	198	219
Uranium-238	17.6	35	140.2	199	796

Table B.123. Upper Confidence Limits for Field Data Expressed as a Percent of the Fixed Laboratory Upper Confidence Limit for Subunit 4

Analyte	Laboratory Upper Confidence Limit	Composite Field Upper Confidence Limit	Grab Sample Field Upper Confidence Limit	Ratio of Composite Field UCL to Laboratory UCL	Ratio of Grab Sample Field UCL to Laboratory UCL
Metals	(mg/kg)	(mg/kg)	(mg/kg)	(%)	(%)
Barium	93.7	369	406.8	394	434
Chromium	45.9	218	218	475	475
Lead	17.4	14.3	18.71	82	107
Uranium	21.6	39.0	321.4	181	1,488
PCBs	(mg/kg)	(mg/kg)	(mg/kg)	(%)	(%)
Total PCBs	0.0971	1.83	5.769	1,885	5,944
Radionuclides	(pCi/g)	(pCi/g)	(pCi/g)	(%)	(%)
Cesium-137	0.156	0.318	0.383	204	246
Uranium-238	1.77	54.7	201.1	3,082	11,331

Table B.124. Upper Confidence Limits for Field Data Expressed as a Percent of the Fixed Laboratory Upper Confidence Limit for Subunit 5

Analyte	Laboratory Upper Confidence Limit	Composite Field Upper Confidence Limit	Grab Sample Field Upper Confidence Limit	Ratio of Composite Field UCL to Laboratory UCL	Ratio of Grab Sample Field UCL to Laboratory UCL
Metals	(mg/kg)	(mg/kg)	(mg/kg)	(%)	(%)
Barium	130	415	448	320	345
Chromium	13.4	218	218	1,627	1,627
Lead	75.3	39.6	46.0	53	61
Uranium	1.89	13	30.2	687	1,597
PCBs	(mg/kg)	(mg/kg)	(mg/kg)	(%)	(%)
Total PCBs	ND	ND	3.12[a]	ND	ND
Radionuclides	(pCi/g)	(pCi/g)	(pCi/g)	(%)	(%)
Cesium-137	0.351	0.55	0.67	157	191
Uranium-238	0.523	67.9	18.41	12,983	3,520

ND = Not Detected.

[a] There were not enough detected data to compute an UCL. Reported value is the largest detected value.

B.10.4 EFFICACY OF FIELD METHODS FOR SCREENING PURPOSES

A common use of field data is as a screening method to refine sampling efficacy. The idea is to collect many samples using less expensive field techniques, analyze the resulting data, and then use the results to determine locations for laboratory sampling to ensure that areas of concern are more heavily sampled than areas with little or no contamination. It also can be used to identify hotspots. It is not necessary for field data to accurately predict concentrations of target analytes. It is only necessary that larger concentrations observed in field samples correspond to larger concentrations observed in fixed laboratory analysis. Bubble plots were generated for each of the five subunits to assess this relationship between field and fixed laboratory measurements (Figures B.2–B.5). The *x*- and *y*-axes of the plot represent the global positioning system coordinates. Each bubble represents a sampling location with the radius of the bubble indicating the concentration of the analyte at that location. The radii are computed so that all of the bubbles are on the same scale, but the actual concentration cannot be determined by measuring the radius of a given point. A red bubble that represents the background level is placed on each plot to provide a reference point for the data user to interpret the observed concentrations. The field data are represented by the red bubbles and the fixed laboratory data are represented by the blue bubbles.

Data for barium are difficult to interpret. Field data shows concentrations in excess of the background values while the fixed laboratory data concentrations were less than background concentrations. The concentrations for both the fixed laboratory data and the field data detected in the soils all were very similar to one other in each of the subunits; therefore, it cannot be verified that large field concentrations correspond to large fixed laboratory barium concentrations.

Bubble plots for the lead data (Figure B.2) show that larger concentrations seen in the field data correspond to larger values in the fixed laboratory data. There are locations in subunits 2, 4, and 5 that show large field results. These areas correspond to the largest fixed laboratory concentrations of lead. The bubble plots indicate that when field data show large concentrations of lead in the soils, the fixed laboratory results also are higher in those areas.

Uranium (Figure B.3) results also show useful correspondence. Examination of the plots shows that when fixed laboratory concentrations are less than background, uranium usually is not detected with the field methods. When fixed laboratory methods detect uranium results above background, field methods also detect uranium. The largest of the uranium values measured by fixed laboratory analysis also correspond with the largest of the field results. This means that field data may be a good indicator of where fixed laboratory uranium samples should be collected.

Plots for the PCB (Figure B.4) data show that the field methods grossly overestimate the PCB concentrations. PCBs were not detected in the fixed laboratory data in subunits 2 and 5. The concentrations measured by field techniques in these two subunits were smaller than those seen in the other subunits. Concentrations from the field data did not correspond well to concentrations from fixed laboratory data in subunits 1, 3, and 4. Large concentrations of PCBs were observed in field methods when there were no detected or very small concentrations observed in the fixed laboratory data; however, large fixed laboratory results were always accompanied by large field results. This means that if fixed laboratory samples are collected from areas where large concentrations of PCBs are observed from field analysis, areas with larger concentrations most likely will be sampled. Areas that do not have large concentrations will be sampled as well, but the large concentrations should be captured by fixed laboratory analysis.

Concentrations of cesium-137 are fairly steady within subunits for both the field and fixed laboratory data so it cannot be verified that large concentrations observed in the field data correspond with large values in the cesium-137 data. The data in subunit 5 do not correspond well. Although field and fixed laboratory data were collected from the same locations, it appears that field data were unable to detect cesium-137 where the fixed laboratory methods did. Concentrations from the field data occurred primarily in locations where fixed laboratory samples were not collected; therefore, it is difficult to determine if the detected field values may correspond to larger values in the fixed laboratory data. All of the cesium-137 values were detected at concentrations that were very close to or less than background. It is not clear how the cesium-137 field data can be used for screening.

Field data concentrations of uranium-238 (Figure B.5) corresponded well with the fixed laboratory uranium-238 results if the fixed laboratory results were notably above background. If the fixed laboratory data were below background or close to background, ISOCS analysis was unable to detect uranium-238 in the soils. Results from subunit 1 indicate that the actual concentration of uranium-238 must be three to five times as large as background for ISOCS analysis to detect the radionuclide in the soils.

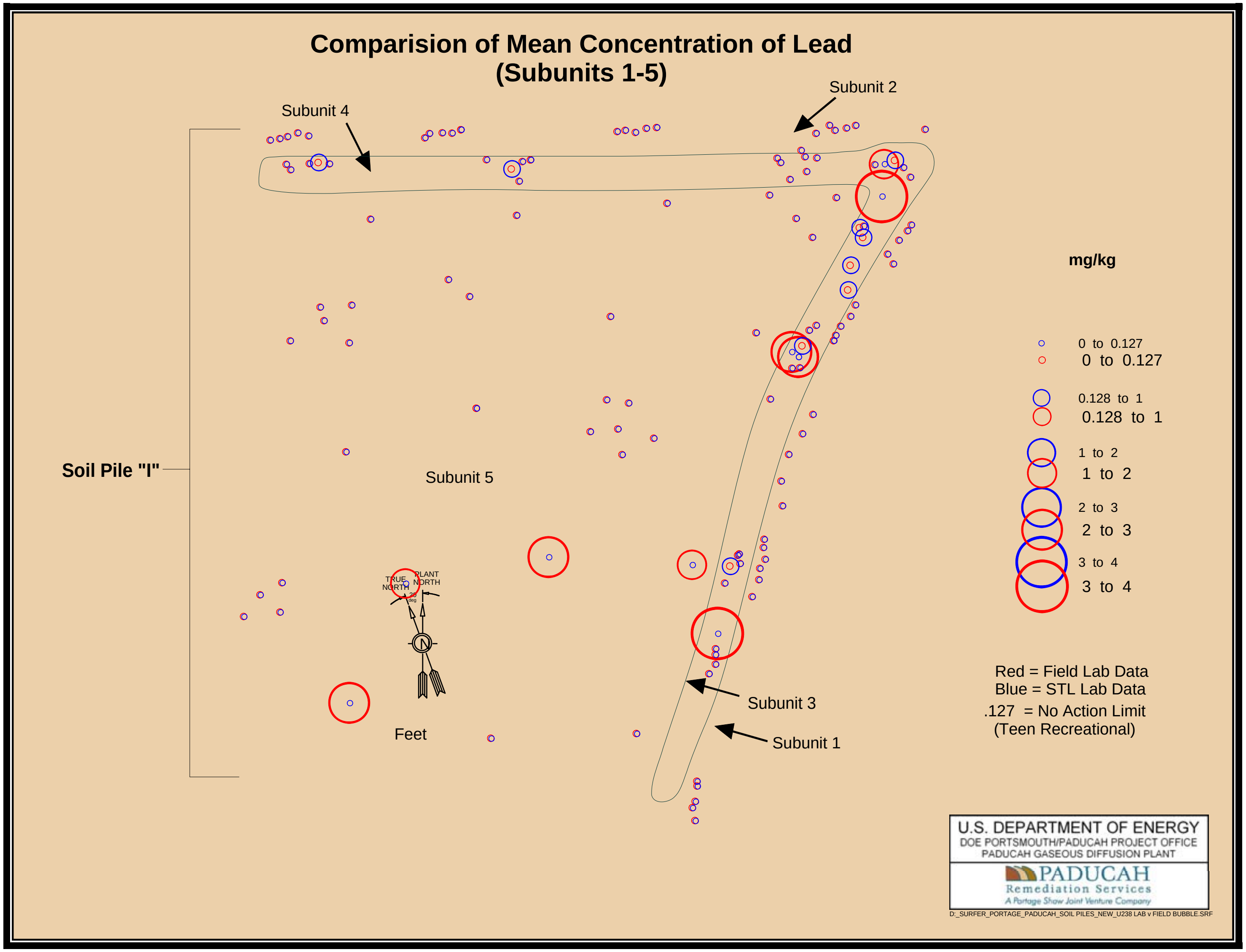


Figure B.2. Bubble Plots for Lead Data

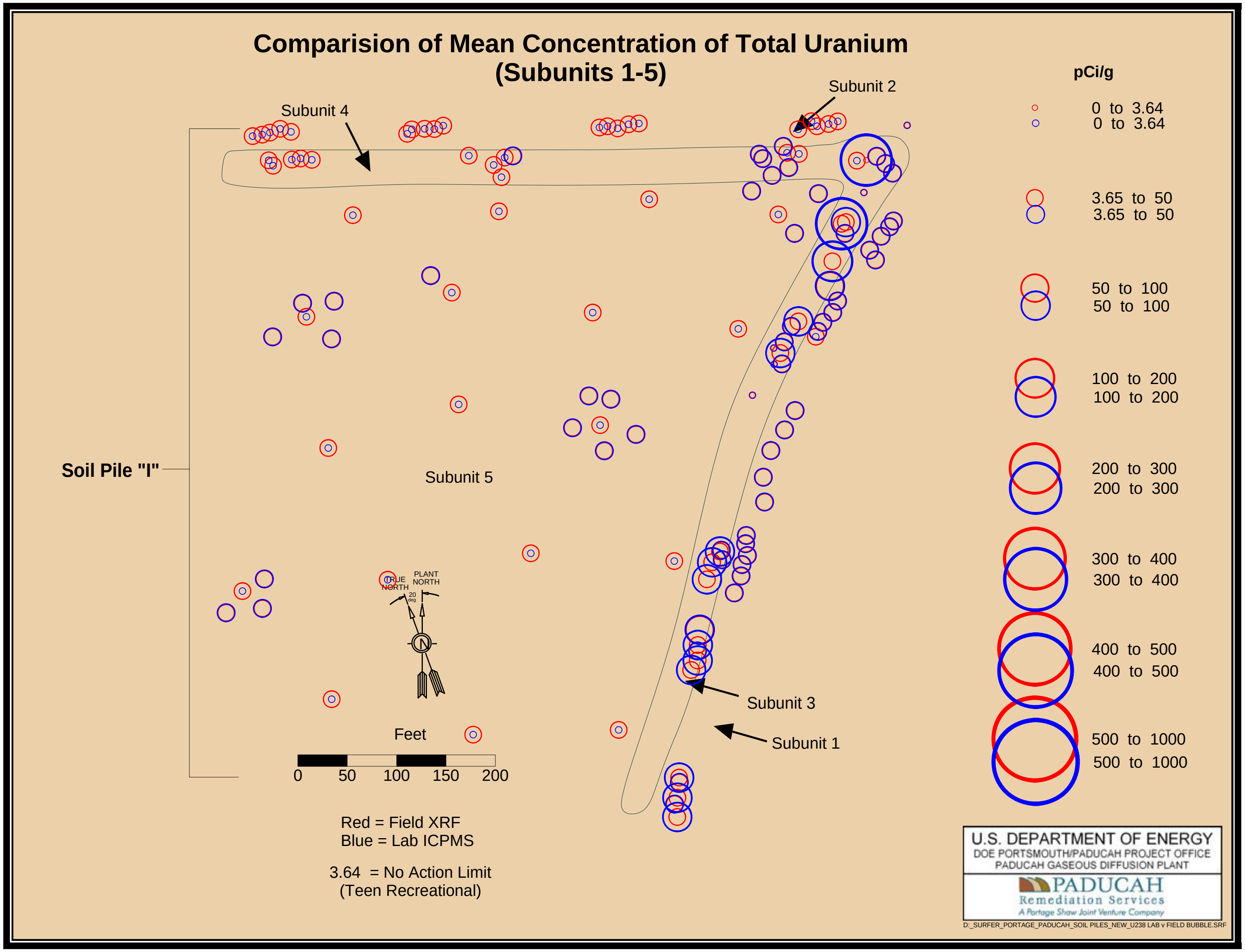


Figure B.3. Bubble Plots for Uranium Data

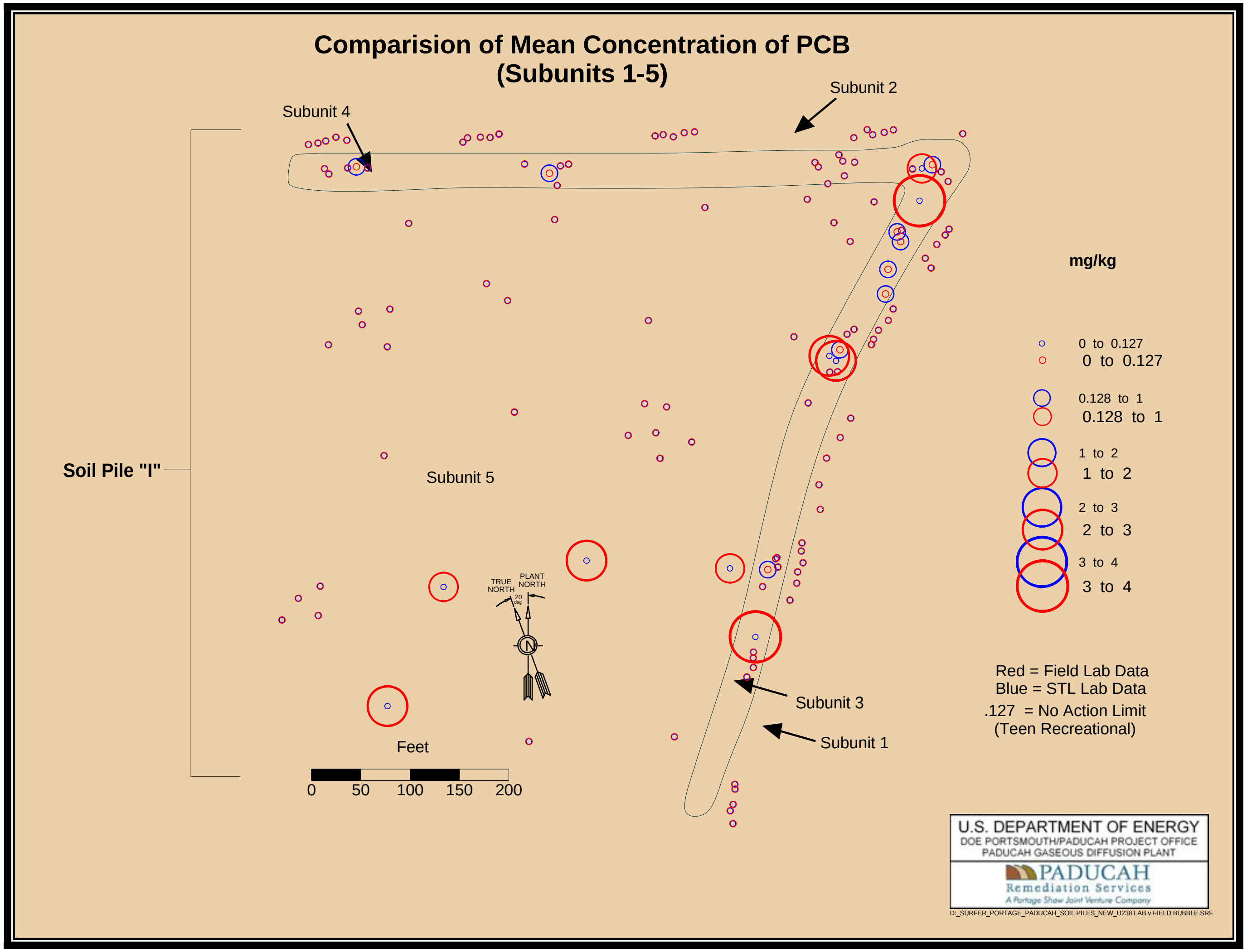


Figure B.4. Bubble Plots for PCB Data

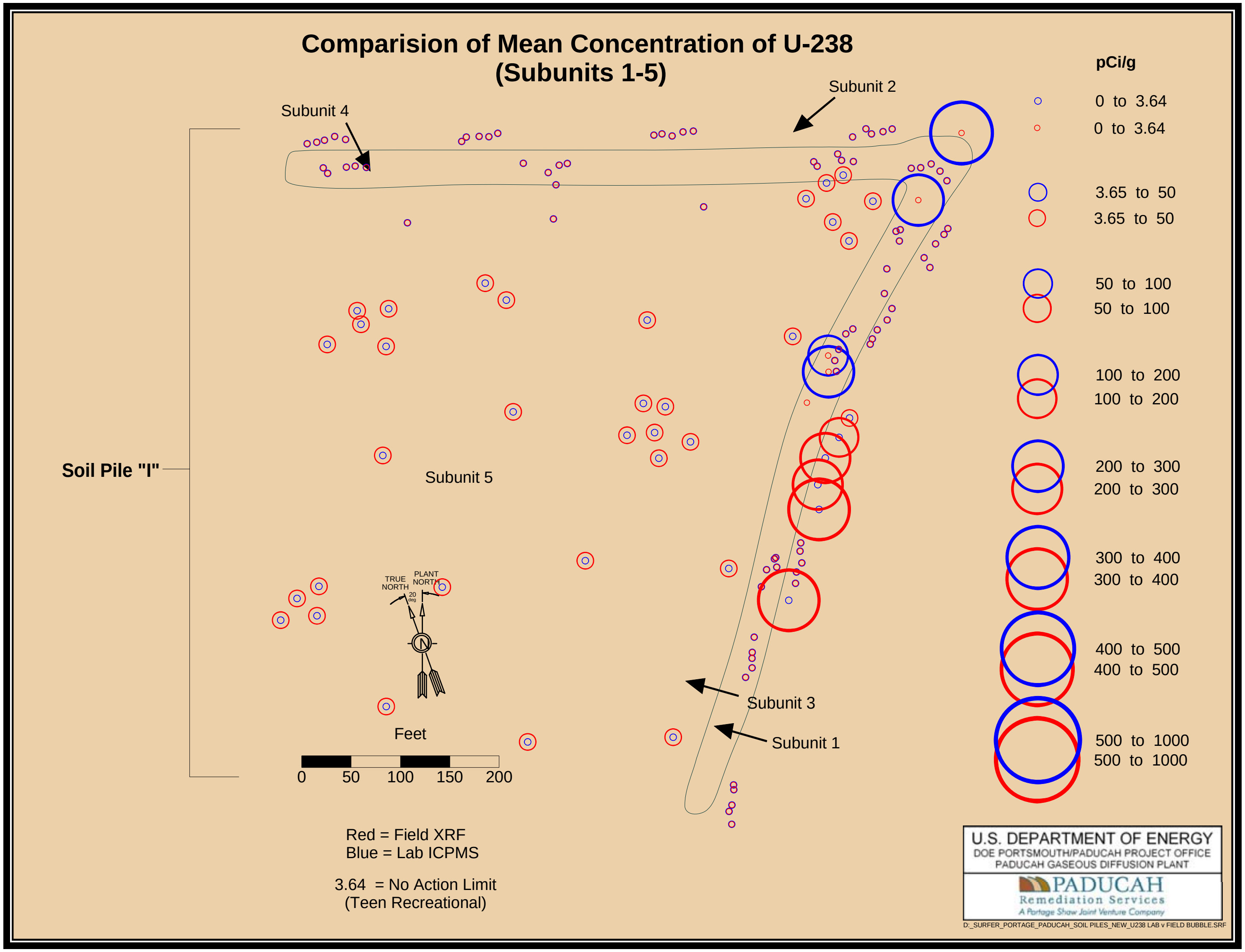


Figure B.5. Bubble Plots for Uranium-238 Data

B.10.5 CONCLUSIONS

Comparison of data obtained from fixed laboratory analysis and field analysis shows that field data can be used in decision making in a limited manner. Correlations computed on these data show no clear 1-to-1 relationship between the methods. That is, a result obtained from field results cannot be used to adequately predict a result obtained from fixed laboratory analysis. This is not surprising given that field methods are known to have high variability relative to fixed laboratory results.

Error rates were examined for the different field methods and indicate that lead and uranium have large false negative results (40% and 16%, respectively). Uranium results indicated that concentrations were less than the no action limit when, in fact, they were greater than the no action limit 89% of the time. Lead indicated that concentrations were less than background 16% of the time when the actual concentrations were greater than background. Chromium and uranium-238 field methods were unable to detect concentrations below background and the no action limits.

Means, standard deviations, and UCLs were computed and compared for all of the data that had a sufficient number of detects. Comparison of the means indicates that there is a high degree of bias in the barium results. Lead and uranium field and fixed laboratory results seem to coincide well, but there are not enough detected data to make the determination for the PCB or uranium-238 results. UCLs correspond fairly well for lead and cesium-137. Uranium field UCLs correspond well if a large majority of the EPC estimates grossly overestimate the UCLs obtained from the fixed laboratory data. The estimates obtained from the field data were the maximum detected value because there were not enough detected data to compute an UCL; therefore, it cannot be determined how well the UCLs will coincide if a large proportion of the field data are detects. Review of the bubble plots indicates that field methods for PCBs and uranium-238 produce concentration estimates that greatly exceed those obtained from fixed laboratory analysis. It is likely that UCLs computed from field data for PCBs or uranium-238 will far exceed those obtained from fixed laboratory analysis.

Bubble plots were generated to determine how well field data could be used as a screening method for focusing fixed laboratory samples. Bubble plots show that field results lead, uranium, and uranium-238 can be used to determine the location of large fixed laboratory concentrations. Uranium field results indicate uranium fixed laboratory results that are above background; however, field methods cannot detect concentrations that are around or below background. Large readings of uranium-238 obtained from field methods often show the location of large fixed laboratory uranium-238 results, but only if the concentrations obtained from fixed laboratory methods are greater than approximately five times background. Results from the PCB data are less consistent than those for uranium and uranium-238. PCB field methods grossly overestimate concentrations obtained from fixed laboratory analysis; however, large values obtained from fixed laboratory analysis were accompanied by large field concentrations. The reverse was not true; frequently large concentrations of PCBs were observed in the field data where concentrations from fixed laboratory data were small or undetected. If PCB concentrations were small in the field data, they were small in the fixed laboratory data. It is difficult to determine how well the field data correspond with the laboratory data for barium and cesium-137 results because concentrations were steady within subunits for both the field and fixed laboratory data; therefore, it cannot be determined how field data correspond with large concentration of either of these analytes.

B.11 INVESTIGATION OF INDICATOR CHEMICALS

Another objective of interest was to determine if any chemicals were present in the data that corresponded well with other chemicals. This was done by performing a correlation analysis on the measured variables. The Pearson Product correlation (*r*) was computed for each pair of analytes that was detected. The correlation (*r*) is a number between -1 and 1 that indicates the strength of the relationship between two analytes. A correlation of 0 indicates no relationship, and a correlation of 1 or -1 indicates a 1-to-1 relationship between the two analytes. That is, if the correlation between two analytes is equal to one, then given the concentration of one analyte, the concentration of the other analyte can be precisely determined. The closer a correlation is to 1, or -1, the stronger the correlation between the analyte concentrations. If the correlation is positive, then it indicates that the relationship is positive (the larger concentrations in one analyte are associated with larger concentration in the other analyte). If the correlation is negative, then the relationship between the two analyte concentrations is negative (larger concentrations in one analyte are associated with smaller concentrations in the other analyte). For a chemical to be considered as an indicator variable, the correlations between the variables or transformations of the variables must be positive and close to 1.

PCBs are of interest in this type of analysis, but PCBs were not detected in enough samples to perform a correlation analysis so they are omitted from this section. The gamma walkover plots shown in Figures 13–17 in the site evaluation report for PCBs, uranium, and uranium-238 concentrations at the site shows that higher concentrations of these analytes appear together. The graphs and a discussion of the PCB, uranium, and uranium-238 correspondence can be found in the site evaluation report.

The indicator chemical analysis is presented in two phases. First, correlations were computed among all measured analytes that have a sufficient number detects to do calculations. Because of the large number detected chemicals, it is not possible to thoroughly investigate all possible combinations of indicator chemicals. The second phase of the analysis investigates arsenic, chromium, uranium, and uranium-238 because these are of interest based on knowledge of site activities. Data for these four analytes were examined for outliers and to determine if transformations could be employed to achieve greater correlation.

B.11.1 CORRELATION CALCULATIONS FOR ALL DETECTED ANALYTES

Tables B.125 through B.129 show the correlations computed for all of the analytes detected in enough analytes to perform the calculations. Strong correlations were found between several of the chemicals; however, only a few of the correlations are helpful. Some of the relationships that are notable are lead versus arsenic, uranium versus uranium-235 activity, and uranium versus uranium-234 and uranium-238. Several other strong relationships were observed in the data; however, they do not involve analytes that are of particular interest at this site.

Table B.125. Correlations between Chemicals Detected in the Soil Pile I Soils

	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium
Aluminum	1.00	0.53	0.48	0.38	0.30	-0.10	-0.18	-0.29
Antimony	0.53	1.00	0.74	0.51	0.80	0.01	-0.02	0.04
Arsenic	0.48	0.74	1.00	0.34	0.57	0.02	-0.02	-0.07
Barium	0.38	0.51	0.34	1.00	0.49	0.04	-0.05	-0.10
Beryllium	0.30	0.80	0.57	0.49	1.00	0.09	0.09	0.26
Cadmium	-0.10	0.01	0.02	0.04	0.09	1.00	0.15	0.06
Calcium	-0.18	-0.02	-0.02	-0.05	0.09	0.15	1.00	0.53
Chromium	-0.29	0.04	-0.07	-0.10	0.26	0.06	0.53	1.00
Cobalt	0.20	0.52	0.40	0.50	0.63	0.06	-0.12	0.01
Copper	0.33	0.47	0.67	0.23	0.40	0.04	0.26	0.12
Iron	0.55	0.92	0.63	0.38	0.84	0.02	0.14	0.19
Lead	0.35	0.56	0.93	0.27	0.44	0.04	-0.03	-0.13
Magnesium	0.91	0.38	0.41	0.25	0.13	-0.06	0.00	-0.27
Manganese	0.16	0.45	0.33	0.80	0.56	0.08	-0.25	-0.13
Mercury	0.04	0.00	0.12	-0.09	0.06	0.28	0.11	0.19
Molybdenum	0.54	0.92	0.65	0.66	0.84	0.04	-0.08	-0.01
Nickel	0.62	0.83	0.54	0.49	0.75	0.06	0.12	0.06
Selenium	0.16	0.33	0.36	0.26	0.31	0.01	-0.17	-0.08
Silver	0.23	0.28	0.09	0.17	0.19	0.02	0.07	0.11
Sodium	0.17	0.10	0.01	0.12	0.15	-0.07	0.16	0.10
Thallium	0.72	0.43	0.63	0.31	0.21	-0.13	-0.35	-0.38
Uranium	-0.46	-0.21	-0.20	-0.16	-0.03	0.06	0.37	0.62
Vanadium	0.45	0.92	0.64	0.42	0.82	0.00	0.09	0.10
Zinc	-0.19	-0.01	-0.06	-0.06	0.19	0.68	0.44	0.66
Activity of Uranium-235	-0.56	-0.27	-0.26	-0.24	-0.06	0.01	0.27	0.40

Table B.125. Correlations between Chemicals Detected in the Soil Pile I Soils (Continued)

	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium
Alpha Activity	-0.26	-0.15	-0.19	0.01	-0.12	-0.01	0.24	0.29
Americium-241	-0.33	-0.03	-0.10	0.01	-0.02	0.08	0.23	0.19
Beta Activity	-0.33	-0.19	-0.22	-0.05	-0.12	0.01	0.26	0.31
Cesium-137	0.21	0.23	0.16	0.06	0.14	0.11	-0.17	-0.08
Plutonium-239/240	-0.03	0.05	0.02	-0.12	-0.05	0.00	-0.33	-0.14
Radium-226	0.35	0.26	0.18	0.44	0.18	-0.08	-0.11	-0.08
Technetium-99	-0.15	-0.04	0.03	-0.01	0.12	0.76	-0.09	0.04
Thorium-228	0.56	0.31	0.19	0.44	0.07	-0.05	-0.04	-0.21
Thorium-230	0.55	0.31	0.21	0.50	0.08	-0.05	-0.10	-0.24
Thorium-232	0.53	0.28	0.18	0.50	0.08	-0.05	-0.09	-0.22
Uranium (pCi/g)	-0.56	-0.28	-0.26	-0.23	-0.05	0.02	0.28	0.40
Uranium (µg/g = mg/kg)	-0.15	-0.12	-0.22	-0.13	-0.18	-0.03	-0.15	0.01
Uranium-234	-0.48	-0.22	-0.23	-0.12	-0.01	0.03	0.29	0.40
Uranium-235 (wt%)	0.03	0.20	0.01	0.18	0.21	0.04	-0.18	-0.06
Uranium-238	-0.55	-0.28	-0.26	-0.22	-0.05	0.02	0.28	0.39

🟦 0.6–0.79 correlations
🟩 0.8-1.0 correlations

Table B.126. Correlations between Chemicals Detected in the Soil Pile I Soils

	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Molybdenum
Aluminum	0.20	0.33	0.55	0.35	0.91	0.16	0.04	0.54
Antimony	0.52	0.47	0.92	0.56	0.38	0.45	0.00	0.92
Arsenic	0.40	0.67	0.63	0.93	0.41	0.33	0.12	0.65
Barium	0.50	0.23	0.38	0.27	0.25	0.80	-0.09	0.66
Beryllium	0.63	0.40	0.84	0.44	0.13	0.56	0.06	0.84
Cadmium	0.06	0.04	0.02	0.04	-0.06	0.08	0.28	0.04
Calcium	-0.12	0.26	0.14	-0.03	0.00	-0.25	0.11	-0.08
Chromium	0.01	0.12	0.19	-0.13	-0.27	-0.13	0.19	-0.01
Cobalt	1.00	0.21	0.45	0.43	0.02	0.74	-0.03	0.57
Copper	0.21	1.00	0.44	0.67	0.34	0.14	0.09	0.43
Iron	0.45	0.44	1.00	0.41	0.43	0.27	0.06	0.85
Lead	0.43	0.67	0.41	1.00	0.27	0.34	0.08	0.48
Magnesium	0.02	0.34	0.43	0.27	1.00	-0.07	0.11	0.39
Manganese	0.74	0.14	0.27	0.34	-0.07	1.00	-0.09	0.61
Mercury	-0.03	0.09	0.06	0.08	0.11	-0.09	1.00	0.02
Molybdenum	0.57	0.43	0.85	0.48	0.39	0.61	0.02	1.00
Nickel	0.42	0.41	0.89	0.34	0.54	0.36	0.01	0.83
Selenium	0.30	0.11	0.29	0.29	0.11	0.26	0.15	0.39
Silver	0.02	0.19	0.28	0.01	0.21	0.03	0.14	0.31
Sodium	-0.09	0.07	0.18	-0.07	0.23	-0.09	-0.05	0.14
Thallium	0.20	0.23	0.37	0.50	0.66	0.21	0.04	0.42
Uranium	-0.06	-0.03	-0.12	-0.19	-0.41	-0.11	0.16	-0.23
Vanadium	0.46	0.43	0.94	0.45	0.33	0.34	0.00	0.86
Zinc	-0.01	0.10	0.15	-0.09	-0.14	-0.10	0.34	-0.02
Activity of Uranium-235	-0.07	-0.10	-0.17	-0.22	-0.53	-0.12	0.09	-0.29

Table B.126. Correlations between Chemicals Detected in the Soil Pile I Soils (Continued)

	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Molybdenum
Alpha Activity	-0.07	-0.03	-0.14	-0.17	-0.24	-0.04	-0.04	-0.16
Americium-241	-0.10	0.17	-0.09	-0.02	-0.32	-0.01	-0.06	-0.02
Beta Activity	-0.06	-0.03	-0.17	-0.18	-0.31	-0.06	0.00	-0.20
Cesium-137	0.03	0.15	0.16	0.17	0.20	0.04	0.28	0.31
Plutonium-239/240	0.08	-0.05	-0.10	0.10	-0.13	0.10	0.05	0.05
Radium-226	0.17	0.05	0.22	0.12	0.28	0.25	-0.09	0.32
Technetium-99	0.19	-0.08	-0.02	0.06	-0.21	0.23	0.23	0.00
Thorium-228	0.06	0.11	0.27	0.11	0.53	0.13	-0.11	0.32
Thorium-230	0.10	0.11	0.25	0.14	0.49	0.20	-0.13	0.36
Thorium-232	0.09	0.06	0.24	0.11	0.48	0.19	-0.09	0.33
Uranium (pCi/g)	-0.08	-0.10	-0.17	-0.21	-0.51	-0.13	0.10	-0.29
Uranium (µg/g = mg/kg)	-0.09	-0.22	-0.22	-0.18	-0.25	0.03	-0.14	-0.17
Uranium-234	-0.07	-0.06	-0.11	-0.20	-0.45	-0.08	0.09	-0.20
Uranium-235 (wt%)	0.21	0.08	0.08	0.04	-0.09	0.29	0.01	0.27
Uranium-238	-0.08	-0.11	-0.17	-0.22	-0.51	-0.12	0.09	-0.28

