Annapolis Lead Mine
Human Health Risk Assessment
Annapolis Lead Mine NPL Site
Annapolis, Missouri

Final

Prepared for

U.S. Environmental Protection Agency
Region 7

August 11, 2005

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Acronyms

°C	degrees celsius
°F	degrees Fahrenheit
$\mu g/cm^2$	micrograms per square centimeter
µg/dL	micrograms per deciliter
µg/L	micrograms per liter
95% UCL	95th percent upper confidence limit
ADD	average daily dose
AF	Absorption factor
ALM	Adult Lead Methdology
ALS	Annapolis Lead Mine Site
AT	Average time
ATSDR	Agency for Toxic Substances and Disease Registry
BAF	bioavailability factors
BW	body weight
CERCLA	Comprehensive Environmental Response, Compensation, and Liablity Act
CDC	Centers for Disease Control
CDI	chronic daily intake
CDM	CDM Federal Programs Corporation
CLP	Contract Laboratory Procedures
cm^2	square centimeter
COPC	chemicals of potential concern
CrVI	Chromium VI
CSC	Carpenter-Snow Creek NPL Site
CSF	cancer slope factor
CTE	central tendency exposure
DEQ	Montana Department of Environmental Quality
DO	dissolved oxygen
DTSC	Department of Toxic Substances Control
EF	Exposure frequency
EPA	Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
ESI	extended site investigation
FDA	Food and Drug Administration
FI	fraction ingested
FS	feasibility study
ft.	foot/feet

g/day	grams per day
GP	Geoprobe©
GSD	geometric standard deviation
GWIC	groundwater information center
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
IEUBK	Integrated Exposure Uptake Biokinetic
IRIS	Integrated Risk Information System
kg	kilogram
L	liter
LADD	lifetime average daily dose
LOAEL	lowest-observed-adverse-effect-level
m^3	cubic meters
MCL	maximum contaminant level
MDESE	Missouri Department of Elementary and Secondary Education
MDHSS	Missouri Department of Health and Senior Services
MDNR	Missouri Department of Natural Resources
mg	milligrams
mg/cm^2	Milligrams per square centimeter
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram per day
mg/L	milligrams per liter
ml	milliliter
mm	millimeter
NA	not applicable/not available
NCP	National Contingency Plan
NHANES	National Health and Nutrition Examination Survey
NOAEL	no-observed-adverse-effect-level
NPL	National Priority List
ORP	oxidation-reduction potential
ORV	off-road vehicle
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
PARCC	precision, accuracy, representativeness, completeness, and comparability
PbB	Baseline blood lead concentration
PEA	Preliminary Environmental Assessment
PEF	particulate emission factor

pH	hydrogen ion activity
ppm	parts per million
PRG	preliminary remediation goal
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
RA	Removal Assessment
RAGS	Risk Assessment Guidance for Superfund
RfC	reference concentration
RfD	reference dose
RI	remedial investigation
RME	reasonable maximum exposure
RPM	remedial project manager
SARA	Superfund Amendments and Reauthorization Act
SC	specific conductance
SCEM	site conceptual exposure model
SSI	screening site inspection
START	Superfund technical assessment and response team
TAL	target analyte list
TCRA	time-critical removal action
TRW	Technical Review Workgroup
UCL	Upper confidence limit
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
WQB	Montana Water Quality Bureau
XRF	x-ray fluorescence

Section 1 Introduction

HydroGeoLogic, Inc. (HGL) has been tasked by the U.S. Environmental Protection Agency (USEPA) Region 7 to evaluate human health risks associated with the release of hazardous chemicals at the Annapolis Lead Mine National Priority List Site (ALS) (CERCLIS ID# MO00009568611). This Task Order is being executed under Contract Number EP-57-05-05, Task Order 0005. In order to meet the accelerated project schedule, HGL has delegated primary responsibility for this task to AES team partner CDM Federal Programs Corporation (CDM). The ALS is an inactive lead mine located approximately 1 mile east and 3/8 of a mile north of Annapolis, Iron County, Missouri. Primary sources of contamination at the ALS consist of unconsolidated and recently consolidated mine tailings/chat and mixed waste and soil (herein referred to as tailings) resulting from mining and ore processing which took place at the site from approximately 1920 to 1940. The ALS was listed as a National Priority List (NPL) site on July 24, 2004 under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) based on potential risk to humans and the environment associated with the presence of crushed and concentrated wastes resulting from on-site historical mining activities (USEPA 2004b). Mining wastes at the former mine site and downstream from the site contain elevated levels of heavy metals, particularly lead.

Contamination of area groundwater, surface water, sediment, and surface soil were observed during site investigations (Sverdrup 1996; E & E 1999; USEPA 2005a; Tetra Tech 2005), including detectable concentrations of heavy metals in Big Creek, a Missouri Outstanding Resource Water, and its tributary, Sutton Branch Creek. Elevated levels of heavy metals were reported in surface and subsurface soils in the former mining operations area and in soils near former on-site residences. The maximum concentration of lead at the mining operation area was 20,000 mg/kg, detected in a surface soil adjacent to a former on-site residence (E & E 1999). Dust and wipe samples within the residence also contained elevated concentrations of lead, and an emergency response action was implemented by USEPA to remove two children from the residence due to elevated blood lead concentrations. In addition to lead, other heavy metals/metalloids detected at the site and in nearby areas include: aluminum, antimony, arsenic, cadmium, chromium, cobalt, iron, manganese, molybdenum, selenium, thallium, vanadium, and zinc. Total on-site, contaminated waste was estimated to be 51,677 cubic yards (Tetra Tech 2005).

USEPA identified four areas within the former mining operations area as problem areas due to elevated concentrations of lead in surface soils and the migration of site contaminants into off-site surface waters. Problem areas within the mining operations area were scheduled for "time-critical removal action" beginning in May 2004. These areas include the exposed mine tailings pile, an outwash area from the tailings, the mill slime pond, and the mining operations area, all of which were in close proximity to several residences (UEPA 2004c). During 2004, removal activities were completed to limit the migration of contaminants to the Sutton Branch Creek floodplain and limit exposure to sources of contamination at the ALS mining operations area. Soils exceeding the USEPA action level of 400 mg/kg for lead were removed and placed in the source mine tailings pile, which was designated as an on-site repository. Excavation activities were ceased at a depth of 18 inches or when soil concentrations were below the action level for lead. The tailings pile was leveled, compacted, capped and revegetated. In addition, settling basins were constructed to reduce migration to surface waters. The capped tailings waste pile was fenced and gated to limit access, but other portions of the site are openly accessible. As part of the removal action, access to the tailings pile and the integrity of the in-place cap will be maintained by the State of Missouri.

This Human Health Risk Assessment (HHRA) was implemented to determine if contamination in soil, surface water, sediment, and groundwater may pose a significant risk to human health. The site is divided into two segments: (1) a segment north of Highway 49, termed the mining operations area; and, (2) a segment south of Highway 49, termed the floodplain area. All removal activities to date have taken place in the former mining operations area. This area is also the only part of the site that has land outside of the floodplain and, in theory, could be redeveloped in the future.

The 50-acre mining area is the primary source of contamination. A significant source of contamination in this area, the mine tailings waste pile, covered 10 acres. Surface contamination in the mining area was consolidated in 2004 into an on-site repository. Any residual contamination left after removal of surface materials (0 to 18 inches) was covered with 18" of clean fill and reseeded. Any risk or hazards in this area would be limited to future receptors that could be exposed to residual contamination after intrusive activities that would bring such contamination to the surface.

Further, mine tailings have migrated from source areas in the mining operations area to adjacent and downstream locations within the Sutton Branch Creek floodplain (USEPA 2005d). Site-visits indicate the presence of mine tailings and associated material in floodplain soils south of Highway 49 and north and east of Big Creek (CDM 2005; Tetra Tech 2005). The amount of tailings estimated to have migrated or transported off site may be in the thousands of tons (Tetra Tech 2005). Currently, no removal or remedial actions have taken place at these areas located approximately 2,400 ft south of the ALS mining operations area. Conclusions of this HHRA, therefore, represent a typical baseline analysis. These baseline risks may subsequently be used as one of several criteria used for risk management of this area.

1.1 Objectives of the HHRA

The purpose of this report is to document the methodology and results of the HHRA for the site, which includes the former mining operations area and the Sutton Branch Creek floodplain. The HHRA evaluates current and potential future risks to human health associated with the presence of heavy metals, particularly lead, in soils, surface water, sediment, and groundwater at the site. Specific objectives of the HHRA are:

- Evaluate available data for applicability to the risk assessment process and identify existing data gaps;
- Identify chemicals of potential concern (COPCs) to human health;
- Identify areas of elevated COPC concentrations (exposure units) within site boundaries;
- Evaluate potential health risks associated with exposure to COPCs for several exposure groups, based on anticipated or potential land uses;
- Identify uncertainties associated with risk characterization.

1.2 Overview of Report

This report was conducted in accordance with *USEPA Risk Assessment Guidance for Superfund (RAGS), Volume 1: Human Health Evaluation Manual (Part A), Interim Final* (USEPA 1989), other guidance documents and peer-reviewed literature with site-specific chemical data. Additionally, applicable USEPA national and regional guidance have been used as deemed appropriate:

- *RAGS, Volume 1, Human Health Evaluation Manual Supplemental Guidance: Standard Default Exposure Factors.* OSWER Directive 9285.6-03. (USEPA 1991b).
- *Guidance Manual for the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children.* USEPA PB93-963510. OSWER 9285.7-15-1. (USEPA 1994b).
- USEPA. 1996. *Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil.* December
- *RAGS, Volume 1, Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Final,* (RAGS Part E). OSWER Directive 9285.7-02EP. EPA/540/R/99/005. (USEPA 2004f).
- *Exposure Factors Handbook. Volume I: General Factors.* EPA/600/P-95/002Fa. Office of Research and Development. U.S. Environmental Protection Agency, Washington, DC. August (USEPA 1997a).

The HHRA is documented as specified in the USEPA guidance, RAGS, Volume I: Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments), Final, (RAGS Part D) (USEPA 2001). Deviations from this guidance are made as appropriate to account for the use of the Integrated Exposure Uptake Biokinetic (IEUBK) and the Adult Lead Methodology (ALM) models for assessing exposure to lead in soils and dust.

1.3 Organization of Report

The HHRA is organized as follows:

- Section 1 - Introduction
- Section 2 - Site Background (describes the site, the background, and the environmental factors relating to potential exposure pathways);
- Section 3 - Summary of Available Data (describes the analytical data and their adequacy for inclusion in the HHRA) and Selection of COPCs (describes methods used to select COPCs and identifies COPCs for each medium that will be carried through the risk assessment process);
- Section 4 - Exposure Assessment (identifies potentially exposed populations, media of concern, and exposure pathways);
- Section 5 - Toxicity Assessment (summarizes the potential for each COPC to cause adverse effects in exposed individuals);
- Section 6 - Risk Characterization (combines the risk characterization with the toxicological criteria presented in the toxicity assessment to estimate carcinogenic risks and non-carcinogenic hazards);
- Section 7 - Uncertainties (describes the impact of uncertainties associated with the database, exposure assumptions, and toxicity assessment on the final step of the risk assessment, risk characterization);
- Section 8 - Conclusions and Recommendations (summarizes findings and provides risk management recommendations); and
- Section 9 - References.

Section 2
Site Background

This section presents a brief description of the site location, attributes, previous investigations, and demography.

2.1 Site Location

The Annapolis Lead Mine NPL source area and the adjacent floodplain of Sutton Branch are in Iron County in southeastern Missouri, approximately 1 mile east and 3/8 of a mile north of Annapolis, Missouri (Figure 2-1). Four landowners, none of whom were responsible for mining contamination, currently own portions of the site. The site is divided into two segments for the purposes of this risk assessment: (1) a 50-acre area of source contamination at the former mining operations area; and, (2) a 60-acre floodplain area of Sutton Branch (Figure 2-2). Missouri Highway 49 bisects the site and separates it into the mining area and the floodplain area. The entire site is roughly rectangular in shape and is within the Sutton Branch Creek drainage. The area under investigation is bordered by the confluence of the western boundary of the Sutton Branch Creek floodplain and Big Creek to the south; the eastern boundary of the Sutton Branch Creek floodplain to the east; ALS property boundaries to the north; and the western edge of the Sutton Branch floodplain to the west. The mining area includes the repository of mine waste and outwash from the former waste pile to Sutton Branch Creek, while the floodplain area is entirely within the floodplain of Sutton Branch Creek. The Sutton Branch Creek floodplain south of the mining operations area is contaminated with mine tailing outwash deposited during flood events. The geographic coordinates of the approximate center of the site are 37.35111 degrees north latitude and -90.70806 degrees west longitude. The site is 916 ft above mean sea level.

2.2 Site Description

The ALS mining area and floodplain area are within the Big Creek Watershed. Sutton Branch Creek flows from north to south along the western boundary of the mining operations area and drains into Big Creek approximately ¾ of a mile from the operations area. The former mining operations area is comprised of a single abandoned residence, foundations of buildings, a mill slime pond, and a capped mine tailings and chat pile that is now a repository for contaminated waste (Figure 2-3). Removal activities were conducted at the site in 2004 (USEPA 2004c). The activities consisted of excavation of surface soil (0 to 18 inches) from the former mining operations area where lead concentrations were above 400 mg/kg, backfilling excavated areas, consolidating and capping the tailings pile, and limiting access to the area with fences.

The Sutton Branch Creek floodplain area is primarily floodplain pastureland (36 acres) with two wooded areas (24 acres). An occupied residence is adjacent to the floodplain. No commercial activity is known to operate at either of the areas under investigation, but the site may be used for recreation by local residents. Big Creek may be used for swimming and fishing downstream of the city of Annapolis, and canoeing and kayaking is possible along the stretches of Big Creek near its confluence with Sutton Branch Creek. Beneficial uses for Big Creek include livestock and wildlife watering and protection of warm water aquatic life and human health associated with fish consumption (Missouri Department of Natural Resources [MoDNR] 2004). Sam A. Baker State Park, popular for hiking, swimming, fishing, birding, biking, and camping, is 15 miles downstream from the mining operations facility (Missouri Department of Health and Senior Services [MDHSS] 2004).

2.3 Site History

The Annapolis Lead Mine was in operation for sporadic periods from approximately 1919 to about 1940 in an area known as the Missouri Old Lead Belt (USEPA 2004b). The Annapolis Lead Company purchased 926 acres in 1919 (Missouri State Mine Inspector 1923) and operated the mine until approximately 1931. During that period, the mine produced approximately 1,173,000 tons of mining waste from the extraction and processing of galena ore (Neustaedter 1934). The mine operators excavated ore bodies, crushed and concentrated ore, and stored the ore for off-site smelting. Waste products consisting of fine to medium sand-sized particles to boulder-sized ore bodies were disposed in a 10-acre ravine, which drains into Sutton Branch Creek (USEPA 2004b). Ore bodies from the Missouri Old Lead Belt are known to contain lead, antimony, cadmium, copper, calcium, iron, magnesium, nickel, silver, and thallium. Since 1931, several owners have operated the site, but mining operations ceased in 1940. In recent years, materials from the mine tailings pile have been removed and sold to concrete companies, county road crews, and the local school district (MoDNR 1993). Currently, four owners, none of whom live on-site, have stake in the contaminated portions of the property.

2.4 Previous Site Investigation Activities

The USEPA and the State of Missouri have conducted several investigations into source contamination and migration at the Annapolis Lead Mine, including:

- *Remedial Planning Activities at Selected Uncontrolled Hazardous Substances Disposal Site in a Zone for EPA Regions VI, VII, & VIII. Screening Site Inspection (SSI) Report for Site Assessment Activity at the Annapolis Lead Mine Site, Annapolis, Missouri.* Prepared by Sverdrup Corporation, Inc. for the U.S. Environmental Protection Agency Region VII, Kansas City, Kansas. June 19 (Sverdrup 1996);

- *Expanded Site Investigation (ESI) and Removal Assessment (RA) at the Annapolis Lead Mine, Annapolis, Missouri.* Prepared by Ecology and Environment, Inc. (E&E) for Region VII Site Assessment and Cost Recovery Branch, U.S. Environmental Protection Agency. February 19 (E & E 1999);

- *Ecological Risk Assessment of the Annapolis Lead Mine Site, Annapolis, Missouri.* U.S. Environmental Protection Agency Region VII, Kansas City, Kansas. (USEPA 2005a);

- *Health Consultation, Sam A. Baker State Park, Patterson, Wayne County, Missouri.* Division of Environmental Health and Communicable Disease Prevention, Missouri Department of Health and Senior Services (MDHSS). November 23 (MDHSS 2004); and,

- *Remedial Investigation Report, Annapolis Lead Mine Site, Annapolis, Missouri.* Prepared by Tetra Tech EM Inc. for U.S. Environmental Protection Agency Region VII, Kansas City, Kansas. June 24 (Tetra Tech 2005).

The State of Missouri and USEPA undertook several investigations prior to the listing of the ALS as a Superfund site. The earliest investigations into heavy metal contamination at the ALS were conducted in 1992 by the MoDNR, which collected sediment and surface water samples from Sutton Branch Creek near the ALS source area (Smith 1988). Chemical analyses demonstrated elevated concentrations of lead, copper, nickel, and zinc in the sediments of Sutton Branch Creek, with lead concentrations exceeding thresholds for the protection of wildlife. Fish biomarker studies, unrelated to investigations at the ALS, found elevated concentrations of lead and cadmium in the fish of Big Creek at locations downstream of the ALS, and the ALS was listed as a probable source (Schmidt et al. 1993).

During the late 1990s, the USEPA began conducting a series of investigations into heavy metal contamination at the ALS. Analytical results associated with these sampling activities indicated the presence of heavy metals in on-site groundwater, surface water, sediment and surface soil. The SSI, conducted in 1996, measured concentrations of heavy metals in groundwater, sediment, surface water, and soil using X-ray fluorescence spectrometer (XRF); XRF results were verified by laboratory analyses (Sverdrup 1996). Elevated levels of arsenic, cadmium, copper, lead, nickel, and zinc were reported in soil and sediment samples, and surface water from Sutton Branch Creek had elevated concentrations of lead (maximum concentration of 11.6 micrograms per liter [μg/L]). Concentrations of arsenic and lead in soil exceeded their respective USEPA Region 9 Preliminary Remediation Goals (PRG) for residential soils.

An emergency response action was implemented at the on-site residence (currently abandoned) in 1997 in response to high blood lead levels in two children living at the site (USEPA 2004b). Two wells in the area, an irrigation well and a drinking water well, contained lead at concentrations of 51.8 μg/L and 1.1 μg/L, respectively. The USEPA regulatory action level for lead in drinking water is 15 μg/L. Wipe and dust samples from the residence also contained lead at concentrations up to 0.625 micrograms per square centimeter ($\mu g/cm^2$) and 1,170 mg/kg, respectively. Concentrations of lead in soils collected near the residence ranged from 53.4 mg/kg to 5,510 mg/kg. Office of Solid Waste and Emergency Response (OSWER) Directive 9355.4-12 (USEPA 1994c) recommends a residential soil screening criteria of 400 mg/kg.

USEPA initiated an ESI/RA at the site beginning in 1997 (E & E 1999). During the ESI, over 100 XRF readings were collected at source locations within the ALS to determine localized areas of contamination, the extent of the contamination, and the volume of material. The mine tailings pile and mill slime pond that occupied about 10 acres in the mine operations area contained mining wastes extending from the surface to a depth of 21 feet, with an approximate volume of 39,989 cubic yards. The maximum detected concentration within the mill slime pond was 7,000 mg/kg of lead, and 58% of the samples from the tailings pile exceeded the USEPA removal action level and Region 9 PRG of 400 mg/kg. Arsenic, cadmium, and zinc also exceeded background concentrations, but only arsenic was above the residential PRG from EPA Region 9. Surface water in Sutton Branch and Big Creeks, as well as soils around other areas of the facility contained elevated levels of heavy metals. No groundwater wells used for drinking within a 1-mile radius of the site contained levels of heavy metals exceeding those allowable, but arsenic was detected in a shallow irrigation well at levels that exceed the Region 9 tap-water PRG (0.45 μg/L). The on-site, shallow irrigation well also contained a measurable amount of lead and cadmium, but poor construction may make this well unrepresentative of local groundwater contamination. Other wells at the site and on the adjacent property had elevated concentrations of lead and cadmium.

After the ALS was listed on the NPL in 2004, further investigations and remedial activities commenced at the site and at downstream areas. An Ecological Risk Assessment (ERA) was conducted in 2005 (USEPA 2005a) and focused on hazards to the environment due to migration of contaminants into surface waters and the health of terrestrial species at source areas. Algae, benthic macroinvertebrates, and fish populations were affected by heavy metal contamination at the ALS, and terrestrial plants in the vicinity of the tailings pile, soil organisms, and vermivores were also affected. Pre-remedial levels of heavy metals appeared to affect the environment at ecologically relevant levels.

At the request of the MoDNR, the MDHSS conducted a health consultation at the Sam A. Baker State Park, 15 miles downstream from the ALS along Big Creek, to evaluate contaminant concentrations of heavy metals, exposure, and threat to the public. Concentrations of arsenic, cadmium, chromium, lead, nickel, thallium, and zinc were found in various media from locations within the park, but no contaminants exceeded human health-based hazard screening levels (MDHSS 2004). The MDHSS issued a finding of "No Apparent Health Hazard" for residents near and visitors to the park.

Removal activities at the mining area were undertaken by the USEPA as a time critical response action in 2004 (USEPA 2004c). Activities focused on limiting the exposure to tailings and migration of tailings from the tailings pile and mill slime pond into Sutton Branch Creek by constructing settling ponds between the source area and the creek. Soils with concentrations exceeding the 400 mg/kg removal criteria were excavated and placed in the tailings pile, which was leveled, compacted, capped, and fenced. The repository of waste will be maintained by the State of Missouri indefinitely. No action was taken at the adjacent floodplain area between Highway 49 and Big Creek.

The floodplain area remedial investigation (RI) commenced in early 2004, prior to the time critical response action at the ALS mining operations area (Tetra Tech 2005). Contamination of the floodplain area likely occurred due to outwash of the source pile prior to the time critical removal action and capping of the tailings pile. Lead, arsenic, and manganese were detected in surface soil (0 to 2 feet) in one or more samples at values exceeding their respective Region 9 residential soil PRGs. Significant concentrations of lead were detected in surface soil across the site. Lead concentrations exceeding 400 mg/kg exist within the Sutton Branch Creek floodplain in an area approximately 2,000 feet by 900 feet in size. Elevated concentrations of arsenic were typically found in samples that also contained significant concentrations of lead. The residential soil PRG for manganese was exceeded in only one surface soil sample. Arsenic and lead were also detected at concentrations exceeding their respective residential surface soil PRGs (there are no subsurface soil PRGs) in samples collected from subsurface soils (4 to 6 feet). Lead concentrations greater than 400 mg/kg in subsurface soil surround a subsurface soil zone in the central portion of the floodplain with concentrations of lead below 400 mg/kg. This distribution of lead contamination may reflect the fanning out of flood waters. Soil samples collected along Highway 49 also contained elevated concentrations of lead which are likely attributable to sources other than the outwash from the mine tailings (Tetra Tech 2005). Surface water and sediment samples were collected during the RI from three locations along Sutton Branch Creek and two locations in Big Creek. Barium, calcium, magnesium, selenium, and manganese were detected at similar concentrations in surface waters of Big Creek and Sutton Branch Creek. Arsenic was detected only at the background location, about 450 feet above Sutton Branch Creek. Eleven metals were detected in sediment at similar concentrations; however, lead was detected in all sediment samples ranging from 7.25 mg/kg at the background location to 1,070 mg/kg downstream of the ALS. Concentrations of lead in sediment at the time of the RI indicated that Sutton Branch Creek had been impacted by mine tailings from the ALS.