🟦	0.6–0.79 correlations
🟩	0.8-1.0 correlations

Table B.127. Correlations between Chemicals Detected in the Soil Pile I Soils

	Nickel	Selenium	Silver	Sodium	Thallium	Uranium	Vanadium	Zinc
Aluminum	0.62	0.16	0.23	0.17	0.72	-0.46	0.45	-0.19
Antimony	0.83	0.33	0.28	0.10	0.43	-0.21	0.92	-0.01
Arsenic	0.54	0.36	0.09	0.01	0.63	-0.20	0.64	-0.06
Barium	0.49	0.26	0.17	0.12	0.31	-0.16	0.42	-0.06
Beryllium	0.75	0.31	0.19	0.15	0.21	-0.03	0.82	0.19
Cadmium	0.06	0.01	0.02	-0.07	-0.13	0.06	0.00	0.68
Calcium	0.12	-0.17	0.07	0.16	-0.35	0.37	0.09	0.44
Chromium	0.06	-0.08	0.11	0.10	-0.38	0.62	0.10	0.66
Cobalt	0.42	0.30	0.02	-0.09	0.20	-0.06	0.46	-0.01
Copper	0.41	0.11	0.19	0.07	0.23	-0.03	0.43	0.10
Iron	0.89	0.29	0.28	0.18	0.37	-0.12	0.94	0.15
Lead	0.34	0.29	0.01	-0.07	0.50	-0.19	0.45	-0.09
Magnesium	0.54	0.11	0.21	0.23	0.66	-0.41	0.33	-0.14
Manganese	0.36	0.26	0.03	-0.09	0.21	-0.11	0.34	-0.10
Mercury	0.01	0.15	0.14	-0.05	0.04	0.16	0.00	0.34
Molybdenum	0.83	0.39	0.31	0.14	0.42	-0.23	0.86	-0.02
Nickel	1.00	0.25	0.34	0.20	0.43	-0.19	0.88	0.07
Selenium	0.25	1.00	0.01	0.08	0.37	-0.10	0.32	-0.07
Silver	0.34	0.01	1.00	0.04	0.15	-0.05	0.30	0.09
Sodium	0.20	0.08	0.04	1.00	0.10	0.06	0.13	-0.01
Thallium	0.43	0.37	0.15	0.10	1.00	-0.41	0.34	-0.30
Uranium	-0.19	-0.10	-0.05	0.06	-0.41	1.00	-0.18	0.46
Vanadium	0.88	0.32	0.30	0.13	0.34	-0.18	1.00	0.03
Zinc	0.07	-0.07	0.09	-0.01	-0.30	0.46	0.03	1.00
Activity of Uranium-235	-0.27	-0.16	-0.20	-0.03	-0.49	0.56	-0.22	0.29

Table B.127. Correlations between Chemicals Detected in the Soil Pile I Soils (Continued)

	Nickel	Selenium	Silver	Sodium	Thallium	Uranium	Vanadium	Zinc
Alpha Activity	-0.15	-0.18	-0.06	-0.04	-0.32	0.70	-0.19	0.19
Americium-241	-0.18	-0.20	-0.02	0.00	-0.58	0.18	-0.05	0.15
Beta Activity	-0.20	-0.17	-0.05	-0.07	-0.36	0.74	-0.21	0.21
Cesium-137	0.14	0.06	0.31	-0.06	0.08	-0.07	0.16	0.05
Plutonium-239/240	-0.15	-0.11	0.03	-0.23	-0.11	-0.04	-0.13	-0.07
Radium-226	0.29	0.17	0.07	0.20	0.24	-0.11	0.21	-0.10
Technetium-99	0.01	0.04	-0.09	-0.14	-0.03	0.16	-0.04	0.53
Thorium-228	0.34	0.01	0.10	0.20	0.28	-0.26	0.23	-0.13
Thorium-230	0.33	0.05	0.09	0.19	0.29	-0.24	0.22	-0.15
Thorium-232	0.31	0.05	0.07	0.20	0.27	-0.25	0.20	-0.14
Uranium (pCi/g)	-0.26	-0.16	-0.19	0.00	-0.49	0.58	-0.22	0.28
Uranium (µg/g = mg/kg)	-0.20	-0.24	-0.03	-0.16	-0.16	0.08	-0.25	-0.03
Uranium-234	-0.20	-0.17	-0.17	0.03	-0.51	0.54	-0.16	0.29
Uranium-235 (wt%)	0.07	-0.16	0.07	-0.02	-0.18	-0.05	0.09	-0.05
Uranium-238	-0.26	-0.16	-0.19	0.00	-0.49	0.58	-0.22	0.27

🟦 0.6–0.79 correlations
🟩 0.8-1.0 correlations

Table B.128. Correlations between Chemicals Detected in the Soil Pile I Soils

	Uranium-235	Alpha Activity	Americium-241	Beta Activity	Cesium-137	Plutonium-239/240	Radium-226	Technetium-99
Aluminum	-0.56	-0.26	-0.33	-0.33	0.21	-0.03	0.35	-0.15
Antimony	-0.27	-0.15	-0.03	-0.19	0.23	0.05	0.26	-0.04
Arsenic	-0.26	-0.19	-0.10	-0.22	0.16	0.02	0.18	0.03
Barium	-0.24	0.01	0.01	-0.05	0.06	-0.12	0.44	-0.01
Beryllium	-0.06	-0.12	-0.02	-0.12	0.14	-0.05	0.18	0.12
Cadmium	0.01	-0.01	0.08	0.01	0.11	0.00	-0.08	0.76
Calcium	0.27	0.24	0.23	0.26	-0.17	-0.33	-0.11	-0.09
Chromium	0.40	0.29	0.19	0.31	-0.08	-0.14	-0.08	0.04
Cobalt	-0.07	-0.07	-0.10	-0.06	0.03	0.08	0.17	0.19
Copper	-0.10	-0.03	0.17	-0.03	0.15	-0.05	0.05	-0.08
Iron	-0.17	-0.14	-0.09	-0.17	0.16	-0.10	0.22	-0.02
Lead	-0.22	-0.17	-0.02	-0.18	0.17	0.10	0.12	0.06
Magnesium	-0.53	-0.24	-0.32	-0.31	0.20	-0.13	0.28	-0.21
Manganese	-0.12	-0.04	-0.01	-0.06	0.04	0.10	0.25	0.23
Mercury	0.09	-0.04	-0.06	0.00	0.28	0.05	-0.09	0.23
Molybdenum	-0.29	-0.16	-0.02	-0.20	0.31	0.05	0.32	0.00
Nickel	-0.27	-0.15	-0.18	-0.20	0.14	-0.15	0.29	0.01
Selenium	-0.16	-0.18	-0.20	-0.17	0.06	-0.11	0.17	0.04
Silver	-0.20	-0.06	-0.02	-0.05	0.31	0.03	0.07	-0.09
Sodium	-0.03	-0.04	0.00	-0.07	-0.06	-0.23	0.20	-0.14
Thallium	-0.49	-0.32	-0.58	-0.36	0.08	-0.11	0.24	-0.03
Uranium	0.56	0.70	0.18	0.74	-0.07	-0.04	-0.11	0.16
Vanadium	-0.22	-0.19	-0.05	-0.21	0.16	-0.13	0.21	-0.04
Zinc	0.29	0.19	0.15	0.21	0.05	-0.07	-0.10	0.53
Activity of	1.00	0.47	0.20	0.53	-0.16	-0.01	-0.21	0.24

Table B.128. Correlations between Chemicals Detected in the Soil Pile I Soils (Continued)

	Uranium-235	Alpha Activity	Americium-241	Beta Activity	Cesium-137	Plutonium-239/240	Radium-226	Technetium-99
Uranium-235								
Alpha Activity	0.47	1.00	0.20	0.98	-0.11	-0.03	0.08	0.03
Americium-241	0.20	0.20	1.00	0.20	0.16	0.25	0.04	-0.05
Beta Activity	0.53	0.98	0.20	1.00	-0.08	-0.03	-0.02	0.05
Cesium-137	-0.16	-0.11	0.16	-0.08	1.00	0.43	-0.03	-0.07
Plutonium-239/240	-0.01	-0.03	0.25	-0.03	0.43	1.00	-0.07	0.09
Radium-226	-0.21	0.08	0.04	-0.02	-0.03	-0.07	1.00	-0.09
Technetium-99	0.24	0.03	-0.05	0.05	-0.07	0.09	-0.09	1.00
Thorium-228	-0.34	0.07	0.02	-0.05	-0.02	-0.15	0.63	-0.20
Thorium-230	-0.31	0.09	0.06	-0.03	0.06	-0.07	0.67	-0.17
Thorium-232	-0.32	0.07	0.03	-0.04	0.01	-0.16	0.65	-0.18
Uranium (pCi/g)	0.99	0.48	0.19	0.53	-0.15	-0.05	-0.20	0.24
Uranium (µg/g = mg/kg)	0.15	0.11	0.14	0.10	-0.05	0.49	-0.17	0.10
Uranium-234	0.95	0.49	0.27	0.52	-0.12	-0.06	-0.07	0.18
Uranium-235 (wt%)	-0.03	0.03	0.33	0.02	0.36	0.42	0.13	0.00
Uranium-238	0.98	0.49	0.19	0.54	-0.16	-0.06	-0.19	0.24

🟦 0.6–0.79 correlations
🟩 0.8-1.0 correlations

Table B.129. Correlations between Chemicals Detected in the Soil Pile I Soils

	Thorium-228	Thorium-230	Thorium-232	Uranium (pCi/g)	Uranium-234	Uranium-238
Aluminum	0.56	0.55	0.53	-0.56	-0.48	-0.55
Antimony	0.31	0.31	0.28	-0.28	-0.22	-0.28
Arsenic	0.19	0.21	0.18	-0.26	-0.23	-0.26
Barium	0.44	0.50	0.50	-0.23	-0.12	-0.22
Beryllium	0.07	0.08	0.08	-0.05	-0.01	-0.05
Cadmium	-0.05	-0.05	-0.05	0.02	0.03	0.02
Calcium	-0.04	-0.10	-0.09	0.28	0.29	0.28
Chromium	-0.21	-0.24	-0.22	0.40	0.40	0.39
Cobalt	0.06	0.10	0.09	-0.08	-0.07	-0.08
Copper	0.11	0.11	0.06	-0.10	-0.06	-0.11
Iron	0.27	0.25	0.24	-0.17	-0.11	-0.17
Lead	0.11	0.14	0.11	-0.21	-0.20	-0.22
Magnesium	0.53	0.49	0.48	-0.51	-0.45	-0.51
Manganese	0.13	0.20	0.19	-0.13	-0.08	-0.12
Mercury	-0.11	-0.13	-0.09	0.10	0.09	0.09
Molybdenum	0.32	0.36	0.33	-0.29	-0.20	-0.28
Nickel	0.34	0.33	0.31	-0.26	-0.20	-0.26
Selenium	0.01	0.05	0.05	-0.16	-0.17	-0.16
Silver	0.10	0.09	0.07	-0.19	-0.17	-0.19
Sodium	0.20	0.19	0.20	0.00	0.03	0.00
Thallium	0.28	0.29	0.27	-0.49	-0.51	-0.49
Uranium	-0.26	-0.24	-0.25	0.58	0.54	0.58
Vanadium	0.23	0.22	0.20	-0.22	-0.16	-0.22
Zinc	-0.13	-0.15	-0.14	0.28	0.29	0.27
Activity of Uranium-235	-0.34	-0.31	-0.32	0.99	0.95	0.98

Table B.129. Correlations between Chemicals Detected in the Soil Pile I Soils (Continued)

	Thorium-228	Thorium-230	Thorium-232	Uranium (pCi/g)	Uranium-234	Uranium-238
Alpha Activity	0.07	0.09	0.07	0.48	0.49	0.49
Americium-241	0.02	0.06	0.03	0.19	0.27	0.19
Beta Activity	-0.05	-0.03	-0.04	0.53	0.52	0.54
Cesium-137	-0.02	0.06	0.01	-0.15	-0.12	-0.16
Plutonium-239/240	-0.15	-0.07	-0.16	-0.05	-0.06	-0.06
Radium-226	0.63	0.67	0.65	-0.20	-0.07	-0.19
Technetium-99	-0.20	-0.17	-0.18	0.24	0.18	0.24
Thorium-228	1.00	0.96	0.97	-0.32	-0.13	-0.31
Thorium-230	0.96	1.00	0.97	-0.29	-0.09	-0.28
Thorium-232	0.97	0.97	1.00	-0.30	-0.10	-0.29
Uranium (pCi/g)	-0.32	-0.29	-0.30	1.00	0.97	1.00
Uranium (µg/g = mg/kg)	-0.14	-0.11	-0.15	0.09	0.05	0.09
Uranium-234	-0.13	-0.09	-0.10	0.97	1.00	0.97
Uranium-235 (wt%)	0.13	0.19	0.16	-0.06	0.03	-0.07
Uranium-238	-0.31	-0.28	-0.29	1.00	0.97	1.00

🟦 0.6–0.79 correlations
🟩 0.8-1.0 correlations

B.11.2 CORRELATION ANALYSIS FOR SELECTED CHEMICALS

Arsenic, chromium, uranium, and uranium-238 are of particular interest in this area because of knowledge of site activities. A more thorough correlation was done on these chemicals. Scatter plots were generated for each pair combination of these chemicals to determine which transformations, if any, were appropriate and to identify potential influential points. Table B.130 shows the correlations computed with and without the transformations and the potential influential points. Figures B.6–B.17 show the scatter plots for the variable pairs.

Scatter plots including arsenic indicate that there is potentially a logarithmic relationship between arsenic and the other variables; therefore, the natural logarithm of all of the arsenic values was computed and compared to the other chemicals. This transformation shows improvement, but the correlations are still negative and weak. This means there is little relationship between arsenic concentrations, and the other chemicals and the little relationship that exists indicates that small concentrations of arsenic are associated with larger concentrations of the other three chemicals. Two outliers were present in the scatter plots comparing arsenic with uranium and with uranium-238; however, removal of these points does not change the correlation to a degree where the relationship can be helpful.

Scatter plots between chromium and both uranium and uranium-238 shows that there is a positive relationship between these chemicals. That is, higher concentrations of chromium are associated with higher concentrations of uranium and uranium-238. The plots indicate that a transformation is neither necessary nor helpful. The correlation between chromium and uranium is notable, but probably not high enough to use one as an indicator of the other. The correlation between chromium and uranium-238 is too small to use one as an indicator of the other. Two outliers were identified in the uranium data that may be influential to the correlations. These two points were removed from the correlation calculation to determine their effect, and the resulting correlation shows that they were influential in that they increased the correlation. Two outliers also were present in the uranium-238 data; removal of these points only slightly changes the correlation, so the points are not influential.

Uranium and uranium-238 are expected to correlate well when they are in secular equilibrium. The correlation computed from all of the points is not very high; however, there are two extreme outliers in the uranium data. When these points are removed and the correlation is recalculated, the resulting correlation is quite large. This means that the two outliers were very influential and that uranium and uranium-238 are good indicators of each other.

Table B.130. Correlation Calculations for Selected Chemicals

Analyte	Correlation
Arsenic vs. Chromium	-0.040
Ln(Arsenic) vs. Chromium	-0.040
Arsenic vs. Uranium	-0.208
Ln(Arsenic) vs. Uranium	-0.208
Ln(Arsenic) vs. Uranium (2 Outliers Removed)	-0.311
Arsenic vs. Uranium-238	-0.298
Ln(Arsenic) vs. Uranium-238	-0.298
Ln(Arsenic) vs. Uranium-238 (2 Outliers Removed)	-0.357
Chromium vs. Uranium	0.621
Chromium vs. Uranium (2 Outliers Removed)	0.558
Chromium vs. Uranium-238	0.391
Chromium vs. Uranium-238 (2 Outliers Removed)	0.396
Uranium vs. Uranium-238	0.579
Uranium vs. Uranium-238 (2 Outliers Removed)	0.829

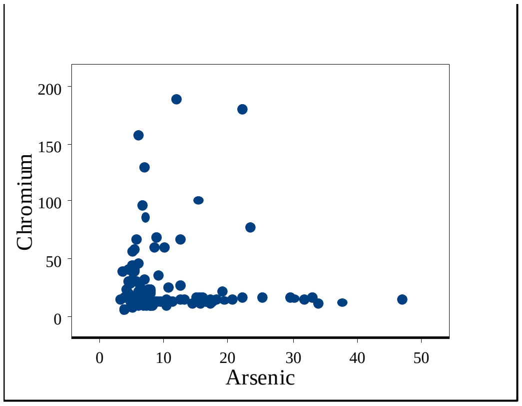


Figure B.6. Scatter Plot of Arsenic and Chromium Data

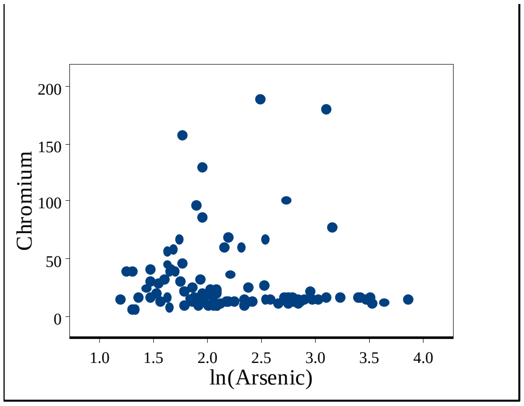


Figure B.7. Scatter Plot of ln(arsenic) and Chromium Data

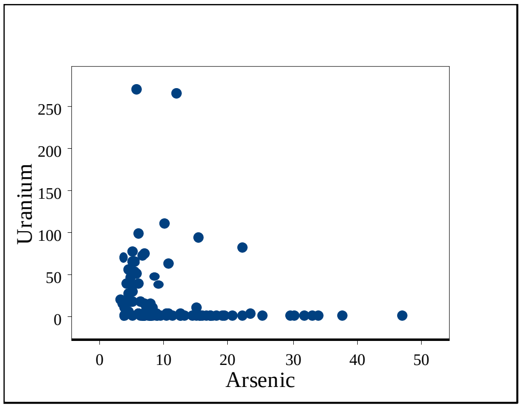


Figure B.8. Scatter Plot of Arsenic and Uranium Data

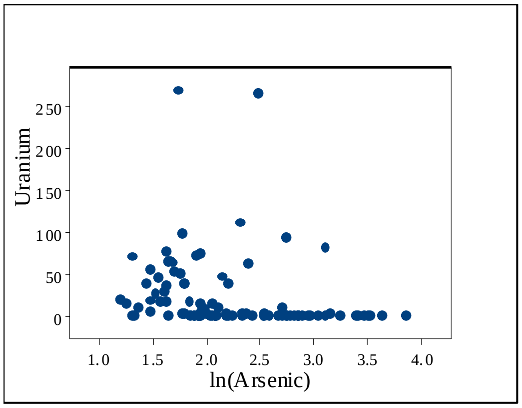


Figure B.9. Scatter Plot of ln(arsenic) and Uranium Data

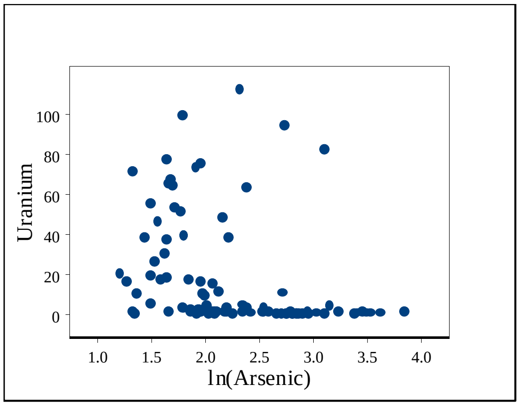


Figure B.10. Scatter Plot of ln(arsenic) and Uranium Data with Two Outliers Removed

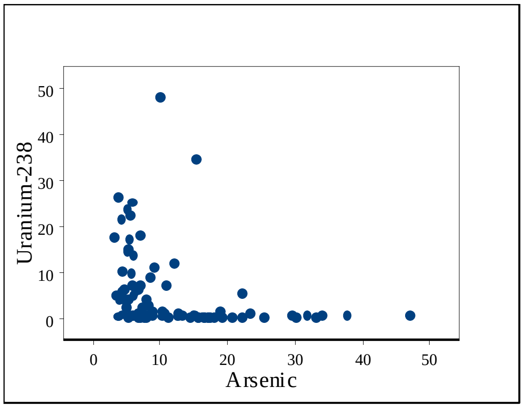


Figure B.11. Scatter Plot of Arsenic and Uranium-238 Data

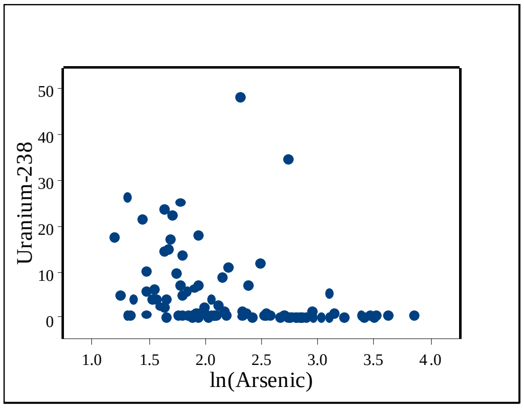


Figure B.12. Scatter Plot of ln(arsenic) and Uranium-238 Data

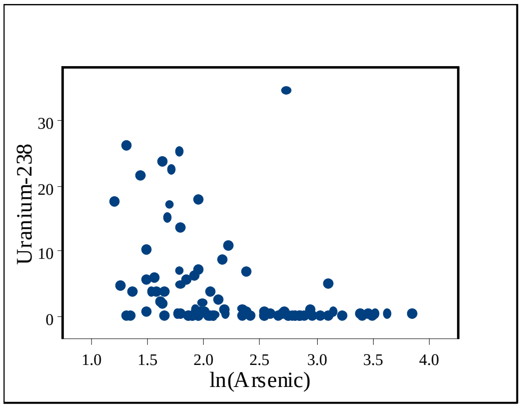


Figure B.13. Scatter Plot of ln(arsenic) and Uranium-238 Data with Two Outliers Removed

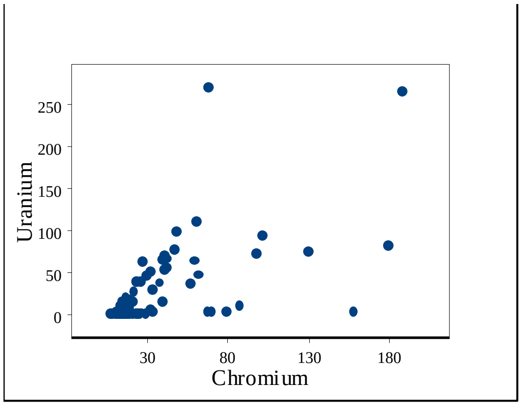


Figure B.14. Scatter Plot of Chromium and Uranium Data

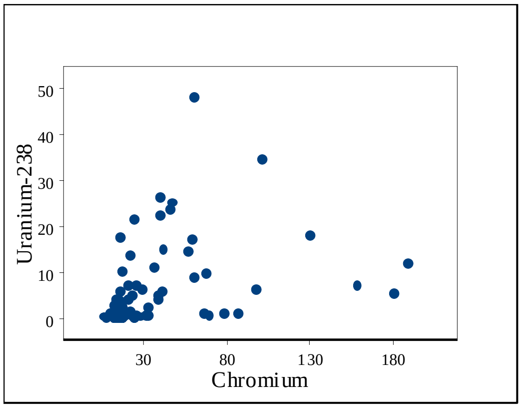


Figure B.15. Scatter Plot of Chromium and Uranium-238 Data

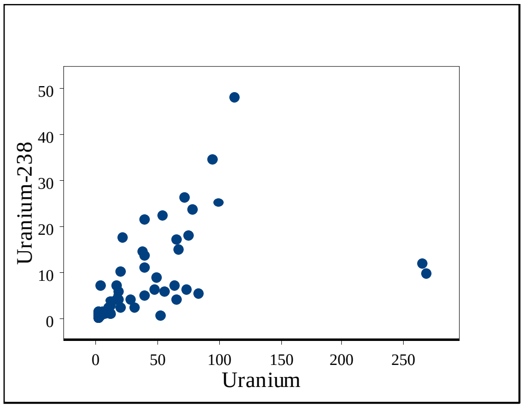


Figure B.16. Scatter Plot of Uranium and Uranium-238 Data

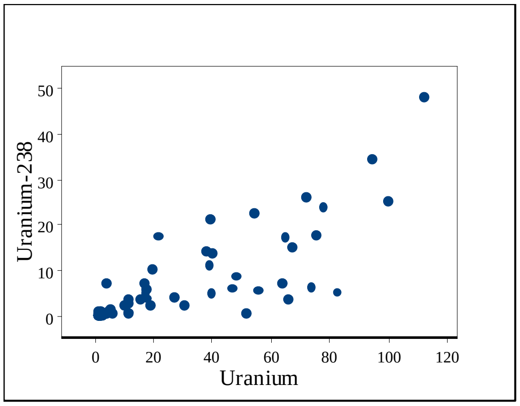


Figure B.17. Scatter Plot of Uranium and Uranium-238 Data with Two Uranium Outliers Removed

B.12 CONCLUSIONS

Several different analyses were performed on the Soil Pile I data to meet project objectives. The primary objectives include the following:

(1) Determine nature and extent of contamination in the area.
(2) Assess the risk to human health.
(3) Determine to what extent field data can be used for decision making.
(4) Identify indicator chemicals that may be present in the data.

The first objective was addressed in several ways. First, the subunits were examined as a whole to identify differences between the subunits or determine whether the entire Soil Pile I area could be considered one EU. Analysis showed that subunits 1, 2, 4, and 5 are similar to one other, but subunit 3 is significantly different than the other four subunits. Subunits 1 through 4 consisted of segments, four of which were selected at random for sampling; then they were analyzed to determine if any of the subunits should be divided into multiple EUs. This analysis shows that it is not necessary to divide the subunits into multiple EUs.

Five contingency samples were collected from the area where subunits 3 and 4 meet. These samples were collected from areas that previously had been determined to have higher levels of contamination than the rest of the Soil Pile I area; however, the area is localized and not large enough to comprise its own EU. Rather, it was determined to be considered an elevated location. These samples were compared to the other data collected from subunits 3 and 4. It was observed that the contingency samples contained concentrations of uranium, uranium-238, and PCBs in excess of subunits 3 and 4; therefore, this small area is different than the rest of subunits 3 and 4, and the contingency samples should not be used in determining the level of contamination in the subunits as a whole. The fact that concentrations of uranium, uranium-238, and PCBs are significantly higher than in subunit 3 and 4 does not indicate that the contingency area poses a threat to human health. The potential threat of the contingency sample area to human health needs to be further examined outside of this DQA report.

UCLs were computed to aid in a risk assessment for the Soil Pile I area. The risk assessment is not part of the DQA report, but is found in the SER.

Data obtained from XRF, ISOCS, and PCB field test kits were compared to fixed laboratory results to determine the role field data may play in decision making. The comparison shows that in this instance, laboratory data and field data do not correlate strongly. This does not mean that the field data cannot be used. UCLs computed from lead and uranium field results correspond well with UCLs obtained from fixed laboratory data as long as the majority of the field data are detected results. The UCL analysis for PCBs and uranium-238 was inconclusive because of the large number of nondetects. Analysis of the detected concentrations suggests that UCLs computed from these data could grossly overestimate the UCLs obtained from fixed laboratory data even if there was a large proportion of detected field data. Bubble plots were examined to determine if field data could be used to determine where fixed laboratory samples should be collected. Barium and cesium-137 relationships were difficult to establish because concentrations were consistent within each subunit; therefore, it cannot be determined how well field methods can detect large concentrations of these analytes. Lead field data provided a good indication of fixed laboratory data. Uranium and uranium-238 field results were able to detect fixed laboratory concentrations that were above background and the uranium-235 data were able to detect only fixed laboratory results that were about five times background. PCB relationships were more difficult to establish than for the uranium and uranium-238. Large concentrations observed in the fixed laboratory data corresponded to large concentrations detected in field data. Field data measured large concentrations of PCBs where PCBs were not detected or had small concentrations in fixed laboratory analysis.

The fourth objective was to determine the presence of indicator variables. Correlation analysis was done to find indicator chemicals. If the correlation between two analytes was close to 1, then one may be considered an indicator chemical for the other. There were several correlations that were close to 1. None of the relationships found with correlation analysis were useful in guiding future sampling efforts in neighboring areas. Not enough PCBs were detected in the soils to include them in the correlation analysis; however, isopleths were made for the uranium, uranium-238, and PCB data that show the largest concentrations of these three analytes occur in the same area.

B.13 REFERENCES

Alf, C., and Lohr, S., "Sampling Assumptions in Introductory Statistics Classes," *The American Statistician*, 61, 71-77.

DOE (U.S. Department of Energy) 2001. *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, Volume 1, *Human Health*, DOE/OR/07-1506&D2, December.

DOE 2007a. *Addendum 1-A to Sampling and Analysis Plan at the Paducah Gaseous Diffusion Plant Paducah, Kentucky, Sampling and Analysis Plan for the Characterization of the Soil Piles, Characterization: Little Bayou Creek Study Area Between McCaw Road and Outfall 002 Ditch*, DOE/LX/07-0015/A1/D2/R1, September.

DOE 2007b. *Sampling and Analysis Plan for Soil Piles at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/LX/07-0015&D2/R1, September.

EPA (U.S. Environmental Protection Agency) 2006a. *Data Quality Assessment: Statistical Tools for Practitioners*, U.S. Environmental Protection Agency, Office of Environmental Information, Washington, DC, EPA/240/B-06/003, QA/G-9S, February.

EPA 2006b. *Guidance on Systematic Planning Using the data Quality Objectives Process*, EPA QA/G-4, EPA/240/B-06/001, U.S. Environmental Protection Agency, Office of Environmental Information, Washington, DC, February.

EPA 2007. *ProUCL Version 4.0 Technical Guide*. EPA/600/R-07/041.ORD NERL ESC Technical Support Center, Characterization and Monitoring Branch, Las Vegas, NV, April.

Gilbert, R. 1987. *Statistical Methods for Environmental Pollution Monitoring*, John Wiley & Sons Inc.

Hamilton, L.C. 1992, *Regression With Graphics*, Brooks/Cole Publishing Company.

Helsel D. 2004. *Nondetects and Data Analysis: Statistic for Censored Environmental Data*, Wiley Interscience, October.

ProUCL., 2007: *A Statistical Software,* Version 4.0.0.01, National Exposure Research Lab, EPA, Las Vegas, NV, April.

R Development Core Team 2006. *R: A Language and Environment for Statistical Computing,* R Foundation for Statistical Computing, Vienna, Austria, ISBN 3-900051-07-0, URL.

Shaw 2007a. *Soils Piles Little Bayou Creek Subunit 3 Contingency, Paducah Gaseous Diffusion Plant*, SDG Number: SP07-LBC-SU3C, SP07LBCS32, Shaw, September 28.

Shaw 2007b. *Soils Piles Little Bayou Creek Subunit 3 Subsurface, Paducah Gaseous Diffusion Plant*, SDG Number: SP07-LBC-SU3SSF, SP07LBCS332, Shaw, October 1.

Singh, A., Maichle, R., and Lee, S. 2006. *On the Computation of a 95% Upper Confidence Limit of the Unknown Population Mean Based Upon Data Sets with Below Detection Limit Observations.* EPA/600/R-06/022, March.

Statsoft Inc., 2005. Statsoft Version 7.1, 2005. Tulsa, Oklahoma: *Statistica* (Data Analysis Software System), Tulsa, OK.

APPENDIX C

SUMMARY STATISTICS FOR THE SOIL PILE I INVESTIGATION

Table C.1. Summary Statistics for Subunit 1 Metals (Fixed Laboratory)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	95% Upper Confidence Limit (mg/kg)
Aluminum	13,000	20	20	6,540	7,895	8,940	7,294	8,336	7,980
Antimony	0.21	20	20	0.12	0.17	0.45	0.13	0.22	0.19
Arsenic	12	20	20	3.9	6.0	22.2	4.6	8.3	7.7
Barium	200	20	20	42.8	75.0	117	54.3	85.0	77.2
Beryllium	0.67	20	20	0.31	0.47	0.87	0.36	0.48	0.50
Cadmium	0.21	20	20	0.034	0.058	0.23	0.049	0.091	0.069
Calcium	200,000	20	20	350	519	1,390	430	727	590
Chromium	16	20	20	10	17	180	17	64	32
Cobalt	14	20	20	4.5	6.3	31	5.0	6.1	8.0
Copper	19	20	20	6	7.6	12.3	7.0	8.8	7.9
Iron	28,000	20	20	8,890	10,850	26,000	9,528	13,286	12,524
Lead	36	20	20	9.8	14	36.4	11	18	17
Magnesium	7,700	20	20	655	906	1,060	749	958	899
Manganese	1,500	20	20	495	849	2,230	705	679	961
Mercury	0.20	20	20	0.0133	0.028	0.06	0.023	0.043	0.034
Molybdenum	NA	20	20	0.37	0.53	1.2	0.45	0.65	0.61
Nickel	21	20	20	5.7	7.7	11.5	6.7	8.1	7.7
Selenium	0.8	20	20	0.24	0.34	0.57	0.282	0.35	0.37
Silver	2.3	20	20	0.032	0.042	0.12	0.036	0.078	0.052
Sodium	320	20	20	14.5	17.6	59.3	15.1	19.2	20.9
Thallium	0.34	20	20	0.17	0.21	0.26	0.19	0.23	0.21
Uranium (mg/kg)	4.9	20	20	3.5	18	82	19	56	30
Vanadium	38	20	20	15	18	40.5	15	21	20
Zinc	65	20	20	22.8	27.7	140	24.8	60.6	38.3

Table C.2. Summary Statistics for Subunit 1 PCBs (Fixed Laboratory)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (µg/kg)	Median (µg/kg)	Maximum (µg/kg)	Mean (µg/kg)	Standard Deviation (µg/kg)	95% Upper Confidence Limit (µg/kg)
PCB, Total	NA	8	20	33.1	40	360	75	18	82
PCB-1260	NA	8	20	33.1	40	360	75	18	82

Table C.3. Summary Statistics for Subunit 1 Radionuclides (Fixed Laboratory)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (pCi/g)	Median (pCi/g)	Maximum (pCi/g)	Mean (pCi/g)	Standard Deviation (pCi/g)	95% Upper Confidence Limit (pCi/g)
Uranium-235	0.14	20	20	0.0268	0.0870	0.257	0.0918	0.0175	0.099
Cesium-137	0.49	15	20	0.0638[a]	0.093	0.56	0.14	0.039	0.16
Plutonium-239/240	0.025	1	20	0.0103[a]	0.012[a]	0.018	NA[b]	NA[b]	0.018[c]
Radium-226	1.5	20	20	0.688	0.808	0.956	0.825	0.0172	0.83
Technetium-99	2.5	3	20	0.868[a]	0.92[a]	1.4	NA[b]	NA[b]	1.4[c]
Thorium-228	1.6	20	20	0.19	0.32	0.396	0.32	0.017	0.32
Thorium-230	1.5	20	20	0.16	0.28	0.335	0.27	0.012	0.28
Thorium-232	1.5	20	20	0.229	0.358	0.405	0.341	0.0155	0.35
Thorium-234	NA	20	20	1.98	6.38	19.8	7.32	1.46	7.9
Uranium (mg/kg)	4.9	20	20	2.00	12	41.0	12.8	2.94	14
Uranium-234	2.5	20	20	0.126	0.443	1.45	0.549	0.104	0.59
Uranium-238	1.2	20	20	0.666	3.89	13.7	4.29	0.986	4.7

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the method detection limit.

[b] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

[c] An insufficient number of detections were recorded for this analyte in order to calculate the UCL. The value shown is the maximum reported value.

Table C.4. Summary Statistics for Subunit 1 PAHs (Fixed Laboratory)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (µg/kg)	Median (µg/kg)	Maximum (µg/kg)	Mean (µg/kg)	Standard Deviation (µg/kg)	95% Upper Confidence Limit (µg/kg)
Benz(a)anthracene	NA	1	20	NA[a]	NA[a]	66	NA[a]	NA[a]	66[b]
Benzo(a)pyrene	NA	1	20	NA[a]	NA[a]	82	NA[a]	NA[a]	82[b]
Benzo(b)fluoranthene	NA	1	20	NA[a]	NA[a]	95	NA[a]	NA[a]	95[b]
Benzo(ghi)perylene	NA	1	20	NA[a]	NA[a]	66	NA[a]	NA[a]	66[b]
Benzo(k)fluoranthene	NA	1	20	NA[a]	NA[a]	68	NA[a]	NA[a]	68[b]
Chrysene	NA	1	20	NA[a]	NA[a]	110	NA[a]	NA[a]	110[b]
Fluoranthene	NA	1	20	NA[a]	NA[a]	280	NA[a]	NA[a]	280[b]
Phenanthrene	NA	1	20	NA[a]	NA[a]	270	NA[a]	NA[a]	270[b]
Pyrene	NA	1	20	NA[a]	NA[a]	220	NA[a]	NA[a]	220[b]

NA = Not Applicable.

[a] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

[b] An insufficient number of detections were recorded for this analyte in order to calculate the UCL. The value shown is the maximum reported value.

Table C.5. Summary Statistics for Subunit 1 Metals (Field Analytical)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	95% Upper Confidence Limit (mg/kg)
Barium	200	116	116	203	407	545	404	59.1	413
Lead	36	54	116	7[a]	7[a]	31.0	16.2	3.44	16.8
Uranium	4.9	21	116	13[a]	NA[b]	130	NA[b]	NA[b]	130

NA = Not Applicable

[a] The value for this statistic is based on a nondetected result. The value shown represents the method detection limit.

[b] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic. The value for this statistic is based on a nondetected result.

Table C.6. Summary Statistics for Subunit 1 Radionuclides (Field Analytical)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (pCi/g)	Median (pCi/g)	Maximum (pCi/g)	Mean (pCi/g)	Standard Deviation (pCi/g)	95% Upper Confidence Limit (pCi/g)
Cesium-137	0.49	42	116	0.147	0.234[a]	0.100	0.312	0.098	0.327
Uranium-238	1.2	1	116	3.27[a]	20.9[a]	49.9	NA[b]	NA[b]	49.9[c]

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the minimum detectable activity

[b] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic

[c] Analyte was not detected in enough samples to compute a UCL. Reported value is the maximum detected value.

Table C.7. Summary Statistics for Subunit 1 PCBs (Field Analytical)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	95% Upper Confidence Limit (mg/kg)
PCB, Total	NA	2	116	1.71[a]	1.75[b]	2.64	NA[b]	NA[b]	2.64[c]

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the largest method detection limit.

[b] An insufficient number of positively detected results (< 30%) were reported for this analyte in order to calculate this statistic

[c] Analyte was not detected in enough samples to compute a UCL. Reported value is the maximum detected value.

Table C.8. Summary Statistics for Subunit 2 Metals (Fixed Laboratory)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	95% Upper Confidence Limit (mg/kg)
Aluminum	13,000	20	20	9,130	10,150	12,600	10,511	203	10,590
Antimony	0.21	20	20	0.16	0.24	0.59	0.27	0.017	0.28
Arsenic	12	20	20	6.8	17	33.1	17	2.3	18
Barium	200	20	20	76.2	97	438	117	18.4	124
Beryllium	0.67	20	20	0.42	0.54	0.83	0.55	0.014	0.55
Cadmium	0.21	20	20	0.03	0.047	0.12	0.051	0.0056	0.053
Calcium	200,000	20	20	381	642	791	625	12.1	630
Chromium	16	20	20	11.6	14	22	15	0.50	15
Cobalt	14	20	20	4.3	6.7	30.9	8.0	1.0	8.4
Copper	19	20	20	8.4	10	12.8	11	0.42	11
Iron	28,000	20	20	12,600	16,800	26,500	17,350	574	17,572
Lead	36	20	20	11.7	32	71.1	33.0	4.90	34.9
Magnesium	7,700	20	20	1,110	1,380	1,880	1,430	39	1,445
Manganese	1,500	20	20	279	520	5,230	871	197	947
Mercury	0.20	19	20	0.013	0.038	0.066	0.036	0.0027	0.037
Molybdenum	NA	20	20	0.62	0.82	2	0.85	0.065	0.88
Nickel	21	20	20	8.2	10	14.2	10	0.22	10
Selenium	0.8	20	20	0.29	0.46	0.7	0.46	0.034	0.47
Silver	2.3	20	20	0.05	0.051	0.07	0.052	0.00069	0.052
Sodium	320	20	20	17	24	31	23	1.4	24
Thallium	0.34	20	20	0.17	0.43	0.52	0.38	0.042	0.40
Uranium	4.9	20	20	0.95	1.2	2.6	1.4	0.11	1.5
Vanadium	38	20	20	20.1	29	50	29	1.2	30
Zinc	65	20	20	25	30	36	30	0.83	30

Table C.9. Summary Statistics for Subunit 2 Radionuclides (Fixed Laboratory)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (pCi/g)	Median (pCi/g)	Maximum (pCi/g)	Mean (pCi/g)	Standard Deviation (pCi/g)	95% Upper Confidence Limit (pCi/g)
Uranium-235	0.14	6	20	0.0241[a]	0.0246[a]	0.069	0.035	0.0074	0.038
Americium-241	NA	1	20	0.0098[b]	0.014[b]	0.019[a]	NA[b]	NA[b]	0.019[a]
Cesium-137	0.49	10	19	0.0636[b]	0.091[b]	0.38	0.12	0.027	0.13
Plutonium-238	0.073	1	20	0.00991[b]	0.011[b]	0.031[b]	NA[b]	NA[b]	0.031[a]
Radium-226	1.5	19	19	0.8	0.91	1.4	0.97	0.045	0.99
Technetium-99	2.5	10	20	0.49[a]	0.77	1.31	0.79	0.065	0.82
Thorium-228	1.6	20	20	0.407	0.513	1.12	0.652	0.103	0.691
Thorium-230	1.5	20	20	0.355	0.456	1.14	0.619	0.128	0.669
Thorium-232	1.5	20	20	0.405	0.508	1.09	0.648	0.00998	0.687
Thorium-234	NA	17	20	1.04	1.70	2.58	1.69	0.188	1.77
Uranium (mg/kg)	4.9	13	20	0.194[a]	0.361	2.73	0.915	0.423	1.08
Uranium-234	2.5	20	20	0.109	0.16	1.1	0.41	0.17	0.48
Uranium-238	1.2	17	20	0.122	0.184	1.25	0.355	0.230	1.00

NA = Not Applicable.

[a] An insufficient number of detections were recorded for this analyte in order to calculate the UCL. The value shown is the maximum reported value.

[b] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

Table C.10. Summary Statistics for Subunit 2 Metals (Field Analytical)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	95% Upper Confidence Limit (mg/kg)
Barium	200	115	116	183	459	704	461	57.81	470
Lead	36	81	116	7[a]	18.52	225.47	21.83	20.720	25.8

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the method detection limit.

[b] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

Table C.11. Summary Statistics for Subunit 2 PCBs (Field Analytical)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	95% Upper Confidence Limit (mg/kg)
PCB, Total	NA	4	116	1.63[a]	1.71[a]	2.47	NA[b]	NA[b]	2.47[c]

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the largest value reported for the minimum detectable activity.

[b] An insufficient number of positively detected (< 30%) results were reported for this analyte in order to calculate this statistic.

[c] Analyte was not detected in enough samples to compute a UCL. Reported Value is the maximum detected value.

Table C.12. Summary Statistics for Subunit 2 Radionuclides (Field Analytical)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (pCi/g)	Median (pCi/g)	Maximu m (pCi/g)	Mean (pCi/g)	Standard Deviation (pCi/g)	Upper Confidence Limit (pCi/g)
Cesium-137	0.49	43	116	0.058	0.226	0.619	0.165	0.151	0.297

Table C.13. Summary Statistics for Subunit 3 Metals in Surface Soils (Fixed Laboratory)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	95% Upper Confidence Limit (mg/kg)
Aluminum	13,000	20	20	5,210	6,600	7,480	6,441	96	6,478
Antimony	0.21	20	20	0.084	0.15	0.21	0.14	0.0083	0.15
Arsenic	12	20	20	3.3	6.3	15.4	7.3	0.89	7.6
Barium	200	20	20	45.9	75.4	89.4	71.6	1.30	72.1
Beryllium	0.67	20	20	0.35	0.50	0.78	0.52	0.041	0.54
Cadmium	0.21	20	20	0.031	0.085	1.2	0.15	0.047	0.17
Calcium	200,000	20	20	580	990	1,550	943	58	965
Chromium	16	20	20	11.9	43.7	189	56.4	10.8	60.6
Cobalt	14	20	20	3.8	6.4	12	6.5	0.38	6.7
Copper	19	20	20	5.2	8.8	17	9.2	0.19	9.2
Iron	28,000	20	20	9,200	11,800	20,000	13,028	707	13,301
Lead	36	20	20	8.5	14	36.1	16	2.0	17
Magnesium	7,700	20	20	492	774	1,030	768	30	779
Manganese	1,500	20	20	193	475	1,070	528	86	561
Mercury	0.20	20	20	0.0195	0.0424	0.0679	0.0449	0.00426	0.0466
Molybdenum	NA	20	20	0.22	0.47	0.90	0.50	0.048	0.52
Nickel	21	20	20	5.9	7.7	12.2	7.8	0.14	7.8
Selenium	0.8	20	20	0.19	0.35	0.62	0.38	0.023	0.38
Silver	2.3	20	20	0.04	0.046	0.065	0.047	0.00080	0.047
Sodium	320	20	20	14.7	18.7	39.5	21.2	2.18	22.0
Thallium	0.34	20	20	0.11	0.14	0.19	0.15	0.0060	0.15
Uranium	4.9	20	20	11.6	64.2	266	69.2	11.8	73.8
Vanadium	38	20	20	15	19	49.1	22	1.2	22
Zinc	65	20	20	29.4	47.4	179	61.4	7.47	64.3

Table C.14. Summary Statistics for Subunit 3 PCBs in Surface Soils (Fixed Laboratory)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (µg/kg)	Median (µg/kg)	Maximum (µg/kg)	Mean (µg/kg)	Standard Deviation (µg/kg)	95% Upper Confidence Limit (µg/kg)
PCB, Total	NA	9	20	40[a]	44[a]	180	86	17	93
PCB-1248	NA	6	20	40[a]	42[a]	110	50	2.5	51
PCB-1254	NA	8	20	40[a]	42[a]	90	50	3.4	51
PCB-1260	NA	6	20	40[a]	42[a]	110	47	2.9	49

[a] The reported result was a nondetect. The value shown represents the method detection limit.

Table C.15. Summary Statistics for Subunit 3 Radionuclides in Surface Soils (Fixed Laboratory)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (pCi/g)	Median (pCi/g)	Maximum (pCi/g)	Mean (pCi/g)	Standard Deviation (pCi/g)	95% Upper Confidence Limit (pCi/g)
Uranium-235	0.14	20	20	0.0212	0.265	0.701	0.270	0.0267	0.280
Cesium-137	0.49	11	20	0.0683	0.105[a]	0.323	0.132	0.0217	0.141
Plutonium-239/240	0.025	3	20	0.00954[a]	0.0100[a]	0.0135	NA[b]	NA[b]	0.014[c]
Radium-226	1.5	20	20	0.72	0.79	0.943	0.81	0.016	0.81
Technetium-99	2.5	15	20	0.863[a]	1.11	8.38	1.52	0.278	1.63
Thorium-228	1.6	20	20	0.226	0.271	0.357	0.276	0.00566	0.279
Thorium-230	1.5	20	20	0.147	0.216	0.283	0.217	0.0113	0.221
Thorium-232	1.5	20	20	0.258	0.308	0.395	0.315	0.00692	0.317
Thorium-234	NA	20	20	5.06	16.9	37.2	18.8	2.33	19.7
Uranium (mg/kg)	4.9	20	20	1.01	18.2	53.5	19.0	2.23	19.9
Uranium-234	2.5	20	20	0.404	1.9	4.7	1.9	0.20	2.0
Uranium-238	1.2	20	20	0.582	16.2	48.2	17.0	2.01	17.6

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the method detection limit.

[b] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic

[c] An insufficient number of detections were recorded for this analyte in order to calculate the UCL. The value shown is the maximum reported value.

Table C.16. Summary Statistics for Subunit 3 PAHs in Surface Soils (Fixed Laboratory)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (µg/kg)	Median (µg/kg)	Maximum (µg/kg)	Mean (µg/kg)	Standard Deviation (µg/kg)	95% Upper Confidence Limit (µg/kg)
Benz(a)anthracene	NA	1	20	NA[a]	NA[a]	310	NA[a]	NA[a]	310[b]
Benzo(a)pyrene	NA	1	20	NA[a]	NA[a]	460	NA[a]	NA[a]	460[b]
Benzo(b)fluoranthene	NA	1	20	NA[a]	NA[a]	420	NA[a]	NA[a]	420[b]
Benzo(ghi)perylene	NA	1	20	NA[a]	NA[a]	390	NA[a]	NA[a]	390[b]
Benzo(k)fluoranthene	NA	1	20	NA[a]	NA[a]	450	NA[a]	NA[a]	450[b]
Chrysene	NA	1	20	NA[a]	NA[a]	340	NA[a]	NA[a]	340[b]
Dibenz(a,h)anthracene	NA	1	20	NA[a]	NA[a]	100	NA[a]	NA[a]	100[b]
Fluoranthene	NA	1	20	NA[a]	NA[a]	270	NA[a]	NA[a]	270[b]
Indeno(1,2,3-cd)pyrene	NA	1	20	NA[a]	NA[a]	340	NA[a]	NA[a]	340[b]
Phenanthrene	NA	1	20	NA[a]	NA[a]	110	NA[a]	NA[a]	110[b]
Pyrene	NA	1	20	NA[a]	NA[a]	270	NA[a]	NA[a]	270[b]

NA = Not Applicable.

[a] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

[b] An insufficient number of detections were recorded for this analyte in order to calculate the UCL. The value shown is the maximum reported value.

Table C.17. Summary of Subunit 3 Metals in Subsurface Soils (Fixed Laboratory)

Metals	Depth (ft)	# of Detects/ # of Samples	Minimum Value	Maximum Value	Mean Value	Background Value
Aluminum (mg/kg)	1–4	13/13	6,440	12,500	8,555	12,000
	4–7	11/11	3,500	11,100	7,285	
	7–10	1/1	NA	6,250	NA[a]	
Antimony (mg/kg)	1–4	13/13	0.1	0.21	0.15	0.21
	4–7	11/11	0.095	0.16	0.12	
	7–10	1/1	NA	0.08	NA[a]	
Arsenic (mg/kg)	1–4	13/13	3.9	9.2	5.8	7.9
	4–7	11/11	2.8	6.7	5.1	
	7–10	1/1	NA	2.6	NA[a]	
Barium (mg/kg)	1–4	13/13	77.2	119	94.2	170
	4–7	11/11	71.9	100	86.0	
	7–10	1/1	NA	44.7	NA[a]	
Beryllium (mg/kg)	1–4	13/13	0.33	0.67	0.49	0.69
	4–7	11/11	0.12	0.58	0.41	
	7–10	1/1	NA	0.27	NA[a]	
Cadmium (mg/kg)	1–4	13/13	0.016	0.12	0.077	0.21
	4–7	11/11	0.026	0.11	0.054	
	7–10	1/1	NA	0.018	NA[a]	
Calcium (mg/kg)	1–4	13/13	328	1,260	939	6100
	4–7	11/11	391	1,060	702	
	7–10	1/1	NA	498	NA[a]	

Table C.17. Summary of Subunit 3 Metals in Subsurface Soils (Fixed Laboratory) (Continued)

Metals	Depth (ft)	# of Detects/ # of Samples	Minimum Value	Maximum Value	Mean Value	Background Value
Chromium (mg/kg)	1–4	13/13	9.6	241	80.2	43
	4–7	11/11	10.5	250	53.8	
	7–10	1/1	NA	7.8	NA[a]	
Cobalt (mg/kg)	1–4	13/13	4	8.1	6.3	13
	4–7	11/11	3.7	7.1	5.3	
	7–10	1/1	NA	3.2	NA[a]	
Copper (mg/kg)	1–4	13/13	6.7	19.2	10.9	25
	4–7	11/11	6.1	15.9	9.3	
	7–10	1/1	NA	4.8	NA[a]	
Iron (mg/kg)	1–4	13/13	9,270	15,000	12,044	28,000
	4–7	11/11	8,670	14,100	10,523	
	7–10	1/1	NA	7,070	NA[a]	
Lead (mg/kg)	1–4	13/13	8.9	19.8	13.2	23
	4–7	11/11	7.3	14	10.9	
	7–10	1/1	NA	6.8	NA[a]	
Magnesium (mg/kg)	1–4	13/13	748	1,770	1,028	2100
	4–7	11/11	684	1,570	943	
	7–10	1/1	NA	858	NA[a]	
Manganese (mg/kg)	1–4	13/13	282	810	429	820
	4–7	11/11	33.5	911	462	
	7–10	1/1	NA	273	NA[a]	
Mercury (mg/kg)	1–4	13/13	0.0152	0.0524	0.0299	0.13
	4–7	11/11	0.0183	0.0373	0.0254	
	7–10	1/1	NA	0.0254	NA[a]	
Molybdenum (mg/kg)	1–4	13/13	0.44	0.78	0.53	NA
	4–7	11/11	0.25	0.6	0.45	
	7–10	1/1	NA	0.24	NA[a]	
Nickel (mg/kg)	1–4	13/13	7.7	12	9.9	22
	4–7	11/11	3	13	9.1	
	7–10	1/1	NA	9.4	NA[a]	
Selenium (mg/kg)	1–4	10/13	0.22	0.59	0.48	0.7
	4–7	8/11	0.2	0.62	0.46	
	7–10	1/1	NA	0.61	NA[a]	
Silver (mg/kg)	1–4	13/13	0.046	0.077	0.061	2.7
	4–7	11/11	0.033	0.11	0.062	
	7–10	1/1	NA	0.055	NA[a]	
Sodium (mg/kg)	1–4	10/13	23.3[b]	174	79.9	340
	4–7	11/11	21.3	242	132	
	7–10	1/1	NA	98.9	NA[a]	
Thallium (mg/kg)	1–4	13/13	0.11	0.21	0.16	0.34
	4–7	10/11	0.091	0.24	0.15	

Table C.17. Summary of Subunit 3 Metals in Subsurface Soils (Fixed Laboratory) (Continued)

Metals	Depth (ft)	# of Detects/ # of Samples	Minimum Value	Maximum Value	Mean Value	Background Value
	7–10	1/1	NA	0.13	NA[a]	
Uranium (mg/kg)	1–4	13/13	1.2	502	167	4.6
	4–7	11/11	0.5	300	80.4	
	7–10	1/1	NA	3.2	NA[a]	
Vanadium (mg/kg)	1–4	13/13	15.5	35.4	23.5	37
	4–7	11/11	8.6	34.1	19.3	
	7–10	1/1	NA	16.7	NA[a]	
Zinc (mg/kg)	1–4	13/13	24.1	123	61.6	60
	4–7	11/11	9.4	81.1	37.7	
	7–10	1/1	NA	18.7	NA[a]	

NA = Not Applicable.

[a] An insufficient number of results were reported for this analyte in order to calculate this statistic.

[b] The reported result was a nondetect. The value shown represents the maximum detection limit.

Table C.18. Summary of Subunit 3 PCBs in Subsurface Soils (Fixed Laboratory)

PCB (μg/kg)	Depth (ft)	# of Detects/# of Samples	Minimum Value	Maximum Value	Mean Value	Background Value
PCB, Total	1–4	11/13	39[b]	6,600	1,478	NA
	4–7	7/11	39[b]	2,500	653	
	7–10	0/1	40[b]	NA	NA[a]	
PCB-1016	1–4	0/13	38[b]	41[b]	NA[a]	NA
	4–7	0/11	38[b]	41[b]	NA[a]	
	7–10	0/1	40[b]	NA	NA[a]	
PCB-1248	1–4	10/13	39[b]	3,800	773	NA
	4–7	7/11	39[b]	1,300	336	
	7–10	0/1	40[b]	NA	NA[a]	
PCB-1254	1–4	11/13	39[b]	1,800	435	NA
	4–7	5/11	39[b]	800	217	
	7–10	0/1	40[b]	NA	NA[a]	
PCB-1260	1–4	11/13	39[b]	990	281	NA
	4–7	5/11	39[b]	420	145	
	7–10	0/1	40[b]	NA	NA[a]	

NA = Not Applicable.

[a] An insufficient number of results were reported for this analyte in order to calculate this statistic.

[b] The reported result was a nondetect. The value shown represents the maximum detection limit.

Table C.18. Summary of Subunit 3 Radionuclides in Subsurface Soils (Fixed Laboratory)

Radionuclides	Depth (ft)	# of Detects/# of Samples	Minimum Value	Maximum Value	Mean Value	Background Value
Uranium-235 (pCi/g)	1–4	11/13	0.127[b]	1.7	0.52	0.14
	4–7	10/11	0.013[b]	1.34	0.339	
	7–10	1/1	NA	0.0161	NA[a]	
Cesium-137 (pCi/g)	1–4	7/13	0.0621[b]	0.155	0.105	0.28
	4–7	6/11	0.0641[b]	0.279	0.134	
	7–10	0/1	0.0661	NA	NA[a]	
Uranium (pCi/g)	1–4	12/13	0.131[b]	118	38.3	NA
	4–7	11/11	0.403	72.1	21.3	
	7–10	1/1	NA	0.833	NA[a]	
Uranium-238 (pCi/g)	1–4	13/13	0.183	105	34.0	1.2
	4–7	11/11	0.279	63.5	18.7	
	7–10	1/1	NA	0.694	NA[a]	
Radium-226 (pCi/g)	1–4	13/13	0.775	1.02	0.908	1.5
	4–7	11/11	0.861	1.29	0.992	
	7–10	1/1	NA	0.94	NA[a]	
Technetium-99 (pCi/g)	1–4	9/13	0.913	1.45	1.028	2.8
	4–7	3/11	0.889[b]	1.31	0.959	
	7–10	0/1	0.921[b]	NA	NA[a]	
Thorium-228 (pCi/g)	1–4	13/13	0.318	0.447	0.371	1.6
	4–7	11/11	0.293	0.51	0.382	
	7–10	1/1	NA	0.289	NA[a]	
Thorium-230 (pCi/g)	1–4	13/13	0.195	0.475	0.306	1.4
	4–7	11/11	0.208	0.421	0.290	
	7–10	1/1	NA	0.203	NA[a]	
Thorium-232 (pCi/g)	1–4	13/13	0.328	0.466	0.398	1.5
	4–7	11/11	NA	0.538	0.374	
	7–10	1/1	NA	0.299	NA[a]	
Thorium-234 (pCi/g)	1–4	13/13	1.89	141	43.0	NA
	4–7	11/11	1.91	94.7	26.5	
	7–10	1/1	NA	2.81	NA[a]	
Uranium-234 (pCi/g)	1–4	13/13	0.106	11.1	3.73	2.4
	4–7	11/11	0.112	7.58	2.20	
	7–10	1/1	NA	0.123	NA[a]	
Uranium-235 (% wt)	1–4	11/11	0.191	0.319	0.251	NA
	4–7	10/10	0.218	0.415	0.278	
	7–10	1/1	NA	0.359	NA[a]	

NA = Not Applicable.

[a] An insufficient number of results were reported for this analyte in order to calculate this statistic.

[b] The reported result was a nondetect. The value shown represents the maximum detection limit.

Table C.19. Summary Statistics for Subunit 3 Metals in Surface Soils (Field Analytical)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	95% Upper Confidence Limit (mg/kg)
Barium	200	115	115	108.9	336.25	537.26	344	87.3	358
Chromium	16	3	115	185	218[a]	528.44	NA[a]	NA[a]	528[c]
Lead	36	35	115	7[a]	7[a]	35.07	16.4	3.41	16.9
Uranium	4.9	61	115	13[a]	25.17	473.19	62.9	80.1	76.1

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the maximum detection limit.

[b] An insufficient number of positively detected results (< 30%) were reported for this analyte in order to calculate this statistic.

[c] Analyte was not detected in enough samples to compute a UCL. Reported value is the maximum detected value.

Table C.20. Summary Statistics for Subunit 3 PCBs Detected in Surface Soils (Field Analytical)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	95% Upper Confidence Limit (mg/kg)
PCB, Total	NA	19	116	1.63[a]	1.69[a]	4.30	NA[b]	NA[b]	4.3[c]

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the method detection limit.

[b] An insufficient number of positively detected results (< 30%) were reported for this analyte in order to calculate this statistic.

[c] Analyte was not detected in enough samples to compute a UCL. Reported value is the maximum detected value.

Table C.21. Summary Statistics for Subunit 3 Radionuclides Surface Soils (Field Analytical)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (pCi/g)	Median (pCi/g)	Maximum (pCi/g)	Mean (pCi/g)	Standard Deviation (pCi/g)	95% Upper Confidence Limit (pCi/g)
Cesium-137	0.49	36	116	0.0007[a]	0.216[a]	0.659	0.277	0.0827	0.306
Uranium-238	1.2	6	116	0.0860[a]	21.7[a]	140	NA[b]	NA[b]	140[c]

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the maximum detection limit.

[b] An insufficient number of positively detected results (< 30%) were reported for this analyte in order to calculate this statistic.

[c] Analyte was not detected in enough samples to compute a UCL. Reported value is the maximum detected value.

Table C.22. Summary Statistics by Depth for Subunit 3 Subsurface Soils (Field Analytical)

Analyte	Depth	# of Detects/ # of Samples	Minimum Value	Maximum Value	Mean Value	Background Value
Metals	(ft)		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Barium	1–4	28/28	221.87	520.44	373.23	170
	4–7	22/22	340.89	549.78	441.43	
	7–10	7/7	379.74	519.99	453.77	
Chromium	1–4	0/28	218[b]	NA[a]	NA[a]	43
	4–7	0/22	218[b]	NA[a]	NA[a]	
	7–10	0/7	218[b]	NA[a]	NA[a]	
Lead	1–4	2/28	7[b]	18.92	7.82	23
	4–7	5/22	7[b]	29.65	10.48	
	7–10	5/7	7[b]	20.84	15.38	
Uranium	1–4	20/28	13[b]	294.94	75.81	4.6
	4–7	14/22	13[b]	224.71	59.68	
	7–10	1/7	13[b]	349.21	61.03	
Organics	(ft)		(mg/kg)	(mg/kg)	(µg/kg)	(mg/kg)
PCB, Total	1–4	13/28	1.55[b]	4.36	2.07	NA
	4–7	10/22	1.59[b]	3.81	1.97	
	7–10	1/7	1.61[b]	15.83	3.64	
Radionuclides	(ft)		(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)
Cesium-137	1–4	4/28	-0.43[a]	0.30	0.11	0.28
	4–7	0/22	0.39[a]	0.30[b]	NA[a]	
	7–10	0/7	0.34[a]	0.17[b]	NA[a]	
Uranium-238	1–4	1/28	68.30[a]	125.82[b]	NA[a]	1.2
	4–7	0/22	88.80[a]	65.18	NA[a]	
	7–10	1/7	55.30[a]	161.24	NA[a]	

NA = Not Applicable.

[a] An insufficient number of results were reported for this analyte in order to calculate this statistic.

[b] The reported result was a nondetect. The value shown represents the maximum detection limit.

Table C.23. Summary Statistics for Subunit 4 Metals in Surface Soils (Fixed Laboratory)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	95% Upper Confidence Limit (mg/kg)
Aluminum	13,000	20	20	6,150	8,495	10,100	8,490	349	8,624
Antimony	0.21	20	20	0.11	0.17	0.84	0.20	0.030	0.21
Arsenic	12	20	20	3.5	7.0	23.3	8.6	1.2	9.0
Barium	200	20	20	52.2	89.7	144	91.1	6.78	93.7
Beryllium	0.67	20	20	0.38	0.51	1.5	0.56	0.056	0.58
Cadmium	0.21	20	20	0.027	0.063	0.1	0.063	0.0032	0.064
Calcium	200,000	20	20	691	922	1,210	935	31.3	948
Chromium	16	20	20	13.9	26.8	158	42.4	9.06	46
Cobalt	14	20	20	4	6.1	11.3	6.4	0.13	6.4
Copper	19	20	20	7.8	10	29.1	11	0.98	12
Iron	28,000	20	20	8,150	13,600	48,500	15,053	1,688	15,705
Lead	36	20	20	9.5	14.1	32.9	16.6	2.05	17
Magnesium	7,700	20	20	804	1,205	1,460	1,199	75.7	1,228
Manganese	1,500	20	20	212	379	775	412	37.8	427
Mercury	0.20	9	20	0.0086	0.0401	0.0442[a]	0.0308	0.00282	0.0319
Molybdenum	NA	20	20	0.3	0.65	2.40	0.71	0.084	0.74
Nickel	21	20	20	6.7	8.7	20.7	9.1	0.56	9.3
Selenium	0.8	13	20	0.16	0.38	0.62	0.41	0.041	0.43
Silver	2.3	20	20	0.042	0.057	0.085	0.057	0.0015	0.058
Sodium	320	20	20	17.6	23	35	23	1.1	24
Thallium	0.34	20	20	0.15	0.22	0.3	0.22	0.021	0.22
Uranium	4.9	20	20	1.3	2.7	269	17	11	22
Vanadium	38	20	20	14.1	22.8	86.9	26.3	3.09	27.4
Zinc	65	20	20	27.8	35.1	77.7	41.6	4.12	43.2

[a] The reported result was a nondetect. The value shown represents the method detection limit.

Table C.24. Summary Statistics for Subunit 4 PCBs in Surface Soils (Fixed Laboratory)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (µg/kg)	Median (µg/kg)	Maximum (µg/kg)	Mean (µg/kg)	Standard Deviation (µg/kg)	95% Upper Confidence Limit (µg/kg)
PCB, Total	NA	10	20	39[a]	46	490	90	18	97
PCB-1260	NA	10	20	39[a]	46	490	90	18	97

[a] The reported result was a nondetect. The value shown represents the method detection limit.

Table C.25. Summary Statistics for Subunit 4 Radionuclides in Surface Soils (Fixed Laboratory)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (pCi/g)	Median (pCi/g)	Maximum (pCi/g)	Mean (pCi/g)	Standard Deviation (pCi/g)	95% Upper Confidence Limit (pCi/g)
Uranium-235	0.14	6	20	0.024[a]	0.025[a]	0.244[a]	0.048	0.010	0.052
Cesium-137	0.49	18	20	0.0493[a]	0.131	0.371	0.148	0.0179	0.156
Radium-226	1.5	20	20	0.706	0.825	0.974	0.827	0.0188	0.834
Thorium-228	1.6	20	20	0.252	0.348	0.484	0.356	0.0159	0.362
Thorium-230	1.5	20	20	0.166	0.260	0.412	0.269	0.0216	0.277
Thorium-232	1.5	20	20	0.266	0.370	0.466	0.362	0.0200	0.370
Thorium-234	NA	20	20	1.52	2.16	61.4	5.38	2.62	6.4
Uranium (mg/kg)	4.9	16	20	0.231	1.22	28.8	5.67	3.57	2.13
Uranium-234	2.5	20	20	0.129	0.253	0.866	0.342	0.0710	0.369
Uranium-238	1.2	20	20	0.172	0.356	9.67	1.45	0.834	1.77

[a] The reported result was a nondetect. The value shown represents the method detection limit.

Table C.26. Summary Statistics for Subunit 4 PAHs in Surface Soils (Fixed Laboratory)

Analyte	Background Values	# Positive Detections	# Data Points	Minimum (µg/kg)	Median (µg/kg)	Maximum (µg/kg)	Mean (µg/kg)	Standard Deviation (µg/kg)	95% Upper Confidence Limit (µg/kg)
Benz0(a)anthracene	NA	1	20	NA[a]	NA[a]	43	NA[a]	NA[a]	43[b]
Benzo(a)pyrene	NA	1	20	NA[a]	NA[a]	56	NA[a]	NA[a]	56[b]
Benzo(b)fluoranthene	NA	1	20	NA[a]	NA[a]	55	NA[a]	NA[a]	55[b]
Benzo(k)fluoranthene	NA	1	20	NA[a]	NA[a]	46	NA[a]	NA[a]	46[b]
Chrysene	NA	1	20	NA[a]	NA[a]	64	NA[a]	NA[a]	64[b]
Fluoranthene	NA	6	20	46	400[a]	440[a]	308	16	314
Phenanthrene	NA	1	20	NA[a]	NA[a]	120	NA[a]	NA[a]	120[b]
Pyrene	NA	4	20	NA[a]	NA[a]	110	NA[a]	NA[a]	110[b]

NA = Not Applicable.

[a] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

[b] An insufficient number of detections were recorded for this analyte in order to calculate the UCL. The value shown is the maximum reported result.

Table C.27. Summary for Subunit 4 Metals by Depth (Fixed Laboratory)

Metals	Depth (ft)	# of Detects/ # of Samples	Minimum Value	Maximum Value	Mean Value	Background Value
Aluminum (mg/kg)	1–4	13/13	7,320	14,700	9,527	12,000
	4–7	13/13	7,630	17,600	10,821	
	7–10	4/4	8,130	12,900	9,818	
Antimony (mg/kg)	1–4	13/13	0.098	0.22	0.145	0.21
	4–7	13/13	0.12	0.23	0.16	
	7–10	4/4	0.14	0.23	0.17	
Arsenic (mg/kg)	1–4	13/13	4.2	15	7.0	7.9
	4–7	13/13	5.7	12.5	8.55	
	7–10	4/4	6.4	17.6	9.70	
Barium (mg/kg)	1–4	13/13	85	141	99.8	170
	4–7	13/13	82.5	138	105	
	7–10	4/4	93.6	111	104	
Beryllium (mg/kg)	1–4	13/13	0.36	0.72	0.48	0.69
	4–7	13/13	0.4	0.6	0.5	
	7–10	4/4	0.44	0.52	0.47	
Cadmium (mg/kg)	1–4	13/13	0.024	0.098	0.053	0.21
	4–7	13/13	0.015	0.093	0.046	
	7–10	4/4	0.037	0.11	0.070	
Calcium (mg/kg)	1–4	13/13	639	1150	889	6.1
	4–7	13/13	351	1190	681	
	7–10	4/4	615	853	721	
Chromium (mg/kg)	1–4	13/13	15.4	55.4	26.6	43
	4–7	13/13	8.9	65.6	19.8	
	7–10	4/4	17.8	30.8	21.5	
Cobalt (mg/kg)	1–4	13/13	4.6	8.9	6.0	13
	4–7	13/13	3.7	18.4	7.15	
	7–10	4/4	6	6.4	6.2	
Copper (mg/kg)	1–4	13/13	7.5	15.5	10.4	25
	4–7	13/13	7.3	17.4	10.6	
	7–10	4/4	7.9	12.7	11.0	
Iron (mg/kg)	1–4	13/13	10,600	19,300	13,969	28
	4–7	13/13	11,000	18,600	15,431	
	7–10	4/4	12,700	17,100	14,300	
Lead (mg/kg)	1–4	13/13	9.7	24	13	23
	4–7	13/13	11.4	33.6	16.4	
	7–10	4/4	11.2	34.3	19.1	
Magnesium (mg/kg)	1–4	13/13	1,030	1,660	1,231	2.1
	4–7	13/13	832	2,190	1,380	
	7–10	4/4	1,120	1,430	1,243	
Manganese (mg/kg)	1–4	13/13	196	891	383	820
	4–7	13/13	95.7	2,640	747	
	7–10	4/4	512	700	591	
Mercury (mg/kg)	1–4	13/13	0.0075	0.123	0.061	0.13

Table C.27. Summary for Subunit 4 Metals by Depth (Fixed Laboratory) (Continued)

Metals	Depth (ft)	# of Detects/ # of Samples	Minimum Value	Maximum Value	Mean Value	Background Value
	4–7	13/13	0.0089	0.139	0.066	
	7–10	3/4	0.0333	0.112	0.0581	
Molybdenum (mg/kg)	1–4	13/13	0.37	0.93	0.57	NA
	4–7	13/13	0.47	1.1	0.66	
	7–10	4/4	0.62	0.83	0.68	
Nickel (mg/kg)	1–4	13/13	7.9	14.9	10.2	22
	4–7	13/13	8.3	18.5	13.3	
	7–10	4/4	14	22.8	18.1	
Selenium (mg/kg)	1–4	8/13	0.18[a]	0.59[a]	0.34	0.7
	4–7	9/13	0.21	0.62[a]	0.40	
	7–10	3/4	0.19[a]	0.43	0.28	
Silver (mg/kg)	1–4	12/13	0.05	1.1	0.14	2.7
	4–7	12/13	0.047	1.2[a]	0.152	
	7–10	4/4	0.059	0.065	0.063	
Sodium (mg/kg)	1–4	13/13	22.1	135	61.2	340
	4–7	13/13	29.3	136	60.9	
	7–10	4/4	42.9	104	72.7	
Thallium (mg/kg)	1–4	12/13	0.13	1.1	0.23	0.34
	4–7	12/13	0.14	1.2	0.29	
	7–10	4/4	0.17	0.23	0.19	
Uranium (mg/kg)	1–4	13/13	1.4	344	28.8	4.6
	4–7	13/13	1.1	155	13	
	7–10	4/4	1.4	58.6	15.9	
Vanadium (mg/kg)	1–4	13/13	19.7	36.9	25.6	37
	4–7	13/13	19	34.2	27.1	
	7–10	4/4	22.9	35.5	29.6	
Zinc (mg/kg)	1–4	13/13	24.4	63.2	35	60
	4–7	13/13	18.4	55.8	32.1	
	7–10	4/4	26	55.8	38.4	

[a] The reported result was a nondetect. The value shown represents the maximum detection limit.