2.5 Demographics and Land Use

The Annapolis Lead Mine is within 1 mile of the city of Annapolis, which has a population of 310 (US Census 2000a). The population living within a 4-mile radius of the site, as of 1996, is estimated to be 1,325 persons, with 180 persons living within a 1-mile radius (Sverdrup 1996). As many as 18 people have lived on the site, but at last count, no one resides directly within the contaminated area; however, one occupied residence is adjacent to the Sutton Branch Creek floodplain and one is just north and west of Highway 49 and ICR 138. A school attended by 489 students is within 2 miles of the site (MDESE 2005). There are no known drinking water intakes from Big Creek for residential use. One manufacturing facility is known to use water from Big Creek during the manufacturing process to produce roofing granules (Sverdrup 1995a). The MoDNR also may use water from Big Creek at Sam A. Baker State Park, which is 15 miles downstream of the ALS. Both the villages of Vulcan, population 157, and Des Arc, population 187, are downstream along Big Creek (U.S. Census 2000a). Fishing is popular south of Annapolis near Des Arc village; local fisherman take crappie, catfish, large and small mouth bass, and sunfish (Sverdrup 1995b).

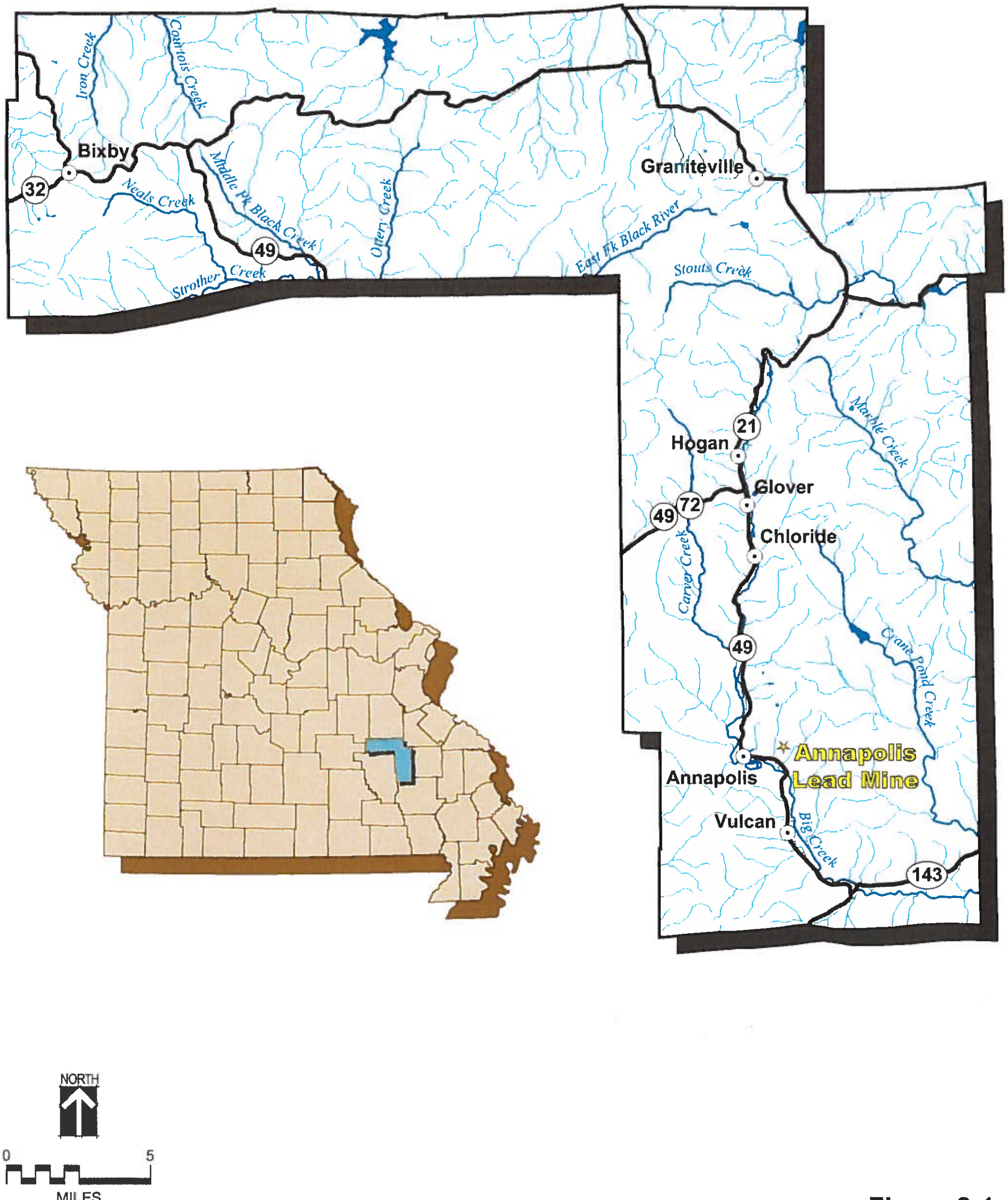


Figure 2-1
Vicinity Map, Annapolis Lead Mine NPL Site

CDM

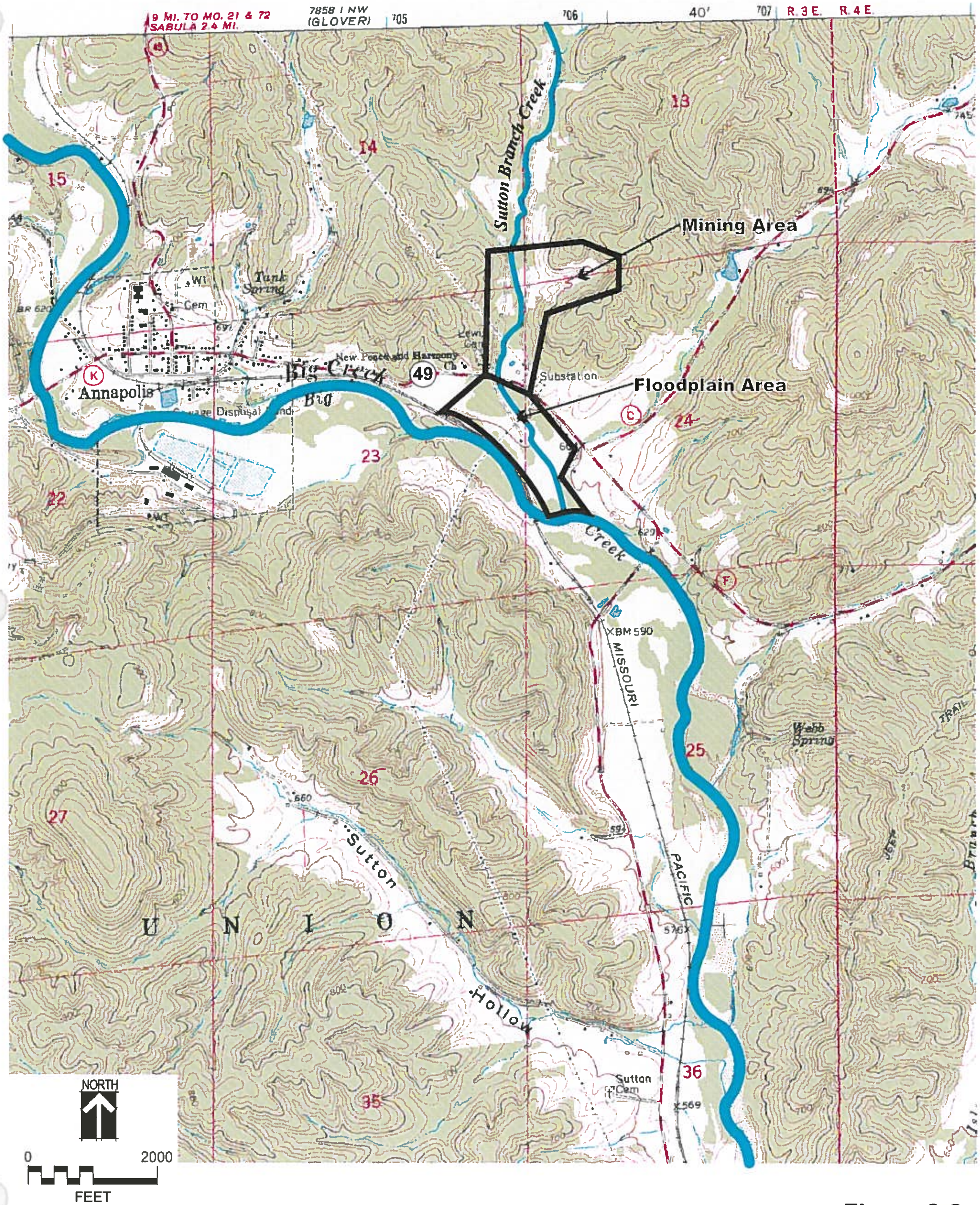
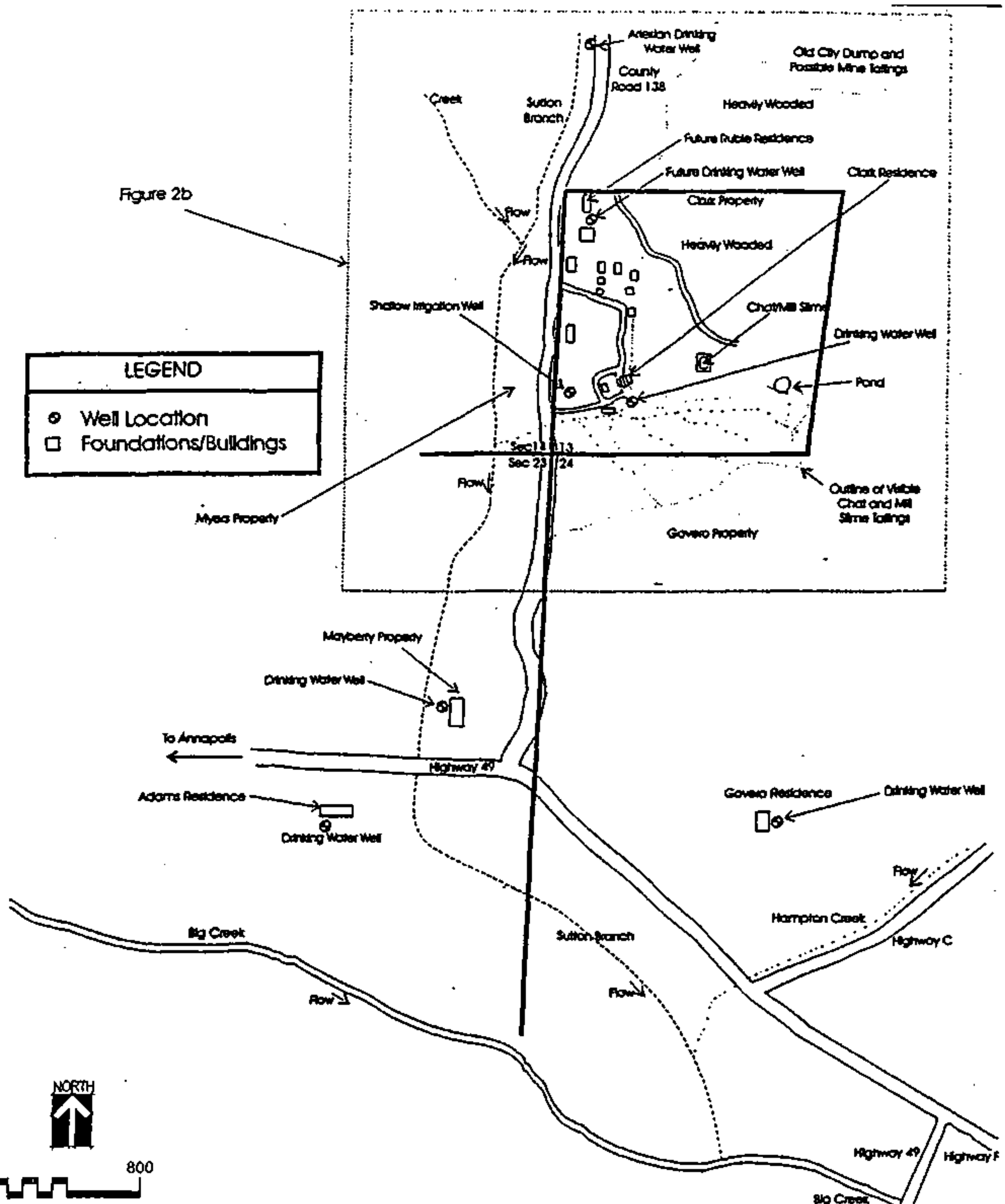


Figure 2-2
Site Map, Annapolis Lead Mine NPL Site



Source: Ownership Map of Iron County, Missouri (Iron County Tax Assessor).

Figure 2-3
Detailed Site Map, Annapolis Lead Mine NPL Site

Section 3
Summary of Available Data and Selection of COPCs

The following sections present a summary of data available for the HHRA, a summary of the data evaluation, and the selection of COPCs. Data used in the HHRA were obtained from sampling events conducted by USEPA START in 2004 and 2005. USEPA START collected soil, surface water, stream sediment, and groundwater samples from within the ALS and areas in the Sutton Branch Creek floodplain in response to public health concerns and to help determine the need for remediation actions.

A data evaluation was performed to determine the usability of existing data for risk assessment. Selection of data used to support quantitative evaluation is based on quality, quantity, comparability (e.g., similar detection limits, comparability of analytical methods), and representativeness of data for current site conditions and potential exposures at the site. During data evaluation, a set of data appropriate for use in quantitative risk assessment is compiled. These data are then used in selection of COPCs and in estimation of exposure point concentrations used in the calculation of possible chronic daily intake.

3.1 Data Used in the HHRA

During the remedial investigation, samples were collected from surface soils, subsurface soils, surface water, sediment, and groundwater. Soil samples were collected from the mine site north of Highway 49 and the Sutton Branch Creek floodplain south of the highway. Surface water and sediment samples were collected from Sutton Branch Creek and Big Creek. Groundwater samples were collected from residential and irrigation wells.

USEPA START collected surface water, sediment, and soil samples in March and April 2004. The protocol used and data generated from those sampling efforts are discussed in detail in the Remedial Investigation Report (Tetra Tech 2005). Additional soil samples were collected during March 2005 to more accurately define the extent of contamination along Highway 49.

Data used in the HHRA is briefly discussed by medium in the following sections. The data are presented in Appendix A.

3.1.1 Soil

USEPA START collected samples in the ALS mining and floodplains areas during March and April 2004. Many of the soil samples collected from the former mine site had lead concentrations above the USEPA action level for lead of 400 mg/kg. Based on these results, USEPA determined that action was necessary to remove contaminated soil at the mine site. The removal and reclamation process consisted of excavating soil to at least 18 inches below ground surface, transporting the contaminated soil to a centralized area, backfilling and capping the areas with uncontaminated fill and soil, capping the centralized area, and revegetating all disturbed surface soils. Soil samples were also collected during these remediation activities from June through October 2004 and in March 2005. Soil sample locations are shown on Figures 3-1 and 3-2.

Sampling in both 2004 and 2005 was conducted using a truck-mounted Geoprobe©. Fifty soil borings taken in the floodplain area (GP1-39 [2004] and GP70-81[2005]) were advanced from 4 to 12 feet below-ground-surface (bgs) depending upon where the groundwater interface was encountered. Sampling intervals were determined in the field based on in-situ X-ray fluorescence (XRF) readings or changes in lithology (Tetra Tech 2005). An additional 54 soil borings (GP40-69 and GP82-105 [2005]) were installed along the north side of Highway 49. Each of the 54 soil borings were composed of one soil sample from the top 12 inches of soil. Soil samples collected during remediation activities were taken on a grid basis (see Figure 3-2) to a depth of 18 inches.

All soil samples were screened by taking the average of three consecutive XRF readings after sample homogenization (Tetra Tech 2005). Approximately one-third of the samples were submitted to a laboratory for analysis of TAL metals. As part of the data evaluation process, the correlation between XRF and wet laboratory analyses was assessed to determine if any systematic errors were present that could influence risk calculations. This analysis showed that XRF and wet laboratory analytical results were comparable (Tetra Tech 2005).

A total of 70 surface soil samples (26 percent of 267 samples), soil samples taken completely within the top 24 inches, contained lead concentrations greater than 400 mg/kg. This value is based on the USEPA Region 9 residential soil PRG for lead. Sampling locations within the ALS with lead concentrations greater than the screening value (hotspots) appear to be:

- along the south side of Highway 49 in the Sutton Branch Creek floodplain;
- immediately adjacent to the north side of Highway 49;
- approximately 100 meters north of the Mayberry property on the east side of Walnut Hollow Road (below an 18"cap of clean soil);
- surrounding the Clark residence (below an 18" cap of clean soil); and,
- in the Sutton Branch Creek floodplain just to the west of the Clark residence (below an 18" cap of clean soil).

These hotspots are shown in Figures 3-1 and 3-3.

A total of 22 subsurface soil samples (61 percent of 39 samples), samples including soil taken below 24 inches, contained lead concentrations greater than 400 mg/kg.

Subsurface samples were only collected in the floodplain area of the ALS. As with surface soils, sampling locations within the ALS with lead concentrations greater than the screening value were located in the Sutton Branch Creek floodplain south of Highway 49 before the confluence of Hampton Creek.

3.1.2 Groundwater

Groundwater samples were collected from four wells in 2004. Groundwater sampling locations are shown on Figure 3-4. Groundwater samples were analyzed for arsenic, cadmium, chromium, copper, iron, lead, nickel, silver, thallium, and zinc. Results of sampling indicated that groundwater exceeded USEPA Region 9 PRGs for tap water for arsenic in all wells and for iron in the Rubble Residence well. Lead concentrations in the shallow irrigation well were above the USEPA Region 9 PRG for lead in tap water. Note: the Region 9 PRG is based on the EPA's Health Advisory Level of 15 µg/dL.

3.1.3 Surface Water

In April 2004, USEPA collected surface water samples from 40 locations along Sutton Branch and Big Creeks. Mapped surface water sampling locations are shown on Figure 3-5. Surface water samples were analyzed for total recoverable and dissolved metals and metalloids and common ions. Maximum reported concentrations (total) of chemicals detected in surface water were compared to USEPA Region 9 PRGs for tap water or the Health Advisory Level (lead only). Arsenic, lead, manganese and thallium exceeded their respective tap water PRGs or Health Advisory Level in surface water in Sutton Branch Creek.

3.1.4 Sediment

Sediment samples collected by USEPA in April 2004 were co-located with surface water samples. Sediment sampling locations are shown on Figure 3-5. Sediment samples taken in early April 2004 were analyzed for total metals and metalloids. Samples taken in late April 2004 were only analyzed for arsenic, cadmium, lead, nickel, and zinc. Arsenic concentrations in sediment ranged from 2.9 to 40 mg/kg. All reported concentrations of arsenic in sediment exceed the USEPA Region 9 residential soil screening value of 0.39 mg/kg for arsenic. Three samples exceeded the USEPA Region 9 screening level (400 mg/kg) for lead in residential soil. Lead concentrations ranged from to 7.25 to 1070 mg/kg. The highest concentrations of lead in sediment occurred in Sutton Branch Creek south of Highway 49.

3.2 Data Evaluation

The USEPA has established guidelines for data usability in the following documents:

- *Guidance for Data Useability in Risk Assessment – Quick Reference Fact Sheet.* OSWER Publication 9285.7-05FS. September 1990.
- *Guidance for Data Useability in Risk Assessment (Part A) Final.* OSWER Publication 9285.7-09A. April 1992.

- *Guidance for Data Useability in Risk Assessment (Part B) Final.* OSWER Publication 9285.7-09B. May 1992.

These guidelines are used as a nationally-consistent basis for determining the minimum quality and quantity of data sufficient to support risk assessment decisions (USEPA 1990). The USEPA has identified six criteria for ensuring the usability of data:

- Data sources;
- Documentation;
- Analytical methods and detection limits;
- Data quality indicators;
- Data review; and,
- Reports to risk assessors.

USEPA has identified minimum requirements for each of these criteria in the *Quick Reference Fact Sheet* (1990) in Highlight 5.

Data are available from several sources as discussed above, all of which provide basic documentation of when, where and how samples were collected. Moreover, data used in the risk assessment are taken from samples analyzed with standard methods and that passed some measure of validation. Detection limits used were typical for analysis of inorganic constituents and are sufficiently low to detect concentrations of metals and metalloids that could be off concern even for residential settings.

Data sets were not collected to support risk assessment; therefore, no criteria were established prior to field activities on which completeness, precision and accuracy can be evaluated. In some cases, for example, groundwater, the dataset is limited and may not represent groundwater impacts in the vicinity of the site. However, for other media (mainly soils), the dataset is extensive and is likely to adequately represent current site conditions.

Not all data are available in reports to the risk assessor. In fact, some of the post-removal data are available currently only in spreadsheets and accompanying figures. However, EPA staff knowledgeable about the removal have been available to answer questions and provide insight into the removal process. Thus, sufficient information concerning data collected during the removal has been obtained to support use of the data in this risk assessment. Nonetheless, data gaps were identified during the data evaluation. These gaps, along with additional insight into data available to support the risk assessment are included below and in Section 7, Uncertainties.

Data evaluation also included the following efforts. Tetra Tech conducted a regression analysis on the XRF and the confirmatory lab samples for the remedial investigation. Tetra Tech found that the correlation coefficient (r^2) for the XRF used during the RI field activities was 0.717 (Tetra Tech 2005). Coefficients above the threshold value of 0.70 indicate that the associated XRF data for that instrument are acceptable as quantitative values (Tetra Tech 2005). A similar regression analysis was conducted by CDM on the post-remedial action XRF and confirmatory sampling data. The correlation coefficient for this data was 0.993, well above the threshold. The USEPA Region 7 Regional Laboratory reviewed and verified the USEPA's lab results from the 2005 sampling event in accordance with procedures described in the USEPA's Quality Manual (USEPA 2005f). Although some results were qualified as estimated, analytical data produced during the RI was found to be of high quality and are useable for risk assessment purposes. Some uncertainties do exist, however, and are discussed in more detail below and in Section 7.

Data representativeness is one of the most important criteria that must be evaluated when selecting data for use in the quantitative HHRA. Representativeness is the extent to which available data characterize potential exposure conditions for people or ecological receptors. Proper selection of sampling locations, consideration of potential hot spots, assessment of background concentrations, and collection of a sufficient number of samples help maximize data representativeness. Data for soils were collected in contaminated or potentially contaminated areas and in areas where human contact is possible either currently or in the future. The available data are extensive given the size of the site and are expected to be sufficient to support quantitative risk assessment.

Data collected during the removal action are also extensive. Samples were collected in 50 foot square grids over the entire mine operations area. This systematic sampling provides a representative dataset for residual lead contamination. As note above, most data are from XRF analyses, but the correlation between XRF and typical CLP analyses is reasonably good. This issue is further discussed in Section 7, Uncertainties.

Site-specific bioavailability estimates for arsenic and lead are not available, however. Bioavailability of these COPCs can be critical in accurately assessing potential risks. Uncertainties associated with the lack of these data are also discussed in Section 7.

Surface water, sediment, and groundwater data sets are small, but do provide a range of possible exposure concentrations. Samples of surface water and sediment were collected in areas that represent entry points for mine wastes and are likely to represent higher levels of contamination at the site. These concentrations can be used to address a high-end estimate of possible recreational risks and hazards. Uncertainties in data sets for surface water, sediment, and groundwater are further discussed in Section 7.

All soil, groundwater, surface water, and sediment data collected during the RI denoted as useable during the data quality review process were included in the COPC selection process, except where the removal action in the mine operations area render the data obsolete. Data collection, sampling methods, quality assurance/quality control (QA/QC) procedures, and the nature and extent of contamination are described in more detail in a remedial investigation report (Tetra Tech 2005).

Several data gaps were identified during the data evaluation. These include:

- Lack of surface soil data for the mine operations area. After the removal action, excavated areas were covered with 18 inches of soil from a nearby borrow area. Data are apparently not available to characterize borrow soils. Although not information exists to suggest that this material would have elevated arsenic or metals concentrations, confirmation data are lacking.

- Lack of data on soil constituents other than lead in the mine operations area. Confirmation sampling during the removal action analyzed soil only for lead. Thus, no information exists to characterize residual contamination, if any, for arsenic and other potential mine-related contaminants.

- Lack of current data for sediments and surface water. After the completion of the removal action and some runoff events earlier this year (2005), sediments in the stream have changed appearance from a chalky white associate with chat (mine waste) to a nondescript brown more typical of the area. The removal action at the mine operations area apparently has stopped erosion of mine wastes into Sutton Branch Creek. Prevention of erosion combined with runoff events will change the amount and profile of mine-related contamination in the creek. Available (pre-removal) data are likely to overestimate current and future concentrations of arsenic, lead and other mine-related constituents in sediments and surface water.

3.3 Identification of COPCs

Available data, described above, were used in a screen for COPCs. General methods for selection of COPCs are outlined in USEPA (1989), which recommends considering background concentrations, frequency of detection, and toxicity when selecting COPCs for a site. These factors were considered in screening of COPCs for the Annapolis Lead Site. The screening process is conducted to limit the number of contaminants included in quantitative risk assessment to those that might drive remediation considerations, while also assuring that all significant contaminants are addressed. COPCs include all chemicals reasonably expected to be present at the site that are associated with historical mining operations and that are present in sufficient quantities to present a potential concern for human health effects (USEPA 1989). Specific COPC screening criteria used in the HHRA are discussed below.

Summary statistics for data from all media of concern (i.e., surface soil, subsurface soil, groundwater, surface water, and sediment) for the site as a whole (i.e., a single exposure unit) are presented in Tables 3-1 through 3-5. These tables show minimum and maximum concentrations, the range of reporting limits, and the detection frequency. COPCs are selected on a site-wide basis, consistent with the streamlined approach to the assessment discussed in detail in Section 4.

3.3.1 Essential Nutrients

Essential nutrients were eliminated from consideration as a COPC in accordance with USEPA guidance (USEPA 1989). The guidelines allow the elimination of essential nutrients that are critical to human health, are present at concentrations only slightly elevated compared to naturally occurring concentrations, and are toxic at high doses. The essential nutrients eliminated from consideration at the ALS were calcium, magnesium, potassium, and sodium. No analytical chemistry data is available for these nutrients in groundwater, but due to the low toxicity of these nutrients, they are not expected to pose significant risk to receptors. Incidental ingestion of essential nutrients represents a negligible pathway for exposure compared to drinking water consumption. Iron was retained for consideration due to a maximum concentration of 41.5 mg/L in a drinking water well at the site. Maximum concentrations of essential nutrients in evaluated media, recommended daily allowances (RDA), and tolerable upper intake levels (UIL) are reported in Table 3-6.

3.3.2 Comparison to Background Concentrations

Background concentrations may be used to limit the number of COPCs, or they may be used after risk calculations are complete to assess mine waste-related contributions to total site risks and hazards. However, no local background data are available for the site and no background COPC screening was possible. All constituents that exceed screening levels are carried further in the COPC screening process.

3.3.3 Frequency of Detection

Chemicals that are detected very infrequently at a site generally are unlikely to contribute significantly to overall risk. Many compounds reported in samples collected from groundwater, surface water, and sediment at the site were infrequently detected (less than a 5 percent frequency) and are not expected to contribute significantly to potential overall risk.

Infrequently detected chemicals are further evaluated to ensure that chemicals are not Class A carcinogens (known human carcinogens), are not detected at very high concentrations, and/or are not concentrated in "hotspots." Hotspots are defined as relatively small areas with chemical concentrations that are significantly higher than those in surrounding areas. In most cases, hotspots correlate with source areas. Chemicals classified as known human carcinogens, detected at very high concentrations, or concentrated in a hotspot area could theoretically be significant, even if their site-wide occurrence is low. Chemicals were not eliminated as COPCs based on frequency of detection in this HHRA.

3.3.4 Comparison with USEPA Region 9 PRGs

During the preliminary COPC screening process, PRGs were used as screening criteria for comparison with maximum detected concentrations. PRGs for soil and groundwater are screening chemical concentrations that have been developed by USEPA Region 9 (USEPA 2004e) based on residential and commercial/industrial exposure assumptions and a target cancer risk of 1×10^{-6} (one-in-one million) or target noncarcinogenic hazard quotient (HQ) of 1. For chemicals with carcinogenic as well as noncarcinogenic effects, the lower PRG based on residential exposure was used in the preliminary COPC screening. If the maximum detected concentration exceeds the most conservative screening criteria, the chemical was selected as a COPC.

One further evaluation was completed to ensure that the potential for cumulative effects was adequately addressed in the selection of COPCs. PRGs were divided by 10, consistent with a target cancer risk of 1×10^{-7} and a hazard index (HI) of 0.1 and then compared to maximum chemical concentrations. Several additional chemicals that exceeded USEPA Region 9 PRGs based on either a target cancer risk of 1×10^{-7} or an HI of 0.1, were identified. These additional chemicals generally were infrequently detected and very few locations had concentrations above the adjusted screening criteria. For those chemicals where detection above the screening criteria was more frequent, most exceedances of the adjusted screening criteria were observed at locations where elevated concentrations of lead or arsenic were also reported. The contribution of these chemicals to total site hazards would therefore be expected to be minimal, and have no effect on risk management decisions for the site. For these reasons, chemicals whose maximum concentration exceeded adjusted PRGs were not selected for quantitative evaluation in the main body of the HHRA. A quantitative evaluation of these chemicals is found in Appendix B. COPCs that would be selected using the adjusted screening criteria are discussed in the following sections to provide additional information concerning potential site contaminants and their relative contribution to total risks and hazards at the site.

For surface and subsurface soil data and sediment data, maximum concentrations for each chemical were compared to USEPA Region 9 residential soil screening concentrations. Region 9 risk-based concentrations for soil are screening concentrations based on potential exposure from incidental ingestion of soil, inhalation of particulates, and dermal absorption. For groundwater and surface water, maximum concentrations for each chemical were compared to USEPA Region 9 residential drinking water screening concentrations. Risk-based concentrations for non-volatile contaminants in tap water are screening concentrations based on potential exposure from ingestion of groundwater. If a chemical was not detected in one of the media, the maximum reporting limit was compared to the screening concentration. Chemicals with maximum concentrations or maximum reporting limits greater than the appropriate screening concentration were retained as COPCs.

3.3.5 Selection of COPCs for Soil

3.3.5.1 Selection of COPCs for Surface Soil

Maximum concentrations for each constituent were compared to USEPA Region 9 residential soil screening concentrations. COPCs were selected for surface soil for the site as a whole (i.e., a single exposure unit); as discussed previously a lack of data on soil constituents other than lead in the mine operations area exists. Chemicals with maximum concentrations greater than screening concentrations (HI=1 or target cancer risk=10^{-6}) were selected as COPCs. COPCs consist of the following:

- Arsenic

- Lead
- Manganese

These COPCs are likely to represent most or all mining-related contaminants at the site that could be of concern for human health. Additional chemicals that would be selected as COPCs if an HI of 0.1 was used as a screening criterion include aluminum, antimony, cadmium, iron, thallium, vanadium, and zinc. These metals could be minor contributors to total site risks and hazards, but are unlikely to be "drivers" for risk management decisions. Chemicals selected as COPCs for surface soil at the Annapolis Lead Site are summarized in Table 3-1.

3.3.5.2 Selection of COPCs for Subsurface Soil

Maximum concentrations for each chemical were compared to USEPA Region 9 residential soil screening concentrations. COPCs were selected for subsurface soil for the site as a whole (i.e., a single exposure unit). Chemicals in subsurface soil with maximum concentrations greater than screening criteria and therefore selected as COPCs are:

- Arsenic
- Lead
- Manganese

Additional chemicals that would be COPCs if an HI of 0.1 was used as a screening criterion include antimony, cadmium, chromium, cobalt, copper, iron, thallium, and vanadium. These metals could be minor contributors to total site risks and hazards, but are unlikely to be "drivers" for risk management decisions. Chemicals selected as COPCs for subsurface soil at the Annapolis Lead Site are summarized in Table 3-2.

3.3.6 Selection of COPCs for Groundwater

Maximum detected chemical concentrations in groundwater at the site are compared to USEPA Region 9 residential tap water PRGs. Chemicals selected as COPCs in groundwater are:

- Arsenic
- Iron
- Lead
- Thallium

Chemicals that would also be selected as COPCs if an HI of 0.1 was used as a screening criterion include cadmium and zinc. These metals could be minor contributors to total site risks and hazards, but are unlikely to be "drivers" for risk management decisions. Chemicals selected as COPCs for groundwater are summarized in Table 3-3.

3.3.7 Selection of COPCs for Surface Water

Maximum detected concentrations in surface water are compared with USEPA Region 9 Residential PRGs for tap water. If the maximum detected concentration exceeds the PRG, the compound is selected as a COPC for surface water. The following compounds were selected as COPCs for surface water:

- Arsenic
- Lead
- Manganese
- Thallium

Iron, molybdenum, selenium, and vanadium would also be selected COPCs for surface water if an HI of 0.1 was used as a screening criterion. These metals could be minor contributors to total site risks and hazards, but are unlikely to be "drivers" for risk management decisions. Chemicals selected as COPCs for surface water are summarized in Table 3-4.

3.3.8 Selection of COPCs for Sediment

Maximum detected concentrations in sediment are compared with USEPA Region 9 PRGs for residential soil. If the maximum detected concentration in sediment exceeds the PRG the compound is selected as a COPC for sediment. COPCs selected for sediment include:

- Arsenic
- Lead

Chemicals that would also be selected as COPCs for sediment, if an HI of 0.1 was used as a screening criterion, include cadmium, iron, manganese, and vanadium. These metals could be minor contributors to total site risks and hazards, but are unlikely to be "drivers" for risk management decisions. Chemicals selected as COPC for sediment are summarized in Table 3-5.

3.3.9 Summary of COPCs Selected for the Site

COPCs selected for soil, groundwater, surface water, and sediment are presented in Table 3-7.

Table 3-7 Summary of COPCs by Media

COPCs Selected Based on a Target Risk of $1x10^{-6}$ or an HI=1				
Surface Soil	**Subsurface Soil**	**Groundwater**	**Surface Water**	**Sediment**
Arsenic	Arsenic	Arsenic	Arsenic	Arsenic
Lead	Lead	Iron	Lead	Lead
Manganese	Manganese	Lead	Manganese	
		Thallium	Thallium	

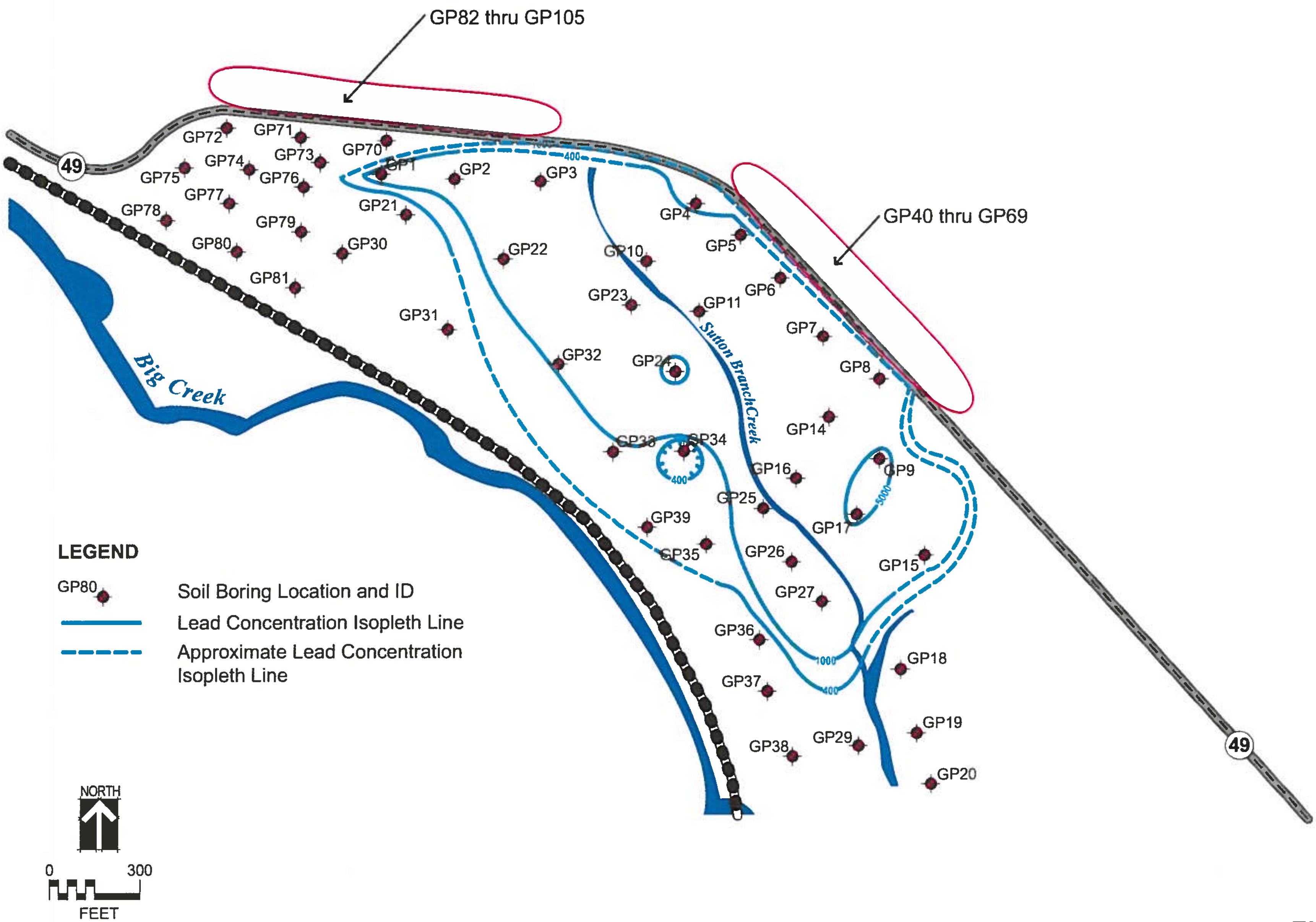


Figure 3-1

Soil Sample Locations (Floodplain Area), Annapolis Lead Mine NPL Site

CDM

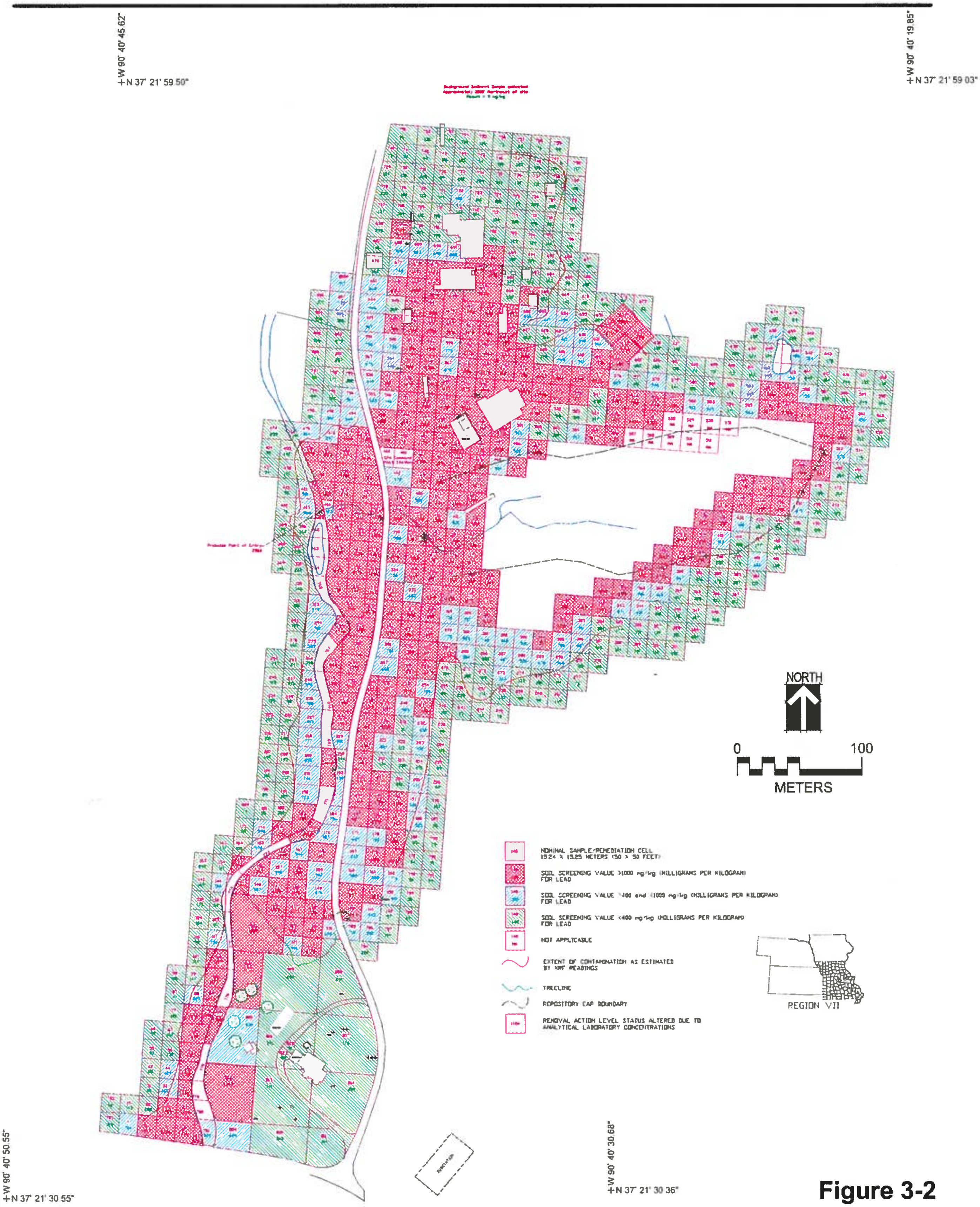
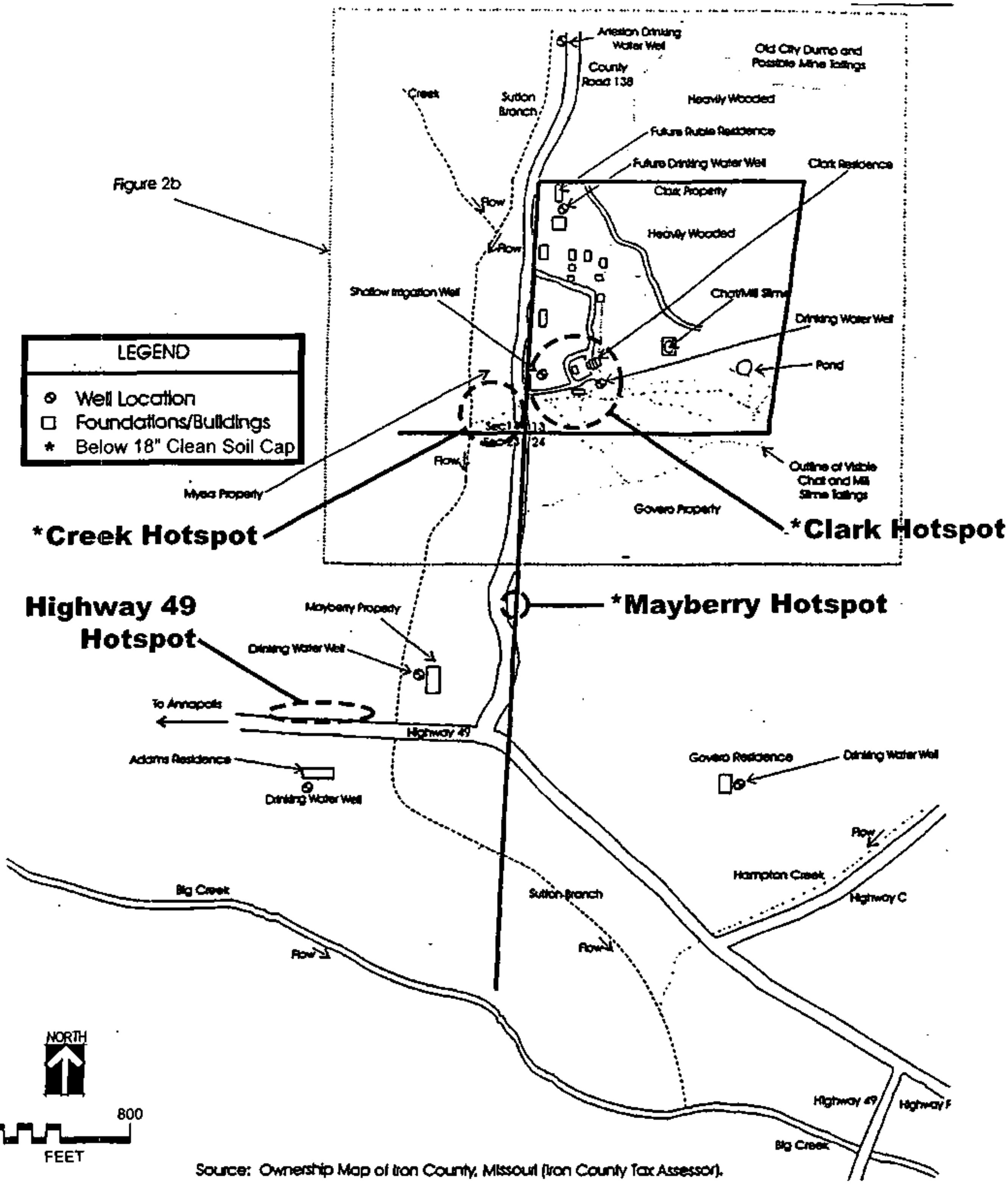


Figure 3-2
Soil Sample Locations Pre-Remediation (Mine Area),
Annapolis Lead Mine NPL Site

CDM



Source: Ownership Map of Iron County, Missouri (Iron County Tax Assessor).