Table C.28. Summary for Subunit 4 PCBs by Depth (Fixed Laboratory)

PCB (µg/kg)	Depth (ft)	# of Detects/# of Samples	Minimum Value	Maximum Value	Mean Value	Background Value
PCB, Total	1–4	8/13	38[b]	1,200	215	NA
	4–7	5/13	38[b]	840	123	
	7–10	2/3	40[b]	580	229	
PCB-1016	1–4	0/13	37[b]	39[b]	NA[a]	NA
	4–7	0/13	36[b]	41[b]	NA[a]	
	7–10	0/3	37[b]	40[b]	NA[a]	
PCB-1248	1–4	0/13	37[b]	39[b]	NA[a]	NA
	4–7	1/13	36[b]	54	NA[a]	
	7–10	0/3	37[b]	40[b]	NA[a]	
PCB-1254	1–4	1/13	37[b]	740	92	NA
	4–7	1/13	38[b]	450	71	
	7–10	1/3	39[b]	180	86	
PCB-1260	1–4	8/13	38[b]	470	155	NA
	4–7	4/13	38[b]	400	88	
	7–10	2/3	40[b]	400	169	

NA = Not Applicable.

[a] An insufficient number of positive results were reported for this analyte in order to calculate this statistic.

[b] The reported result was a nondetect. The value shown represents the maximum detection limit.

Table C.29. Summary for Subunit 4 Radionuclides by Depth (Fixed Laboratory)

Radionuclides	Depth (ft)	# of Detects/ # of Samples	Minimum Value	Maximum Value	Mean Value	Background Value
Uranium-235 (pCi/g)	1–4	11/13	0.0143	2.03	0.1758	0.14
	4–7	6/13	0.011[b]	0.506	0.054	
	7–10	2/4	0.0141[b]	1.24	0.3215	
Cesium-137 (pCi/g)	1–4	5/13	0.0609[b]	0.165	0.094	0.28
	4–7	4/13	0.0566[b]	0.154	0.091	
	7–10	2/4	0.0729[b]	0.2	0.1134	
Uranium (pCi/g)	1–4	11/13	0.133[b]	149	12.1	NA
	4–7	10/13	0.127[b]	43.7	3.71	
	7–10	2/4	0.154[b]	11.5	3.26	
Uranium (mg/kg)	1–4	0/0	NA	NA	NA[a]	4.6
	4–7	0/0	NA	NA	NA[a]	
	7–10	0/0	NA	NA	NA[a]	
Uranium-238 (pCi/g)	1–4	13/13	0.222	132	10.6	1.2
	4–7	13/13	0.11	38.7	3.18	
	7–10	2/4	0.226	8.76	2.44	
Americium-241 (pCi/g)	1–4	0/0	NA	NA	NA[a]	NA
	4–7	0/0	NA	NA	NA[a]	
	7–10	0/0	NA	NA	NA[a]	
Neptunium-237 (pCi/g)	1–4	0/0	NA	NA	NA[a]	NA
	4–7	0/0	NA	NA	NA[a]	
	7–10	0/0	NA	NA	NA[a]	

Table C.29. Summary for Subunit 4 Radionuclides by Depth (Fixed Laboratory) (Continued)

Radionuclides	Depth (ft)	# of Detects/ # of Samples	Minimum Value	Maximum Value	Mean Value	Background Value
Plutonium-239/240 (pCi/g)	1–4	0/0	NA	NA	NA[a]	NA
	4–7	0/0	NA	NA	NA[a]	
	7–10	0/0	NA	NA	NA[a]	
Radium-226 (pCi/g)	1–4	13/13	0.844	1.05	0.950	1.5
	4–7	13/13	0.793	1.11	0.963	
	7–10	2/4	0.859	1.18	1.01	
Technetium-99 (pCi/g)	1–4	1/13	0.878[b]	1.16	NA[a]	2.8
	4–7	0/13	0.878[b]	0.919[b]	NA[a]	
	7–10	0/4	0.878[b]	0.919[b]	NA[a]	
Thorium-228 (pCi/g)	1–4	13/13	0.361	0.584	0.457	1.6
	4–7	13/13	0.329	0.582	0.453	
	7–10	2/4	0.429	0.525	0.478	
Thorium-230 (pCi/g)	1–4	13/13	0.267	0.509	0.387	1.4
	4–7	13/13	0.321	0.57	0.409	
	7–10	2/4	0.388	0.494	0.446	
Thorium-232 (pCi/g)	1–4	13/13	0.395	0.592	0.484	1.5
	4–7	13/13	0.396	0.624	0.488	
	7–10	2/4	0.45	0.553	0.496	
Thorium-234 (pCi/g)	1–4	13/13	1.57	109	10.4	NA
	4–7	13/13	1.43	49	5.48	
	7–10	2/4	1.9	10.3	4.33	
Uranium-234 (pCi/g)	1–4	13/13	0.208	14.8	1.43	2.4
	4–7	13/13	0.124	4.53	0.534	
	7–10	2/4	0.173	1.48	0.557	
Uranium-235 (% wt)	1–4	11/11	0.238	1.05	0.771	NA
	4–7	6/6	0.203	1.75	1.15	
	7–10	2/4	0.539	2.16	1.35	

NA = Not Applicable.

[a] An insufficient number of results were reported for this analyte in order to calculate this statistic.

[b] The reported result was a nondetect. The value shown represents the maximum detection limit.

Table C.30. Summary Statistics for Subunit 4 Metals in Surface Soils (Field Analytical)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	95% Upper Confidence Limit (mg/kg)
Barium	200	116	116	182.76	380.24	606.17	374	80.3	387
Lead	36	62	116	7[a]	15.09	58.36	17.7	6.15	18.7
Uranium	4.9	6	116	13[a]	NA[b]	321.36	NA[b]	NA[b]	321[c]

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the maximum detection limit.

[b] An insufficient number of positively detected results (< 30%) were reported for this analyte in order to calculate this statistic.

[c] Analyte was not detected in enough samples to compute an UCL. Reported value is the maximum detected value.

Table C.31. Summary Statistics for Subunit 4 PCBs in Surface Soils (Field Analytical)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	95% Upper Confidence Limit (mg/kg)
PCB, Total	NA	26	116	1.59[a]	1.69[a]	5.77	NA[b]	NA[b]	5.77[c]

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the maximum detection limit.

[b] An insufficient number of positively detected results (< 30%) were reported for this analyte in order to calculate this statistic.

[c] Analyte was not detected in enough samples to compute a UCL. Reported value is the maximum detected result.

Table C.32. Summary Statistics for Subunit 4 Radionuclides in Surface Soils (Field Analytical)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (pCi/g)	Median (pCi/g)	Maximum (pCi/g)	Mean (pCi/g)	Standard Deviation (pCi/g)	95% Upper Confidence Limit (pCi/g)
Cesium-137	0.49	41	116	0.0557[a]	0.262	0.693	0.346	0.0872	0.348
Uranium-238	1.2	2	116	0[a]	NA[b]	201	NA[b]	NA[b]	201[c]

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the maximum detection limit.

[b] An insufficient number of positively detected results (< 30%) were reported for this analyte in order to calculate this statistic.

[c] Analyte was not detected in enough samples to compute a UCL. Reported value is the maximum detected value.

Table C.33. Summary Statistics by Depth for Subunit 4 Subsurface Soils (Field Analytical)

Analyte	Depth	# Detected/ # of Samples	Minimum Value	Maximum Value	Mean Value	Background Value
Metals	(ft)		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Barium	1–4	28/28	312.97	510.35	428.62	170
	4–7	25/25	368.54	563.76	480.15	
	7–10	7/7	466.12	564.9	499.06	
Chromium	1–4	0/28	218[b]	NA[a]	NA[a]	43
	4–7	0/25	218[b]	NA[a]	NA[a]	
	7–10	0/7	218[b]	NA[a]	NA[a]	
Lead	1–4	20/28	7[b]	33.37	17.53	23
	4–7	15/25	7[b]	40.65	17.03	
	7–10	6/7	7[b]	32.13	23.65	
Uranium	1–4	1/28	13[b]	324.83	NA[a]	4.6
	4–7	1/25	13[b]	85.32	NA[a]	
	7–10	0/7	13[b]	NA[a]	NA[a]	
Organics	(ft)		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
PCB, Total	1–4	7/28	1.52[b]	3.12	1.76	NA
	4–7	5/25	1.57[b]	2.47	1.70	
	7–10	0/7	1.52[b]	1.63[b]	NA[a]	
Radionuclides	(ft)		(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)
Cesium-137	1–4	3/28	0.31[b]	0.36	0.10	0.28
	4–7	1/25	0.38[b]	0.27[b]	NA[a]	
	7–10	1/7	0.00	0.26[b]	NA[a]	
Uranium-238	1–4	2/28	57.70[b]	94.17[b]	5.61	1.2
	4–7	1/25	75.30[b]	30.90[b]	NA[a]	
	7–10	0/7	52.00[b]	13.30[b]	NA[a]	

NA = Not Applicable.

[a] An insufficient number of results were reported for this analyte in order to calculate this statistic.

[b] The reported result was a nondetect. The value shown represents the maximum detection limit.

Table C.34. Summary Statistics for Subunit 5 Metals in Surface Soils (Fixed Laboratory)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	95% Upper Confidence Limit (mg/kg)
Aluminum	13,000	18	18	5,650	8620	13,800	9,293	2,423	10,286
Antimony	0.21	18	18	0.089	0.26	0.49	0.25	0.11	0.30
Arsenic	12	18	18	3.7	12	47	17	13	23
Barium	200	18	18	52.3	89.3	327	103	60.8	130
Beryllium	0.67	18	18	0.26	0.59	1.4	0.61	0.25	0.72
Cadmium	0.21	18	18	0.021	0.066	0.19	0.074	0.046	0.093
Calcium	200,000	18	18	137	479	1,230	547	331	683
Chromium	16	18	18	6.2	12	17.8	12	3.4	13
Cobalt	14	18	18	2.6	7	32	8.8	6.6	11
Copper	19	18	18	4.8	11	27.1	12	6.9	15
Iron	28,000	18	18	6,690	16,850	24,200	15,498	5,268	17,658
Lead	36	18	18	9	20	115	38	36	75
Magnesium	7,700	18	18	610	1,035	1,980	1,206	474	1,425
Manganese	1,500	18	18	169	609	8,340	1,187	1,892	1,822
Mercury	0.20	17	18	0.0099	0.043	0.0735	0.043	0.016	0.049
Molybdenum	NA	18	18	0.29	0.89	2.3	0.91	0.45	1.1
Nickel	21	18	18	4.5	9.3	14.9	9.0	2.6	10
Selenium	0.8	13	18	0.22	0.50	0.73	0.48	0.18	0.55
Silver	2.3	18	18	0.035	0.046	0.12	0.051	0.019	0.059
Sodium	320	18	18	15.5	19.6	25.9	20.1	3.03	21
Thallium	0.34	18	18	0.23	0.30	0.44	0.31	0.053	0.34
Uranium	4.9	18	18	1.3	1.7	2.3	1.8	0.33	1.89
Vanadium	38	18	18	13.5	27.4	48.4	27.7	8.83	31.3
Zinc	65	18	18	17.6	26.3	40.3	28.5	6.65	31.2

Table C.35. Summary Statistics for Subunit 5 Radionuclides in Surface Soils (Fixed Laboratory)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (pCi/g)	Median (pCi/g)	Maximum (pCi/g)	Mean (pCi/g)	Standard Deviation (pCi/g)	95% Upper Confidence Limit (pCi/g)
Uranium-235	0.14	12	18	0.0124[a]	0.0203	0.0442	0.0173	0.00949	0.0224
Americium-241	NA	1	18	0.0131[a]	NA[b]	0.034	NA[b]	NA[b]	0.034[c]
Cesium-137	0.49	18	18	0.142	0.282	0.5\55	0.302	0.121	0.351
Plutonium-239/240	0.025	4	18	0.00982[a]	0.0106[a]	0.0141	0.0123	0.000618	0.0137
Radium-226	1.5	18	18	0.643	0.807	0.999	0.821	0.108	0.865
Technetium-99	2.5	1	18	0.877[a]	NA[b]	3.65	NA[b]	NA[b]	3.65[c]
Thorium-228	1.6	18	18	0.214	0.312	0.494	0.323	0.0776	0.355
Thorium-230	1.5	18	18	0.113	0.309	0.453	0.282	0.110	0.327
Thorium-232	1.5	18	18	0.272	0.350	0.507	0.363	0.0743	0.394
Thorium-234	NA	18	18	1.04	1.76	3.07	1.91	0.600	2.16
Uranium (mg/kg)	4.9	18	18	0.656	1.09	3.46	1.30	0.656	0.855
Uranium-234	2.5	18	18	0.119	0.274	0.441	0.279	0.0825	0.312
Uranium-238	1.2	18	18	0.219	0.365	1.16	0.434	0.220	0.523

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the method detection limit.

[b] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

[c] Analyte was not detected in enough samples to compute a UCL. Reported value is the maximum detected result.

Table C.36. Summary Statistics for Subunit 5 Metals in Surface Soils (Field Analytical)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	95% Upper Confidence Limit (mg/kg)
Barium	200	84	84	231.54	436.48	636.34	437	61.0	448
Lead	36	75	84	7[a]	20.41	209.69	38.2	40.9	46.0
Uranium	4.9	1	84	13[a]	NA[b]	30.16	NA[b]	NA[b]	30.1[c]

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the maximum detection limit.

[b] An insufficient number of positively detected results (<30%) were reported for this analyte in order to calculate this statistic.

[c] Analyte was not detected in enough samples to compute a UCL. Reported value is a maximum detected result.

Table C.37. Summary Statistics for Subunit 5 PCBs Detected in Surface Soils (Field Analytical)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)	95% Upper Confidence Limit (mg/kg)
PCB, Total	NA	2	84	1.78[a]	1.78[s]	3.12	NA[b]	NA[b]	3.12[c]

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the maximum detection limit.

[b] An insufficient number of positively detected results (< 30%) were reported for this analyte in order to calculate this statistic.

[c] Analyte was not detected in enough samples to compute a UCL. Reported value is a maximum detected result.

Table C.38. Summary Statistics for Subunit 5 Radionuclides in Surface Soils (Field Analytical)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (pCi/g)	Median (pCi/g)	Maximum (pCi/g)	Mean (pCi/g)	Standard Deviation (pCi/g)	95% Upper Confidence Limit (pCi/g)
Cesium-137	0.49	9	84	0.056[a]	0.30[a]	0.67	NA[b]	NA[b]	0.67[c]
Uranium-238	1.2	7	84	0[a]	35.1[a]	18.4	NA[b]	NA[b]	18.4[c]

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the maximum detection limit.

[b] An insufficient number of positively detected results (< 30%) were reported for this analyte in order to calculate this statistic.

[c] Analyte was not detected in enough samples to compute a UCL. Reported value is the maximum detected result.

Table C.39. Summary Statistics for Metals in Contingency Surface Soils (Fixed Laboratory)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (mg/kg)	Median (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	Standard Deviation (mg/kg)
Aluminum	13,000	5	5	6,090	6,500	7,500	6,724	579
Antimony	0.21	5	5	0.094	0.15	0.33	0.17	0.10
Arsenic	12	5	5	3.8	5.5	39.6	13	15
Barium	200	5	5	70.6	105	137	106	25
Beryllium	0.67	5	5	0.33	0.40	0.78	0.46	0.19
Cadmium	0.21	5	5	0.1	0.21	0.57	0.27	0.19
Calcium	200,000	5	5	1,120	1,420	1,470	1,344	144
Chromium	16	5	5	74.7	145	1,140	385	444
Cobalt	14	5	5	4.4	5.2	11.5	6.9	2.9
Copper	19	5	5	10.2	19.1	62.3	26.6	21.7
Iron	28,000	5	5	7,300	10,300	19,400	11,854	4,606
Lead	36	5	5	10.4	16.9	53.5	22.9	17.7
Magnesium	7,700	5	5	620	841	1,040	858	161
Manganese	1,500	5	5	170	452	666	392	216
Mercury	0.20	5	5	18.4	34.2	90.6	43.3	28.7
Molybdenum	NA	5	5	0.31	0.67	1.3	0.70	0.38
Nickel	21	5	5	7.5	11	12.7	10	2.4
Selenium	0.8	2	5	0.25	NA[b]	0.78	NA[\b]	NA[b]
Silver	2.3	5	5	0.046	0.072	0.14	0.085	0.043
Sodium	320	5	5	20.3[a]	21.5	103	39.5	35.8
Thallium	0.34	5	5	0.1	0.12	0.15	0.12	0.023
Uranium	4.9	5	5	322	1,030	6,410	1,912	2,551
Vanadium	38	5	5	13.1	16.8	41.9	22.5	11.8
Zinc	65	5	5	69.3	178	591	265	210

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the method detection limit.

[b] An insufficient number of positively detected results (< 30%) were reported for this analyte in order to calculate this statistic.

Table C.40. Summary Statistics for PCBs in Contingency Surface Soils (Fixed Laboratory)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (µg/kg)	Median (µg/kg)	Maximum (µg/kg)	Mean (µg/kg)	Standard Deviation (µg/kg)
PCB, Total	NA	4	5	39[a]	3,700	79,000	19,908	33,455
PCB-1248	NA	3	5	39[a]	NA[b]	57,000	NA[b]	NA[b]
PCB-1254	NA	4	5	39[a]	1,500	16,000	4,562	6,615
PCB-1260	NA	4	5	39[a]	2,200	6,400	2,412	2,476

NA= Not Applicable.

[a] The reported result was a nondetect. The value shown represents the method detection limit.

[b] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

Table C.41. Summary Statistics for Radionuclides in Contingency Surface Soils (Fixed Laboratory)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (pCi/g)	Median (pCi/g)	Maximum (pCi/g)	Mean (pCi/g)	Standard Deviation (pCi/g)
Uranium-235	0.14	5	5	3.17	4.33	5.81	4.44	0.959
Americium-241	NA	1	5	0.014[a]	NA[b]	0.0162	NA[b]	NA[b]
Cesium-137	0.49	5	5	0.151	0.357	1.01	0.440	0.333
Neptunium-237	0.1	4	5	0.0232	0.0478[a]	0.0678	0.0425	0.0190
Plutonium-239/240	0.025	4	5	0.0104[a]	0.014	0.046	0.0223	0.0154
Radium-226	1.5	5	5	0.547	0.865	0.976	0.833	0.166
Technetium-99	2.5	5	5	0.984	1.88	2.42	1.79	0.554
Thorium-228	1.6	5	5	0.37	0.41	0.486	0.43	0.047
Thorium-230	1.5	5	5	0.282	0.300	0.532	0.368	0.111
Thorium-232	1.5	5	5	0.348	0.375	0.477	0.399	0.0580
Thorium-234	NA	5	5	202	307	1,550	531	573
Uranium (mg/kg)	4.9	5	5	524	754	939	767	166
Uranium-234	2.5	5	5	20.2	28.7	34.4	28.5	5.88
Uranium-238	1.2	5	5	176	253	315	257	55.6

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the method detection limit.

[b] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

Table C.42. Summary Statistics for PAHs in Contingency Surface Soils (Fixed Laboratory)

Analyte	Background Value	# Positive Detections	# Data Points	Minimum (µg/kg)	Median (µg/kg)	Maximum (µg/kg)	Mean (µg/kg)	Standard Deviation (µg/kg)
Benzo(a)anthracene	NA	3	5	73	NA[b]	390[a]	NA[b]	NA[b]
Benzo(a)pyrene	NA	3	5	78	NA[b]	390[a]	NA[b]	NA[b]
Benzo(b)fluoranthene	NA	2	5	92	NA[b]	390[a]	NA[b]	NA[b]
Benzo(ghi)perylene	NA	3	5	74	NA[b]	390[a]	NA[b]	NA[b]
Benzo(k)fluoranthene	NA	2	5	91	NA[b]	390[a]	NA[b]	NA[b]
Chrysene	NA	3	5	100	NA[b]	390[a]	NA[b]	NA[b]
Fluoranthene	NA	5	5	45	230	170	140	85
Indeno(1,2,3-cd)pyrene	NA	3	5	75	NA[b]	390[a]	NA[b]	NA[b]
Phenanthrene	NA	3	5	100	NA[b]	390[a]	NA[b]	NA[b]
Pyrene	NA	5	5	43	190	150	118	68

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the method detection limit.

[b] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

Table C.43. Summary Statistics for Contingency Surface Soils (Field Analytical)

Analyte	Minimum Value	First Quartile	Median	Third Quartile	Maximum Value	Background Value
Metals	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Barium	293.86	388.70	401.02	430.65	499.71	170
Chromium	218[a]	NA[b]	NA[b]	NA[b]	440.2	43
Lead	7[a]	NA[b]	NA[b]	NA[b]	7[a]	23
Uranium	324.78	608.75	657.81	748.55	3799.12	4.6
Organics	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
PCB, Total	2.59	3.63	4.34	12.06	24.14	
Radionuclides	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)
Cesium-137	0.15[a]	NA[b]	NA[b]	NA[b]	0.74	0.28
Uranium-238	145.60	240.73	243.61	355.45	2,184.19	1.2

NA = Not Applicable.

[a] The reported result was a nondetect. The value shown represents the detection limit.

[b] An insufficient number of positively detected results were reported for this analyte in order to calculate this statistic.

Table C.44. Summary of Metals – Soil Pile I Tree Tissue

Metals (mg/kg)	Background Value	Number of Detects	Number of Samples	Minimum	Maximum	Average	Standard Deviation
Aluminum	13,000	1	5	8	8	8	NA[a]
Barium	200	5	5	10	51.1	21.3	17.1
Cadmium	0.21	2	5	0.17	0.24	0.21	0.05
Calcium	200,000	5	5	1,030	2,580	1,850	751
Iron	28,000	2	5	5.7	15	10	6.6
Lead	36	1	5	0.38	0.38	0.38	NA[a]
Magnesium	7,700	5	5	57.7	114	93.2	25.3
Manganese	1,500	5	5	4.1	84	36	37
Nickel	21	1	5	0.95	0.95	0.95	NA[a]
Uranium (pCi/g)	NA	1	5	0.07626	0.07626	0.07626	NA[a]
Zinc	65	1	5	2.4	2.4	2.4	NA[a]

NA = Not Applicable.

[a] Not enough detects to compute this statistic.

Table C.45. Summary Statistics for Radionuclides – Soil Pile I Tree Tissue

Radiological (pCi/g)	Background Value	Number of Detects	Number of Samples	Minimum	Maximum	Average	Standard Deviation
Thorium-230	1.5	1	5	0.02367	0.02367	0.02367	NA[a]
Thorium-234	NA	2	5	0.0379	0.07413	0.05602	0.02562
Uranium-233/234	2.5	1	5	0.03453	0.03453	0.03453	NA[a]
Uranium-238	1.2	1	5	0.0379	0.0379	0.0379	NA[a]

[a] Not enough detects to compute this statistic.

Table C.46. Summary Statistics for Organics – Soil Pile I Tree Tissue

Organics (µg/kg)	Background Value	Number of Detects	Number of Samples	Minimum	Maximum	Average	Standard Deviation
Toluene	NA	5	5	430	1,800	788	573

Table C.47. TCLP Results Summary

TCLP Metals mg/L	Number of Detects	Number of Samples
Chromium	2	6

TCLP Volatiles ug/L	Number of Detects	Number of Samples
1,1-Dichloroethene	0	9
1,2-Dichloroethane	0	9
2-Butanone	2	9
Benzene	0	9
Carbon tetrachloride	0	9
Chlorobenzene	0	9
Chloroform	0	9
Tetrachloroethene	0	9
Trichloroethene	0	9
Vinyl chloride	0	9

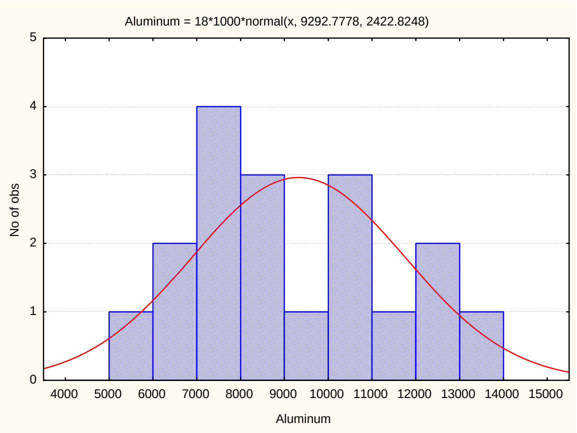
TCLP Semivolatiles ug/L	Number of Detects	Number of Samples
1,4-Dichlorobenzene	0	5
2,4,5-Trichlorophenol	0	5
2,4,6-Trichlorophenol	0	5
2,4-Dinitrotoluene	0	5
Hexachlorobenzene	0	5
Hexachlorobutadiene	0	5
Hexachloroethane	0	5
Nitrobenzene	0	5
Pentachlorophenol	0	5
Pyridine	0	5

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX C, ATTACHMENT C1

GRAPHICAL REPRESENTATIONS OF METALS LABORATORY DATA

THIS PAGE INTENTIONALLY LEFT BLANK



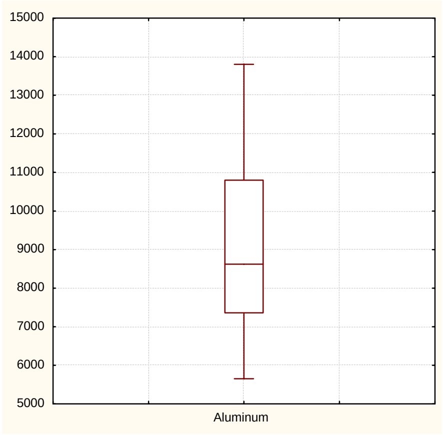
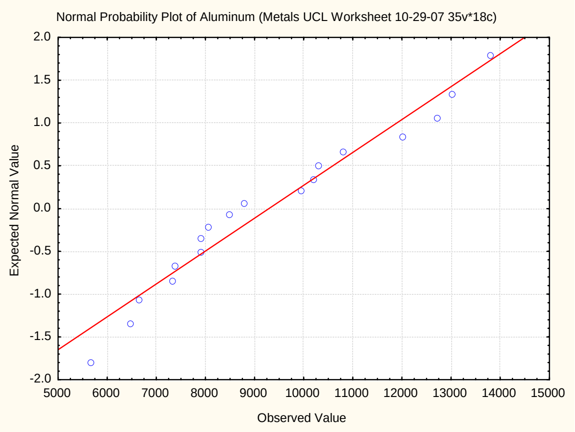


Figure C1.1. Histogram for Aluminum Data

Figure C1.2. Box Plot for Aluminum Data



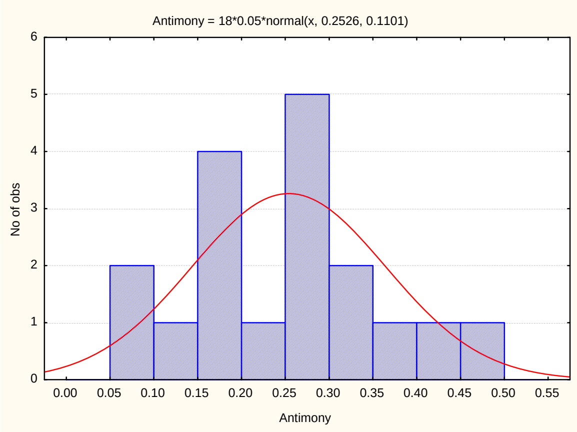
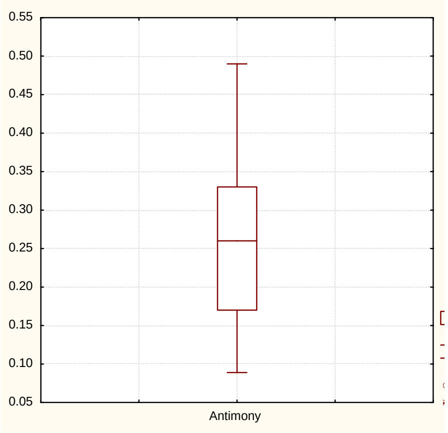


Figure C1.3. Normal-Quantile Plot for Aluminum Data

Figure C1.4. Histogram for Antimony Data



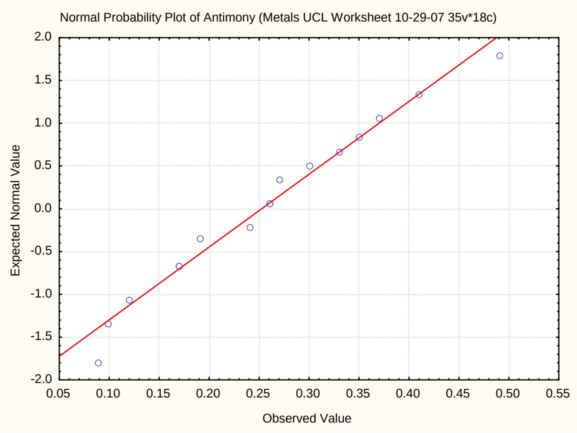
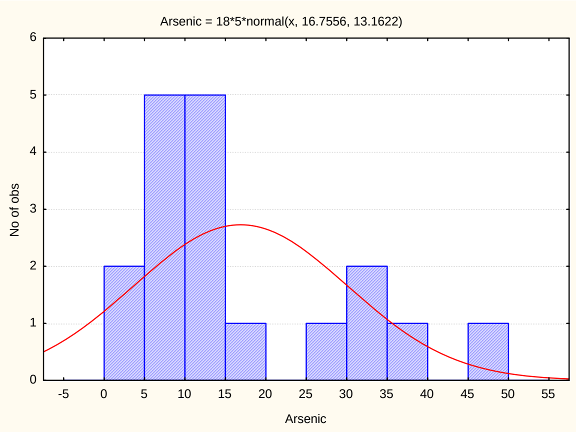


Figure C1.5. Box Plot for Antimony Data

Figure C1.6. Normal-Quantile Plot for Antimony Data



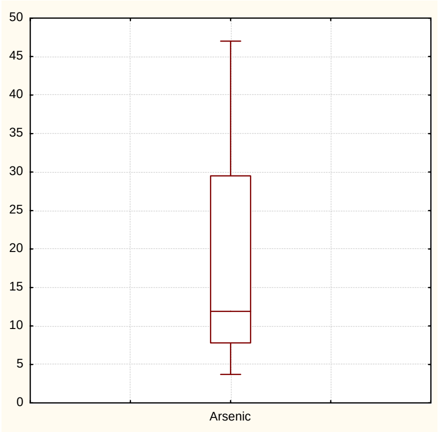
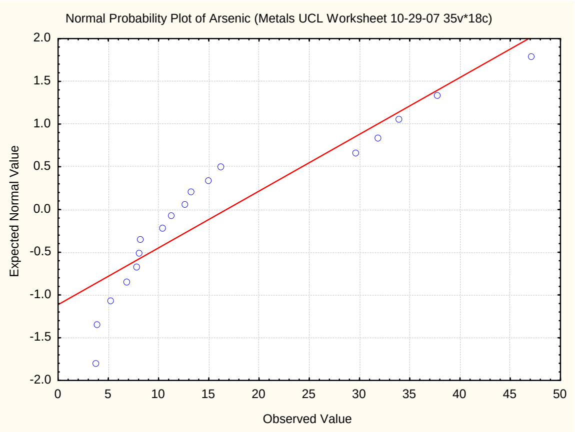


Figure C1.7. Histogram for Arsenic Data

Figure C1.8. Box Plot for Arsenic Data



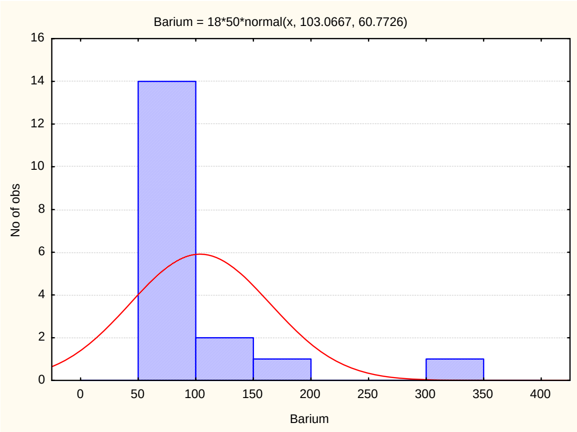
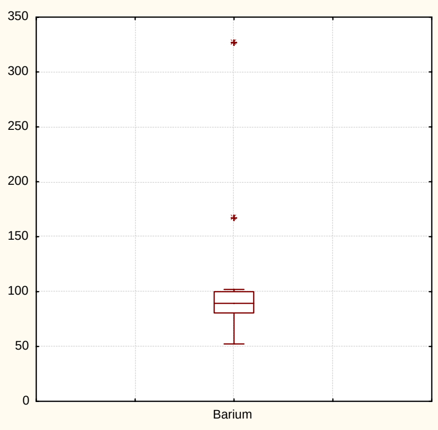