Figure 3-3
Hotspot Locations (Mine Area), Annapolis Lead Mine NPL Site

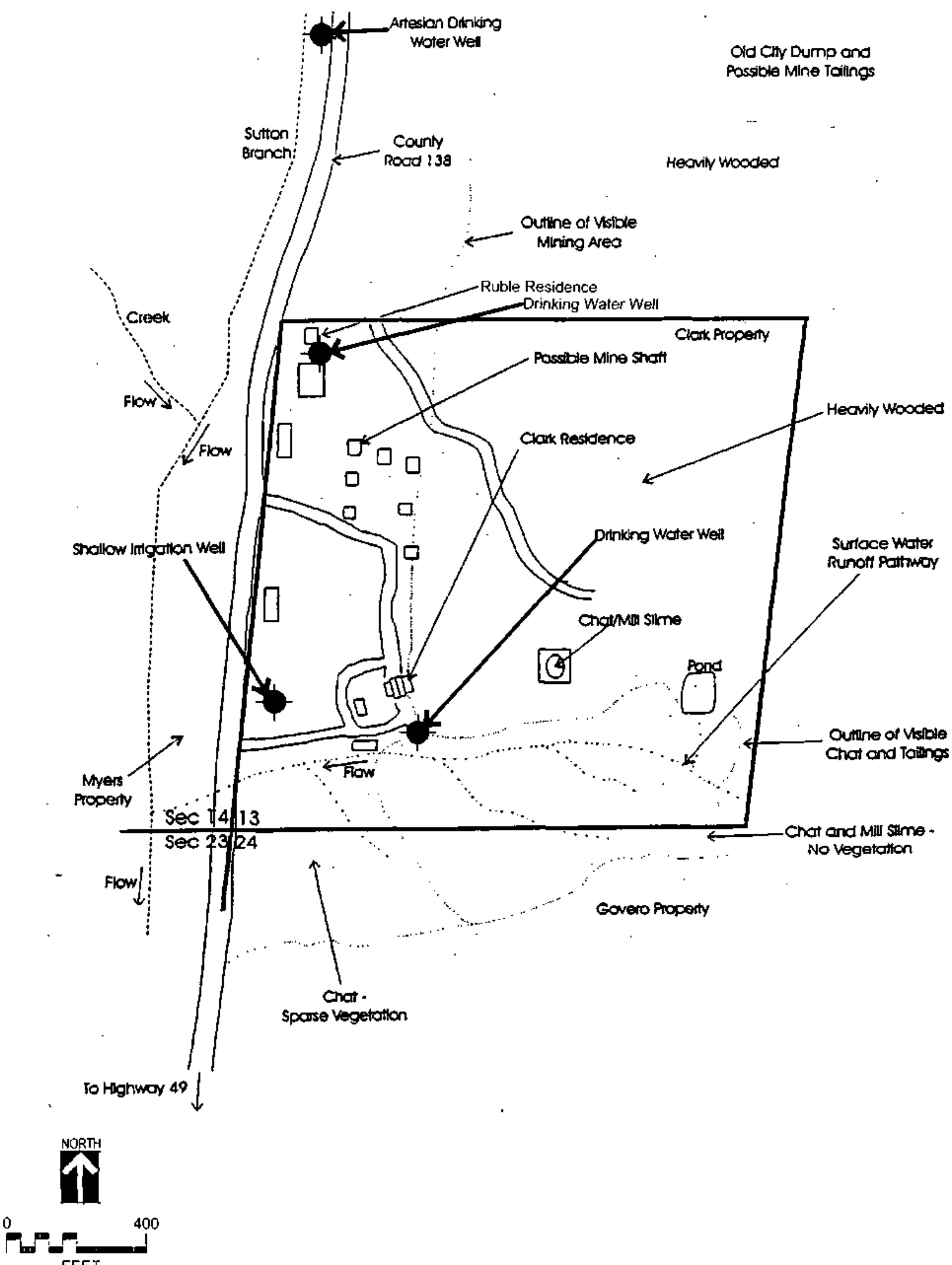


Figure 3-4
Groundwater Sample Locations, Annapolis Lead Mine NPL Site

CDM

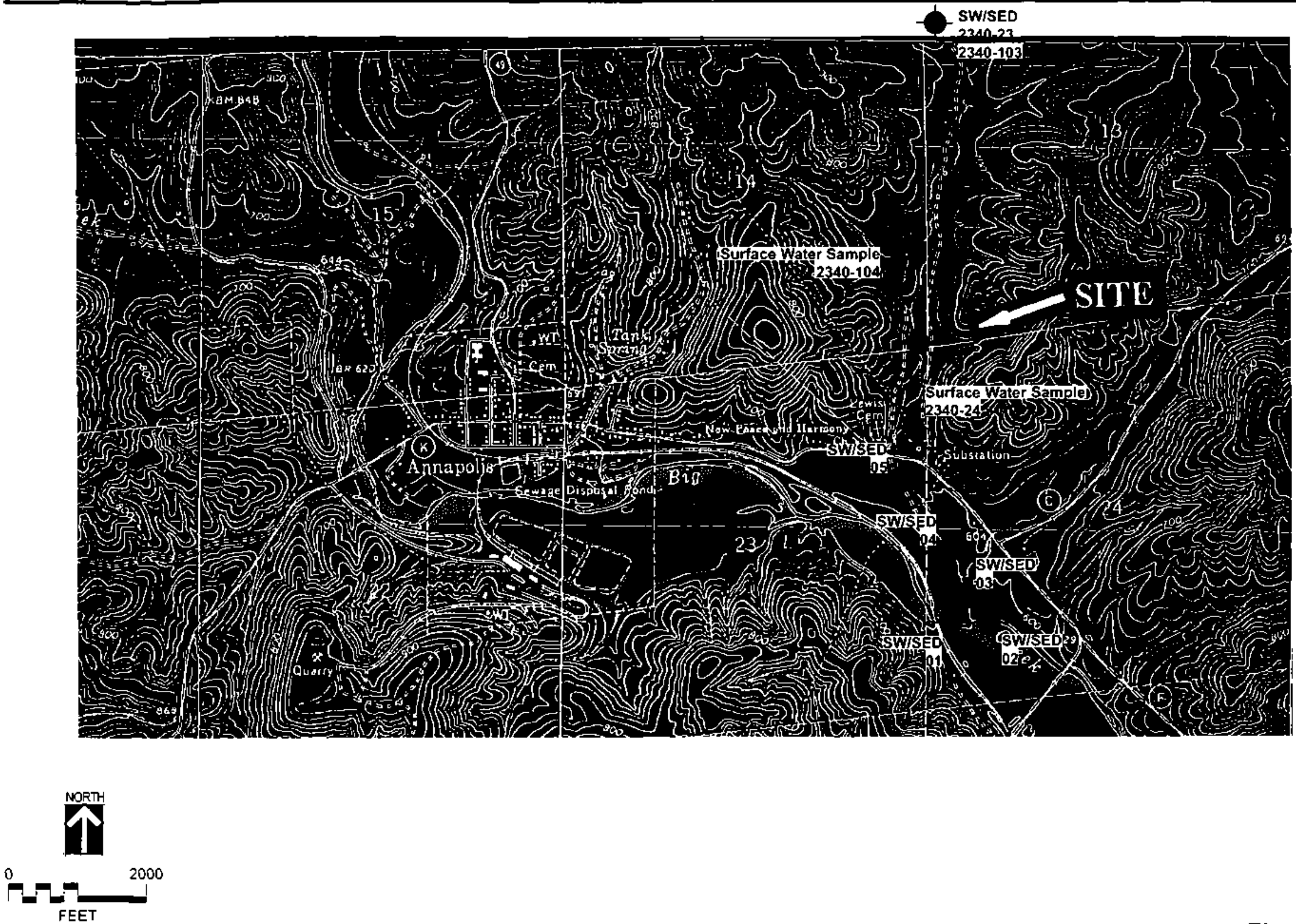


Figure 3-5
Surface Water and Sediment Sample Locations, Annapolis Lead Mine NPL Site

TABLE 3-1

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

ANNAPOLIS LEAD MINE SITE

Scenario Timeframe: Current / Future
Medium: Soil - Surface
Exposure Medium: Soil - Surface
Exposure Point: Soil - Surface
ct Contact Exposure Pathway: Contact, Ingestion, and Inhalation with Surface Soils Onsite

CAS Number	Chemical	Minimum Concentration	Qualifier[1]	Maximum Concentration	Qualifier[1]	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening[2]	Background Value[3]	Screening Toxicity Value[4] (c/nc)		COPC Flag (yes/no)	Rationale for Selection or Deletion[6]	Screening Toxicity Value[4] HI=0.1		COPC Flag (yes/no)
7429-90-5	Al	1140.00		10900.00	J	mg/kg	GP70	31 / 31		10900.00	NA	78000.00	nc	no	< SV	7800.00		yes
7440-36-0	Sb	1.00	U	6.12	UJ	mg/kg	GP65	4 / 31	2.00	6.12	NA	31.00	nc	no	< SV	3.10		yes
7440-38-2	As	4.10	UJ	278.60	J	mg/kg	2293-16	14 / 31	[illegible]	278.60	NA	0.39	ca	yes	> SV	0.04	[illegible]	yes
7440-39-3	Ba	8.71		508.00		mg/kg	GP81	31 / 31		508.00	NA	5400.00	nc	no	< SV	540.00		no
7440-41-7	Be	0.50	U	1.91	J	mg/kg	GP70	20 / 31	1.00	1.91	NA	150.00	nc	no	< SV	15.00		no
7440-43-9	Cd	0.49	UJ	4.49	J	mg/kg	GP67	15 / 31		4.49	NA	37.00	nc	no	< SV	3.70		yes
7440-70-2	Ca	731.00		135000.00		mg/kg	2293-16	31 / 31		135000.00	NA				EN			
18540-29-9	Cr	1.00	U	18.30		mg/kg	GP70	25 / 31	2.00	18.30	NA	210.00	ca*	no	< SV	21.00		no
7440-48-4	Co	7.85	J	81.80		mg/kg	2293-15	31 / 31		81.60	NA	900.00	ca**	no	< SV	90.00		no
7440-50-8	Cu	8.54	J	254.00	J	mg/kg	GP91	31 / 31		254.00	NA	3100.00	nc	no	< SV	310.00		no
7439-89-6	Fe	7870.00		20800.00	J	mg/kg	GP70	31 / 31		20800.00	NA	23000.00	nc	no	< SV	2300.00		yes
7439-92-1	Pb	30.70	J	6370.00	J	mg/kg	GP62	31 / 31		6370.00	NA	400.00	nc	yes	> SV	40.00		yes
7439-95-4	Mg	493.00	U	75000.00		mg/kg	2293-16	27 / 31		75000.00	NA				EN			
7439-96-5	Mn	511.00	J	2760.00	J	mg/kg	GP44	31 / 31	[illegible]	2760.00	NA	1800.00	nc	yes	> SV	180.00		yes
7439-98-7	Mo	1.00	U	1.00	UJ	mg/kg	ND	0 / 14	2.00	1.00	NA	390.00	nc	no	< SV	39.00		no
7440-02-0	Ni	5.71	J	91.50		mg/kg	2293-3	31 / 31		91.50	NA	1600.00	nc	no	< SV	160.00		no
9/7/7440	K	312.00		1180.00	J	mg/kg	GP70	20 / 31		1180.00	NA				EN			
7782-49-2	Se	3.44	UJ	13.20		mg/kg	2293-15	3 / 31		13.20	NA	390.00	nc	no	< SV	39.00		no
7440-22-4	Ag	0.98	UJ	1.02	UJ	mg/kg	ND	0 / 31		1.02	NA	390.00	nc	no	< SV	39.00		no
7440-23-5	Na	25.00	U	980.00	J	mg/kg	GP62	14 / 31	50.00	980.00	NA				EN			
7440-28-0	Tl	2.46	UJ	2.55	UJ	mg/kg	GP65	0 / 31		2.55	NA	5.20	nc	no	< SV	0.52		yes
7440-32-6	Ti	NA		NA		mg/kg	NA	NA / 31		NA	NA	100000.00	max	no		10000.00		no
7440-62-2	V	2.50	U	35.30		mg/kg	GP70	28 / 31	5.00	35.30	NA	78.00	nc	no	< SV	7.80		yes
7440-66-6	Zn	22.10	J	3090.00	J	mg/kg	GP82	31 / 31		3090.00	NA	23000.00	nc	no	< SV	2300.00		yes

Footnotes:

(1) Qualifier Code Definitions:

J = The identification of the analyte is acceptable; the reported value is an estimate.

U = The analyte was not detected at or above the reporting limit.

UJ = The analyte was not detected at or above the reporting limit. The reporting limit is an estimate.

(2) The maximum detected concentration was used for screening

(3) NA = Not Applicable-no background values were used

(4) USEPA Region 9 PRGs--Residential Soil PRG

ca=cancer

nc=noncancer

(5) 10 CSR 20-7.031 "Water Quality Standards"-- viewed on 3/21/05 at http://www.sos.mo.gov/adrules/csr/current/10csr/10c20-7.pdf

(6) Define the codes used for the "Rationale for Selection or Deletion".

ND = not detected and not expected to be present in significant quantities

>SV = Maximum (or minimum) value is greater than risk-based screening level

<SV = Maximum (or minimum) value is less than risk-based screening level

NS = No toxicity screening level in the Reg. 9 PRGs--essential nutrient

EN = Essential Nutrient/Macronutrient

TABLE 3-2

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

ANNAPOLIS LEAD MINE SITE

Scenario Timeframe:	Current / Future
Medium:	Soil - Subsurface
Exposure Medium:	Soil - Subsurface
Exposure Point:	Soil - Subsurface
Direct Contact Exposure Pathway:	Contact, Ingestion, and Inhalation with Surface Soils Onsite

CAS Number	Chemical	Minimum Concentration	Qualifier[1]	Maximum Concentration	Qualifier[1]	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening[2]	Background Value[3]	Screening Toxicity Value[4] (c/nc)		COPC Flag (yes/no)	Rationale for Selection or Deletion[6]	Screening Toxicity Value[4] HI=0.1		COPC Flag (yes/no)
7429-90-5	Al	668.00		7480.00		mg/kg	2293-6	36 / 36		7480.00	NA	76000.00	nc	no	< SV	7600.00		no
7440-36-0	Sb	1.00	U	6.09	UJ	mg/kg	GP75	29 / 36	2.00	6.09	NA	31.00	nc	no	< SV	3.10		yes
7440-38-2	As	8.10	UJ	60.40		mg/kg	2293-26	35 / 36	[illegible]	60.40	NA	0.39	ca	yes	> SV	0.04		yes
7440-39-3	Ba	4.85		147.00		mg/kg	2293-29	36 / 36		147.00	NA	5400.00	nc	no	< SV	540.00		no
7440-41-7	Be	0.50	U	1.46		mg/kg	2293-9	27 / 36	1.00	1.46	NA	150.00	nc	no	< SV	15.00		no
7440-43-9	Cd	0.50	U	5.80		mg/kg	2293-24	21 / 36	1.00	5.60	NA	37.00	nc	no	< SV	3.70		yes
7440-70-2	Ca	463.00		139000.00		mg/kg	2293-31	36 / 36		139000.00	NA				EN			
16540-29-9	Cr	1.00	U	51.30		mg/kg	2293-34	20 / 36	2.00	51.30	NA	210.00	ca*	no	< SV	21.00		yes
7440-48-4	Co	8.88		97.50		mg/kg	2293-37	36 / 36		97.50	NA	900.00	ca**	no	< SV	90.00		yes
7440-50-8	Cu	5.60		112.00		mg/kg	2293-12	36 / 36		112.00	NA	3100.00	nc	no	< SV	310.00		no
7439-89-6	Fe	8330.00		14300.00		mg/kg	2293-28	36 / 36		14300.00	NA	23000.00	nc	no	< SV	2300.00		yes
7439-92-1	Pb	19.70		6450.00		mg/kg	2293-6	36 / 36		6450.00	NA	400.00	[illegible]	yes	> SV	40.00		yes
7439-95-4	Mg	280.00		76800.00		mg/kg	2293-31	36 / 36		76800.00	NA				EN			
7439-96-5	Mn	401.00		1610.00		mg/kg	2293-9	36 / 36		1610.00	NA	1800.00	nc	yes	> SV	180.00		yes
7439-98-7	Mo	1.00	U	12.20		mg/kg	2293-34	2 / 35	2.00	12.20	NA	390.00	nc	no	< SV	39.00		no
7440-02-0	Ni	7.66		83.70		mg/kg	2293-37	36 / 36		83.70	NA	1600.00	nc	no	< SV	160.00		no
9/7/7440	K	174.00		715.00	J	mg/kg	2293-6	36 / 36		715.00	NA				EN			
7782-49-2	Se	3.55	UJ	22.70		mg/kg	2293-7	8 / 36		22.70	NA	390.00	nc	no	< SV	39.00		no
7440-22-4	Ag	1.00	U	1.01	UJ	mg/kg	GP75	0 / 36	2.00	1.01	NA	390.00	nc	no	< SV	39.00		no
7440-23-5	Na	25.00	U	507.00	U	mg/kg	GP75	20 / 36	50.00	507.00	NA				EN			
7440-28-0	Tl	2.54	UJ	2.54	UJ	mg/kg	GP75	0 / 1		2.54	NA	5.20	nc	no	< SV	0.52		yes
7440-32-6	Ti	NA		NA		mg/kg	NA	NA / 36		NA	NA	100000.00	max			10000.00		
7440-62-2	V	2.50	U	24.20		mg/kg	GP75	25 / 36	5.00	24.20	NA	78.00	nc	no	< SV	7.80		yes
7440-66-6	Zn	13.80		456.00		mg/kg	2293-24	36 / 36		456.00	NA	23000.00	nc	no	< SV	2300.00		no

Footnotes:

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ca=cancer

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(5) 10 CSR 20-7.031 "Water Quality Standards"-- viewed on 3/21/05 at http://www.sos.mo.gov/adrules/csr/current/10csr/10c20-7.pdf

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NS = No toxicity screening level in the Reg. 9 PRGs--essential nutrient

EN = Essential Nutrient/Macronutrient

TABLE 3-3

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

ANNAPOLIS LEAD MINE SITE

Scenario Timeframe:	Current / Future
Medium:	Groundwater
Exposure Medium:	Groundwater
Exposure Point:	Groundwater
rect Contact Exposure Pathway	Contact and Ingestion with Groundwater Onsite

CAS Number	Chemical	Minimum Concentration	Qualifier[1]	Maximum Concentration	Qualifier[1]	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening[2]	Background Value[3]	Screening Toxicity Value[4] (c/nc)		COPC Flag (yes /no)	Rationale for Selection or Deletion[6]	Screening Toxicity Value[4] Hi=0.1	COPC Flag (yes /no)
7429-90-5	Al					ug/L				0.00	NA						
7440-36-0	Sb					ug/L				0.00	NA						
7440-38-2	As	[illegible]	[illegible]	2.60	[illegible]	ug/L	CC104-001	[illegible]/5	[illegible]	2.60	NA	0.045	[illegible]	yes	>SV	[illegible]	yes
7440-39-3	Ba					ug/L				0.00	NA						
7440-41-7	Be					ug/L				0.00	NA						
7440-43-9	Cd	1.65	U	6.08		ug/L	CC104-004	1/5		6.08	NA	18.200	nc	no	<SV	1.820	yes
7440-70-2	Ca					ug/L				0.00	NA						
18540-29-9	Cr	7.10	U	7.10	U	ug/L	ND	0/5		7.10	NA	109.000	nc	no	<SV	10.900	no
7440-48-4	Co					ug/L				0.00	NA						
7440-50-8	Cu	4.16	U	13.90		ug/L	CC104-004	1/5		13.90	NA	1460.000	nc	no	<SV	146.000	no
7439-89-6	Fe	2400.00	[illegible]	41800.00	[illegible]	ug/L	CC104-004	[illegible]/5	[illegible]	41800.00	NA	10950.000	nc	yes	>SV	1095.000	yes
7439-92-1	Pb	2.60	[illegible]	40.80	[illegible]	ug/L	CC104-001D	[illegible]/5	[illegible]	40.80	NA	[illegible]	[illegible]	yes	[illegible]	[illegible]	yes
7439-95-4	Mg					ug/L				0.00	NA						
7439-96-5	Mn					ug/L				0.00	NA						
7439-98-7	Mo					ug/L				0.00	NA						
7440-02-0	Ni	5.75	U	43.50		ug/L	CC104-004	1/5		43.50	NA	730.000	nc	no	<SV	73.000	no
9/7/7440	K					ug/L				0.00	NA						
7782-49-2	Se					ug/L				0.00	NA						
7440-22-4	Ag	3.94	U	3.94	U	ug/L	ND	0/5		3.94	NA	182.000	nc	no	<SV	18.200	no
7440-23-5	Na					ug/L				0.00	NA						
7440-28-0	Tl	[illegible]	[illegible]	[illegible]	[illegible]	ug/L	CC104-001D	[illegible]/5	[illegible]	[illegible]	NA	2.400	nc	yes	[illegible]	0.241	yes
7440-32-6	Ti					ug/L				0.00	NA						
7440-62-2	V					ug/L				0.00	NA						
7440-66-6	Zn	6.40		1270.00		ug/L	CC104-001D	5/5		1270.00	NA	10950.000	nc	no	<SV	1095.000	yes

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EN = Essential Nutrient/Macronutrient

TABLE 3-4

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

ANNAPOLIS LEAD MINE SITE

Scenario Timeframe:	Current / Future
Medium:	Surface Water
Exposure Medium:	Surface Water
Exposure Point:	Surface Water
Direct Contact Exposure Pathway:	Contact with Intermittent Stream

CAS Number	Chemical	Minimum Concentration	Qualifier[1]	Maximum Concentration	Qualifier[1]	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening [2]	Background Value[3]	Screening Toxicity Value[4] (c/nc)		COPC Flag (yes /no)	Rationale for Selection or Deletion [6]
7429-90-5	Al	17.00	U	94.30		ug/L	2340-5	4 / 40	34 - 50	94.30	NA	36498.67	nc	no	<SV
7440-36-0	Sb	8.50	U	25.00	U	ug/L	ND	0 / 40	17 - 50	25.00	NA	14.60	nc	no	ND
7440-38-2	As	3.50	UJ	29.00		ug/L	2340-27	18 / 40	7 - 25	29.00	NA	0.04	ca	yes	>SV
7440-39-3	Ba	21.60		269.00		ug/L	2340-2	40 / 40	1.00	269.00	NA	2554.99	nc	no	<SV
7440-41-7	Be	0.50	U	1.50	U	ug/L	ND	0 / 40	1 - 3	1.50	NA	73.00	nc	no	ND
7440-43-9	Cd	0.50	U	1.50	U	ug/L	ND	0 / 40	1 - 3	1.50	NA	18.25	nc	no	ND
7440-70-2	Ca	0.01	U	0.09		ug/L	2340-5	40 / 40	0.001	0.09	NA	na	na	no	NS, EN
18540-29-9	Cr	2.00	U	9.49		ug/L	2340-5	3 / 40	4 - 15	9.49	NA	109.50	nc	no	<SV
7440-48-4	Co	1.50	U	51.00		ug/L	2340-36	4 / 40	3 - 10	51.00	NA	730.00	nc	no	<SV
7440-50-8	Cu	1.00	U	9.12		ug/L	2340-26	1 / 40	1 - 5	9.12	NA	1460.00	nc	no	<SV
7439-89-6	Fe	14.50	U	9180.00		ug/L	2340-2	3 / 40	29 - 50	9180.00	NA	10949.88	nc	no	<SV
7439-92-1	Pb	5.00	UJ	274.00		ug/L	2340-5	8 / 40	10 - 50	274.00	NA	15.00	na	yes	>SV
7439-95-4	Mg	0.01	U	0.05		ug/L	2340-5	40 / 40	0.001	0.05	NA	na	na	no	NT, EN
7439-96-5	Mn	1.00	UJ	6620.00		ug/L	2340-2	28 / 40	2.5 - 5	6620.00	NA	876.00	nc	yes	NS
7439-98-7	Mo	2.50	U	26.80		ug/L	2340-5	20 / 40	5 - 15	26.80	NA	182.50	nc	no	<SV
7440-02-0	Ni	3.00	U	45.80		ug/L	2340-5	17 / 40	6 - 20	45.80	NA	730.00	nc	no	<SV
9/7/7440	K	0.001	U	0.004		ug/L	2340-2	16 / 40	0.001	0.00	NA	na	na	no	NS, EN
7782-49-2	Se	20.00	U	59.30		ug/L	2293-105	1 / 40	40 - 50	59.30	NA	182.50	nc	no	ND
7440-22-4	Ag	3.50	UJ	12.50	U	ug/L	ND	0 / 40	7 - 25	12.50	NA	182.50	nc	no	ND
7440-23-5	Na	0.001	U	0.012		ug/L	2340-11	18 / 40	0.002	0.01	NA	na	na	no	<SV, EN
7440-28-0	Tl	18.50	UJ	101.00		ug/L	2293-103	[illegible]0 / 40	37 - 50	101.00	NA	2.41	nc	yes	>SV
7440-32-6	Ti	2.00	U	10.00	U	ug/L	ND	0 / 40	4 - 20	10.00	NA	145978.69	nc	no	ND
7440-62-2	V	1.50	U	5.00	U	ug/L	ND	0 / 40	3 - 10	5.00	NA	36.50	nc	no	ND
7440-66-6	Zn	2.00	U	75.80		ug/L	2340-5	7 / 40	4 - 25	75.80	NA	10949.88	nc	no	<SV

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<SV = Maximum (or minimum) value is less than risk-based scr

NS = No toxicity screening level in the Reg. 9 PRGs--essential n

EN = Essential Nutrient/Macronutrient

TABLE 3-5

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

ANNAPOLIS LEAD MINE SITE

Scenario Timeframe:	Current / Future
Medium:	Sediment
Exposure Medium:	Sediment
Exposure Point:	Sediment
ct Contact Exposure Pathway:	Contact, Ingestion, and Inhalation with Sediment Onsite

CAS Number	Chemical	Minimum Concentration	Qualifier[1]	Maximum Concentration	Qualifier[1]	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening[2]	Background Value[3]	Screening Toxicity Value[4] (c/nc)		COPC Flag (yes /no)	Rationale for Selection or Deletion[5]	Screening Toxicity Value[4] HI=0.1		COPC Flag (yes /no)
7429-90-5	Al	610.00		1450.00		mg/kg	2293-53	5 / 5		1450.00	NA	76141.95	nc	no	<SV	7614.195	nc	no
7440-36-0	Sb	1.00	U	1.00	U	mg/kg	ND	0 / 5	2.00	1.00	NA	31.29	nc	no	<SV	3.129	nc	no
7440-38-2	As	2.50	UJ	26.60		mg/kg	2340-103	12 / 16	6.00	26.60	NA	0.39	ca	yes	>SV	0.004	ca	yes
7440-39-3	Ba	8.32		29.40		mg/kg	2293-51	5 / 5		29.40	NA	5374.91	nc	no	<SV	537.491	nc	no
7440-41-7	Be	0.50	UJ	0.50	U	mg/kg	ND	0 / 5	1.00	0.50	NA	154.37	nc	no	<SV	15.437	nc	no
7440-43-9	Cd	0.50	U	4.17		mg/kg	2340-102	2 / 16	1.00	4.17	NA	37.03	nc	no	<SV	3.703	nc	yes
7440-70-2	Ca	496.00		73900.00		mg/kg	2293-53	5 / 5		73900.00	NA			no	EN			
18540-29-9	Cr	1.00	U	16.60		mg/kg	2293-50	2 / 5		16.60	NA	210.68	ca	no	<SV	21.068	ca	no
7440-48-4	Co	2.85		40.20		mg/kg	2293-53	5 / 5	2.00	40.20	NA	902.89	ca**	no	<SV	90.289	ca**	no
7440-50-8	Cu	4.82		52.10		mg/kg	2293-54	5 / 5		52.10	NA	3128.55	nc	no	<SV	312.855	nc	no
7439-89-6	Fe	4580.00		8400.00		mg/kg	2293-53	5 / 5		8400.00	NA	23463.18	nc	no	<SV	2346.318	nc	yes
7439-92-1	Pb	7.25	[illegible]	1070.00		mg/kg	2293-53	16 / 16		1070.00	NA	400.00	nc	yes	>SV	40.000	nc	yes
7439-95-4	Mg	290.00		42200.00		mg/kg	2293-53	5 / 5		42200.00	NA			no	EN			
7439-96-5	Mn	124.00		1090.00		mg/kg	2293-53	5 / 5		1090.00	NA	1762.35	nc	no	<SV	176.235	nc	yes
7439-98-7	Mo	1.00	U	1.00	U	mg/kg	ND	0 / 5	2.00	1.00	NA	391.07	nc	no	<SV	39.107	nc	no
7440-02-0	Ni	1.00	UJ	32.20		mg/kg	2340-103	14 / 16	2.00	32.20	NA	1564.28	nc	no	<SV	156.428	nc	no
9/7/7440	K	70.70		409.00		mg/kg	2293-53	5 / 5		409.00	NA			no	EN			
7782-49-2	Se	5.00	U	5.00	U	mg/kg	ND	0 / 5	10.00	5.00	NA	391.07	nc	no	<SV	39.107	nc	no
7440-22-4	Ag	1.00	U	1.00	U	mg/kg	ND	0 / 5	2.00	1.00	NA	391.07	nc	no	<SV	39.107	nc	no
7440-23-5	Na	25.00	U	168.00		mg/kg	2293-53	3 / 5	50.00	168.00	NA			no	EN			
7440-28-0	Tl	DR		DR		mg/kg	ND	0 / 0		DR	NA	5.16	max			0.516	max	
7440-32-6	Ti	NA		NA		mg/kg	NA	0 / 0		NA	NA	100000.00	nc			10000.000	nc	
7440-62-2	V	2.50	U	8.39		mg/kg	2293-50	4 / 5	5.00	8.39	NA	78.21	nc	no	<SV	7.821	nc	yes
7440-66-6	Zn	2.50	UJ	108.00		mg/kg	2340-102	12 / 13	5.00	108.00	NA	23463.18	nc	no	<SV	2346.318	nc	no

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EN = Essential Nutrient/Macronutrient

Table 3-6. Essential nutrients eliminated from consideration as a chemical of potential concern and the recommended daily allowances for human intake.

Nutrient	Maximum Concentration in media at the ALS			Maximum Daily Intake of Nutrients at the ALS Based on Ingestion Rate[a]						Recommended Daily Allowance[a] (mg/day)		Tolerable Upper Allowable Intake Level[b] (mg/day)	
	Surface Soil (mg/kg)	Surface Water (mg/L)	Sediment (mg/kg)	Surface Soil (mg/day)		Surface Water (L/day)		Sediment (mg/day)		Child 1-3 years	Adult 19-30 years	Child 1-3 years	Adult 19-30 years
				Child	Adult	Child	Adult	Child	Adult				
Calcium	135000	0.00009	73900	27.00	13.50	4.6E-06	4.6E-06	14.78	7.39	500	1000	2500	2500
Magnesium	75000	0.00005	42200	15.00	7.50	2.5E-06	2.5E-06	8.44	4.22	80	400	65	350
Potassium	1160	0.000004	409	0.23	0.12	2.0E-07	2.0E-07	0.08	0.041	3000	4700	NA	NA
Sodium	980	0.000012	168	0.20	0.10	6.0E-07	6.0E-07	0.03	0.017	1000	1500	1500	2300

a- Ingestion rate for soils and sediments based on 200 mg/day for a child and 100 mg/day for an adult and 0.05 L/day for surface water (USEPA 1991).

b- Recommended Daily Allowance and Upper Allowable Intake Level based on National Academy of Sciences values.

Section 4
Exposure Assessment

Populations that may be exposed to chemicals at a site and pathways by which these populations may come into contact with site chemicals are identified in the exposure assessment. In identifying potential pathways of exposure, both current and possible future land use of the site and surrounding area is considered in this HHRA. The following sections present the exposure assessment, including methods and assumptions used to quantify potential exposures at the site. The exposure assessment is conducted in accordance with the following documents and others cited in the text:

- *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A). Interim Final.* EPA/5401/1-891002. December 1989.
- *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part D - Standardized Planning, Reporting and Review of Superfund Risk Assessments).* EPA/540-R-97-033. January 1998.
- *Exposure Factors Handbook.* Office of Research and Development. National Center for Environmental Assessment. EPA/600/P-95/002Fa. August 1997.
- *Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual. Supplemental Guidance, Standard Default Exposure Factors.* March 1991.
- *Guidance Manual for the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children.* EPA PB93-963510, OSWER 9285.7-15-1.
- *Recommendations of the Technical Review Group for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil.* EPA-540-R-03-001 January 2003. http://www.epa.gov/superfund/programs/lead/products/adultpb.pdf

Exposure assessment defines, in qualitative or quantitative fashion, the ways that people living, working or recreating in the study area might be exposed to heavy metals, particularly lead, released as a result of historic mining operations.

For the Annapolis Lead Mine, the basic approach to the assessment is twofold. First, for the portion of the site north of Highway 49, the assessment addresses residual risks associated with lead contamination left in place following a recently completed removal action. Second, for floodplain areas, particularly those areas south of Highway 49, the assessment addresses potential risks from existing contamination eroded from the mine site and deposited during flood events.

Currently, the Annapolis Lead Site source area and adjacent Sutton Branch Creek floodplain are mainly undeveloped land. There is one home adjacent to and north of Highway 49 and next to the Sutton Branch Creek. The yard of this home has been sampled, and no concentrations of lead above 400 mg/kg were detected. Further, one occupied residence exists adjacent to the southern floodplain of Sutton Branch Creek. Future development of the site is not restricted by specific zoning regulations, so future residential or commercial development is theoretically possible in areas outside of the floodplain. Future use of most of the target area will most likely be for recreational activities. Commercial or industrial applications seem unlikely and are not quantitatively evaluated. Since hypothetical future residential land use is evaluated and would be more restrictive, evaluation of potential commercial or industrial land use does not seem necessary to achieve the goals of this assessment.

4.1 Exposure Assessment Process

Exposure is defined as human contact with a chemical or physical agent (USEPA 1989). Exposure assessment is the estimation of magnitude, frequency, duration, and pathway(s) of exposure to a chemical. Assessment of exposure consists of three steps:

- Characterization of Exposure Setting
- Identification of Exposure Pathways
- Quantification of Exposure

The first step involves identifying the environmental setting of a site (e.g., climate) and the current and potential future human populations on and near the site. Human populations are described with regard to characteristics that could affect exposure to site-related chemicals, including location relative to the site, activities, and the presence of sensitive subgroups (e.g., pre-school children).

Step two of the exposure assessment identifies pathways by which human populations might be exposed to site-related chemicals. Chemical sources, release and transport mechanisms, and inter-media transfer are evaluated. Exposure pathways are identified based on the location and activities of potentially exposed populations and on the types of potentially contaminated media.

The final step, exposure quantification, has two components: estimation of exposure point concentrations and calculation of chemical intake. Exposure point concentrations are chemical concentrations at the point of human contact. Site-specific chemical data from previous investigations for media of concern are used to estimate exposure point concentrations. Exposure point concentrations and equations for estimating these concentrations are presented in the following sections.

4.2 Exposure Setting

The following section details physical settings and human use factors that may influence risk to human health at the ALS.

4.2.1 Physical Setting

The physical setting details physical characteristics of the environment that may influence exposure and risk to the health of human receptors.

4.2.1.1 Climate

Climatological data are included because climate may influence human activity patterns. For example, the daily temperature may affect both the frequency and duration of participation in outdoor activities, types of clothing worn, and the types of activities. USEPA investigated climate based on climatology data from nearby Arcadia, Missouri, which is 15 miles north of the site (Tetra Tech 2005). The area has moderately cold winters and relatively hot summers with January being the coldest month (average maximum temperature of 43.2 °C) and July being the warmest month (average maximum temperature of 89.1 °C). Precipitation averages 44 inches per year and is distributed throughout the year. The majority of the precipitation is rain, but snow does fall annually but remains for only short periods of time. The prevailing wind is in the southerly direction.

4.2.1.2 Hydrology and Hydrogeology

Sutton Branch Creek is a tributary of Big Creek, which are both in hydrogeologic unit 8020202 of the Upper St. Francis Basin. Sutton Branch Creek is considered a small, losing stream which is joined by Hampton Creek, also a losing stream, just before the confluence at Big Creek. Big Creek is rated a class I to II tributary of the St. Francis River, and it is considered to have navigable waterways from Highway K, upstream of the ALS, to Sam A. Baker State Park and its confluence with the St. Francis near Lodi, Missouri and U.S. Highway 67. The St. Francis River originates in St. Francois County and travels through the Ozarks to its outlet at the Mississippi River in Lee County, Arkansas. Descriptions of paddling trips can be found in several guidebooks of the area, suggesting that recreational use of Big Creek is likely and ongoing. There are no known drinking water draws from Sutton Branch Creek or Big Creek by residents, but there is potential use of surface water by downstream residents for irrigation water for gardens and yards. The MoDNR also draws some surface water from Big Creek for use at the Sam A. Baker State Park (Sverdrup 1995a). Big Creek itself is outside the geographical scope of this risk assessment, and information on this creek is provided here only to illustrate the connections among the site and surrounding resources.

An in-depth characterization of Sutton Branch Creek hydrology and hydrogeology took place during January 2005, and the findings are summarized in the RI report (Tetra Tech 2005). The Sutton Branch Creek floodplain is characterized as a wide, flat depositional environment, covered by dense herbaceous vegetation, where water tends to spread and decrease in velocity. The in-stream portions of Sutton Branch Creek are characterized as having a gravel streambed with connectivity to the floodplain at various locations. Some stream modifications have been noted due to natural aggrading and degrading and construction activities by the county. Loss of bank material by erosion has been estimated to be 62.22 tons per year.

Residents are known to use the local groundwater for drinking and irrigation. The locations of wells and groundwater details are discussed in previous reports (E & E 1997; 1999). A total of 245 households (E & E 1999) are within a 4-mile radius of the ALS. Approximately 14 people rely on wells within 0.25 miles of the ALS, and there are artesian, shallow, and drilled wells within the ALS boundaries. Groundwater depth at a monitoring station in Bixby, Missouri is approximately 235-237 feet bgs (MoDNR 2005), and the average well depth of the area is 228 feet with depths ranging from 80 to 525 feet (E & E 1999). At the site, one irrigation well is completed in surface deposits at 10 feet of depth and two drinking wells are completed in bedrock at depths of approximately 220 and 130 feet. Two artesian wells are located within 0.5 miles of the ALS. One artesian well, located 800 feet from the mine tailings pile, is used by approximately 50 people, despite warnings by the health department that the water is not drinkable. The wells of residents near the ALS are situated in shallow alluvium or bedrock and have variable yield due to the lack of lateral continuity in the sedimentary rocks isolated by igneous rocks. Movement of groundwater is via vertical jointing.

4.2.1.3 Geology

Geology is summarized from the QAPP report (E & E 1997). The ALS is in the St. Francois Mountains Physiographic Province of Missouri on westward sloping topography with drainage into Sutton Branch Creek. The area is underlain by Precambrian highland mass with on lapping Paleozoic carbonates and silicates. Lead deposits of the region are in the Cambrian Bonne Terra formation, which is mostly dolomite but may have pure limestone areas. Ore obtained from this formation, and specifically at the ALS, has a whitish appearance due to the presence of limestone. Stratigraphy of completed groundwater wells are associated with unconsolidated valley alluvium (20 to 25 feet thick) and underlying Cambrian sandstone and dolomite.

4.2.2 Biological Setting

The area surrounding the Annapolis Lead Site and the Sutton Branch Creek floodplain is dominated by pastureland and upland wooded areas. The area around the confluence of the Sutton Branch and Big Creeks is designated as palustrine, deciduous broad-leafed forested, temporarily flooded wetland. Beaver (*Castor canadensis*), white-tailed deer (*Odocoileus hemionus*), coyote (*Canis latrans*), red fox (*Vulpes fulva*), striped skunk (*Mephitis mephitis*), rabbit (*Lepus spp.*), waterfowl, squirrel, various bird species, reptiles, and amphibians were identified at the ALS in 2003 and 2004 (USEPA 2005a). Potential species of concern also present in Big Creek are the southern brook lamprey (*Icthyomyzon gagei*), the Big Creek crayfish (*Oronectes peruncus*), and the silver-jaw minnow (*Notropis buccatus*).

Sutton Branch Creek is small and intermittently dry in reaches adjacent to and downstream of the mine operations area. The waterway does not support any fishery along this course. An exception may be the stream reach just upstream of the confluence with Big Creek. At this point, the Sutton Branch Creek has been joined by the Hampton Branch, which is significantly larger, and flows are perennial. In this reach, fish from Big Creek could move up a short distance into the tributary. These fish would likely best be characterized as part of the Big Creek community. Since the Hampton Branch drains a watershed that is not contaminated with mine wastes, any fish that live in its waters would not be affected by releases from the mine operations area.

4.3 Receptor Populations

Receptor populations were selected based on current and potential future land use, activities of the receptor populations, and a complete exposure pathway to contaminated media.

4.3.1 Location of the Current Population

The ALS is entirely within Iron County, Missouri, which covers 551 square miles of southeastern Missouri and has a density of 19.4 people per square mile (US Census 2000b). Based on the most recent census, Iron County has a population of 10,376 persons, a decrease of 0.3% from the 1990 census (US Census Bureau 2000c). The current population within a 4-mile radius of the area under investigation is approximately 1,300 persons, 180 within a 1-mile radius. Other nearby populations include approximately 100 people working at the ISP, Inc. manufacturing facility (Sverdrup 1995a), the South Iron School District with 489 registered students (MDESE 2005), and an unknown number of recreational users. Annapolis, located west of the site, has 310 residents (US Census 2000a). The downstream village of Vulcan has 157 residents and the village of Des Arc has 187 residents. Approximately 15-miles downstream of the site, along Big Creek and the St. Francis River, is Sam A. Baker State Park.

4.3.2 Current and Future Land Use

The ALS is owned by four different landowners. There is an abandoned single-family residence in a former mine building at the ALS source area. One residence, the Mayberry property, is located north of Highway 49, adjacent to Sutton Branch Creek. There is at least one occupied residential dwelling in the southern segment of the ALS area, just adjacent to and above the Sutton Branch Creek floodplain. No gardens are known to exist within the boundaries of the target area, but future use for gardening and the consumption of homegrown vegetables is theoretically possible.

Part of the floodplain area may be harvested for hay. However, the area is not obviously cultivated, is not associated with a farm residence, and no evidence of grazing was observed on a recent site visit by CDM and USEPA (July 8, 2005). Hay harvested from the area would have to be transported to a livestock feeding area and would very likely be mixed with hay and other feed from other sources. Livestock are probably not raised exclusively on hay from the floodplain. Since lead does not biomagnify in the food chain, the amount of lead that might be taken up and retained by livestock fed intermittently with contaminated hay should not be great. In addition, cattle are expected to be exposed to the greatest concentrations of lead through incidental ingestion of soil while feeding (Neuman and Dollhopf 1992). Since cattle are not feeding directly at the site but are instead fed hay cultivated from the site, lead levels in the tissue of cattle would be expected to be greatly reduced. Any lead contained in hay eaten by grazing ruminants will be partitioned to the liver and kidney rather than muscle (Sedki et al. 2003). Liver and kidney are not likely to be the primary tissues of consumed by receptor populations, as less than 2 percent of total beef consumption (based on all sex, age and demographic subgroups) is attributed to edible organ meats, specifically liver and kidney (USEPA 1997b). Furthermore, people consuming meat from livestock raised locally are likely to obtain only a portion of their meat from animals fed contaminated hay. Resulting secondary exposures to lead in the relatively small area of the floodplain that produces hay are likely to be small.

The ALS was also evaluated for industrial/commercial land uses. The property is currently under private ownerships and zoning in the area is non-restrictive. The location of the site and the lack of significant growth in the area suggests that industrial use is unlikely. There is the potential for additional residences to be constructed, either as an additional outbuilding of one of the adjacent residences or through property subdivision and future residential development. Mine tailings have been removed from the site for use by county road crews, the school for the playground, and for concrete (MoDNR 1993). Exposure via mine tailings after removal and transportation from the site is beyond the scope of this assessment due to the lack of information about concentration of contaminants in the removed material, limited knowledge of receptors exposed, and no information on the current distribution of the material.

Recreational activities may be conducted at the ALS by local residents. Off-road vehicle traffic was noted during a site visit on an unimproved road from Highway 49 to Big Creek. Big Creek, a MoDNR Outstanding Resource Water, is immediately adjacent to the Sutton Branch Creek floodplain and is popular for recreational activities including canoeing, kayaking and fishing. This resource is likely to attract people to the area for recreation. Big Creek is likely to be much more attractive than the Sutton Branch Creek floodplain or the mine operations area for people seeking recreation. However, some people, in particular children and residents in the area, might occasionally make use of the mine operations area and/or the floodplain. Fishing is most likely not possible in the portion of Sutton Branch Creek directly west of the source area, however, some bait collection and wading or other water play is, at least, possible. Sutton Branch Creek is difficult to access in most places because of dense riparian vegetation, and recreational use of this creek is likely to be very limited.