Figure C1.9. Normal-Quantile Plot for Arsenic Data

Figure C1.10. Histogram for Barium Data



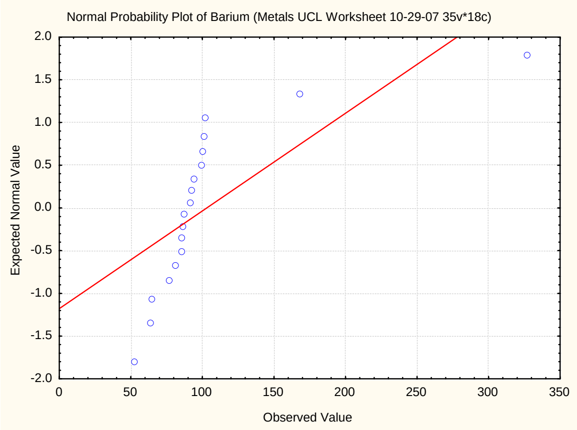
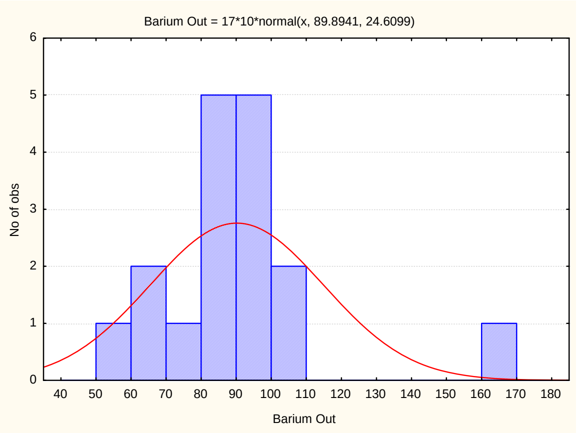


Figure C1.11. Box Plot for Barium Data

Figure C1.12. Normal-Quantile Plot for Barium Data



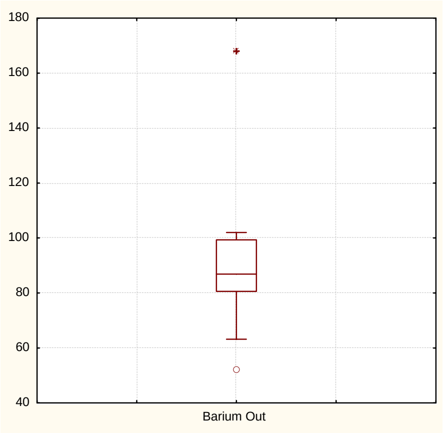
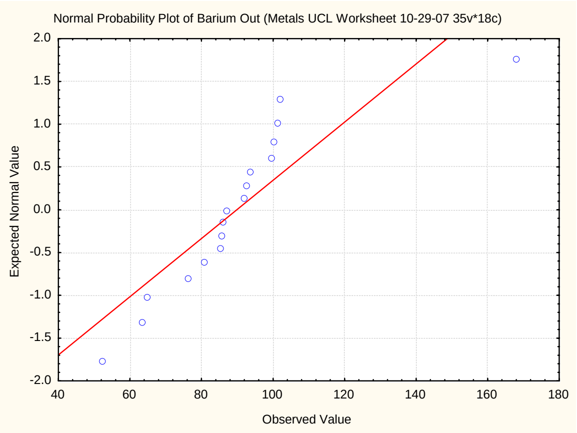


Figure C1.13. Histogram For Barium Out Data

Figure C1.14. Box Plot For Barium Out Data



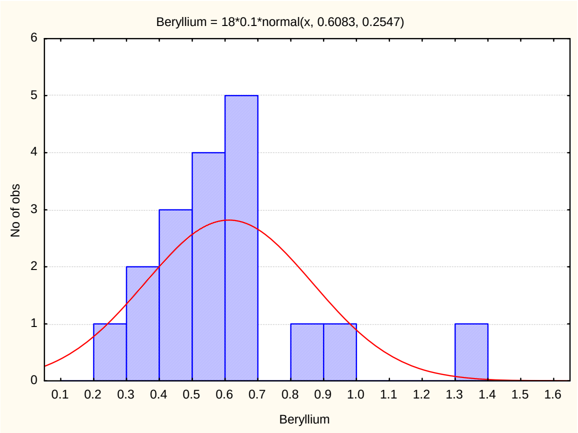
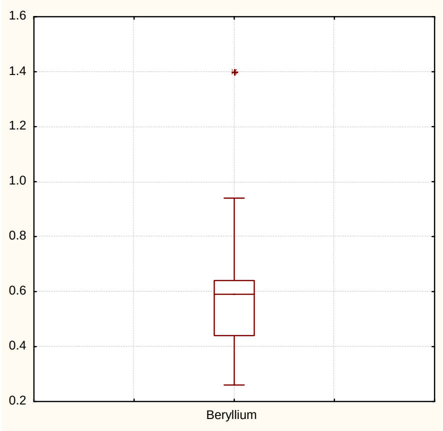


Figure C1.15. Normal-Quantile Plot for Barium Out Data

Figure C1.16. Histogram for Beryllium Data



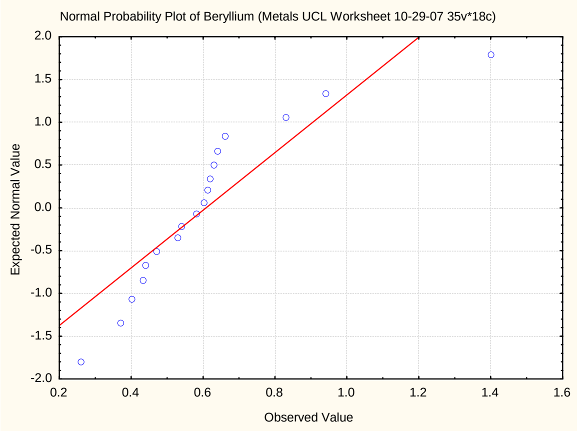
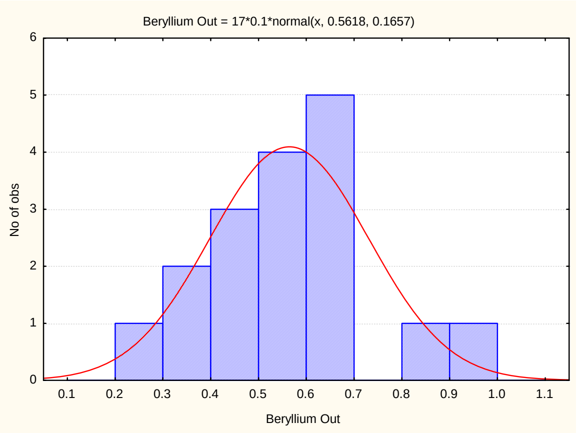


Figure C1.17. Box Plot for Beryllium Data

Figure C1.18. Normal-Quantile Plot for Beryllium Data



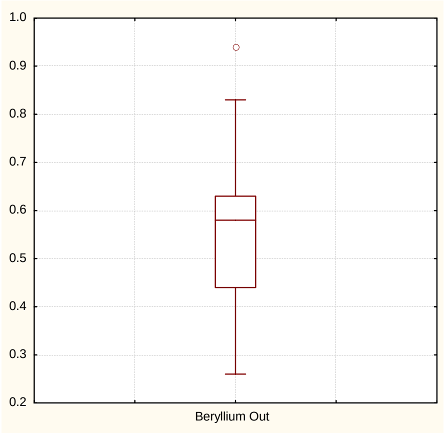
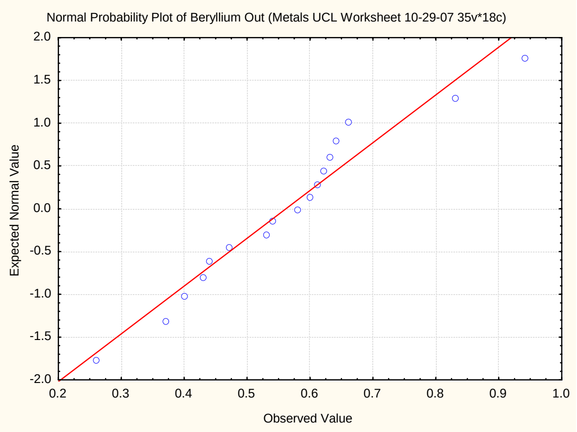


Figure C1.19. Histogram for Beryllium Out Data

Figure C1.20. Box Plot for Beryllium Out Data



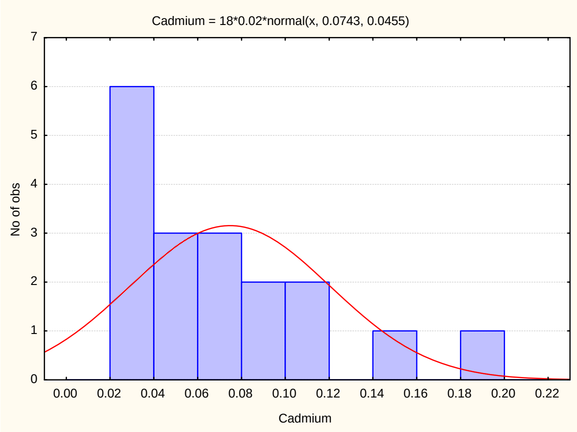
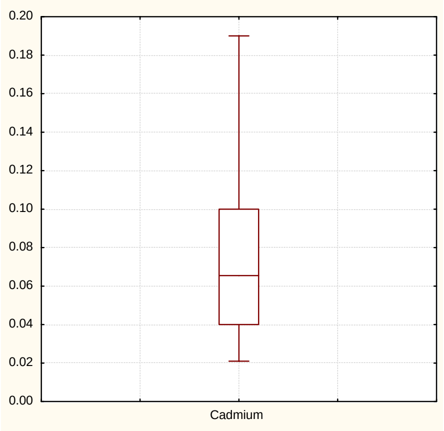


Figure C1.21. Normal-Quantile Plot for Beryllium Out Data

Figure C1.22. Histogram for Cadmium Data



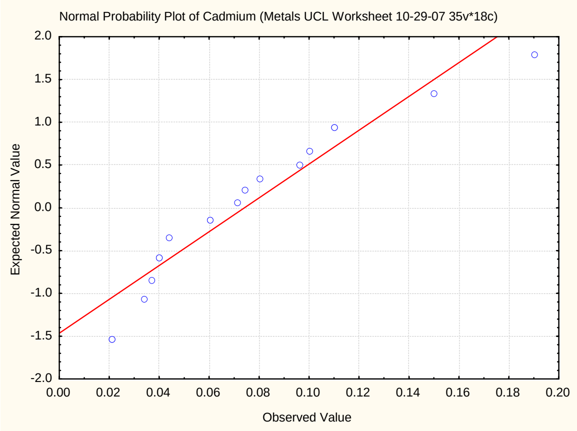
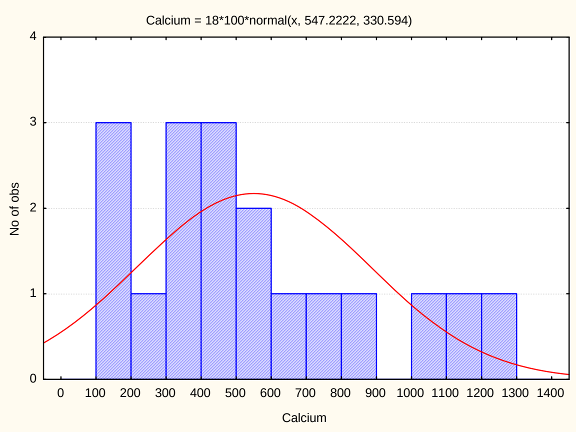


Figure C1.23. Box Plot for Cadmium Data

Figure C1.24. Normal-Quantile Plot for Cadmium Data



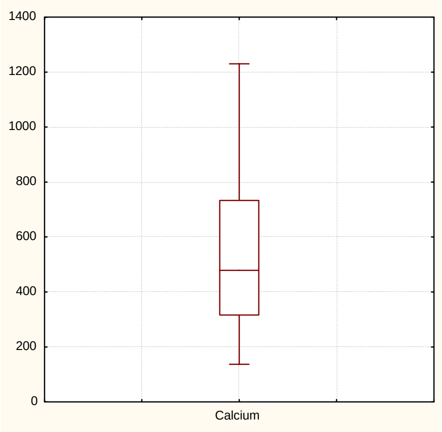
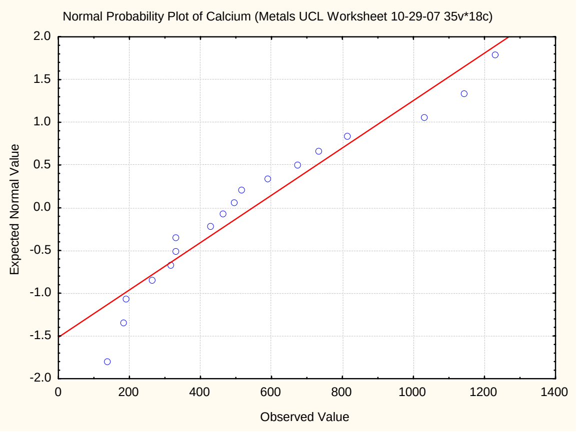


Figure C1.25. Histogram for Calcium Data

Figure C1.26. Box Plot for Calcium Data



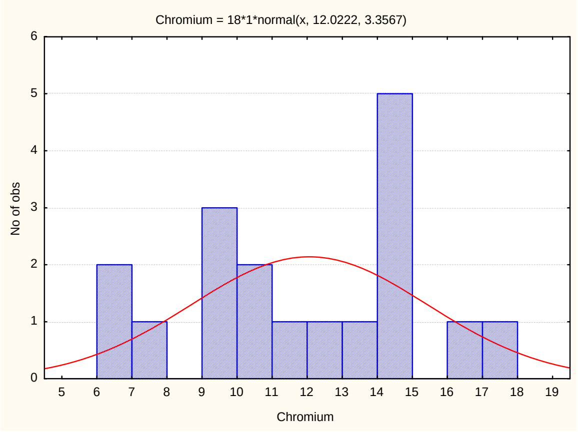
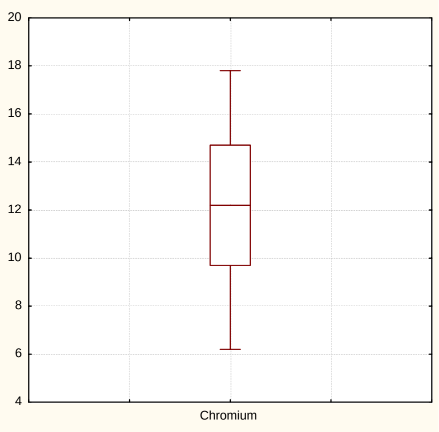


Figure C1.27. Normal-Quantile Plot for Calcium Data

Figure C1.28. Histogram for Chromium Data



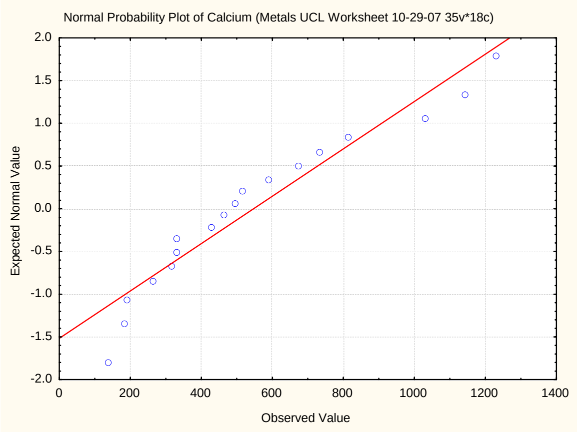
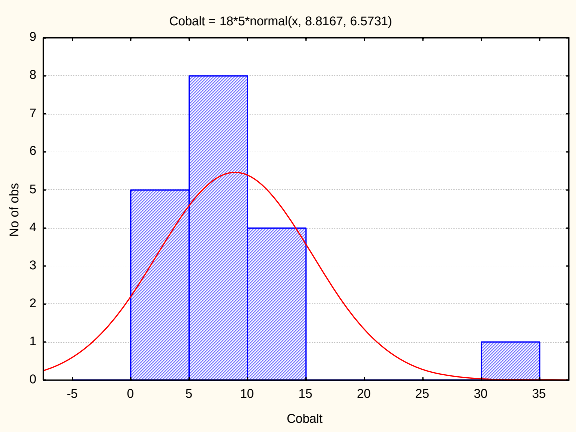


Figure C1.29. Box Plot for Chromium Data

Figure C1.30. Normal-Quantile Plot for Chromium Data



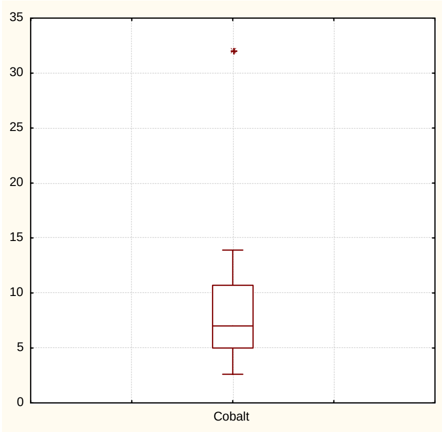
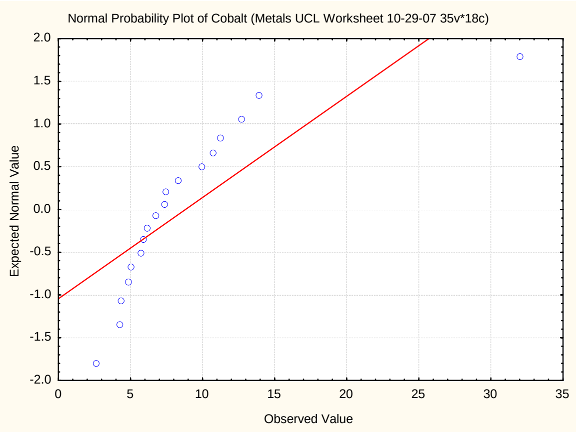


Figure C1.31. Histogram for Cobalt Data

Figure C1.32. Box Plot for Cobalt Data



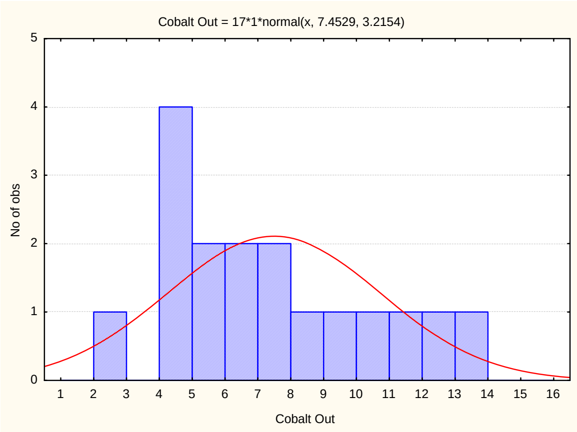
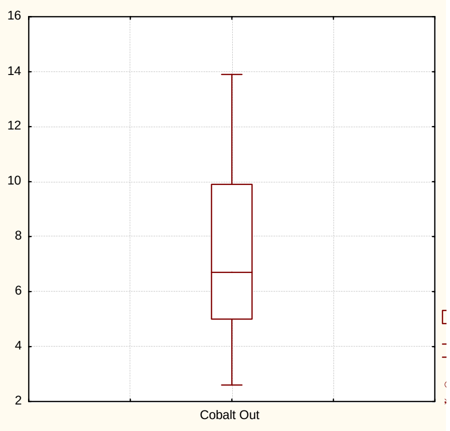


Figure C1.33. Normal-Quantile Plot for Cobalt Data

Figure C1.34. Histogram for Cobalt Out Data



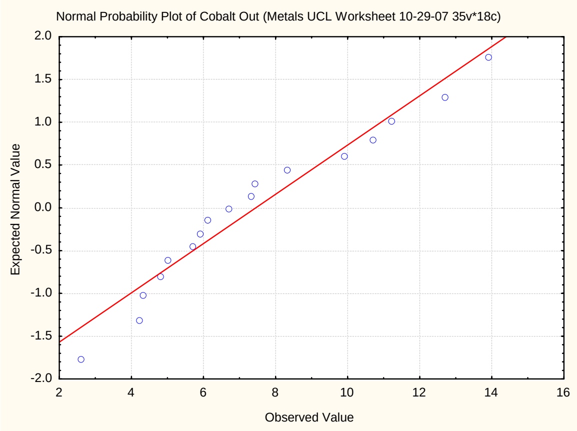
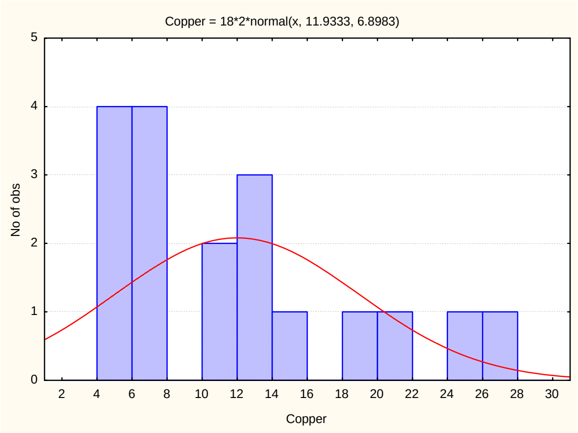


Figure C1.35. Box Plot for Cobalt Out Data

Figure C1.36. Normal-Quantile Plot for Cobalt Out Data



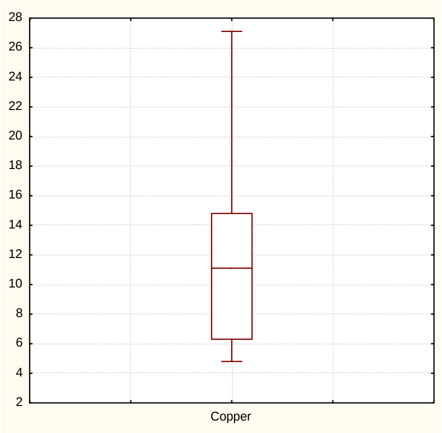
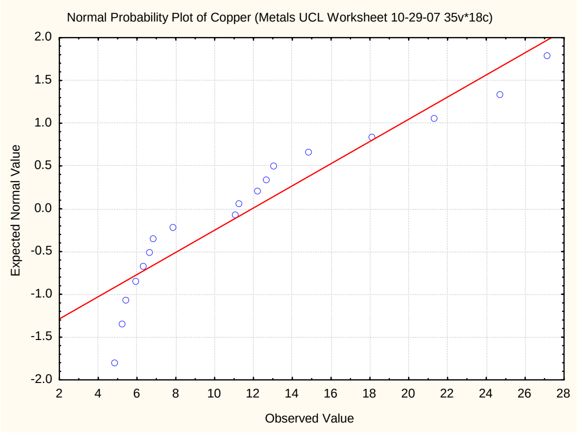


Figure C1.37. Histogram for Copper Data

Figure C1.38. Box Plot for Copper Data



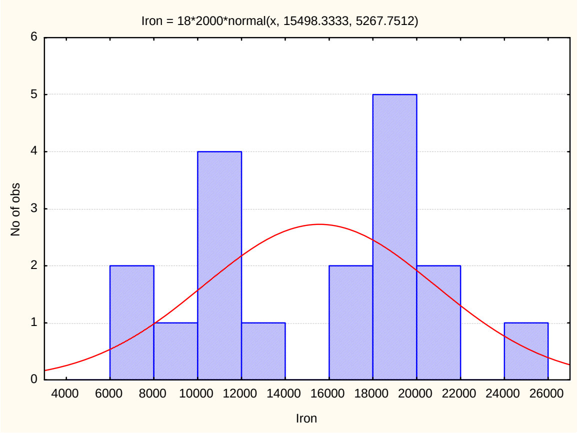
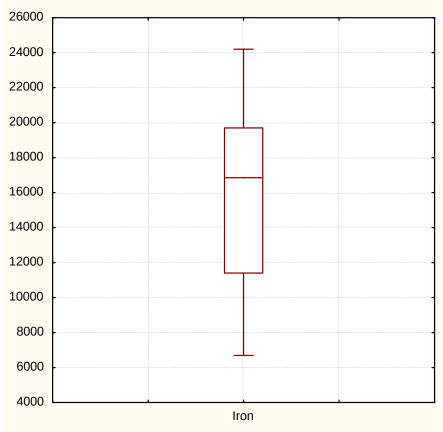


Figure C1.39. Normal-Quantile Plot for Copper Data

Figure C1.40. Histogram for Iron Data



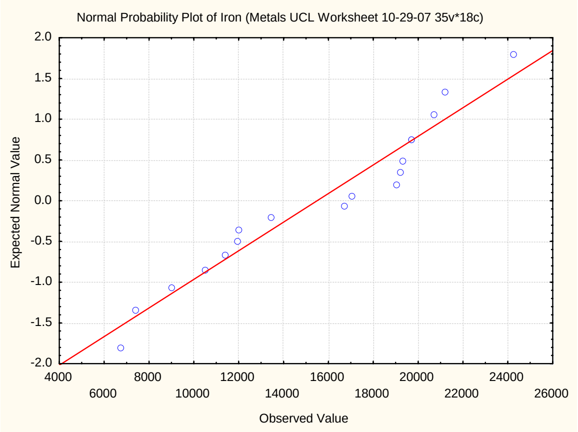
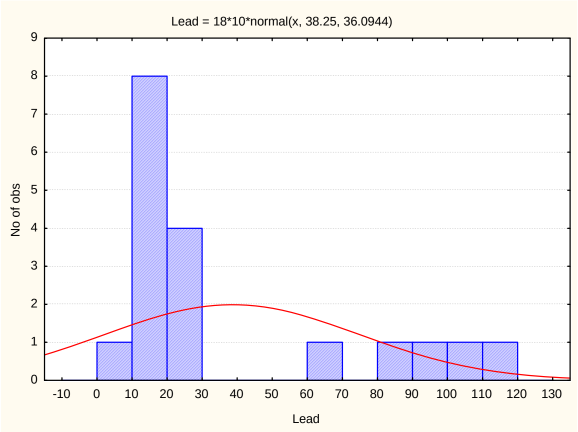


Figure C1.41. Box Plot for Iron Data

Figure C1.42. Normal-Quantile Plot for Iron Data



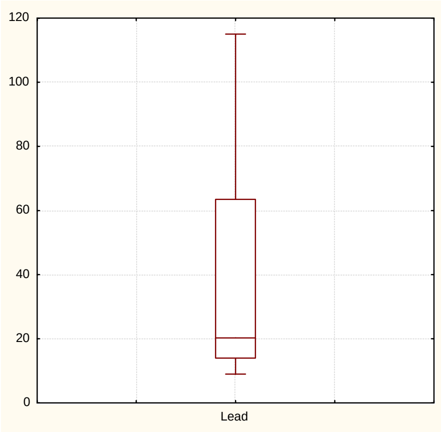
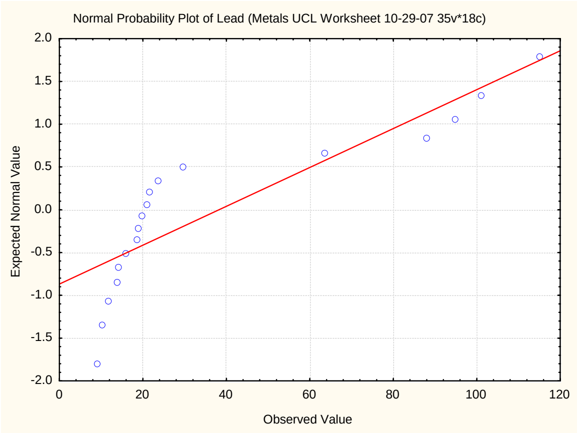


Figure C1.43. Histogram for Lead Data

Figure C1.44. Box Plot for Lead Data



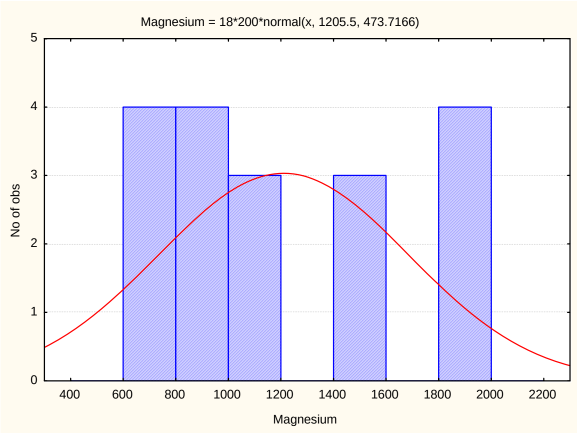
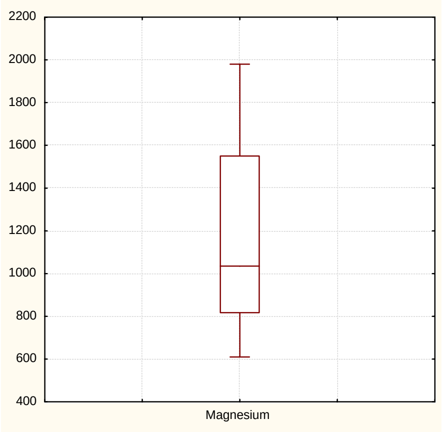


Figure C1.45. Normal-Quantile Plot for Lead Data

Figure C1.46. Histogram for Magnesium Data



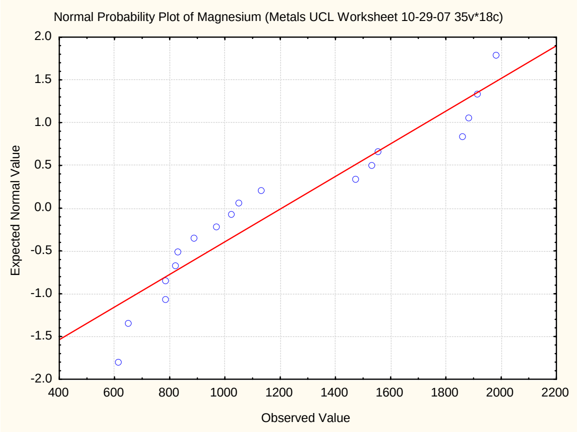
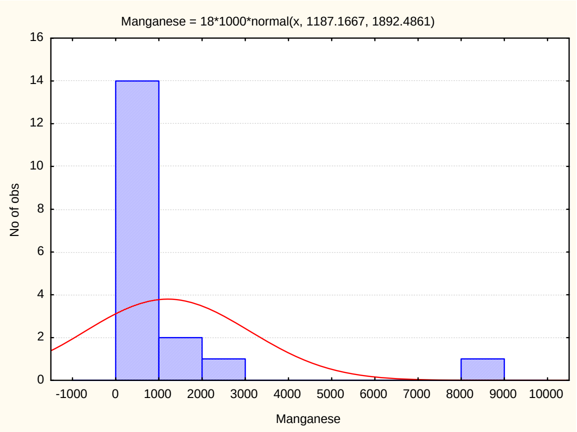


Figure C1.47. Box Plot for Magnesium Data

Figure C1.48. Normal-Quantile Plot for Magnesium Data



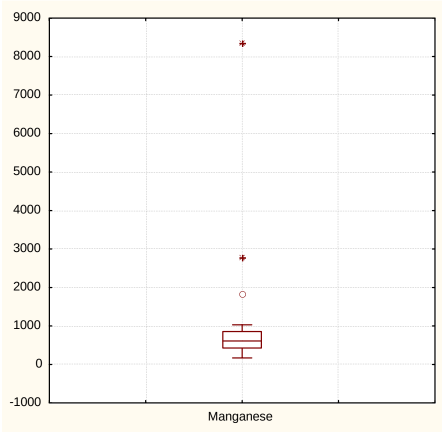
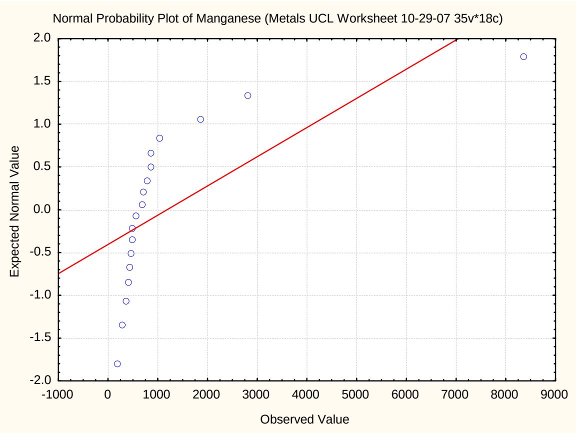


Figure C1.49. Histogram for Manganese Data

Figure C1.50. Box Plot for Manganese Data



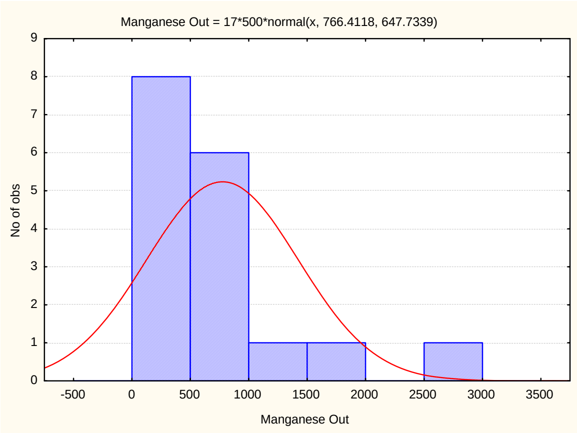
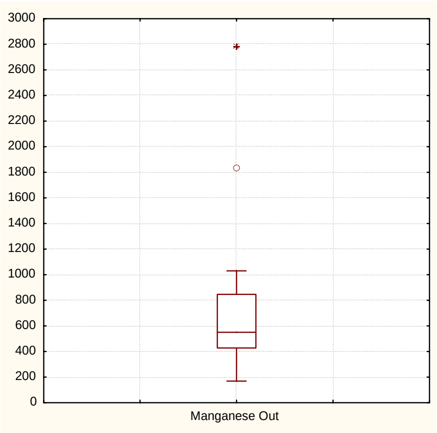