A small amount of fish habitat may exist in the lowest portion of the Sutton Branch Creek, between the confluence with Hampton Branch and the confluence with Big Creek. Fish in this reach, however, are likely to move in and out of Big Creek and/or the uncontaminated Hampton Branch. Anglers that may take fish from this area would best be assessed when examining potential exposures for Big Creek downstream of source areas. Such an evaluation is outside the scope of this risk assessment, and is not further addressed.

Possibly, a limited number of crayfish could also live in the lower reaches of Sutton Branch Creek. Populations of crayfish in the Creek are likely to be small, based on direct observation of the creek during the site visit in July, 2005. Harvesting any significant number of crayfish from the Creek would be difficult, and consumption of contaminated crayfish is not expected to be a significant pathway.

Overall, Sutton Branch Creek provides limited habitat for fish or crayfish. Any significant take of either type of organism from the Creek is highly unlikely. Some animals may make use of habitat near the confluence of Sutton Branch Creek with Big Creek. Assessment of potential exposures from consumption of such organisms is best addressed as part of an analysis of the aquatic environment in Big Creek. Such an evaluation is outside the scope of this assessment.

4.3.3 Sensitive Subpopulations

Subpopulations at the ALS and in the vicinity were identified to characterize groups that could be a greater risk than other people in similar exposure situations. Greater risks for some populations could be attributed to such factors as increased sensitivity, multiple exposure pathways, or a relative increased exposure potential based on the exposure period or contact with contaminated media. Subpopulations of concern depend upon site-specific characteristics and may include infants and young children, pregnant women, the elderly, individuals with respiratory problems, or individuals engaging in a specific activity (e.g. fishing).

Demographics of Iron Country in the 2000 U.S. Census describes the population as 5.9% under the age of 5, 25.0% under the age of 18, and 17.1% over the age of 65 (US Census 2000c). Median age is 39.7 years. The population of Iron County is 51.3% female. Average number of people per household is 2.46 persons, and average number of people per family is 2.94 persons.

Children were identified as a potential sensitive subpopulation because of the presence of children in the nearby school, the potential for children to live or recreate on-site, the demography of the county, and their potential for greater sensitivity or exposure to heavy metals. In fact, the USEPA conducted an emergency response action at the mine operations area of the ALS to remove two children with elevated blood lead levels (USEPA 2004b). Childhood development has been shown to be affected by contamination of heavy metals, especially lead. Children with increased levels of lead in the blood may have damage to the brain, anemia, muscle weakness, stomachache, or other health effects. Lead can also pass from a mother to the fetus and may lead to premature birth, decreased birth weight, and learning deficiencies. Besides greater sensitivity to certain chemicals, children may have a greater exposure than adults. Behaviors which may increase exposure in children include playing in the creek, digging and playing in soil, and frequent hand-to-mouth contact.

Residents or recreational users who consume fish caught in contaminated areas or consume homegrown vegetables, cultivated in contaminated soils or irrigated with contaminated water, may also be sensitive subpopulations due to increased exposure via the diet. Some heavy metals may accumulate to some extent in fish and could, in theory, be a significant source of exposure for anglers that take significant numbers of fish from contaminated areas of creeks and rivers. Frequent consumption of these fish, especially those in close contact with sediment such as catfish, may increase exposure levels to certain contaminants. The consumption of vegetables grown in contaminated media, or irrigated with contaminated surface water, may also increase exposure to some metals, especially if residual soil is present on root vegetables during consumption.

4.3.4 Selection of Receptor Populations

Three different receptor populations were selected based on proximity to sources, sensitivity, and activities or use of land both on-site and in near proximity. The receptors selected are detailed in the following sections.

The receptors selected for the evaluation of risk to human health include:

- Current/Future Residents-Adult and Child (0-6 years) Scenario;
- Current and Future Recreational Users-Older Child (7 through16 years) Scenario; and
- Future Construction Workers.

4.3.4.1 Future Residents

Both child and adult future residents were chosen as receptor populations for the human health risk assessment. Currently, two residences are located on the site, but neither is located in areas where lead concentrations exceed the screening level of 400 mg/kg; future residential use, specifically in the source area, is theoretically possible. Future residential construction in the Sutton Branch Creek floodplain is considered unlikely, however, and residual contamination in floodplain areas are not used in estimates of exposure for current and hypothetical future residents. The resident receptor population has the greatest exposure period of all potential receptors due to their likely presence at the site on a daily basis over an extended period of time. Ingestion of soil and interior dust are considered to be primary pathways of exposure for the current and future resident. However, potential exposure to contaminated groundwater used for domestic purposes is also evaluated.

For the evaluation of residential exposures, data are available only for residual lead concentrations for the mine operations area. This area is the only one where residential development is at all likely. Evaluation of health impacts due to exposure to lead in residential settings is accomplished through the use of the USEPA's Integrated Exposure Uptake Biokinetic (IEUBK) model (USEPA 1994b) for young children. Young children are more susceptible to the toxic effects of lead, and generally receive the highest exposures to lead in soil and dust. Thus, protection of young children will also protect adult residents in the same environment. Thus, hypothetical future residential exposures are evaluated solely through evaluation of lead exposure for young children.

Where exposure to very young children is not expected (e.g. recreational exposure settings or construction workers), the adult lead model is used to estimate potential hazards due to potential lead exposure, as described below.

Other factors could contribute to potential exposure in residential populations. Residents may engage in recreational activities, and therefore, be exposed to additional contaminated media. These individuals may live in areas impacted by mining wastes and may recreate near their homes in contaminated areas, which may lead to exposure through both residential and recreational activities. Residents may also consume fish (e.g., crayfish) and may consume produce from gardens in areas contaminated by mine tailings or watered with surface water or groundwater from contaminated areas. These additional exposure pathways could increase health risks in residents.

Risks based on recreational use of the ALS by residents are evaluated based on use by a "resident" or local recreational user. That is, recreational exposure parameters are chosen to reflect relatively frequent recreational use that may occur for residents with immediate access to contaminated areas.

4.3.4.2 Current and Future Recreational User

Currently and in the future, some recreational use of both the mine operations area and the floodplain area are theoretically possible. Neither of these areas is attractive for recreation, especially given the immediate access to Big Creek. However, residents that live in the areas, particularly children, might visit these areas infrequently. Recreational users of the site are assumed to be local residents (though not residents that might live on the site in the future) that, because of proximity, do visit the site.

Access to the ALS is both possible and probable, at least occasionally, for some recreational users. Health risk to recreational users was investigated due to the accessibility of the site, status of Big Creek as an Outstanding Water Resource, which should attract people to the area, and the potential for exposure through multiple exposure pathways. There are currently no site restrictions in place for use of the source area or the Sutton Branch Creek floodplain, except fencing around much of the removal area in the northern segment. Although the ALS is located on private property, signs of recreational use were evident in limited areas based observations during a recent site visit. There does not appear to be much recreational value of Sutton Branch Creek or the floodplain area. Sutton Branch Creek is choked with vegetation and is dry during portions of the warmer months when use would be most prevalent. The only likely recreational use for Sutton Branch Creek is for children infrequently exploring the area. The floodplain area south of Highway 49 may be used by adjacent residents as an extension of their yard, although no current signs of such activity are obvious. Due to the terrain and distance to nearby residences, very young children are not likely to play in this area or other portions of the site; however, older children may frequent these areas. Older children ranging in age, from 7 to 16 years are quantitatively evaluated as recreational receptors in the HHRA.

For much of the Sutton Branch Creek floodplain, data are available for potentially mine-related constituents other than lead. Thus, potential risks and hazards for recreational visitors to the site are evaluated for exposures to lead, using the Adult Lead Methodology as well as to other chemicals of potential concern that exist in surficial floodplain soils.

4.3.4.3 Future Construction Worker

A large percentage of the ALS is undeveloped and is not currently under restrictions for land use. Thus, the potential for future development must be considered. Current or future property owners could sub-divide their land or build residences on their existing properties. The population of Missouri is projected to grow at a rate of 14.9% over the next 30 years, which is less than the national average of 29.2% (US Census 2000b). Iron County had a decrease in population of 0.3% from 1990 to 2000 (US Census 2000c). The minimal growth of the Missouri population in general and the loss of Iron County residences specifically suggests that large-scale development of the ALS is unlikely for the foreseeable future.

Still, some potential for isolated construction activities exists, especially in the northern segment. County road crews have been active in the past during improvement projects in the Sutton Branch Creek channel and removing mining material for incorporation into concrete mix. If additional development or road construction were to occur at the site, construction workers could be exposed to contaminants at the site. Worker exposures would be less than those for hypothetical future residents because of shorter exposure times, frequencies, and durations, as compared to residents in the area. However, construction workers involved in manual activities may have intensive contact with contaminants in soils, including subsurface soils that contain residual contamination. Construction activities are likely to penetrate the 18-inch clean fill barrier to contamination, especially during excavation activities (e.g. for foundations).

Since construction is anticipated only in the mine operations area outside of the floodplain, data on residual contamination is only available for lead. Thus, construction workers are only evaluated for potential future exposure to lead. This issue is further discussed in Section 7, Uncertainties.

4.4 Site Conceptual Exposure Model (SCEM)

The primary source of contamination at the ALS consists of crushed and concentrated mine waste from the mining of galena ore during historical mining activities. The majority of the waste was deposited in a 10-acre, natural ravine at the southern end of the mining operations area (USEPA 2005a). Over time, the mine pile eroded and the mine tailings traveled with topographic features to the Sutton Branch channel. The creek transported material downstream to its confluence with Big Creek. Contaminated media spread across the floodplain of Sutton Branch, being deposited as water velocities slowed.

Recently, contaminated soil with lead concentrations exceeding 400 mg/kg were excavated from the former mining operations area north of Highway 49 and consolidated into an on-site repository at the site of the former waste pile. The pile was then capped and seeded (USEPA 2004c). Thus, few areas of the site have surface concentrations of lead above 400 mg/kg (mainly within the Sutton Branch Creek floodplain), and current exposure potential for the former mine area is low. Any future exposures would occur only if residual contamination was brought to the surface following future site development. Thus, only future exposures are evaluated for most areas of the former mine site.

Releases from primary (mine waste pile) and secondary sources (soil and air) also resulted in contamination of surface water and sediment, and conceivably may have resulted in contamination of groundwater and biota. Evidence for these releases includes elevated levels of contaminants measured in some media, observed mine wastes on stream banks and in floodplain area, and noticeable erosion of wastes from the source pile.

In contrast, samples collected from nearby domestic wells indicate lead concentrations below levels of concern, suggesting that currently used shallow groundwater has not been affected. Concentrations in biota from Sutton Branch Creek have apparently not been collected and no contamination of biota that can be traced directly to the mine site are available. Fish studies in Big Creek are difficult to interpret since upstream sources (e.g. the Glover smelter) exist and could be significant sources of metals in biota.

These sources and releases, along with the above discussion of possible receptors, form the foundation for the development of a SCEM. This model (Figure 4-1) illustrates potential pathways for exposure of humans to contaminated media. As shown in the SCEM, environmental media potentially impacted by the release and transport of contaminants may include:

- Soil
- Indoor dust (Tracked from outdoor soil)
- Outdoor air (Windblown Particulates)
- Plants/homegrown produce
- Fish
- Surface water
- Sediment
- Groundwater

All of the above potential exposure media are further evaluated to identify those that may be important for risk management of the site. Complete and significant exposure pathways are further discussed in the following sections.

4.5 Exposure Pathways

An exposure pathway generally consists of the following elements:

- A chemical source and mechanism of release
- An environmental transport medium for the released chemical
- A point of potential human exposure with the contaminated medium
- A route of exposure (inhalation, ingestion, dermal absorption) into the receptor

For a given site, not all exposure pathways may be "complete." That is, one or more of the above components may be missing. Further, exposures for some pathways may be too small to be significant for the HHRA. Therefore, an analysis of exposure pathways is included to identify complete and significant exposure pathways that may be important for risk management decisions.

Sources of contamination, mechanisms of contaminant release from sources, and subsequent transport of contaminants through the environment are examined in this section to identify potentially contaminated media at the site. Potential exposure pathways for human receptors are discussed in subsequent sections.

4.5.1 Exposure Pathways of Concern

As discussed above, an exposure pathway generally consists of a chemical source, mechanism for release and transport, a point of exposure to the contaminated medium, and a route of exposure into the receptor. The absence of any one of these elements would result in an incomplete exposure pathway. Furthermore, if one of these steps is very inefficient, exposure potential may be negligible, even though the pathway is theoretically complete. Potential exposure pathways are therefore identified in the SCEM and evaluated to determine whether they are complete and significant. The SCEM (Figure 4-1) identifies complete pathways that may represent significant potential for exposure and are therefore the focus of the HHRA. Current and future residents, constructions workers, or current and future recreational users of the site could be exposed to site-related contaminants, especially arsenic and lead, via several pathways, as illustrated in the SCEM (Figure 4-1).

4.5.1.1 Ingestion

Contaminated media may pose risk to receptors through ingestion of contaminated media, whether such ingestion is incidental or intentional. Ingestion of contaminated material may be in minor quantities, but depending on bioavailability, may lead to relatively great exposure.

Purposeful Ingestion

Ingestion of secondary and tertiary sources of contamination may pose some risk to residents and recreational users. Purposeful ingestion of contaminated media by construction workers is highly unlikely, and so, this pathway is considered incomplete.

Groundwater from 5 wells sampled at the ALS contained concentrations of heavy metals. Two of the wells are used for drinking, and an Artesian well located at the northern end of the site may be used by as many as 50 residents for drinking, despite warnings from the state. The use of groundwater for drinking by residents is evaluated quantitatively. Recreational users and construction workers do not have access to groundwater for drinking purposes, so this pathway is considered incomplete.

The consumption of fish is another potential exposure route for recreational users. Fish (e.g., crayfish) will be exposed to both contaminated surface water and sediment, and fish may accumulate some metals in their tissues. Surface water and sediment of Sutton Branch have had measurable concentrations of heavy metals in the past, although these concentrations are expected to be diminishing since the removal action was completed. Currently, mine wastes (chat) are mostly not visible in the Sutton Branch Creek, a significant change from pre-removal conditions. Furthermore, this creek is too small to support a fishery, and no complete exposure pathway exists for anglers on this creek. As discussed previously, some fish habitat may exist on the creek between confluences with the Hampton Branch and Big Creek. Fish in this reach are likely to move between Sutton Branch Creek and Big Creek and can be most reasonably assessed when addressing potential exposures for anglers that frequent the creek. Such an evaluation is outside the scope of this assessment.

Another purposeful route of exposure for residents may occur from the ingestion of homegrown produce. Vegetables may accumulate contaminants if they are grown in contaminated soil. Plants may accumulate some metals. For instance, plants can take up arsenic from soil and will deposit it in the leaves, so consumption of leafy vegetables may increase exposure to arsenic (ATSDR 1989). Lead is mostly stored in the roots of plants instead of in the shoots or seeds; therefore, consumption of root vegetables may increase exposure to lead (ATSDR 1999).

Uptake and accumulation of metals in vegetables, and subsequent consumption, can lead to increased exposure in residents with gardens. The garden scenario is incomplete based on current site conditions. The only residence with potential use of contaminated areas for a garden is located upland of the floodplain and south of Highway 49. Areas in the mine operations area could be potentially used for a garden if future residential development takes place. However, based on data from other sites, the uptake of arsenic, lead and other metals for soils at mine sites is likely to be insignificant. Thus, this pathway is not included in the quantitative analysis. The pathway is discussed in more detail in Section 7, Uncertainties.

Incidental Ingestion
Incidental ingestion of surface soil is evaluated for all potential receptors at the ALS. If redevelopment were to occur in the northern segment of the site, subsurface contamination may be brought to the surface and current and future residents could be exposed to contaminants while working or playing in their yards. Incidental ingestion of soils may occur via hand to mouth activities. This pathway may be significant, especially for younger children who tend to ingest larger quantities of soil during play. Also, construction workers involved in earthwork (i.e. excavating, grading, landscaping, etc.) in the northern segment of the site may be exposed to contaminants during construction activities and could potentially ingest subsurface contamination via hand-to-mouth activities. Recreational users of the southern segment may also incidentally ingest contaminants while playing in the area.

Incidental ingestion of interior dust is evaluated using the IEUBK model for future residential children assuming a soil-to-indoor dust transfer factor of 0.7, the default in the model.

Incidental ingestion of surface water and sediment during wading or swimming by recreational users of Sutton Branch Creek is a potentially complete exposure pathway. An actual quantitative amount of material ingested may be difficult to quantify but is likely greatest for children who may ingest small amounts of water and/or sediment during wading, bait collection, or other play activities in the waters of Sutton Branch Creek.

4.5.1.2 Dermal Contact

Direct contact with wastes at the mine operations area has been limited by the recent removal action, but tailings waste has migrated to floodplain areas and to sediments in Sutton Branch Creek. Receptors may be exposed through dermal contact with these media currently. In the future, dermal exposure might be possible if residual contamination beneath the 18-inch clean cover in the mine operations area is brought to the surface during excavation.

Dermal exposure pathways are not expected to contribute significantly to overall exposure because most metals are inefficiently absorbed through the skin. However, some measurements exist for absorption of arsenic in soil through the skin and these data can be used to estimate dermal exposure to this COPC. Thus, dermal absorption is quantitatively estimated for arsenic in soils and sediments.

For other soil COPCs, lead, iron, and manganese, no dermal absorption estimates are made. The IEUBK model recognizes the insignificance of this pathway by not including dermal absorption as a route of exposure for lead. In similar fashion, significant absorption of iron and manganese from soil, sediment or indoor dust seems highly unlikely and also is not quantified.

Dermal exposure is theoretically possible for all receptors evaluated in this assessment. However, assessment of dermal exposure to arsenic in soils or dust for hypothetical future residents or construction workers is not possible because of lack of post-removal data for constituents other than lead. Recreational users may come into contact with soil during play or other activities near the bank of the creek and/or elsewhere in the flood plain. These receptors may also come into dermal contact with in-stream sediments. Dermal exposure is evaluated only for current and future recreational visitors to the floodplain.

Dermal contact with contaminated groundwater or surface water is also theoretically possible for the site. However, as indicated above, little groundwater contamination attributable to the site has been detected, and obvious mine waste contamination is no longer present in surface sediments in Sutton Branch Creek. The latter observation suggests that any source of metals to surface water has been reduced significantly since the completion of the removal action. These observations, in turn, suggest that dermal contact with COPCs in groundwater and surface water should be small or negligible. However, in keeping with the evaluation of potential exposure to arsenic via dermal contact, this pathway is evaluated for this single COPC. Only hypothetical future residents are anticipated to use groundwater for domestic purposes. Thus, these are the only receptors evaluated for dermal exposure to arsenic in groundwater.

4.5.1.3 Inhalation

Finally, receptors at the ALS may have an increased exposure to certain contaminants via inhalation of dust and particulates. Any existing surface contamination is mostly covered by vegetation, and wind speeds needed to carry particulates at the site are not likely to be reached. In the future, some materials in the subsurface at the site may be brought to the surface and could represent a source of metals to ambient air. However, such exposures are unlikely to represent significant exposure. For example, a calculation for arsenic suggests that in residential settings, risks associated with inhalation of arsenic may be 2 orders of magnitude less than risks associated with ingestion of contaminated soil. Arsenic is a good test case, because the slope factor for arsenic via inhalation is an order of magnitude higher than that for ingestion. Thus, risks due to inhalation of arsenic should be relatively high compared to those for ingestion. That inhalation risks are still much lower than those for ingestion suggest that the inhalation pathway will be insignificant for all COPCs.

The inhalation pathway is not quantified for any receptors for the ALS.

4.5.2 Receptor-Specific Exposure Assumptions for Evaluation of COPCs Other Than Lead

Exposure assumptions were identified based on characteristics of specific receptor groups reasonably assumed to be affected by mine wastes. Exposure assumptions are presented for estimates of RME. Chemical intake estimates for RME use upper range values for some, but not all, exposure assumptions so that their combination results in a reasonable upper range estimate of exposure for that pathway. Exposure parameters used to evaluate RME are summarized in Tables 4-1 through 4-4. Three receptors exist for the ALS: current/future resident, current/future recreational user, and future construction worker. The assumptions specific to these pathways are further characterized for child and adult receptors, where appropriate. Exposure parameters specific to each receptor are evaluated below.

Often possible risks and hazards for a site are also estimated using parameters consistent with central tendency exposure (CTE). Such estimates were not included in this risks assessment because potential lead exposure was assumed to be the "driver' for site-related health hazards. Thus, the emphasis in this assessment is on estimation of lead exposure using the IEUBK model and Adult Lead Methodology, for which the concepts of RME and CTE do not apply.

Note that the exposure assumptions identified in this section do not apply to the evaluation of lead exposure. Lead is assessed using the IEUBK and Adult Lead Methodology and is separately discussed in Section 4.8, Methods for Evaluating Exposure to Lead.

4.5.2.1 Current/Future Resident

The current and future resident exposure is evaluated for both an adult resident and a young child. Exposure parameters are discussed below. Note again that no soil data are available for constituents other than lead for areas assessed for residential exposure. Thus, lead is the only COPC evaluated for exposure to soil and indoor dust for residents. Soil data used to evaluate lead exposures for residents in the mine area were collected after the removal action, immediately below the 18 inch cap of clean soil. Evaluation of lead exposures is discussed separately in Section 4.7 below. Finally, note also that the only on-site residents live in areas of the site where lead concentrations in soil are less than the screening level of 400 mg/kg. Thus, although a current residential scenario exists, exposure to these residents is expected to be minimal.

Lack of data to characterize post-remediation conditions at the mine operations area for COPCs other than lead is a potentially significant data gap. The impact of this data gap is further discussed in Section 7, Uncertainties.

Exposures to contaminants in groundwater are evaluated for both an adult resident and a young child. Residents are assumed to use groundwater as a drinking water source and for other domestic purposes such as bathing. Exposure parameters are discussed below.

Exposure Frequency
The exposure frequency is the number of days per year an individual participates in a particular activity. An exposure frequency of 350 days/year is used to evaluate residential exposures for children and adults (EPA 1991). This value assumes that a person spends all but 15 days of vacation each year at home.

Exposure Duration
The duration of exposure is the number of years over which exposure may occur. For residential RME exposure durations, exposure durations for ingestion of soil and dust of 24 and 6 years are used for adult and child residents, respectively (EPA 1989). Exposure to noncarcinogens is based on exposure assumptions for adults and children separately (EPA 1991). All other pathways are based on 30 years for adults.

Body Weight
For adult residents, the value selected for body weight is 70 kg. This value is the representative mean body weight for people between the ages of 18 and 75 (EPA 1991). For child residents (ages 0 to 6 years), a value of 15 kg is used for the body weight parameter (EPA 1991).

Averaging Time
Averaging time is the period in days over which intake is averaged. For noncarcinogenic chemicals, intakes are averaged over the exposure duration (exposure duration [years] * 365 days/year). For carcinogens, intake calculations average the total cumulative dose over a lifetime (70 years * 365 days/year).

Consistent with typical EPA practice, a lifespan of 70 years is used in this HHRA. Averaging times differ for carcinogens and noncarcinogens because the effects of carcinogenic chemicals are assumed to have no threshold. Therefore, any exposure to a carcinogen carries a finite risk of cancer during the individual's lifetime. Within reason, this means that a single large exposure to a carcinogen is expected to carry the same risk as the same dose divided into many small exposures. Therefore, carcinogen intakes are expressed in terms of lifetime exposures, regardless of the actual exposure duration (EPA 1989). For noncarcinogenic chemicals, hazards are anticipated to be proportional to average daily exposure, and intakes are therefore averaged over the exposure duration multiplied by 365 days. The averaging time for a child resident is 6 years or 2,190 days.

Ingestion Rate
Ingestion rates used are EPA recommended default values (EPA 1991). Ingestion rate of groundwater used for drinking water is 2 L per day for adults and 1 L per day for children.

Skin Surface Area
For dermal contact with groundwater, the total body surface area for adults and children is assumed to be exposed while bathing. Since surface area is a dependent variable the 50th percentile value is used in order to correlate with average body weights. The exposed skin surface area for the adult resident is 18,000 cm^2, the average of the 50th percentile for males and females greater than 18 years of age (EPA 2004f). The skin surface exposure area for the child is 6,600 cm^2, the average of the 50th percentile for males and females between the ages of 1 year old and 6 years old (EPA 2004f).

Dermal Permeability Coefficient
Dermal permeability coefficients are chemical-specific and were obtained from EPA (EPA 2004f).

Dermal Contact Event Frequency
The dermal contact event frequency is assumed to be one event per day (EPA 2004f) for both adult and child residents.

Dermal Contact Event Duration
The EPA (EPA 2004f) recommended RME event duration for dermal contact during bathing is used. The event duration is assumed to be 0.58 hours per day and 1 hour per day for the adult and child resident, respectively.

4.5.2.2 Current and Future Recreational User

A current and future recreational user is evaluated based on an older child scenario (7 to 16 years). The evaluation of this receptor is considered to be protective of all users because children are the most sensitive receptor for non-carcinogenic effects, and they are the most likely receptor with the most frequent exposure through recreational use of the site. Potential exposures to COPCs in surface water, sediment and surface soil are evaluated for the recreational receptor. Surface soil data collected from the floodplain area are used to evaluate recreational exposures associated with soil. Maximum detected COPC concentrations in surface water and sediment collected from Sutton Branch Creek in the floodplain area are used to evaluate exposures to these media. Evaluation of recreational exposures is uncertain because data on actual recreational use are seldom available. Uncertainties in the quantitative evaluation of this receptor are discussed in some detail in Section 7, Uncertainties.

Exposure Frequency
Exposure frequencies of 2 days per week over the warmest 6 months of the year (52 days total) are used to evaluate exposures in the older child recreational users. This assumption is expected to reflect maximal exposure frequency for a local recreational user living near contaminated land and using the floodplain almost as an extension of their yard. These same assumptions are used for exposure to soils in the floodplain and for exposure to sediments and surface water in the Sutton Branch. Younger children (0 to 6 years) are not evaluated because they are less likely to spend time in floodplain areas because of the need for supervision by adults during recreational activities in these areas.

Exposure Duration
Recreational visitors are assumed to live in the area; therefore, exposure for noncarcinogens and carcinogens is assumed to continue for the entire period from ages 7 through 16 (10 years) based on professional judgment..

Exposure Time
Exposure time for a wading scenario was assumed to be 2 hours/day (USEPA 1997a).

Body Weight
The body weight (BW) was set to 43 kg, which is the average of the mean body weights of boys and girls from age 7 through age 16 (USEPA 1997a).

Averaging Time
A lifetime expectancy of 70 years (USEPA 1989) was used for all receptor groups as the averaging time for exposure to carcinogenic contaminants. For noncarcinogenic chemicals, intakes are averaged over the exposure duration multiplied by 365 days. Therefore, the averaging time is 3,650 days for a child recreational user.

Ingestion Rate
Recreational users will likely have an ingestion rate similar to that of adult residents. The daily incidental ingestion rate for sediment is therefore assumed to be 100 milligrams per day (mg/day), which is 100 percent of the daily soil ingestion rate presented for an older child (USEPA 1997a). In the absence of guidance on this exposure assumption, the above rate was selected as a conservative measure. This value may overestimate sediment ingestion rates; moist sediments might adhere more strongly to skin than drier soil, but creek water would tend to wash the sediments off before the soiled skin reaches the mouth or food. All exposure is assumed to occur at the site during the event; thus, the fraction ingested (FI) was conservatively assumed to be 100 percent.

Recreational users are assumed to ingest 50 ml/hour of surface water during wading (USEPA 1989). This value is actually appropriate for swimming, which is not possible in Sutton Branch Creek. However, no values for activities such as wading appear to exist. This assumption is likely to overestimate possible exposures via surface water ingestion.

Skin Surface Area
A child recreational user is assumed to wear a short-sleeved shirt and shorts (no shoes); therefore, the exposed skin surface area is limited to hands, forearms, lower legs, and feet. The skin surface exposure area for the child is 4,000 cm2, the average of the 50th percentile for males and females between the ages of 7 and 16 years and the percentage of total body surface area by body part (30 percent for hands, feet, forearms and lower legs) for adults (USEPA 1997a). These values assume that relative surface areas for body parts remains constant over the age range of 7 to 16 years.

Soil-to-Skin Adherence Factor
A dermal adherence factor of 0.2 mg/cm^2 was assumed for recreational users for exposure to floodplain soils. An adherence factor of 1 mg/cm^2 was assumed for exposure to sediments in Sutton Branch Creek (USEPA 2004f).

Dermal Absorption Factors
Chemical-specific dermal absorption fraction for arsenic is 0.03 (USEPA 2004f). No other COPCs are quantitatively evaluated for dermal exposure.

Dermal Contact Event Frequency
Dermal contact event frequency is assumed to be one event per day (USEPA 2004f) for recreational users.

4.5.2.3 Construction Worker

Construction workers are only assessed for potential exposure to residual lead in the mine operations area. Thus, no exposure parameters are identified for assessing exposure to other COPCs. Post-remediation soil data was used to evaluate lead exposures for construction workers in the mine area.

4.5.3 Bioavailability of Metals in Soil and Dust

No site-specific bioavailability studies have been conducted for the site. A relative bioavailability of 100 percent is therefore assumed for all COPCs, except lead. This assumption in essence indicates that COPCs are absorbed into the body in similar amounts as the chemical form of the COPC used to define toxicity in human epidemiological or animal laboratory studies.

The oral bioavailability for lead was assumed to be the default in the IEUBK model, 30 percent absolute absorption from the GI tract.

4.6 Exposure Point Concentrations

Exposure point concentrations (EPCs) represent chemical concentrations in environmental media that a person could potentially contact. In a typical baseline risk assessment following USEPA guidance, a conservative estimate of the average concentration that a person might contact is used as the exposure point concentration (e.g., the 95% Upper Confidence Limit (UCL) on the arithmetic mean chemical concentration).

For this assessment, potential exposures for residents, recreationists, and construction workers were performed on the following basis:

- soils beneath the 18" clean soil cover in the mine operations areas of the ALS separately, excluding hotspots (lead only);
- hotspots in soil beneath the 18" soil cover in the mine area of the ALS (see Figure 3-3);
- surface soils in the Sutton Branch Creek floodplain;
- Sutton Branch Creek surface water and sediment in the mine operations and floodplain areas separately; and,
- groundwater in the mine operations area only.

Sample locations are presented on Figures 3-1 through 3-5. Exposure point concentrations are estimates of average concentrations of lead in the mine operations area and lead and other COPCs within the floodplain in the ALS.

The UCL of the arithmetic mean was used as exposure point concentrations for surface and subsurface soil, except as described below. These estimates were then used to assess exposure for residents, recreationists, and construction workers in both the mine operations and floodplain areas of the ALS. The UCL provides a conservative estimate of the mean concentration, such that randomly drawn subsets of site data will have means that are equal to or less than the UCL, some pre-determined percentage of the time. UCLs were calculated according to methods outlined in *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (USEPA 2002). For nondetects, COPCs are assumed to be present at one-half of the laboratory reporting limit, if this value was below the maximum detected value. Computation of an UCL of the population mean depends upon the data distribution. Typically, environmental data are positively skewed, and a default lognormal distribution is often used to model such distributions. EPA's ProUCL (USEPA 2004d) program, Version 3.0, was used to test normality or lognormality of the data distribution and to compute conservative and stable UCLs of population means. ProUCL computes the UCLs of the population means both using parametric (distribution sensitive) and nonparametric (distribution insensitive) procedures. ProUCL calculations and UCLs for surface and subsurface roadway soil are presented in Appendix D.

UCLs were not calculated for surface water, sediment, and groundwater because of the low sample numbers. Instead, the maximum detected concentration of each COPC was used as the EPC for surface water, sediment, and groundwater.

An exception to the use of UCL for exposure point concentrations is lead. Inputs to the IEUBK model are intended to be simple averages. Thus, EPCs for lead were estimated as the simple average of soil data for the mine operations area and the floodplain. Use of the arithmetic mean for the two hotspots identified in the mine operations area that could theoretically support residential development in the future is subject to some uncertainty because of relatively high variability in soil lead concentrations in these areas. This issue is further discussed in Section 7, Uncertainties.

Variability in lead concentrations is also relatively high for the floodplain area south of Highway 49. In this case, however, receptors are expected to access the site randomly; that is, no areas that might be particularly attractive for recreational use are apparent when walking the site. Thus, recreational visitors are anticipated to contact soils throughout the floodplain. The average concentration of lead in this area is 912 mg/kg. This value is not substantially less than UCLs calculated using several bootstrap procedures, which fell in the range of 1,400 to 1,500 mg/kg. Use of these higher values would not affect the conclusions of the risk assessment.

Table 4-5 and Appendix D present the ALS EPCs for surface water, sediment, and groundwater.

Table 4-5: Annapolis Mine Site EPCs

Media	Chemical	Location	EPC Used	EPC
Surface Water[1]	As	Sutton Branch Floodplain Area	Maximum	0.0125 mg/L
	Mn	Sutton Branch Floodplain Area	Maximum	0.0115 mg/L
	Pb	Sutton Branch Floodplain Area	Maximum	0.025 mg/L
	Tl	Sutton Branch Floodplain Area	Maximum	0.101 mg/L
Sediment [1]	As	Sutton Branch Floodplain Area	Maximum	25.60 mg/kg
	Pb	Sutton Branch Floodplain Area	Maximum	1070 mg/kg
Groundwater[2]	As	Mining Area	Maximum	0.00083 mg/L
	Fe	Mining Area	Maximum	41.5 mg/L
	Pb	Mining Area	Maximum	0.0038 mg/L
	Tl	Mining Area	Maximum	0.0023 mg/L
Soil	Pb	Mining Area w/o hotspots	Mean	159.4 mg/kg
	Pb	Mining Area, Clark hotspot	Mean	6959.7 mg/kg
	Pb	Mining Area, Mayberry hotspot	Mean	2639.7 mg/kg
	As	Floodplain Area	95% Approximate Gamma UCL	34.45580 mg/kg
	Mn	Floodplain Area	95% student's-T UCL	1497.025 mg/kg
	Pb	Floodplain Area	Mean	912.4 mg/kg

[1] Maximum detected concentrations of analytes in surface water and sediment from Sutton Branch Creek within the floodplain area are used as EPCs.

[2] The shallow irrigation well, CC104-001 was excluded from the dataset used to estimate groundwater EPCs because this well is screened in an aquifer (10 feet below ground surface) not normally used for drinking water in the area. This shallow irrigation well was included in the dataset used to select COPCs (Table 3-3) and many of the maximum detected values presented in Table 3-3 are from the water sample collected from this well.

4.7 Exposure Calculations for COPCs Other Than Lead

Chronic daily intakes (CDI) are calculated for arsenic, manganese, and thallium using the exposure assumptions described above. CDIs are estimated for each selected exposure pathway. The equations used to calculate CDIs for each exposure pathway are shown below.

4.7.1 Ingestion and Dermal Contact with Soils or Sediments

The following equation is used to estimate CDIs for ingestion and dermal exposure of soil and sediment exposure:

Ingestion of Contaminated Soils

Pathway Intake Equation:

Chronic Daily Intake (CDI) (mg/kg-day) = Cs x CF_s x IRS x EF x ED x 1/BW x 1/AT

Where:

Cs= Chemical Concentration

CF_s = Soil Conversion Factor

IRS = Soil Ingestion Rate

EF = Exposure Frequency

ED = Exposure Duration

BW = Body Weight

AT_c = Averaging Time-Cancer

AT_n = Averaging Time-Non-Cancer

Dermal Contact with Contaminated Soils and Sediments
Pathway Intake Equation:
Dermally Absorbed Dose (DAD) (mg/kg-day) = DA event x EV x ED x EF x SA x 1/BW x 1/AT
Where:
$DA_{event} = C_s \times CF_s \times AF \times ABS_d$
C_s = Chemical Concentration
CF_s = Soil Conversion Factor
SA = Skin Surface Area
ABS_d = Dermal Absorption Fraction
AF - Adherence Fator
ET = Exposure Time
EF = Exposure Frequency
ED = Exposure Duration
EV = Event Duration
BW_c = Body Weight
AT_c = Averaging Time-Cancer
AT_n = Averaging Time-Non-Cancer

4.7.2 Ingestion of and Dermal Contact with Groundwater

The following equation is used to estimate CDIs for ingestion of and dermal contact with groundwater pathway:

Ingestion of Contaminated Groundwater
Pathway Intake Equation:
Chronic Daily Intake (CDI) (mg/kg-day) = $C_w \times EF \times [(IRW_a \times ED_a \times 1/BWa) + (IRW_c \times ED_c \times 1/BW_c)] \times 1/AT$
Where:
C_w = Chemical Concentration
IRW_a = Water Ingestion Rate-Adult
IRW_c = Water Ingestion Rate-Child
EF = Exposure Frequency
ED_a = Exposure Duration-Adult
ED_c = Exposure Duration-Child
BW_a = Body Weight -Adult
BW_c = Body Weight -Child
AT_c = Averaging Time-Cancer
AT_n = Averaging Time-Non-Cancer

Dermal Contact with Contaminated Groundwater
Pathway Intake Equation:
Dermally Absorbed Dose (DAD) (mg/kg-day) = $EF \times CF_w \times EV \times [(DA_a \times SA_a \times ED_a \times 1/BW_a) + (DA_c \times SA_c \times ED_c / BW_c)] \times 1/AT$
Where:
$DA_a = K_p \times C_w \times EVS_a$
$DAc = K_p \times C_w \times EVS_c$
C_w = Chemical Concentration in Water
CF_w = Water Conversion Factor
SA_a = Skin Surface Area-Adult
SA_c = Skin Surface Area-Child
K_p = Permeability Constant
ET_a = Exposure Time-Adult
ET_c = Exposure Time-Child
EF = Exposure Frequency
ED_a = Exposure Duration-Adult
ED_c = Exposure Duration-Child
EVS_a = Event Duration-Adult showering
EVS_c = Event Duration-Child bathing
BW_a = Body Weight-Adult
BW_c = Body Weight-Child
AT_c = Averaging Time-Cancer
AT_n = Averaging Time-Non-Cancer

Specific values used for these daily intake calculations can be found in Appendix E, Table 4.

4.8 Methods for Evaluating Exposure to Lead

Exposures to lead are not evaluated using the same methods as those described above for other site COPCs. Methods used to evaluate such exposures are described in the following sections for young children and for adults.

4.8.1 Use of the IEUBK Model for Young Children

Blood lead level calculations for young children used *Windows* Version 1.0, Build 261 of the IEUBK model. Except as described below, default parameters in this model were used in the analysis.

Concentration of Lead in Drinking Water
Site-specific measurements of lead in groundwater from drinking wells suggest concentrations of 3.8 µg/L or lower, which are not notably different from the default value of 4 µg/L; thus, the default value for this parameter was retained.

Dietary Intake of Lead
Updated dietary lead intake values are available from the Technical Review Workgroup (TRW) and were used in all modeling. An important source of lead

exposure for the IEUBK model is lead consumed with food. Current data from the USDA Total Diet Study (FDA 2001) and the National Health and Nutrition Examination Survey III (NHANES III) (CDC 1997) indicate that dietary lead exposure has decreased since the current default estimates for dietary lead were developed for the IEUBK model. USEPA's TRW for the IEUBK model have provided updated dietary lead intake estimates for use in the model, and have indicated that use of these new dietary estimates may influence risk management decisions at sites where lead is a key contaminant.

Updated dietary intake estimates are provided by USEPA's TRW for lead (http://www.epa.gov/superfund/programs/lead/ ieubkfaq.htm#fda). The recommended updated dietary intake estimates are used in evaluating potential lead exposures in young children. By age group, the updated dietary intake values are:

Age Range (years)	Dietary Lead Intake (μg/d)
0-1	3.16
1-2	2.6
2-3	2.87
3-4	2.74
4-5	2.61
5-6	2.74
6-7	2.99

μg/d = micrograms per day

Alternative estimates for other inputs to the IEUBK model might also be considered in evaluating potential lead exposure. These inputs are not universally accepted and are discussed under uncertainties rather than being included in the quantitative analysis here. Alternative estimates could be considered for soil ingestion rates and soil-to-dust transfer.

Other IEUBK Model Input Parameters

All other input parameters to the IEUBK model were retained as model defaults. These parameters include geometric standard deviation (GSD), 1.6; maternal blood lead concentration, 2.5 microgram per deciliter (μg/dL); concentration of lead in air, 0.1 micrograms per cubic meter (μg/m³); and other sources of lead exposure, 0 μg/d. A complete list of input parameters for the IEUBK model runs is provided along with the output from these runs in Appendix F.

4.8.2 Use of the Adult Lead Methodology

USEPA's adult lead methodology (ALM) (USEPA 1996b) was used to assess intermittent or variable exposures to lead at the site by recreational users (older children) and construction workers. This model actually predicts lead exposure to the fetus of a pregnant women and is therefore not directly applicable to the older child (ages 7 to 16 years) that is evaluated for intermittent lead exposure. However, this model should be conservative for this age group and is the only methodology that can be applied to older children. Use of the model for this age group is likely to overestimate any potential health impacts to lead. This issue is further discussed in later sections.

The model recommended by USEPA (1996b) for use in evaluating lead exposures does not include inputs for either dermal or inhalation exposure to lead in soil. Implicitly, USEPA has determined that these exposure routes are typically insignificant compared to incidental soil ingestion. This conclusion is consistent with the IEUBK model for evaluating lead exposure in young children (USEPA 2002). This model does not consider dermal exposure to lead, and demonstrates that even inhalation exposure represents only a small fraction of total lead exposure in residential situations. Neither dermal nor inhalation exposure are considered in the quantitative estimates of possible impacts of lead exposure on blood lead levels.

For evaluation of adult exposures, the methodology consists of algorithms that concentrate on estimated fetal blood lead concentrations in pregnant women exposed to lead-contaminated soils. Thus, women of child-bearing age are the target receptor group for adult lead exposure. The adult lead model can thus be applied to recreational and adolescent receptors, provided that the appropriate model conditions are met (USEPA 2005e). Empirical data on biokinetic slope factors appear to be similar for young children and adults; however, there is uncertainty in applying a similar estimate for adolescents. Reported low baseline blood concentrations for children between the ages of 12 and 18 years of age (Brody et al., 1994) may be due to a growth spurt in which there is a shift of lead from blood to bone.

Exposure assumptions used in the ALM are discussed below and are summarized in Table 4-6.

Interpretation of Predictions from the Adult Lead Methodology

Interpretation of output from the Adult Lead Methodology is based on fetal blood lead level. EPAs health protection goal, that the probability of blood lead concentrations exceeding 10 µg/dL be 5 percent of less, is used to assess potential lead impacts for a developing fetus.

Background Blood Lead Concentration

The background adult blood lead concentration is the typical blood lead concentration in women of child bearing age in the absence of exposures to the site that is being assessed. Baseline blood lead concentrations (PbB) seem to vary by age, socioeconomic status and race/ethnicity. Lower PbB are often found among non-Hispanic white women, and higher levels among non-Hispanic black women. USEPA (2002) provides a range of values for each of these parameters, and some guidance for choosing values appropriate for a given site. Since site-specific data are unavailable, data from the NHANES III survey were used to determine appropriate values for the site. A PbB of 1.53 was used in this evaluation; this value is representative for all races in the Midwest Region (Table 3a, NHANES III, CDC 1997).

Biokinetic Slope Factor

The biokinetic slope factor relates the increase in adult blood lead concentration to average daily lead uptake (µg/dL blood lead increase per µg/day lead uptake). The default value of 0.4 µg/dL per µg/day provided by USEPA (1996b) is based on steady-state conditions. This value is used for all receptors.

Geometric Standard Deviation
In USEPA's adult lead methodology, the geometric standard deviation (GSD) is the estimated value of GSD among women of child-bearing age that have exposures to similar onsite lead concentrations but that have non-uniform response to site lead and non-uniform offsite lead exposures. GSD estimates seem most sensitive to how heterogeneous the population that may use the site is compared to the US population. USEPA provides a default GSD for four census regions and race/ethnicity (USEPA 2002). A GSD of 2.18 was used in this evaluation; this value is representative for all races in the Midwest Region (Table 3a, NHANES III, CDC 1997).

Averaging Time
An averaging time (AT) of 182 days is used to calculate PbB for construction workers and recreations users. A construction worker is assumed to work at the site only during the warmer six months of the year.

Absorption Fraction
This parameter is the absolute gastrointestinal absorption fraction (AFs) for ingested lead in soil and lead dust derived from soil. The default value of 0.12 (unitless) recommended by the TRW (USEPA 1996b) is used for the PRG calculation. The default value is based on the assumption that the absorption factor for soluble lead is 0.2 ($AF_{soluble}$) and that the relative bioavailability of lead in soil compared to soluble lead ($RBF_{soil/soluble}$) is 0.6:

$$\mathbf{AF_s = AF_{soluble}\ (0.2) * RBF_{soil/soluble}\ (0.6) = 0.12}$$

Soil Ingestion Rate
USEPA (2005e) recommends a default value of 100 mg/day for construction workers engaged in short-term activities that may involve intimate contact with soils (e.g. excavation). USEPA does not recommend CTE values for soil ingestion rates in children older than 6 years. The soil ingestion rate of 50 mg/day is also used for the recreational user.

Exposure Frequency
Exposure frequency (EF) is the number of days per year that an individual may be exposed to site-related contaminants. Construction workers generally participate in only part of the construction or remedial activities, so that a few weeks of exposure are probably all that a single individual might be exposed (e.g. during excavation of a building foundation). Exposures for construction workers are generally short-term and the kinetics of lead exposure require several months before a new equilibrium of blood lead concentration is reached. For this analysis, an EF of 132 days/year is used for construction workers. This site-specific estimate corresponds to 22 days per month (5 days per week) for a 6 month period.