Figure C1.51. Normal-Quantile Plot for Manganese Data

Figure C1.52. Histogram for Manganese Out Data



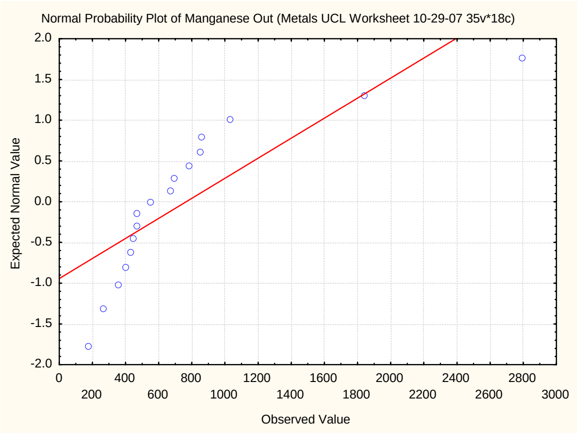


Figure C1.53. Box Plot for Manganese Out Data

Figure C1.54. Normal-Quantile Plot for Manganese Out Data

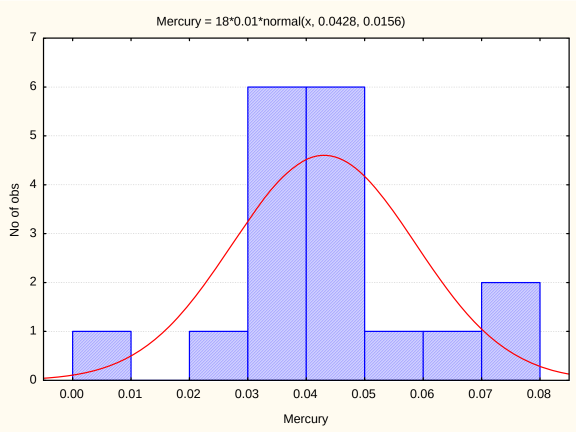


Figure C1.55. Histogram for Mercury Data

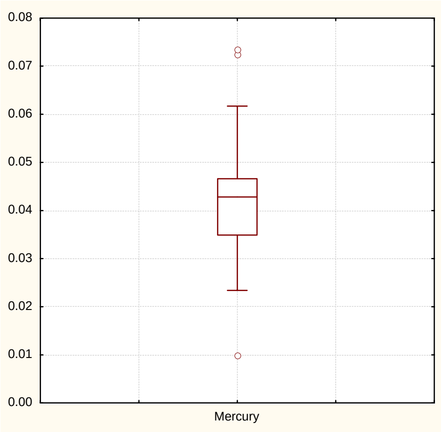


Figure C1.56. Box Plot for Mercury Data

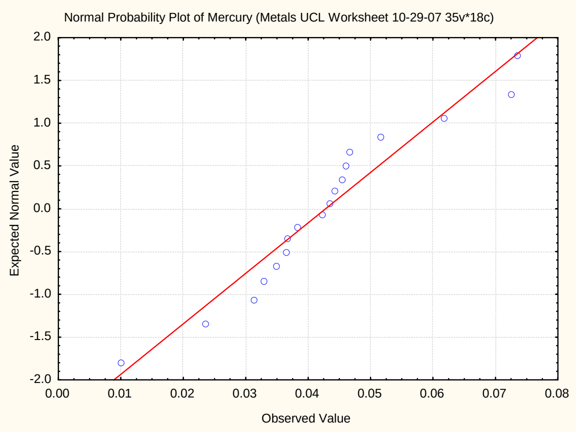


Figure C1.57. Normal-Quantile Plot for Mercury Data

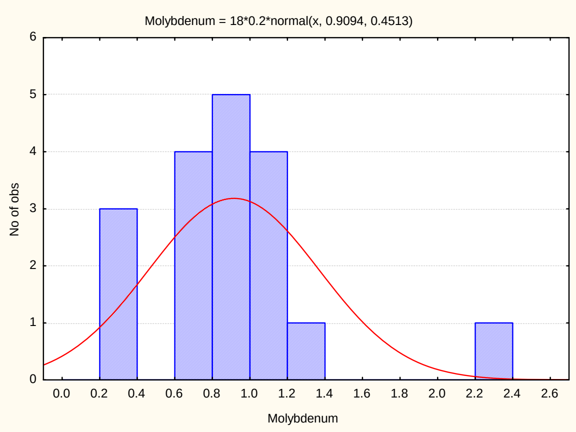


Figure C1.58. Histogram for Molybdenum Data

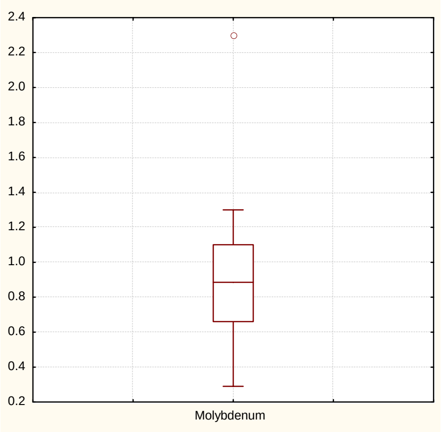


Figure C1.59. Box Plot for Molybdenum Data

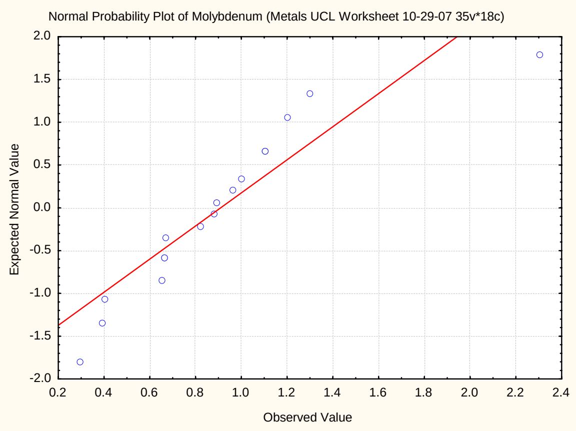


Figure C1.60. Normal-Quantile Plot for Molybdenum Data

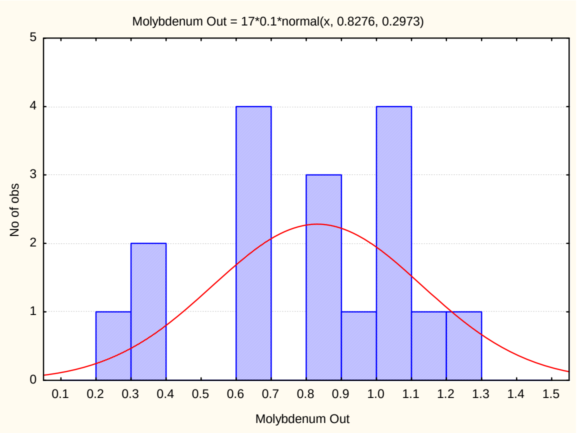


Figure C1.61. Histogram for Molybdenum Out Data

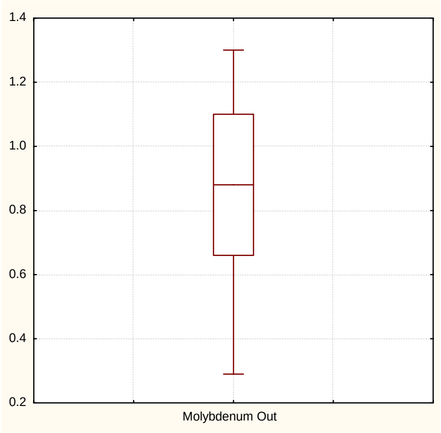


Figure C1.62. Box Plot for Molybdenum Out Data

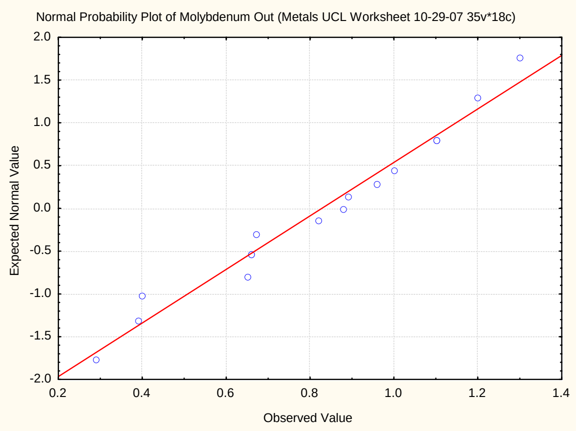


Figure C1.63. Normal-Quantile Plot for Molybdenum Out Data

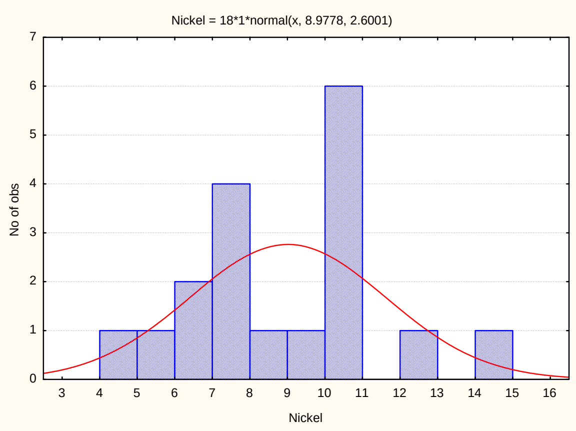


Figure C1.64. Histogram for Nickel Data

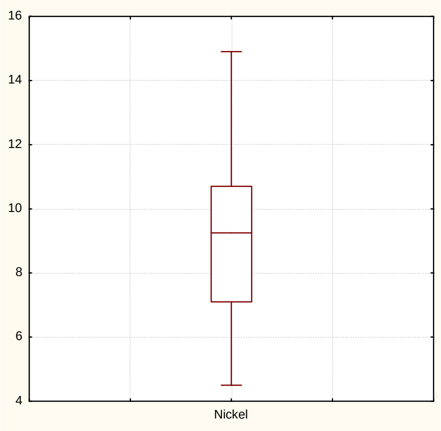


Figure C1.65. Box Plot for Nickel Data

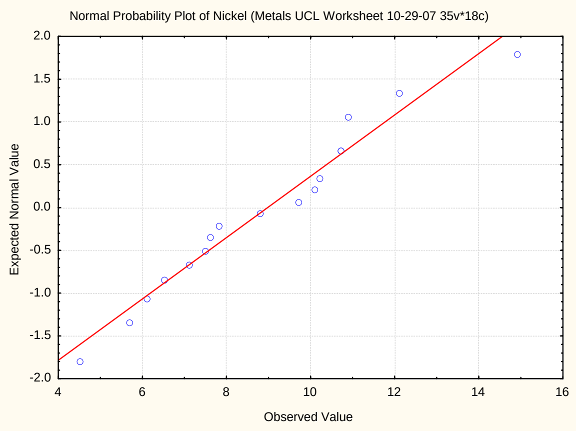


Figure C1.66. Normal-Quantile Plot for Nickel Data

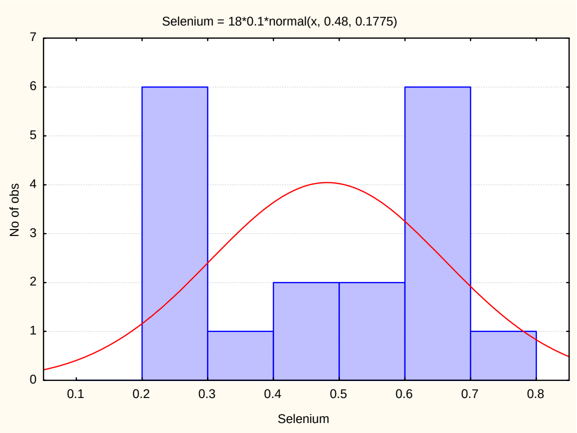


Figure C1.67. Histogram for Selenium Data

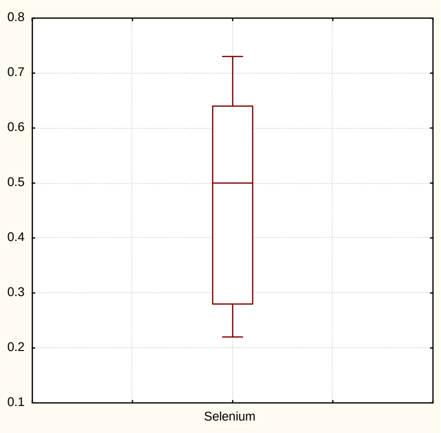


Figure C1.68. Box Plot for Selenium Data

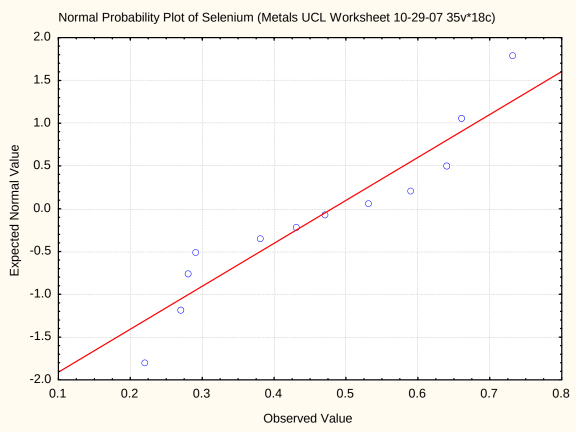


Figure C1.69. Normal-Quantile Plot for Selenium Data

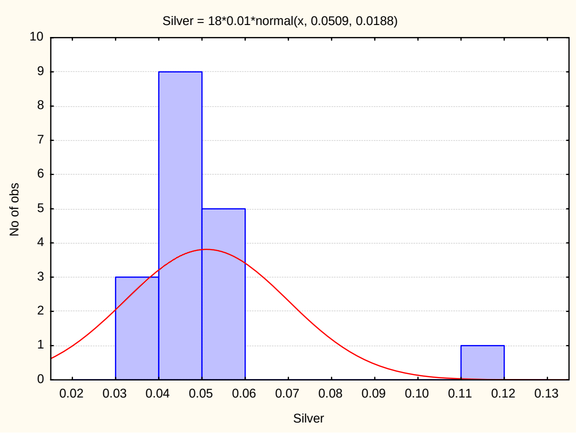


Figure C1.70. Histogram for Silver Data

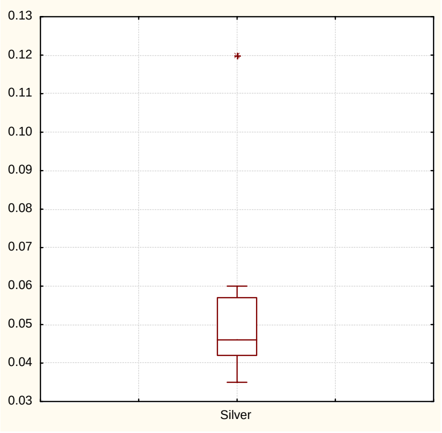


Figure C1.71. Box Plot for Silver Data

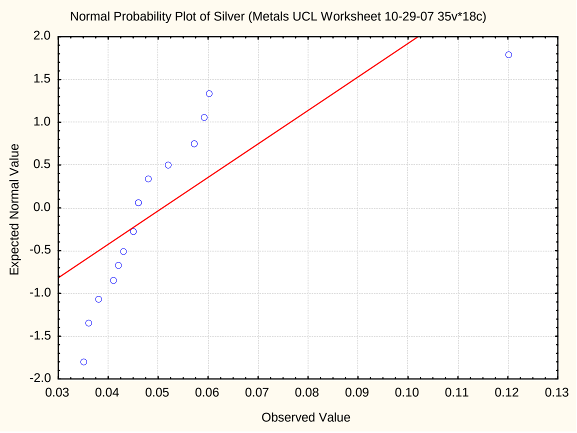


Figure C1.72. Normal-Quantile Plot for Silver Data

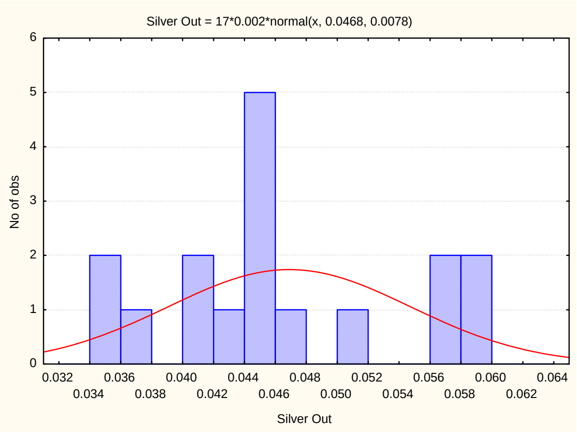


Figure C1.73. Histogram for Silver Out Data

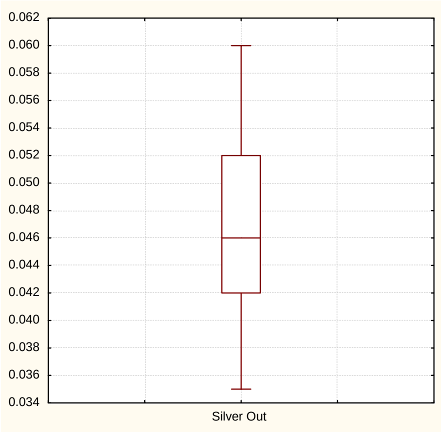


Figure C1.74. Box Plot for Silver Out Data

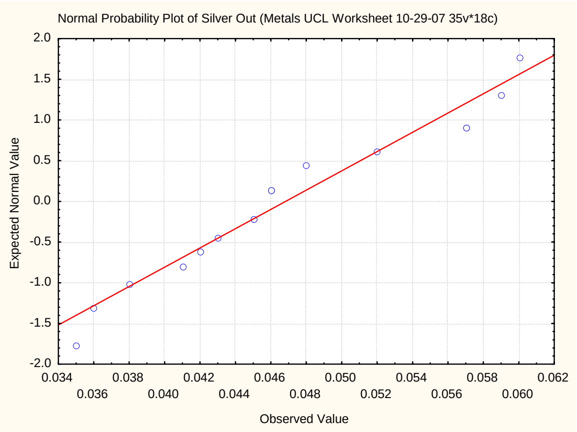


Figure C1.75. Normal-Quantile Plot for Silver Out Data

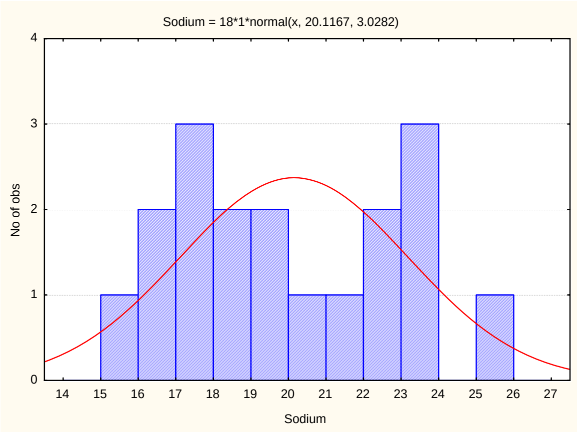


Figure C1.76. Histogram for Sodium Data

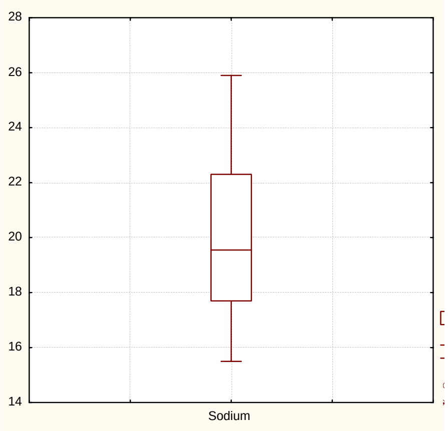


Figure C1.77. Box Plot for Sodium Data

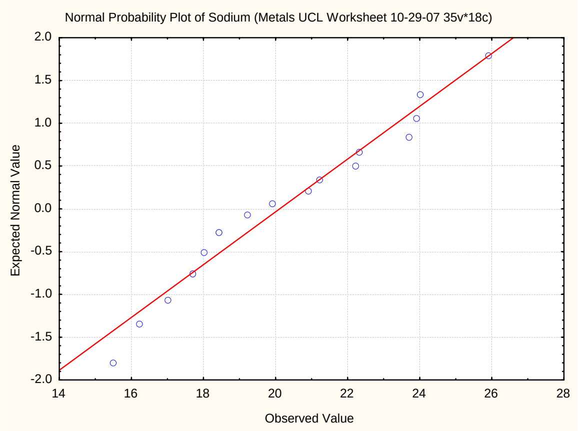
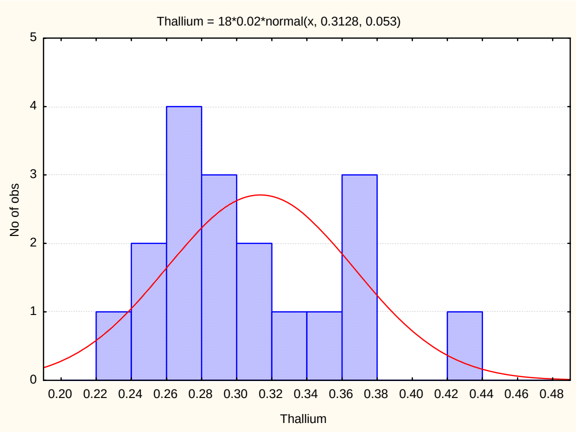


Figure C1.78. Normal-Quantile Plot for Sodium Data



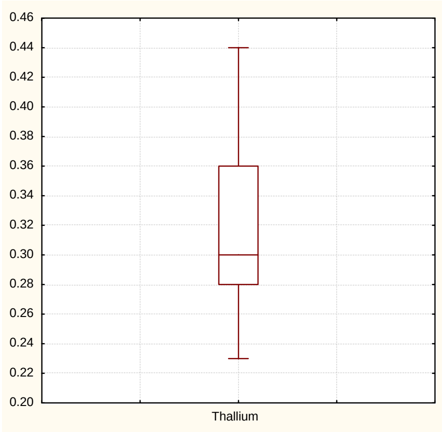
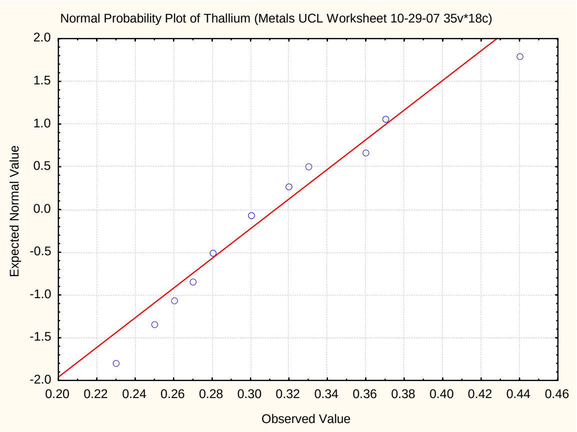


Figure C1.79. Histogram for Thallium Data

Figure C1.80. Box Plot for Thallium Data



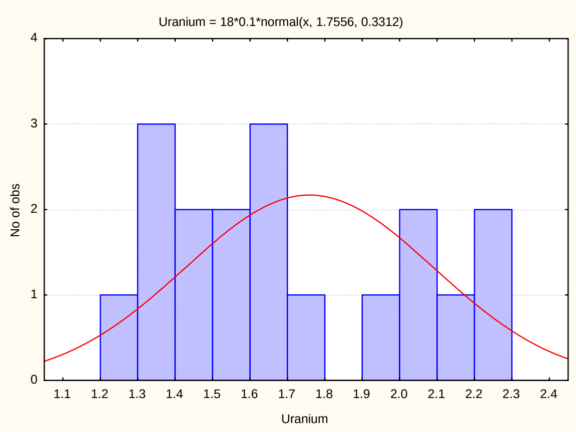
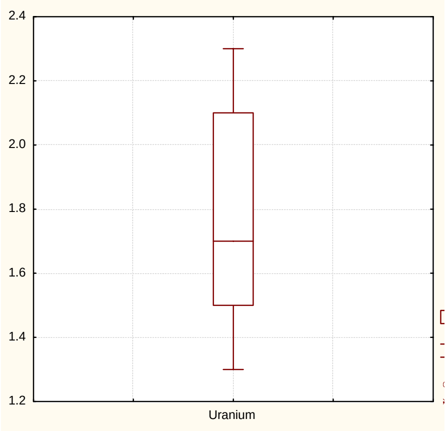


Figure C1.81. Normal-Quantile Plot for Thallium Data

Figure C1.82. Histogram for Uranium Data



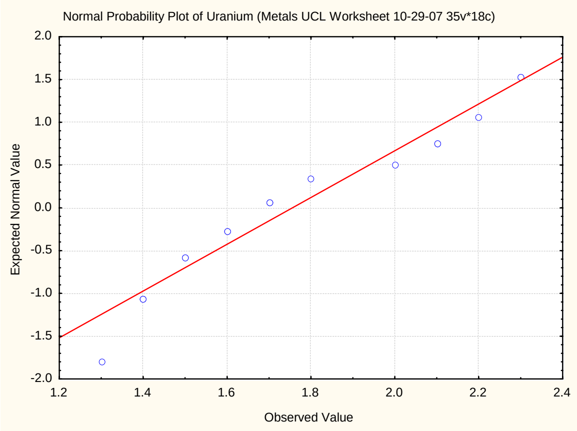
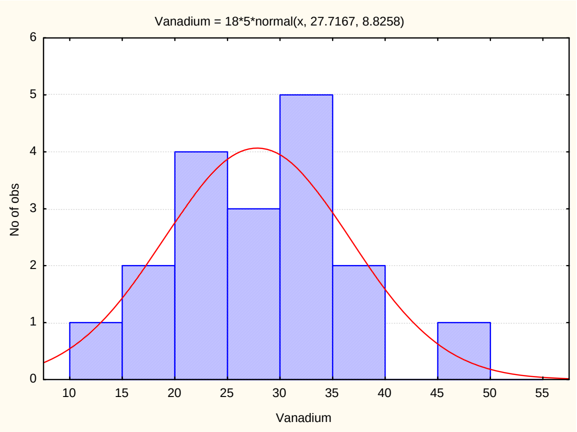


Figure C1.83. Box Plot for Uranium Data

Figure C1.84. Normal-Quantile Plot for Uranium Data



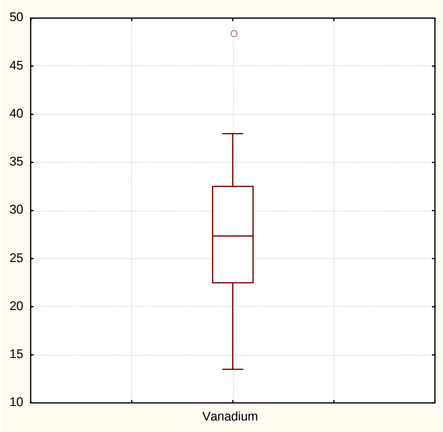
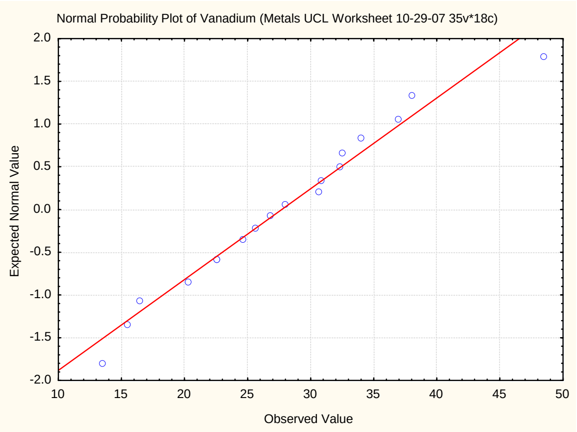


Figure C1.85. Histogram for Vanadium Data

Figure C1.86. Box Plot for Vanadium Data



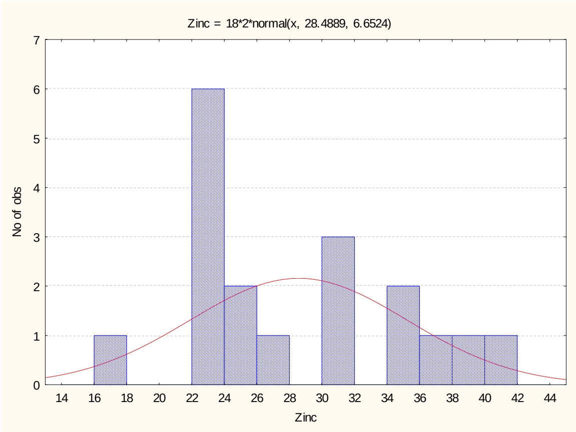
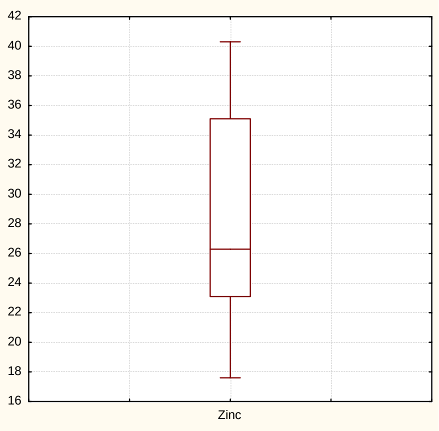


Figure C1.87. Normal-Quantile Plot for Vanadium Data

Figure C1.88. Histogram for Zinc Data



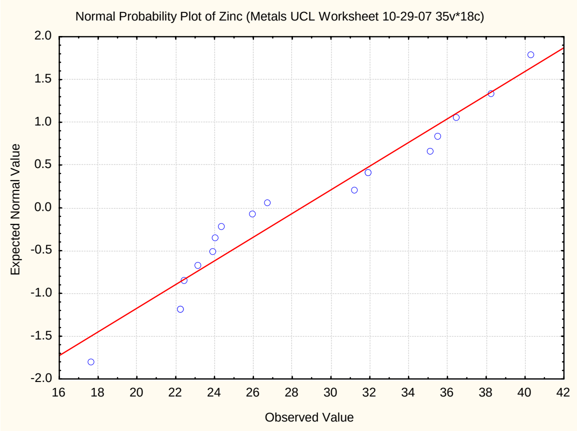


Figure C1.89. Box Plot for Zinc Data

Figure C1.90. Normal-Quantile Plot for Zinc Data

APPENDIX C, ATTACHMENT C2

GRAPHICAL REPRESENTATIONS OF RADIONUCLIDE LABORATORY DATA

THIS PAGE INTENTIONALLY LEFT BLANK

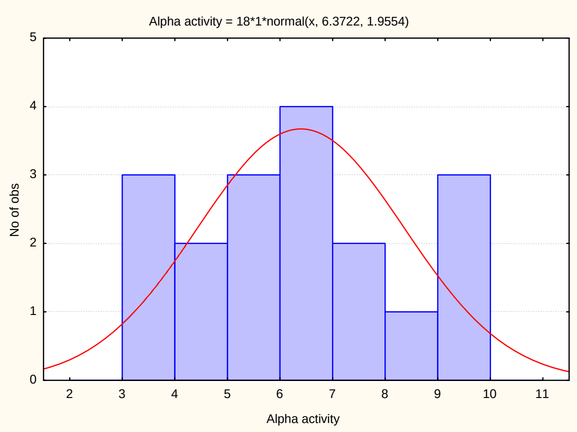


Figure C2.1. Histogram for Alpha Data

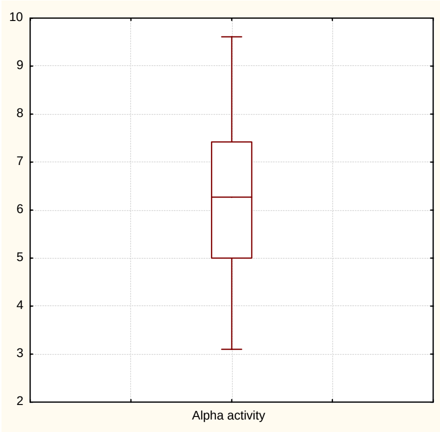


Figure C2.2. Box Plot for Alpha Data

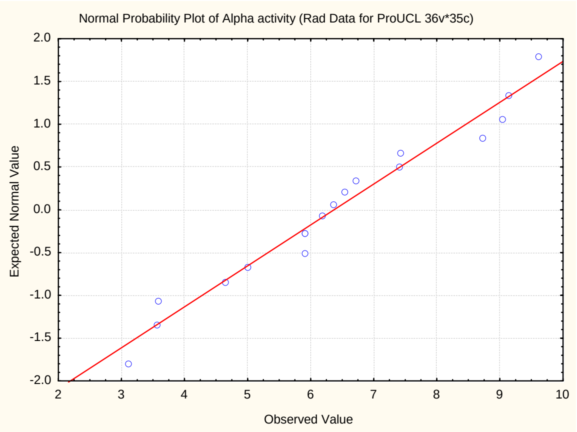


Figure C2.3. Normal-Quantile Plot for Alpha Data

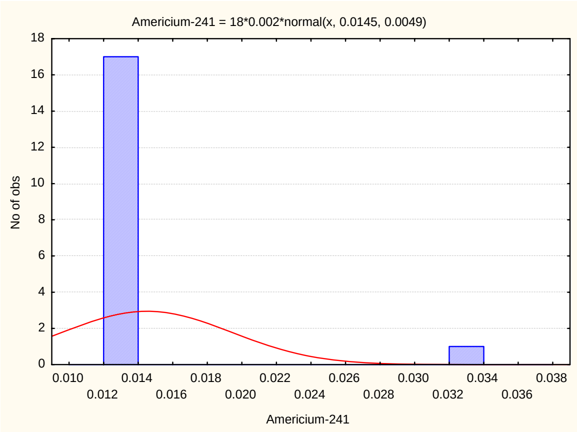


Figure C2.4. Histogram for Americium-241 Data

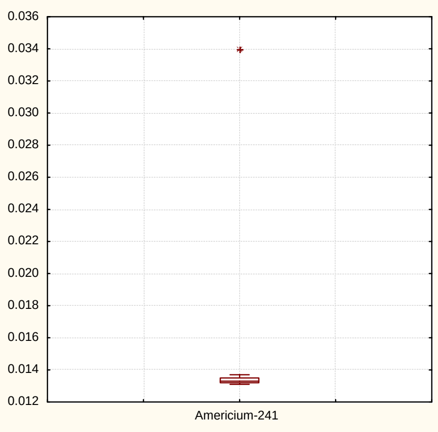


Figure C2.5. Box Plot for Americium-241 Data

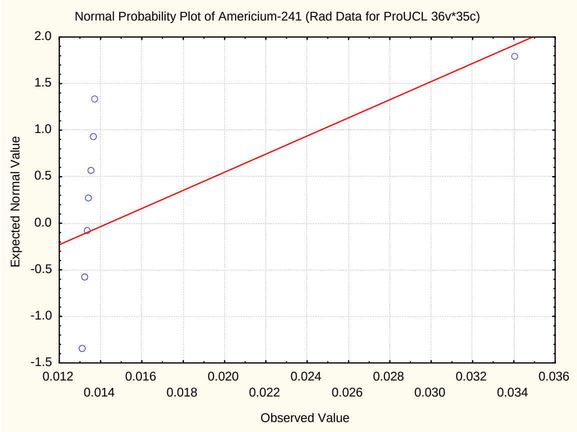
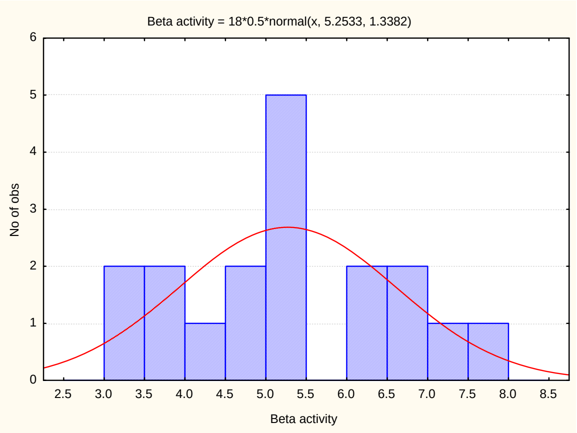


Figure C2.6. Normal-Quantile Plot for Americium-241 Data



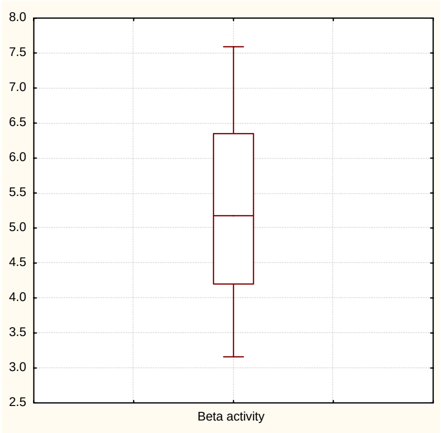
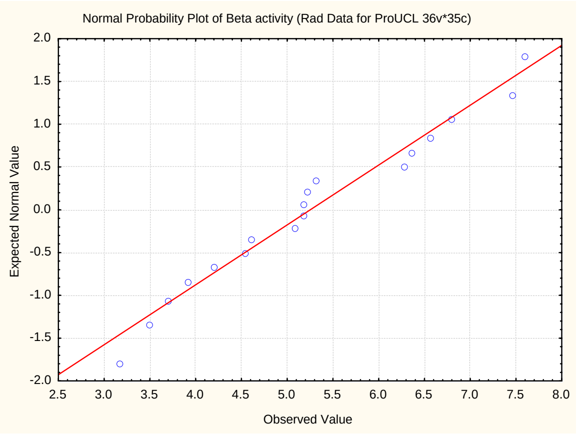


Figure C2.7. Histogram for Beta Data

Figure C2.8. Box Plot for Beta Data



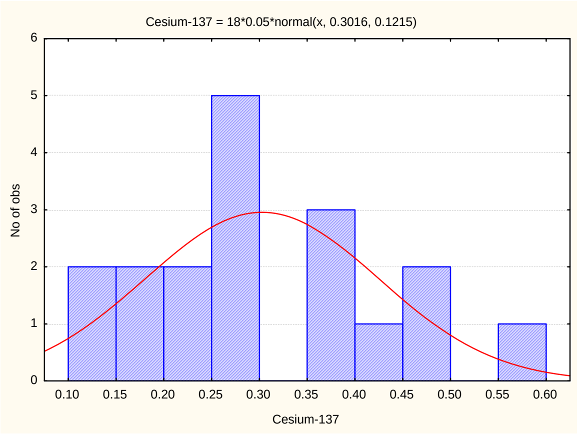
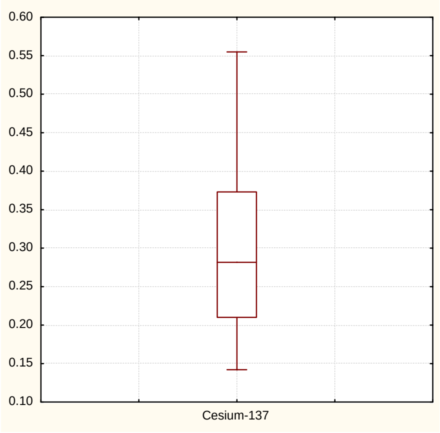


Figure C2.9. Normal-Quantile Plot for Beta Data

Figure C2.10. Histogram for Cesium-137 Data



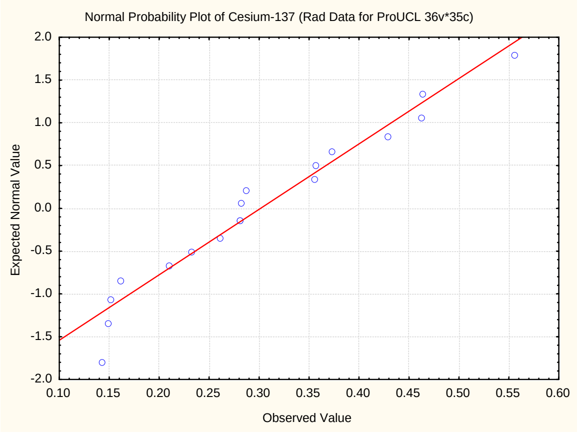


Figure C2.11. Box Plot for Cesium-137 Data

Figure C2.12. Normal-Quantile Plot for Cesium-137 Data

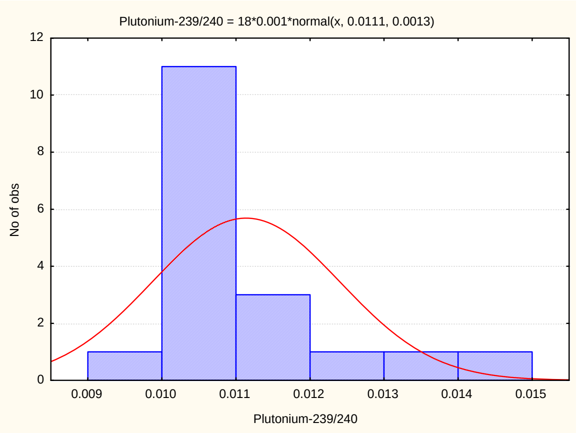


Figure C2.13. Histogram for Plutonium-239/240 Data

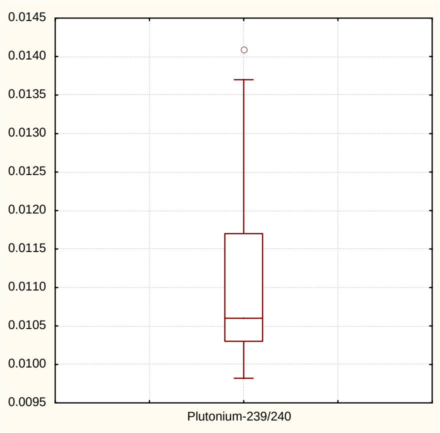


Figure C2.14. Box Plot for Plutonium-239/240 Data

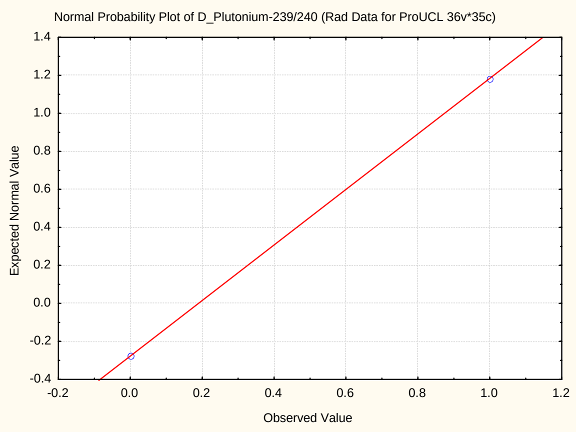


Figure C2.15. Normal-Quantile Plot for Plutonium-239/240 Data

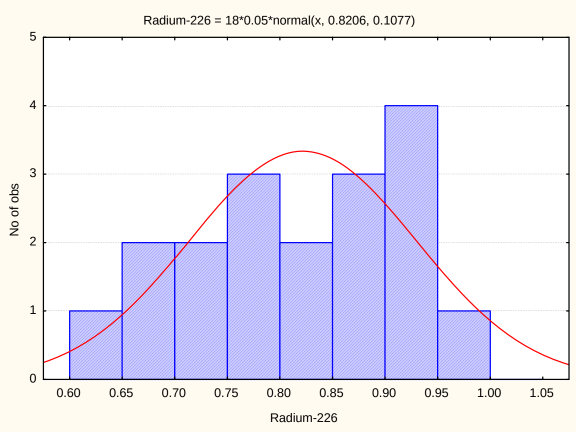


Figure C2.16. Histogram for Radium-226 Data

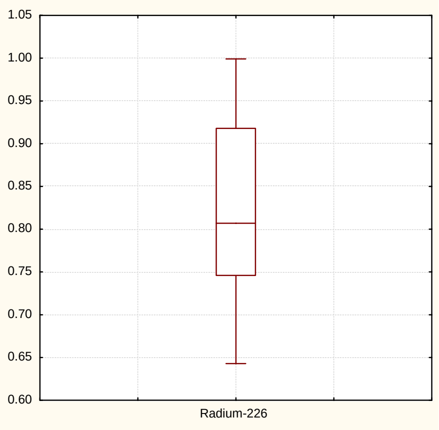


Figure C2.17. Box Plot for Radium-226 Data

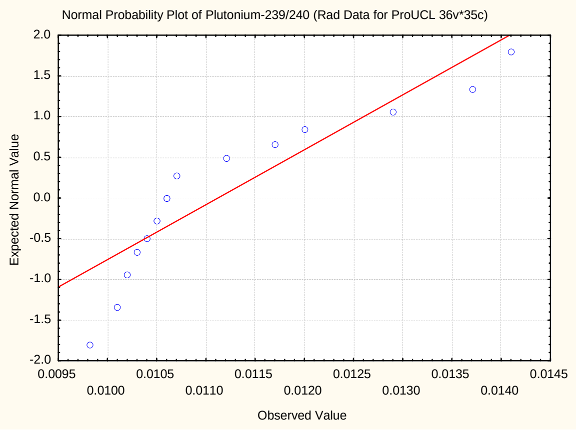
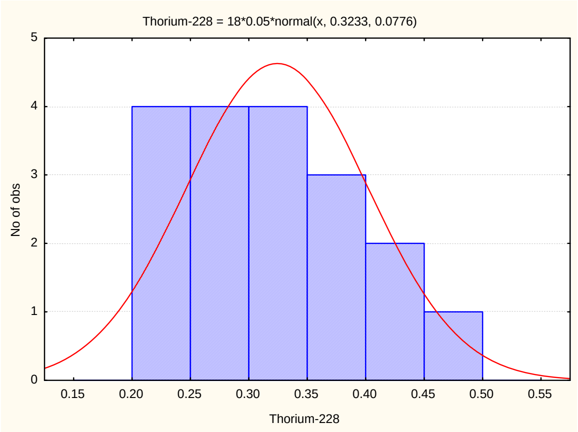


Figure C2.18. Normal-Quantile Plot for Plutonium-239/240 Data



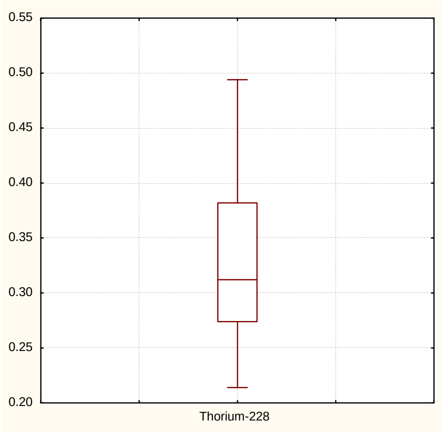
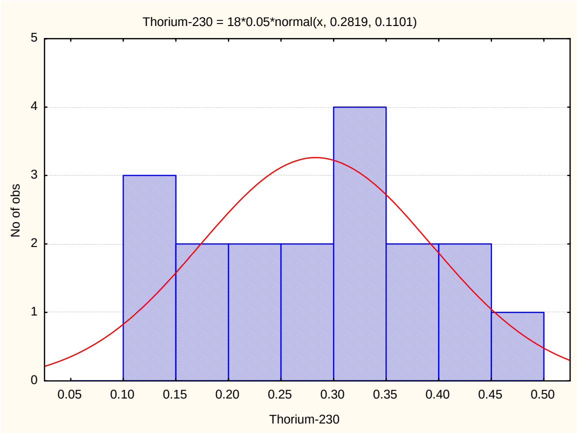


Figure C2.19. Histogram for Thorium-228 Data

Figure C2.20. Box Plot for Thorium-228 Data



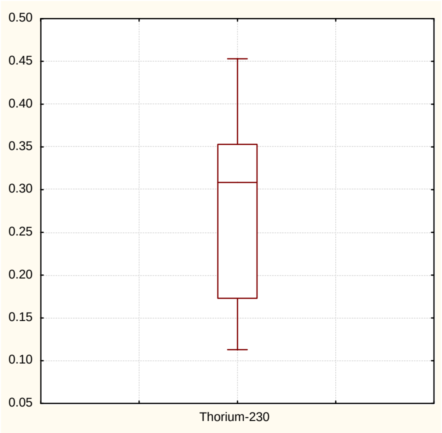
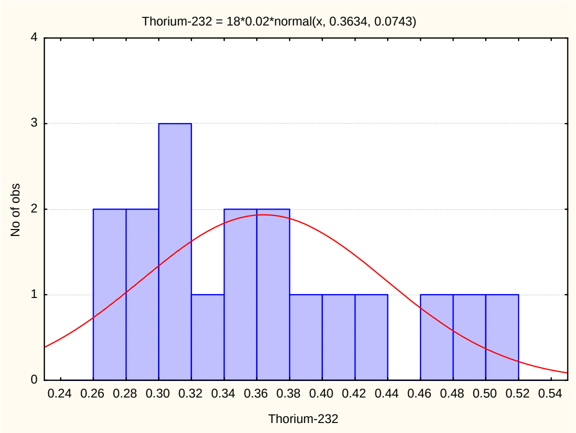


Figure C2.21. Histogram for Thorium-230 Data

Figure C2.22. Box Plot for Thorium-230 Data



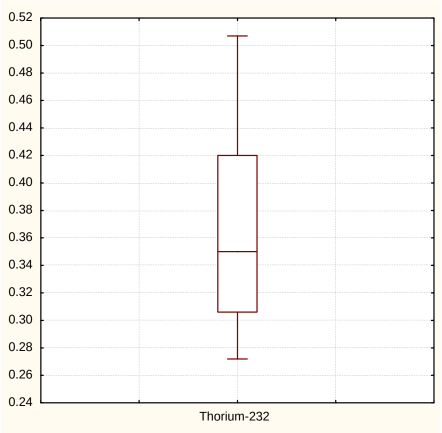
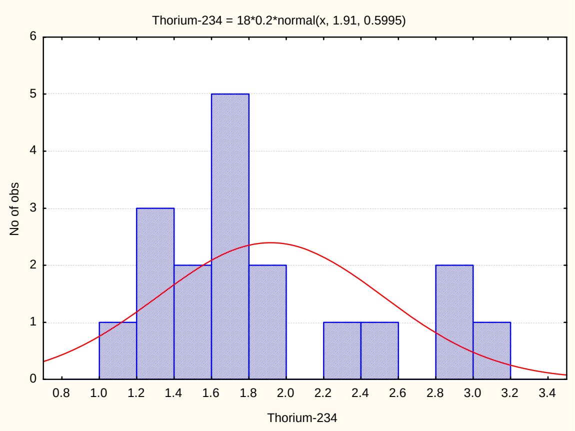


Figure C2.23. Histogram for Thorium-232 Data

Figure C2.24. Box Plot for Thorium-232 Data



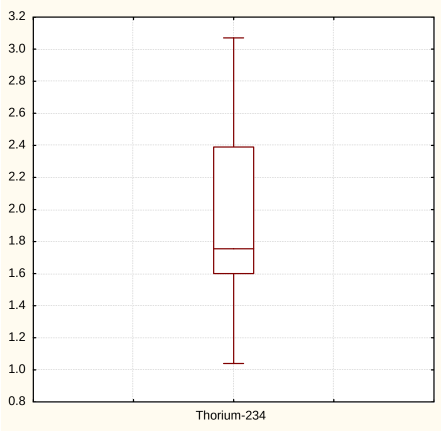
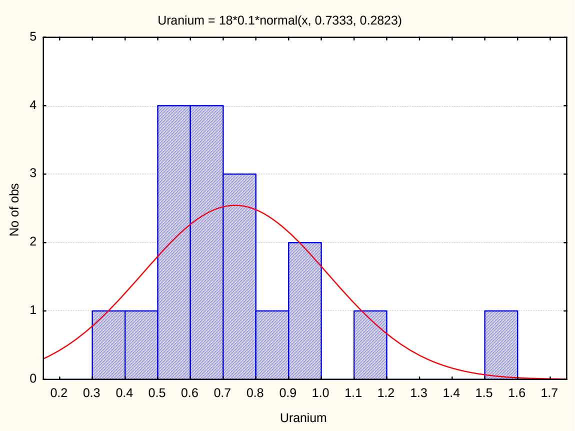


Figure C2.25. Histogram for Thorium-234 Data

Figure C2.26. Box Plot for Thorium-234 Data



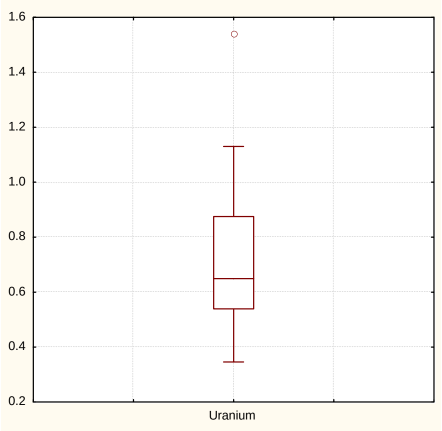
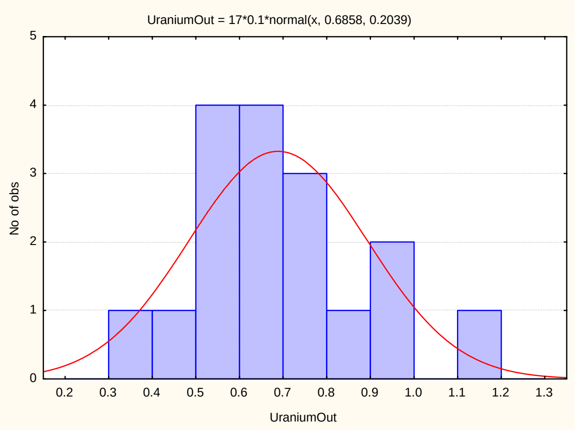


Figure C2.27. Histogram for Uranium Data

Figure C2.28. Box Plot for Uranium Data



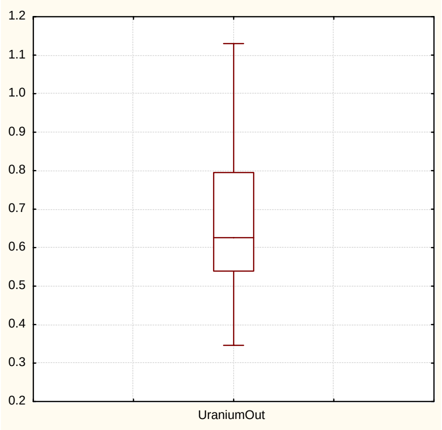


Figure C2.29. Histogram for Uranium Out Data

Figure C2.30. Box Plot for Uranium Out Data

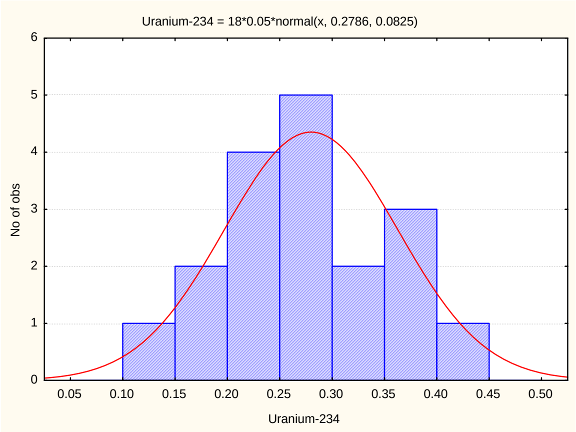


Figure C2.31. Histogram for Uranium-234 Data

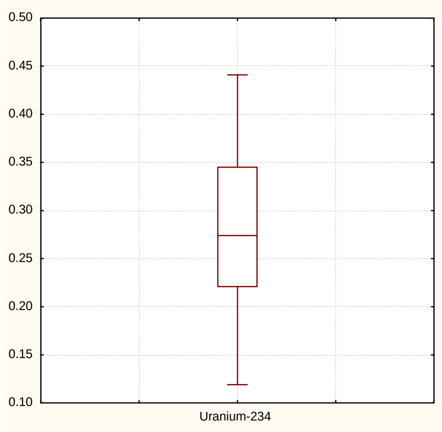


Figure C2.32. Box Plot for Uranium-234 Data

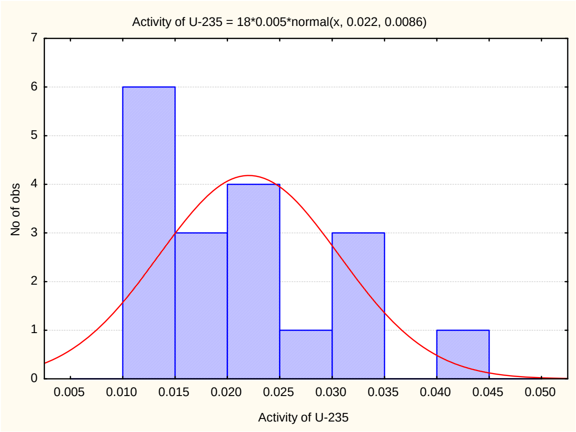


Figure C2.33. Histogram for Uranium-235 Data

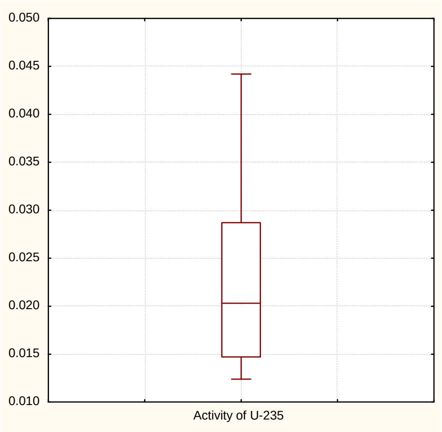


Figure C2.34. Box Plot for Uranium-235 Data

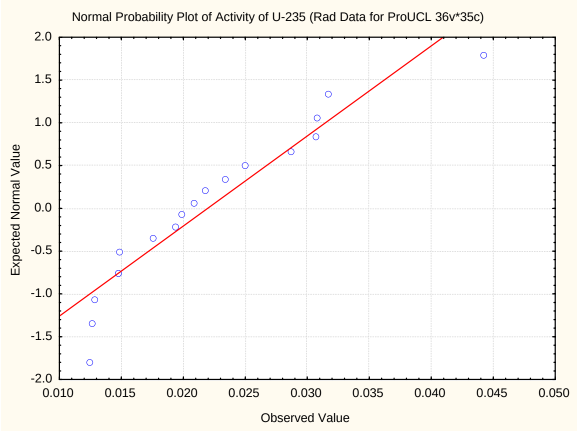


Figure C2.35. Normal-Quantile Plot for Uranium-235 Data

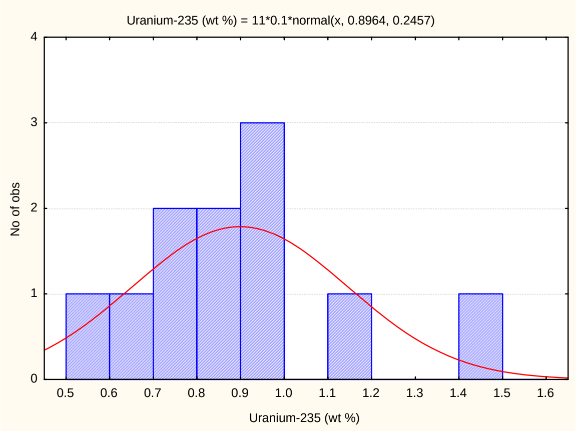


Figure C2.36. Histogram for Uranium-235 (Wt%) Data

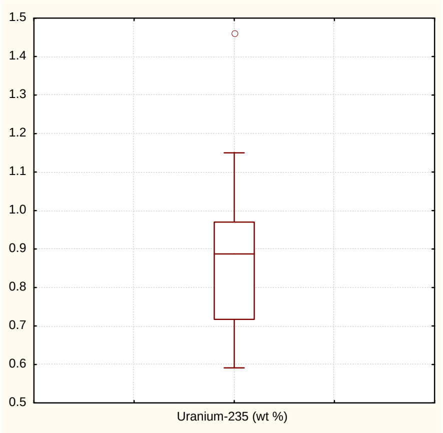


Figure C2.37. Box Plot for Uranium-235 (Wt%) Data

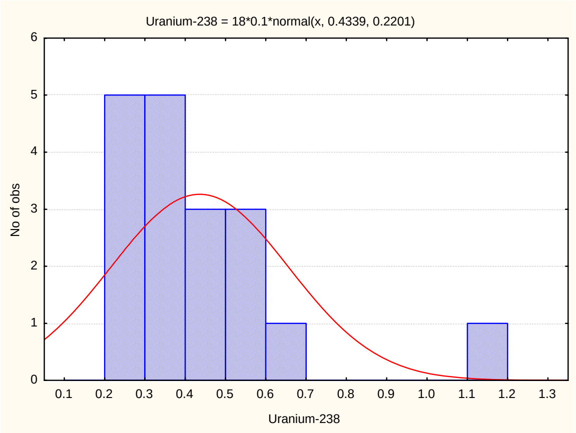


Figure C2.38. Histogram for Uranium-238 Data

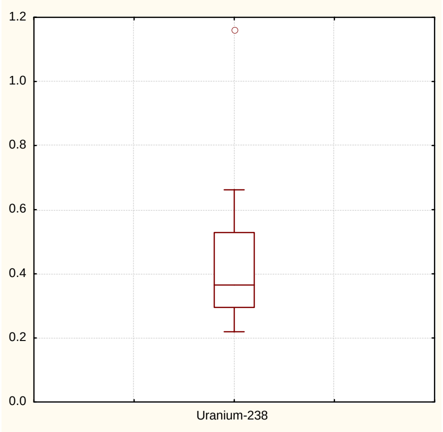


Figure C2.39. Box Plot for Uranium-238 Data

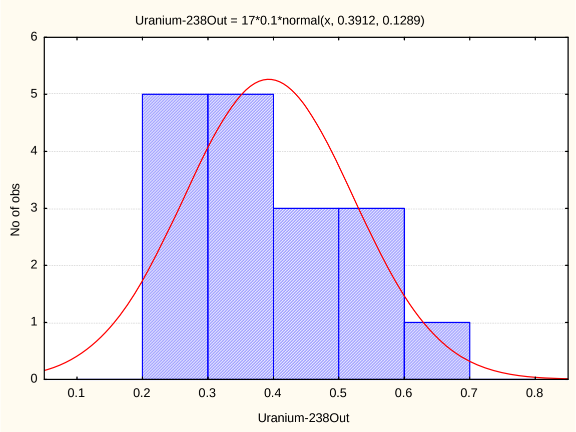


Figure C2.40. Histogram for Uranium-238 Out Data

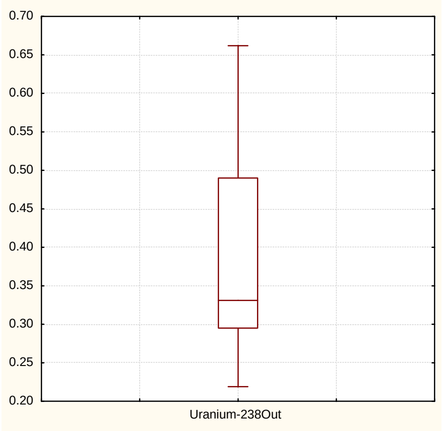


Figure C2.41. Box Plot for Uranium-238 Out Data

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX C, ATTACHMENT C3

GRAPHICAL REPRESENTATIONS OF FIELD DATA

THIS PAGE INTENTIONALLY LEFT BLANK

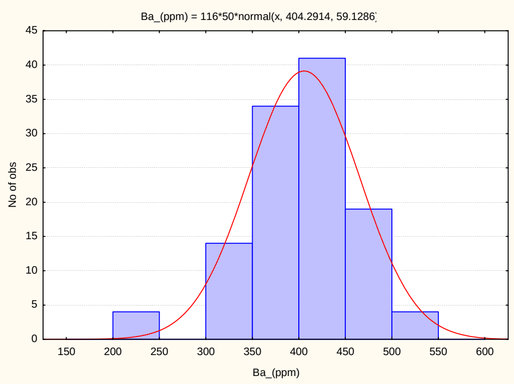


Figure C3.1. Subunit 1 XRF Plot for Barium Field Data

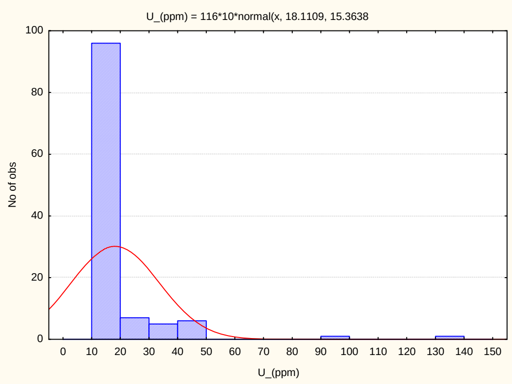


Figure C3.2. Subunit 1 XRF Plot for Uranium Field Data

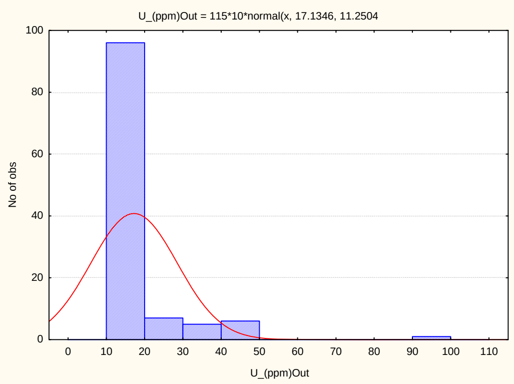


Figure C3.3. Subunit 1 XRF Plot for Uranium Out Field Data

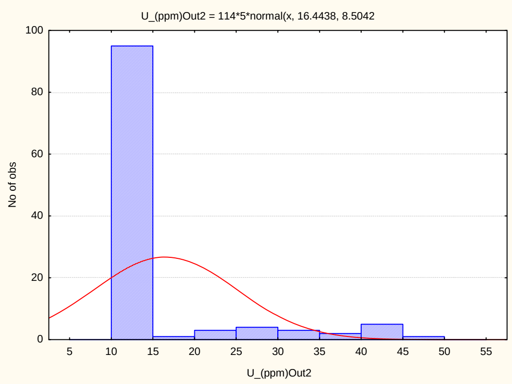


Figure C3.4. Subunit 1 XRF Plot for Uranium Out2 Field Data

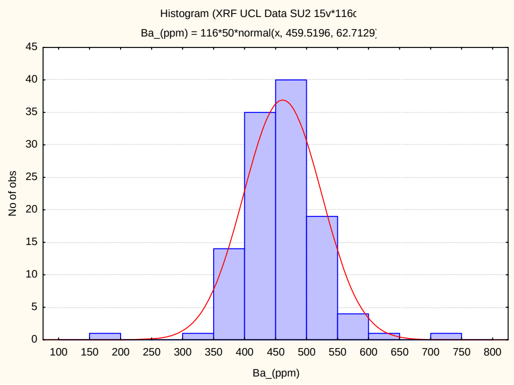


Figure C3.5. Subunit 2 Histogram for Barium Field Data

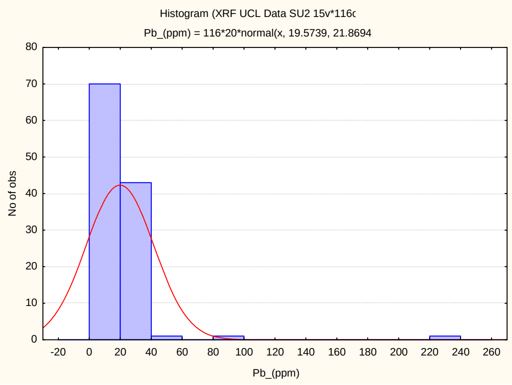


Figure C3.6. Subunit 2 Histogram for Lead Field Data

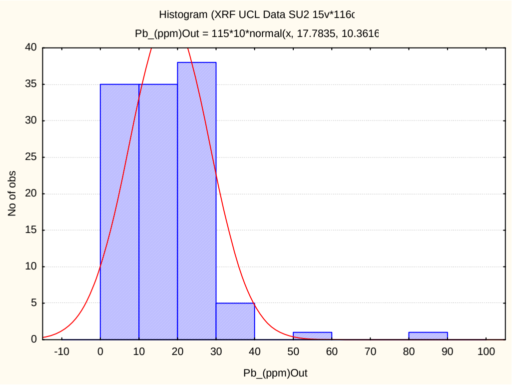


Figure C3.7. Subunit 2 Histogram for Lead Out Field Data

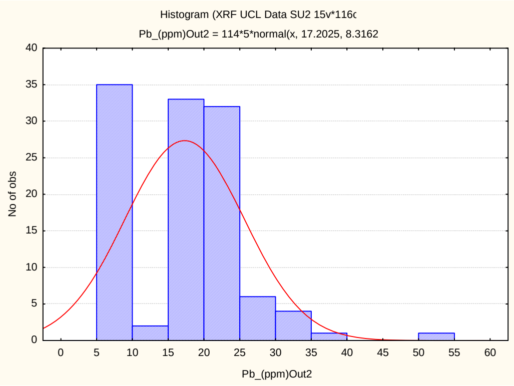


Figure C3.8. Subunit 2 Histogram for Lead Out2 Field Data

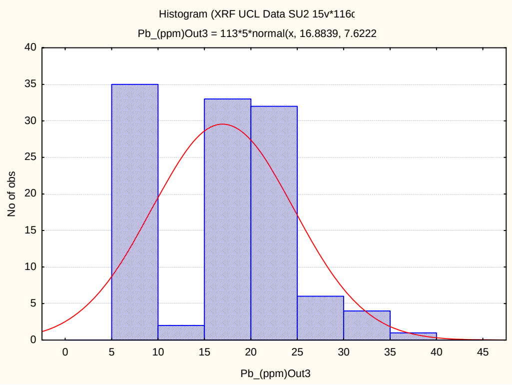


Figure C3.9. Subunit 2 Histogram for Lead Out3 Field Data

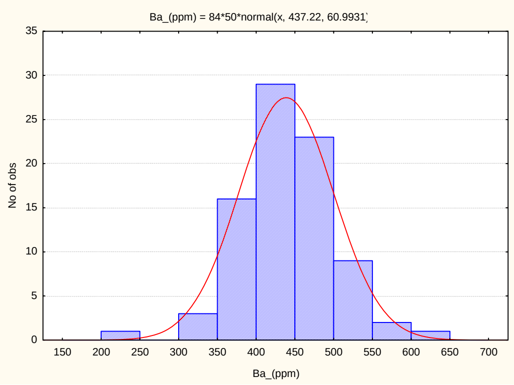


Figure C3.10. Subunit 5 XRF Plot for Barium Field Data

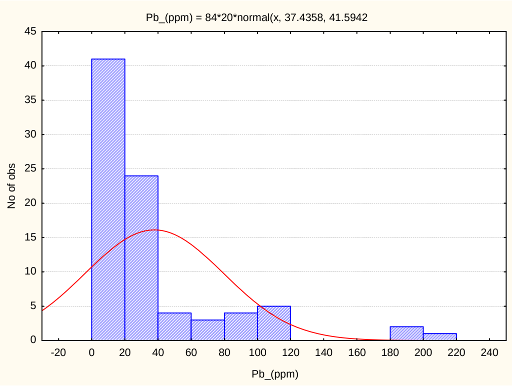


Figure C3.11. Subunit 5 XRF Plot for Lead Field Data

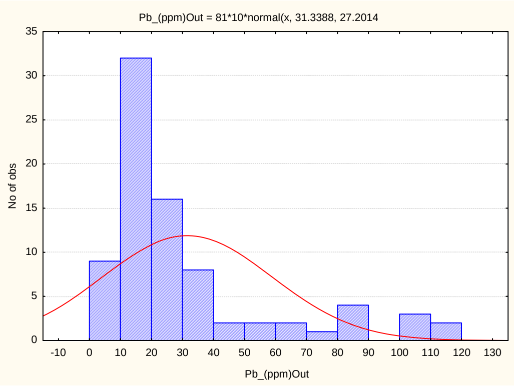


Figure C3.12. Subunit 5 XRF Plot for Lead Out Field Data

APPENDIX C, ATTACHMENT C4

GRAPHICAL REPRESENTATIONS OF METALS CONTINGENCY DATA

THIS PAGE INTENTIONALLY LEFT BLANK

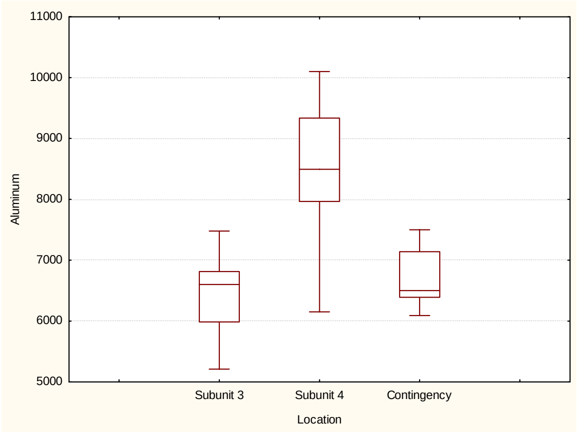


Figure C4.1. Box Plot for Aluminum Data

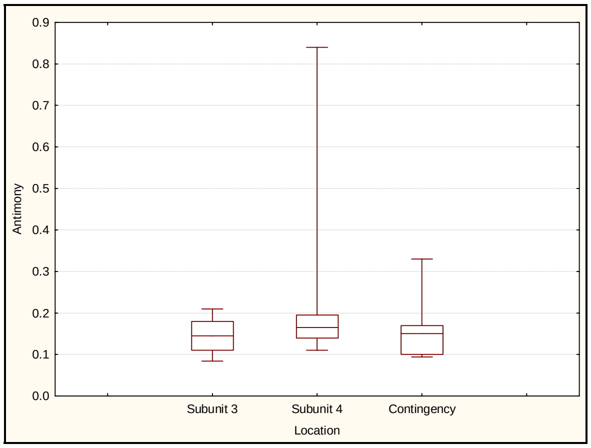


Figure C4.2. Box Plot for Antimony Data

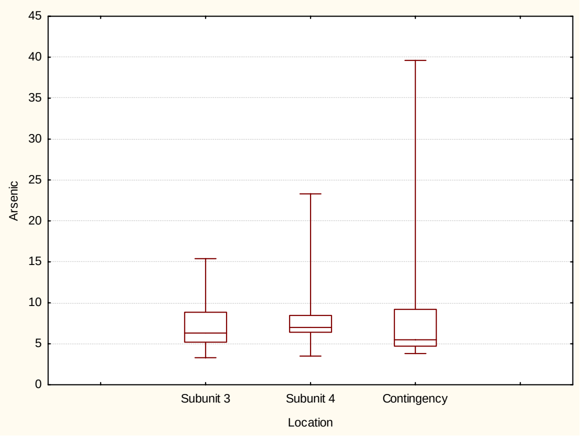


Figure C4.3. Box Plot for Arsenic Data

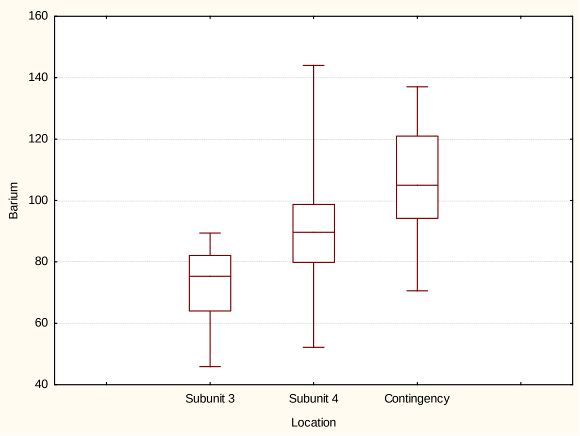


Figure C4.4. Box Plot for Barium Data

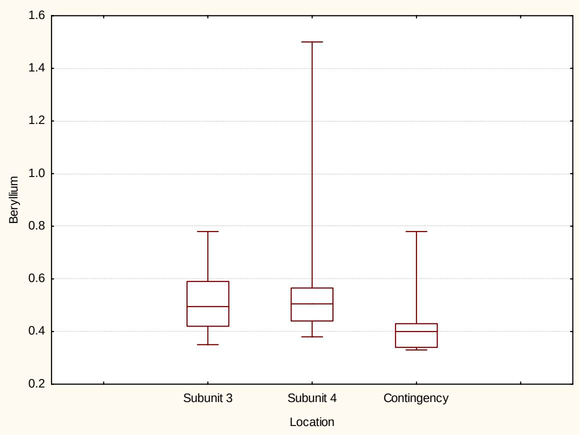


Figure C4.5. Box Plot for Beryllium Data

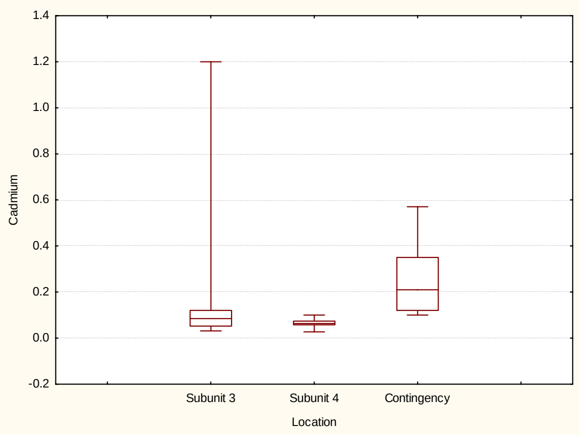


Figure C4.6. Box Plot for Cadmium Data

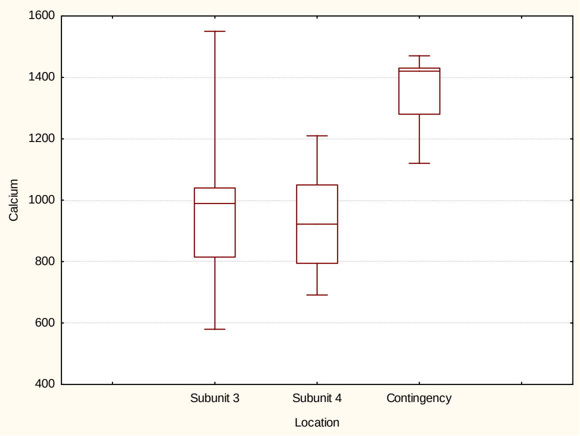


Figure C4.7. Box Plot for Calcium Data

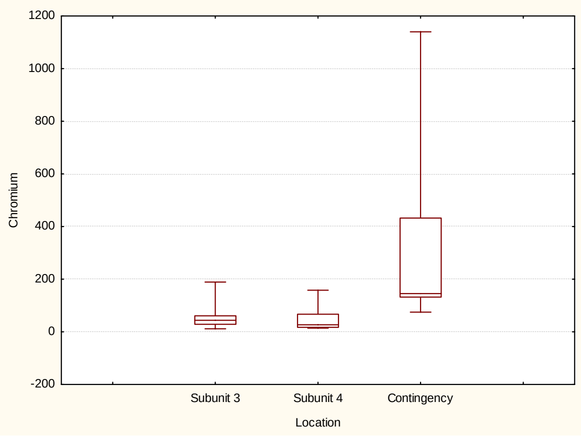


Figure C4.8. Box Plot for Chromium Data

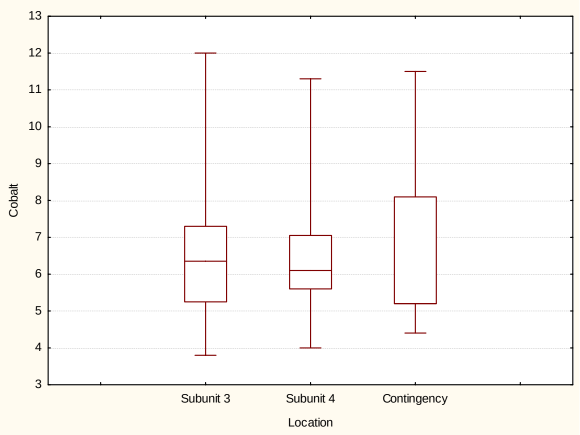


Figure C4.9. Box Plot for Cobalt Data

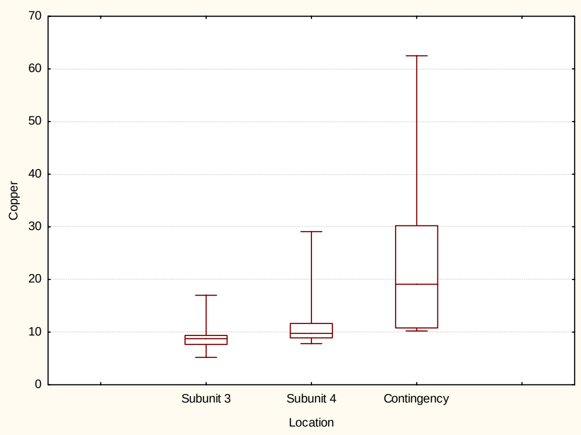


Figure C4.10. Box Plot for Copper Data

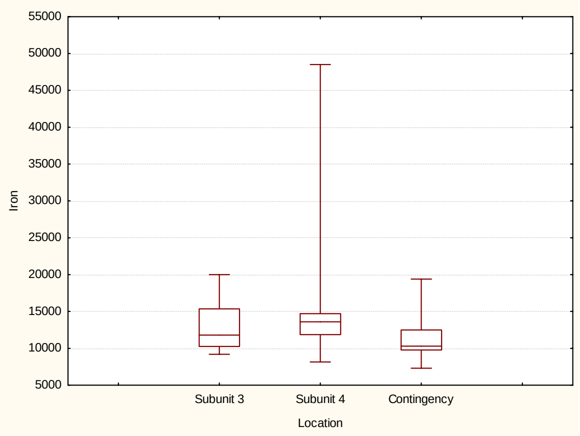


Figure C4.11. Box Plot for Iron Data

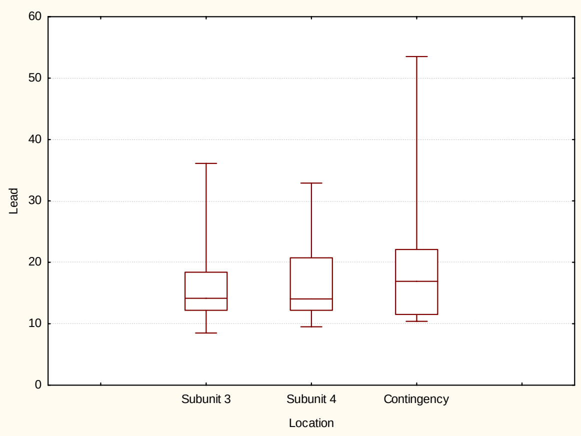


Figure C4.12. Box Plot for Lead Data

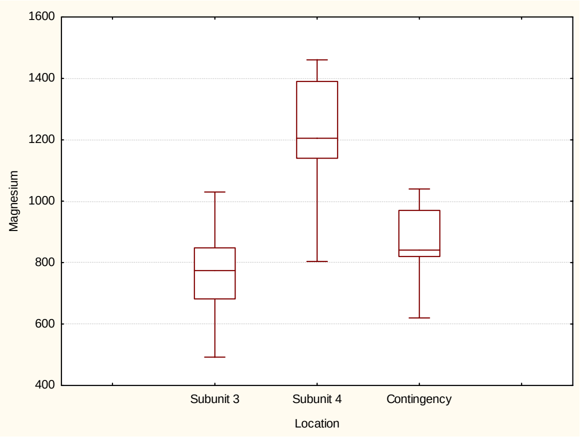


Figure C4.13. Box Plot for Magnesium Data

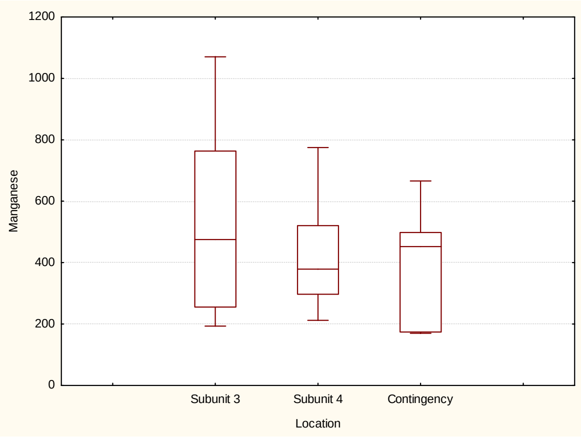


Figure C4.14. Box Plot for Manganese Data

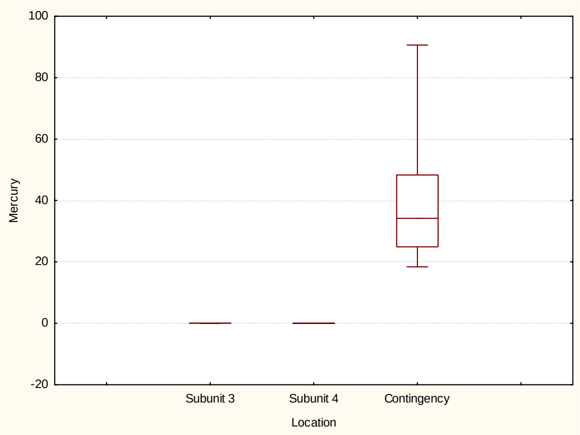


Figure C4.15. Box Plot for Mercury Data

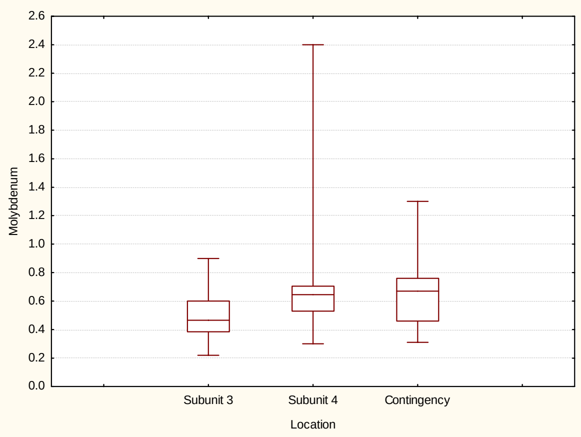


Figure C4.16. Box Plot for Molybdenum Data

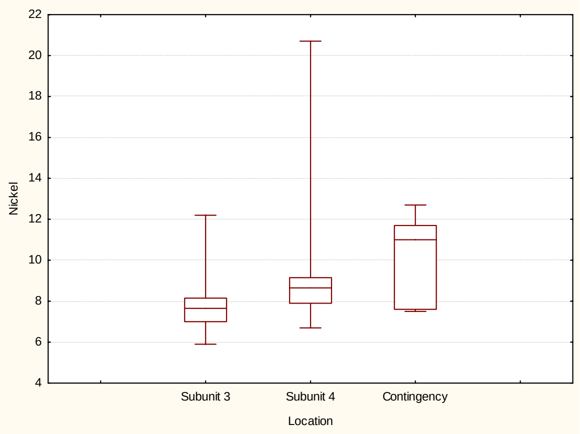


Figure C4.17. Box Plot for Nickel Data

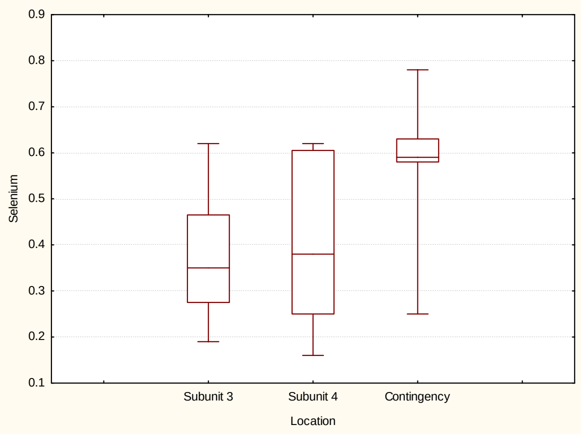


Figure C4.18. Box Plot for Selenium Data

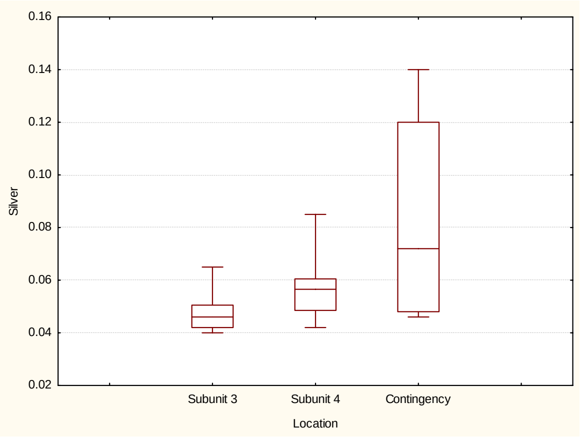


Figure C4.19. Box Plot for Silver Data

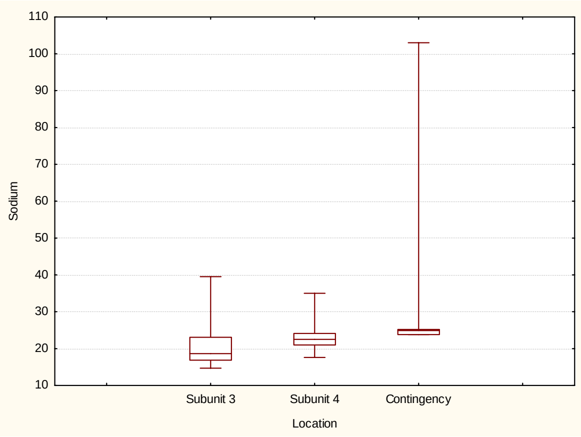


Figure C4.20. Box Plot for Sodium Data

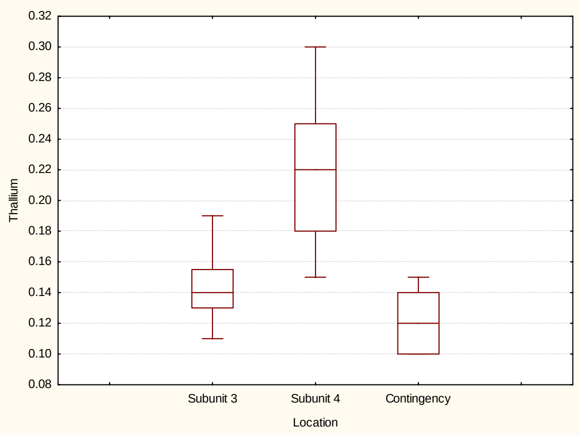


Figure C4.21. Box Plot for Thallium Data

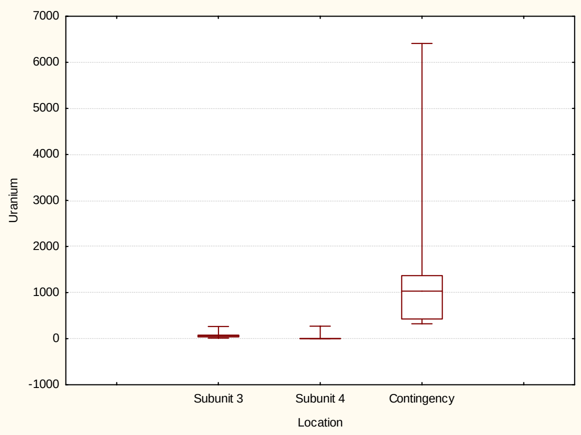


Figure C4.22. Box Plot for Uranium Data

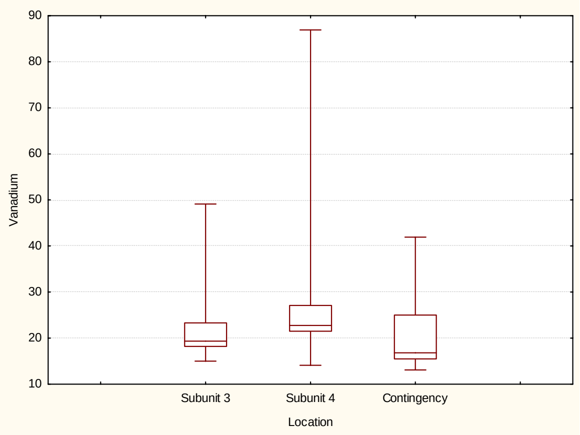


Figure C4.23. Box Plot for Vanadium Data

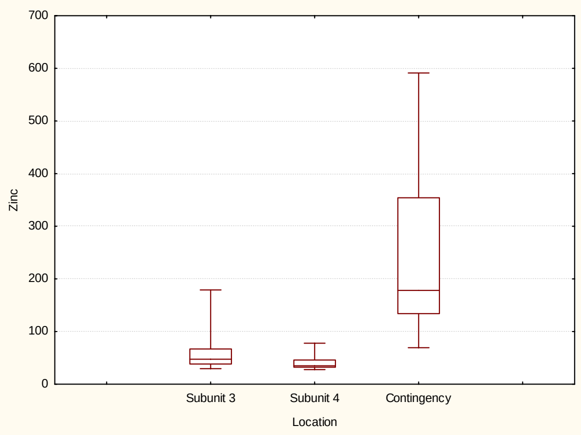


Figure C4.24. Box Plot for Zinc Data

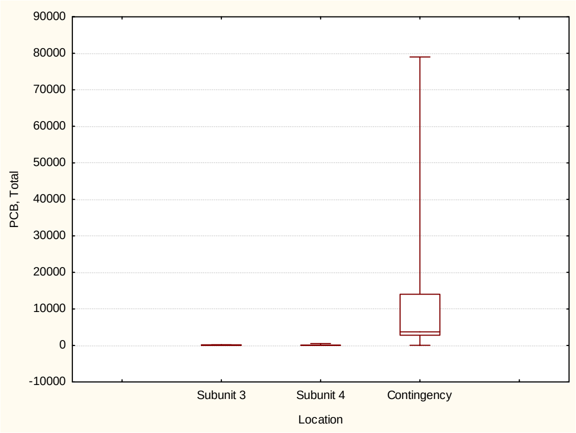


Figure C4.25. Box Plot for Total PCB Data

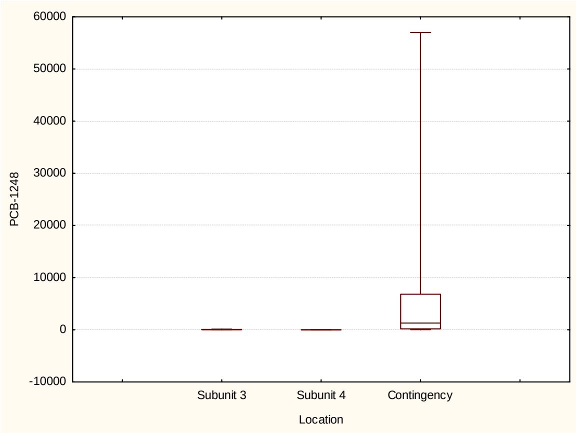


Figure C4.26. Box Plot for PCB-1248 Data

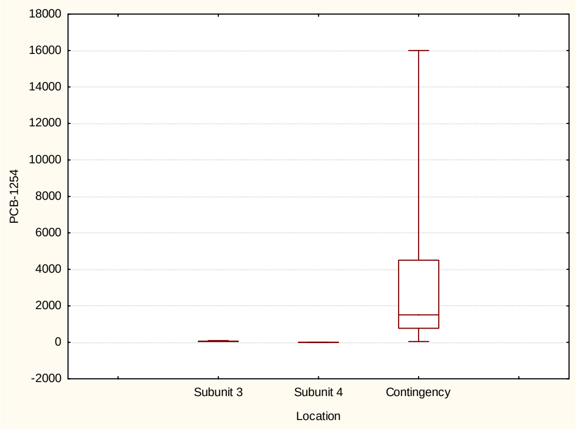


Figure C4.27. Box Plot for PCB-1254 Data

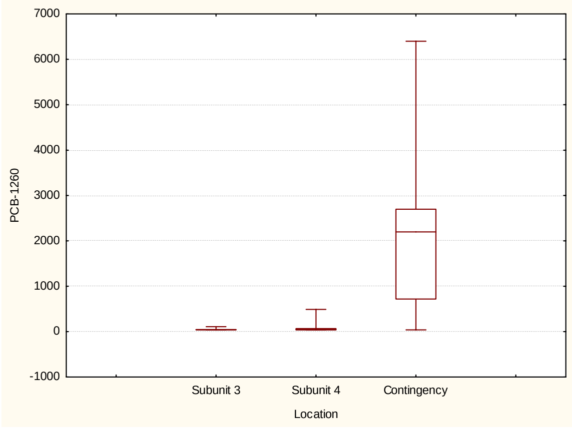


Figure C4.28. Box Plot for PCB-1260 Data

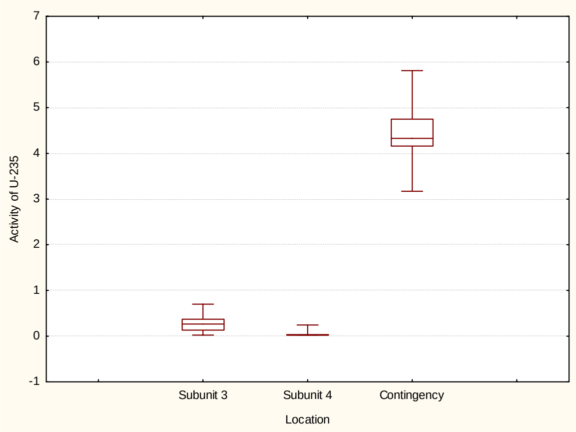


Figure C4.29. Box Plot for Uranium-235 Data

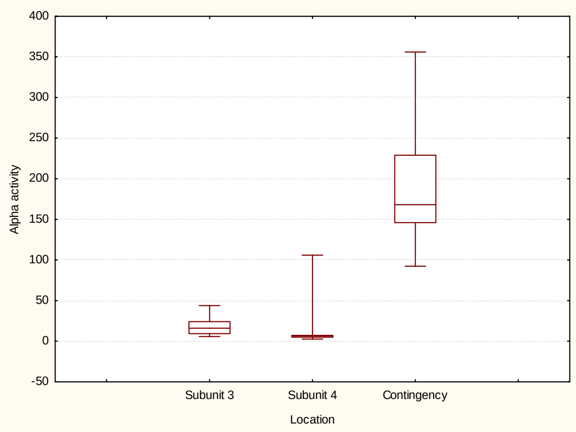


Figure C4.30. Box Plot for Alpha Activity Data

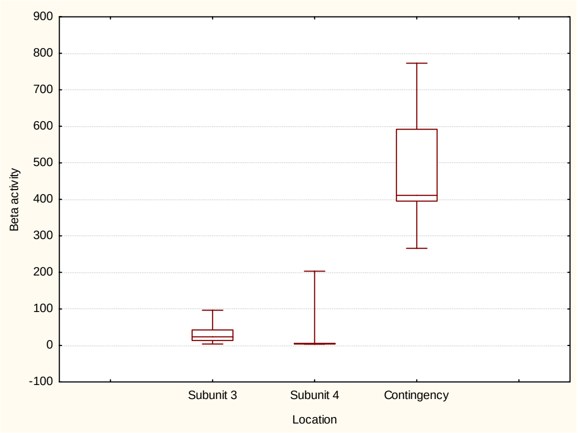


Figure C4.31. Box Plot for Beta Activity Data

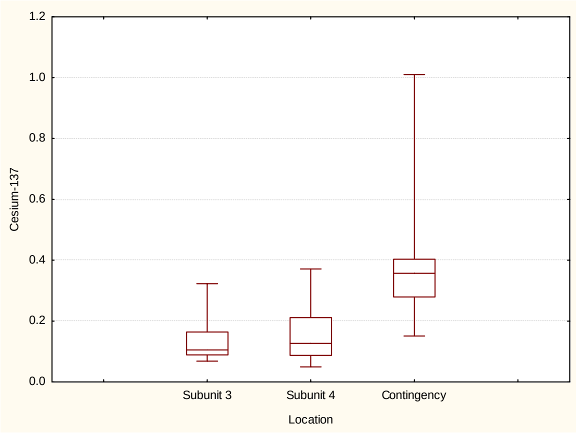


Figure C4.32. Box Plot for Cesium-137 Data

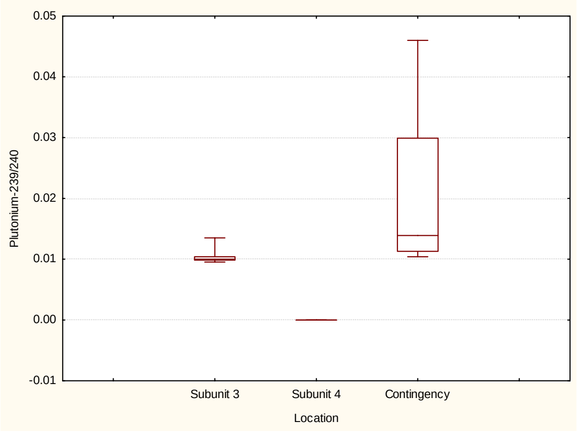


Figure C4.33. Box Plot for Plutonium-239/240 Data

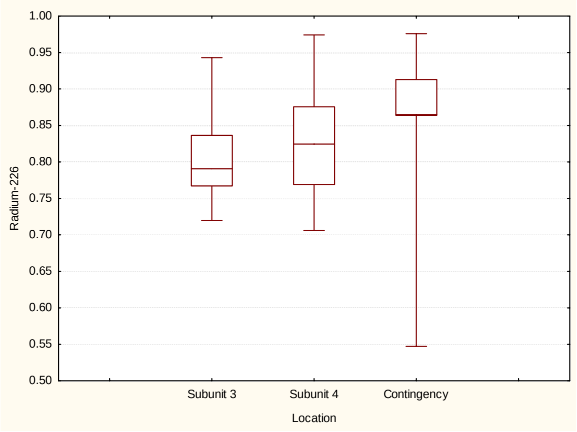


Figure C4.34. Box Plot for Radium-226 Data

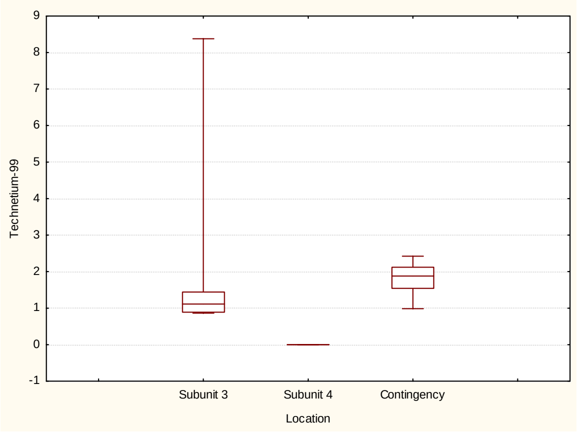


Figure C4.35. Box Plot for Technetium-99 Data

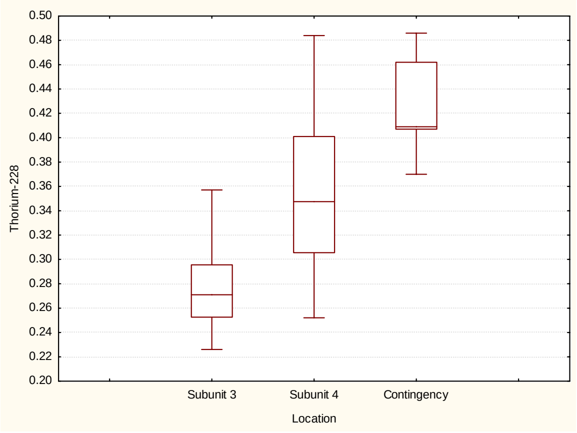


Figure C4.36. Box Plot for Thorium-238 Data

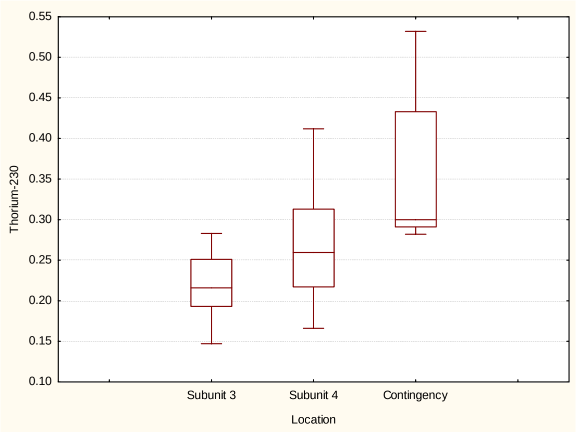


Figure C4.37. Box Plot for Thorium-230 Data

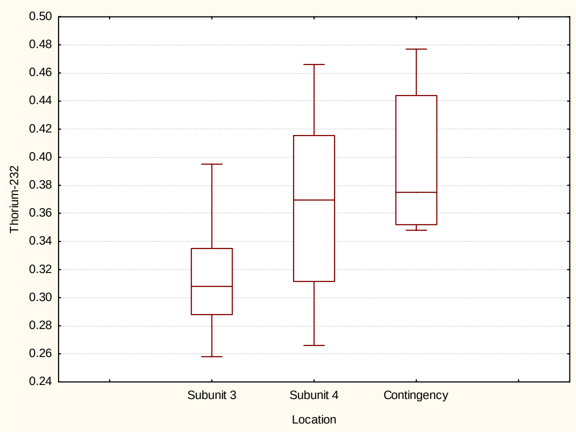


Figure C4.38. Box Plot for Thorium-232 Data

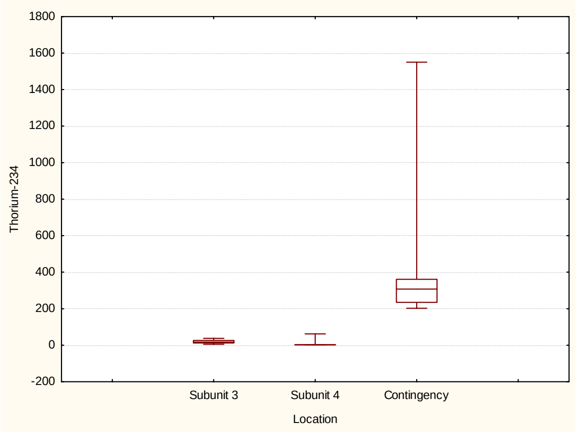


Figure C4.39. Box Plot for Thorium-234 Data

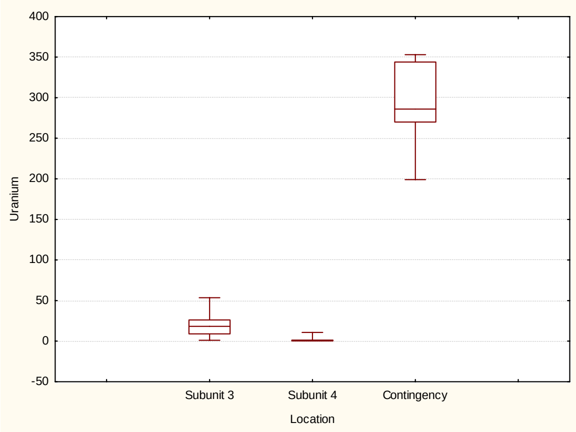


Figure C4.40. Box Plot for Uranium Data

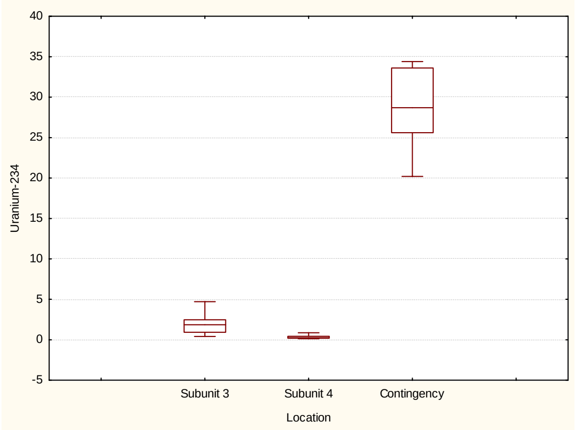


Figure C4.41. Box Plot for Uranium-234 Data

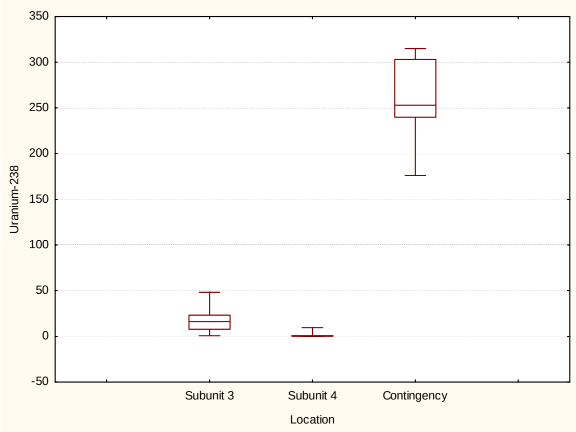


Figure C4.42. Box Plot for Uranium-238 Data