Significant uncertainty exists regarding the number of days a recreational receptor may visit the site. For this analysis, a range of values -- 27, 52 and 132 days (professional judgment) per year -- is used for the recreational user. This range provides an illustration of the sensitivity of the Adult Lead Methodology to exposure frequency. The top of the range, which corresponds to 5 days of exposure per week during the warmest 6 months of the year is likely to be an extreme value, given the lack of access and attractiveness of much of the site for recreational use. Thus, the upper end of the range should provide a ceiling on any lead exposures that might occur.

4.9 Summary

The preceding sections outline an approach to exposure assessment for the Annapolis Lead Site that includes the following:

- Calculation of exposures (and hence risks and hazards) given the baseline conditions within the Sutton Branch floodplain and after completion of soil remediation activities at the source area;
- Quantitative exposure evaluation for residents only in areas outside of the floodplain in the former mine operational area (lead only);
- Use of site-specific information for concentration of lead in tap water;
- Use of standard USEPA default exposure parameters for all non-site specific assumptions, and standard USEPA algorithms for estimation of potential risks and hazards due to exposure to arsenic, manganese, and thallium;
- Use of the USEPA's IEUBK model for estimation of lead exposure for young children and USEPA's Adult Lead Methodology for estimation of lead exposure for construction worker and recreational scenarios; and
- Development of a matrix of plausible lead exposure estimates for recreational visitors to the sites based on a range of exposure frequencies.

Results of the exposure assessment are combined with toxicity criteria identified in Section 5 and are presented in Section 6, Risk Characterization. Important uncertainties in exposure assessment are discussed in Section 7, Uncertainties.

Figure 4-1. Site Conceptual Exposure Model (SCEM) for the Annapolis Lead Mine

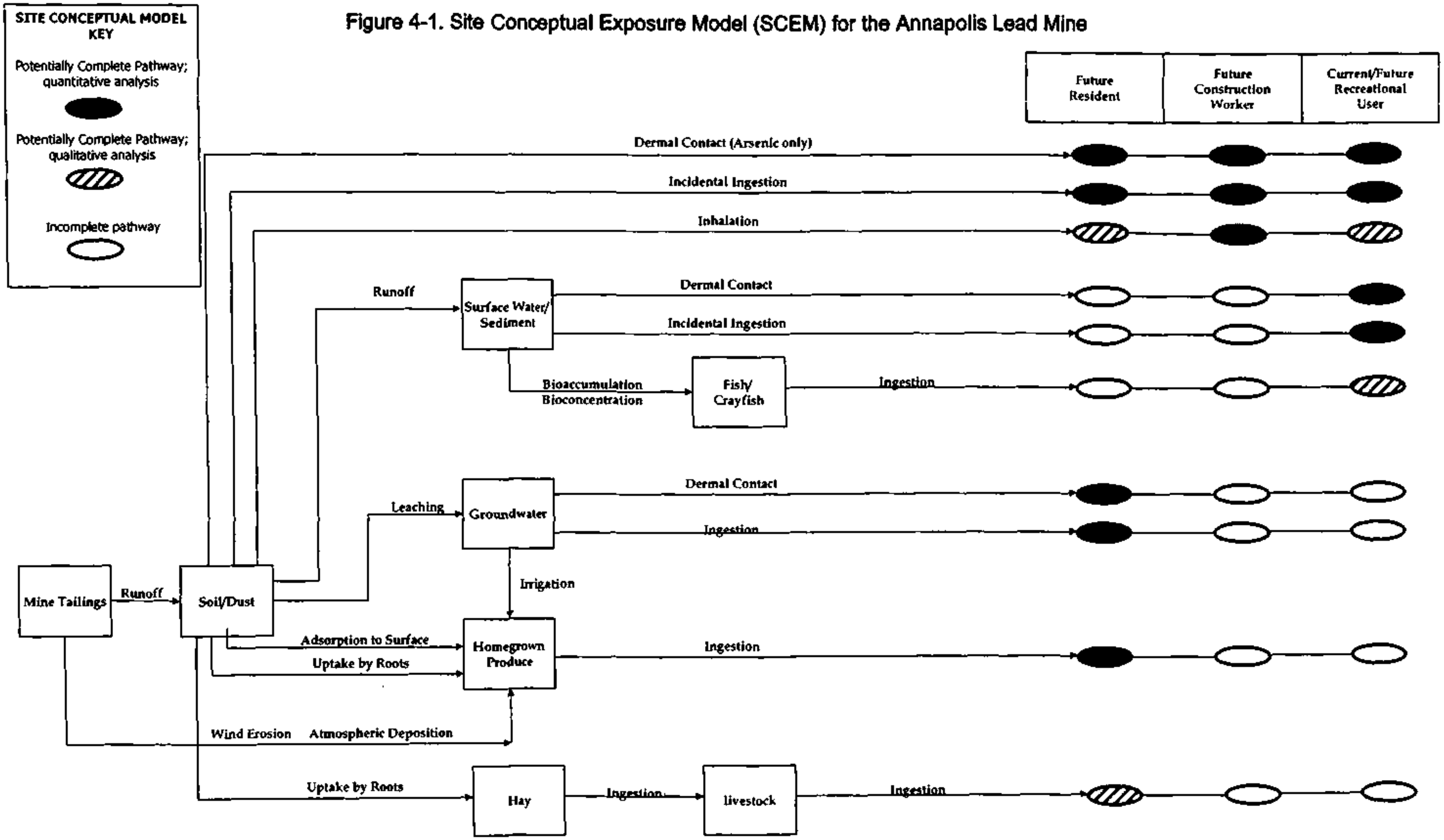

TABLE 4.1.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Scenario Timeframe: Future Exposure
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	RME Value	Units	Rationale/ Reference	Intake Equation Model Name
Dermal	Resident	Adult	Dermal Contact while Showering	DAa	Dermally Absorbed Dose per Event-Adult	chemical-specific	mg/cm^2-event	USEPA 2004	
				CW	Chemical Concentration	chemical-specific	mg/L	Site-specific	Dermally Absorbed Dose (DAD) (mg/kg-day) =
				CF	Water Conversion Factor	0.001	L/cm^3		((DAa x EDa x SAa x 1/BWa) +
				SAa	Skin Surface Area-Adult	18,000	cm^2	USEPA 2004	(DAc x EDc x SAc x 1/BWc)) x EF x EV x 1/AT
				Kp	Permeability Constant	chemical-specific	cm/hour	USEPA 2004	DAa = Kp x CW x CF x t-event$_a$
				EF	Exposure Frequency	350	days/year	USEPA 1991	DAc = Kp x CW x CF x t-event$_c$
				EV	Event Frequency	1	event/day	USEPA 2004	
				EDa	Exposure Duration - Adult	24	years	USEPA 1991	
				t-event$_a$	Event Duration-Adult Showering	0.58	hours/event	USEPA 2004	
				BWa	Body Weight - Adult	70	kg	USEPA 1991	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	10950	days	USEPA 1991	
				DAc	Dermally Absorbed Dose per Event-Child	chemical-specific	mg/cm^2-event	USEPA 2004	
				SAc	Skin Surface Area-Child	6,600	cm^2	USEPA 2004	
				EDc	Exposure Duration - Child	6	years	USEPA 1991	
				t-event$_c$	Event Duration-Child bathing	1 00	hours/event	USEPA 2004	
				BWc	Body Weight - Child	15	kg	USEPA 1991	
		Child	Dermal Contact while Bathing	DA	Dermally Absorbed Dose per Event-Child	chemical-specific	mg/cm^2-event	USEPA 2004	Dermally Absorbed Dose (DAD) (mg/kg-day) =
				Cw	Chemical Concentration	chemical-specific	mg/L	Site-specific	DA x EV x ED x EF x SA x 1/BW x 1/AT
				CF	Water Conversion Factor	0.001	L/cm^3		
				SA	Skin Surface Area-Child	6,600	cm^2	USEPA 2004	DA = Kp x CW x CF x t-event$_c$
				Kp	Permeability Constant	chemical-specific	cm/hour	USEPA 2004	
				EF	Exposure Frequency	350	days/year	USEPA 1991	
				EV	Event Frequency	1	event/day	USEPA 2004	
				ED	Exposure Duration-Child	6	years	USEPA 1991	
				t-event$_c$	Event Duration-Child bathing	1.00	hours/event	USEPA 2004	
				BW	Body Weight-Child	15	kg	USEPA 1991	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	2190	days	USEPA 1991	
Ingestion	Resident	Adult	Drinking Water	CW	Chemical Concentration	chemical-specific	mg/L	Site-specific	
				IR-Wa	Water Ingestion Rate-Adult	2	L/day	USEPA 1991	Chronic Daily Intake (CDI) (mg/gk-day) =
				EF	Exposure Frequency	350	days/year	USEPA 1991	CW x EF x ((IR-Wa x EDa x 1/BWa) +
				EDa	Exposure Duration-Adult	24	years	USEPA 1991	(IR-Wc x EDc x 1/BWc)) x 1/AT
				BWa	Body Weight - Adult	70	kg	USEPA 1991	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	10950	days	USEPA 1991	
				IR-Wc	Water Ingestion Rate-Child	1	L/day	USEPA 1991	
				EDc	Exposure Duration-Child	6	years	USEPA 1991	
				BWc	Body Weight - Child	15	kg	USEPA 1991	
		Child	Drinking Water	CW	Chemical Concentration	chemical-specific	mg/L	Site-specific	
				IR-W	Water Ingestion Rate-Child	1	L/day	USEPA 1991	Chronic Daily Intake (CDI) (mg/gk-day) =
				EF	Exposure Frequency	350	days/year	USEPA 1991	CW x IR-W x EF x ED x 1/BW 1/AT
				ED	Exposure Duration-Child	6	years	USEPA 1991	
				BW	Body Weight - Child	15	kg	USEPA 1991	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	2190	days	USEPA 1991	

USEPA. 1989. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A). Interim Final. EPA/5401/1-89/002. Office of Emergency and Remedial Response. U.S. EPA. Washington, DC.

USEPA. 1991. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual. Supplemental Guidance Standard Default Exposure Factors. OSWER Directive 9285.6-03. Office of Emergency and Remedial Response. U.S. EPA. Washington, D.C.

USEPA. 1997. Exposure Factors Handbook. Volume 1. General Factors. Office of Research and Development. EPA/600/P-95/002Fa. August 1997.

USEPA. 2004d. Risk Assessment Guidance for Superfund, Volume I. Human Health Evaluation Manual. (Part E, Supplemental Guidance for Dermal Risk Assessment). Final. Office of Emergency and Remedial Response. EPA/540/R/99/005. OSWER 9285.7-02EP. PB99-963312.

a- Calculated from USEPA 1997 based on the a total body surface area to individual body part ratio for hands, feet, lower arms, and legs of adults. Proportion of body surface is assumed to be the same for children ages 7-1

TABLE 4.2.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Scenario Timeframe: Current/Future Exposure
Medium: Soils
Exposure Medium: Soils

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	RME Value	Units	Rationale/ Reference	Intake Equation Model Name
Dermal	Resident	Adult	Dermal Contact with Soils/ Indoor Dust	DAa	Dermally Absorbed Dose per Event-Adult	chemical-specific	mg/cm^2-event	USEPA 2004	
				CS	Chemical Concentration	chemical-specific	mg/kg	Site-specific	Dermally Absorbed Dose (DAD) (mg/kg-day) =
				CF	Soil Conversion Factor	0.000001	kg/mg		((DAa x EDa x SAa x 1/BWa) +
				SAa	Skin Surface Area-Adult	5,700	cm^2	USEPA 2004	(DAc x EDc x SAc x 1/BWc)) x EF x EV x 1/AT
				ABSd	Dermal Absorption Factor	chemical-specific	percent	USEPA 2004	DAa = ABSd x CS x CF x AFa
				EF	Exposure Frequency	350	days/year	USEPA 1991	DAc = ABSd x CS x CF x AFc
				AFa	Adherence Factor-Adult	0.07	mg/cm^2	USEPA 2004	
				EDa	Exposure Duration - Adult	24	years	USEPA 1991	
				EV	Event Frequency	1.00	event/day	USEPA 2004	
				BWa	Body Weight - Adult	70	kg	USEPA 1991	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	10950	days	USEPA 1991	
				DAc	Dermally Absorbed Dose per Event-Child	chemical-specific	mg/cm^2-event	USEPA 2004	
				SAc	Skin Surface Area-Child	2,800	cm^2	USEPA 2004	
				AFc	Adherence Factor-Child	0.2	mg/cm^2	USEPA 2004	
				EDc	Exposure Duration - Child	6	years	USEPA 1991	
				BWc	Body Weight - Child	15	kg	USEPA 1991	
		Child	Dermal Contact with Soils/ Indoor Dust	DA	Dermally Absorbed Dose per Event	chemical-specific	mg/cm^2-event	USEPA 2004	Dermally Absorbed Dose (DAD) (mg/kg-day) =
				CS	Chemical Concentration	chemical-specific	mg/kg	Site-specific	DA x EV x ED x EF x SA x 1/BW x 1/AT
				CF	Soil Conversion Factor	0.000001	kg/mg		
				SA	Skin Surface Area	2,800	cm^2	USEPA 2004	DA = ABSd x CS x CF x AF
				ABSd	Dermal Absorption Factor	chemical-specific	percent	USEPA 2004	
				EF	Exposure Frequency	350	days/year	USEPA 1991	
				AF	Adherence Factor	0.2	mg/cm^2	USEPA 2004	
				ED	Exposure Duration	6	years	USEPA 1991	
				EV	Event Frequency	1.00	event/day	USEPA 2004	
				BW	Body Weight	15	kg	USEPA 1991	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	2190	days	USEPA 1991	
	Construction Worker	Adult	Dermal Contact with Soils/ Indoor Dust	DA	Dermally Absorbed Dose per Event	chemical-specific	mg/cm^2-event	USEPA 2004	
				CS	Chemical Concentration	chemical-specific	mg/kg	Site-specific	Dermally Absorbed Dose (DAD) (mg/kg-day) =
				CF	Soil Conversion Factor	0.000001	kg/mg		DA x EV x ED x EF x SA x 1/BW x 1/AT
				SA	Skin Surface Area	3,300	cm^2	USEPA 2004	
				ABSd	Dermal Absorption Factor	chemical-specific	percent	USEPA 2004	DA = ABSd x CS x CF x AF
				EF	Exposure Frequency	132	days/year	Site-specific	
				AF	Adherence Factor	0.3	mg/cm^2	USEPA 2004	
				ED	Exposure Duration	1	years	Site-specific	
				EV	Event Frequency	1.00	event/day	Site-specific	
				BW	Body Weight	70	kg	USEPA 1991	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	365	days	USEPA 1991	

TABLE 4 2.RME (continued)

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Scenario Timeframe: Current/Future Exposure
Medium. Soils
Exposure Medium: Soils

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	RME Value	Units	Rationale/ Reference	Intake Equation Model Name
Dermal (continued)	Recreational User	Child	Dermal Contact with Soils	DA	Dermally Absorbed Dose per Event	chemical-specific	mg/cm^2-event	USEPA 2004	Dermally Absorbed Dose (DAD) (mg/kg-day) =
				CS	Chemical Concentration	chemical-specific	mg/kg	Site-specific	DA x EV x ED x EF x SA x 1/BW x 1/AT
				CF	Soil Conversion Factor	0.000001	kg/mg		
				SA	Skin Surface Area	4,000	cm^2	USEPA 1997[a]	DA = ABSd x CS x CF x AF
				ABSd	Dermal Absorption Factor	chemical-specific	percent	USEPA 2004	
				EF	Exposure Frequency	52	days/year	Site-specific	
				AF	Adherence Factor	0.2	mg/cm^2	USEPA 2004	
				ED	Exposure Duration	10	years	Site-specific	
				EV	Event Frequency	1.00	event/day	USEPA 1991	
				BW	Body Weight	43	kg	USEPA 1997	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	3650	days	USEPA 1991	
Ingestion	Resident	Adult	Hand-to-Mouth Contact with Surface Soil/Indoor Dust	CS	Chemical Concentration	chemical-specific	mg/kg	Site-specific	
				IR-Sa	Ingestion Rate-Adult	100	mg/day	USEPA 1991	Chronic Daily Intake (CDI) (mg/gk-day) =
				EF	Exposure Frequency	350	days/year	USEPA 1991	CS x EF x (IR-Sa x EDa x 1/BWa) +
				EDa	Exposure Duration-Adult	24	years	USEPA 1991	(IR-Sc x EDc x 1/BWc) x 1/AT
				BWa	Body Weight-Adult	70	kg	USEPA 1991	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	10950	days	USEPA 1991	
				IR-Sc	Ingestion Rate-Child	200	mg/day	USEPA 1991	
				EDc	Exposure Duration-Child	6	years	USEPA 1991	
				BWc	Body Weight-Child	15	kg	USEPA 1991	
		Child	Hand-to-Mouth Contact with Surface Soil/Indoor Dust	CS	Chemical Concentration	chemical-specific	mg/kg	Site-specific	
				IR-S	Ingestion Rate	200	mg/day	USEPA 1991	Chronic Daily Intake (CDI) (mg/gk-day) =
				EF	Exposure Frequency	350	days/year	USEPA 1991	CS x IR-S x EF x ED x 1/BW x 1/AT
				ED	Exposure Duration	6	years	USEPA 1991	
				BW	Body Weight	15	kg	USEPA 1991	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	2190	days	USEPA 1991	
	Construction Worker	Adult	Hand-to-Mouth Contact with Surface Soil/Indoor Dust	CS	Chemical Concentration	chemical-specific	mg/kg	Site-specific	
				IR-S	Ingestion Rate	330	mg/day	USEPA 1997	Chronic Daily Intake (CDI) (mg/gk-day) =
				EF	Exposure Frequency	132	days/year	Site-specific	CS x IR-S x EF x ED x 1/BW x 1/AT
				ED	Exposure Duration	1	years	Site-specific	
				BW	Body Weight	70	kg	USEPA 1991	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	365	days	USEPA 1991	
	Recreational User	Child	Hand-to-Mouth Contact with Surface Soil	CS	Chemical Concentration	chemical-specific	mg/kg	Site-specific	
				IR-S	Ingestion Rate	100	mg/day	USEPA 1991	Chronic Daily Intake (CDI) (mg/gk-day) =
				EF	Exposure Frequency	52	days/year	Site-specific	CS x IR-S x EF x ED x 1/BW x 1/AT
				ED	Exposure Duration	10	years	Site-specific	
				BW	Body Weight	43	kg	USEPA 1997	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	3650	days	USEPA 1991	

USEPA. 1989. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A). Interim Final. EPA/5401/1-89/002. Office of Emergency and Remedial Response U.S. EPA, Washington, DC.

USEPA. 1991 Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Supplemental Guidance Standard Default Exposure Factors. OSWER Directive 9285.6-03. Office of Emergency and Remedial Response. U.S. EPA, Washington. D.C

USEPA. 1997. Exposure Factors Handbook. Volume 1. General Factors. Office of Research and Development. EPA/600/P-95/002Fa. August 1997

USEPA. 2004d Risk Assessment Guidance for Superfund, Volume I. Human Health Evaluation Manual. (Part E, Supplemental Guidance for Dermal Risk Assessment). Final Office of Emergency and Remedial Response. EPA/540/R/99/005. OSWER 9285.7-02EP. PB99-963312.

a- Calculated from USEPA 1997 based on the a total body surface area to individual body part ratio for hands, feet, lower arms, and legs of adults. Proportion of body surface is assumed to be the same for children ages 7-16.

TABLE 4.3.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Scenario Timeframe: Current/Future Exposure
Medium: Sediment
Exposure Medium: Sediment

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	RME Value	Units	Rationale/ Reference	Intake Equation Model Name
Dermal	Recreational User	Child	Dermal Contact with Sediment while Wading	DA	Dermally Absorbed Dose per Event	chemical-specific	mg/cm^2-event	USEPA 2004	Dermally Absorbed Dose (DAD) (mg/kg-day) = DA x EV x ED x EF x SA x 1/BW x 1/AT DA = ABSd x CS x CF x AF
				CS	Chemical Concentration	chemical-specific	mg/kg	Site-specific	
				CF	Sediment Conversion Factor	0.000001	kg/mg		
				SA	Skin Surface Area	4,000	cm^2	USEPA 1997[a]	
				ABSd	Dermal Absorption Factor	chemical-specific	percent	USEPA 2004	
				EF	Exposure Frequency	52	days/year	Site-specific	
				AF	Adherence Factor	1	mg/cm^2	USEPA 2004	
				ED	Exposure Duration	10	years	Site-specific	
				EV	Event Frequency	1.00	event/day	USEPA 2004	
				BW	Body Weight	43	kg	USEPA 1997	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	3650	days	USEPA 1991	
Ingestion	Recreational User	Child	Incidental Ingestion of Sediment while Wading	CS	Chemical Concentration	chemical-specific	mg/kg	Site-specific	Chronic Daily Intake (CDI) (mg/gk-day) = CS x IR-S x EF x ED x 1/BW x 1/AT
				IR-S	Ingestion Rate	100	mg/day	USEPA 1991	
				EF	Exposure Frequency	52	days/year	Site-specific	
				ED	Exposure Duration	10	years	Site-specific	
				BW	Body Weight	43	kg	USEPA 1997	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	3650	days	USEPA 1991	

USEPA. 1989. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A). Interim Final. EPA/5401/1-89/002. Office of Emergency and Remedial Response. U.S. EPA. Washington, DC.

USEPA. 1991. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Supplemental Guidance Standard Default Exposure Factors. OSWER Directive 9285.6-03. Office of Emergency and Remedial Response. U.S. EPA. Washington, D.C.

USEPA. 1997. Exposure Factors Handbook. Volume 1. General Factors. Office of Research and Development. EPA/600/P-95/002Fa. August 1997.

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a- Calculated from USEPA 1997 based on the a total body surface area to individual body part ratio for hands, feet, lower arms, and legs of adults. Proportion of body surface is assumed to be the same for children ages 7-16.

TABLE 4.4.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Scenario Timeframe: Future Exposure
Medium: Surface Water
Exposure Medium: Surface Water

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	RME Value	Units	Rationale/ Reference	Intake Equation Model Name
Dermal	Recreational User	Child	Dermal Contact while Wading	DA	Dermally Absorbed Dose per Event-Child	chemical-specific	mg/cm^2-event	USEPA 2004	Dermally Absorbed Dose (DAD) (mg/kg-day) = DA x EV x ED x EF x SA x 1/BW x 1/AT
				Cw	Chemical Concentration	chemical-specific	mg/L	Site-specific	
				CF	Water Conversion Factor	0.001	L/cm^3	USEPA 1991	
				SA	Skin Surface Area-Child	4,000	cm^2	USEPA 1997[a]	DA = Kp x CW x CF x t-event
				Kp	Permeability Constant	chemical-specific	cm/hour	USEPA 2004	
				EF	Exposure Frequency	52	days/year	Site-specific	
				EV	Event Frequency	1	event/day	USPEA 2004	
				ED	Exposure Duration - Child	10	years	Site-specific	
				t-event	Event Duration-Child Wading	2.00	hours/event	Site-specific	
				BW	Body Weight - Child	43	kg	USEPA 1997	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	3650	days	USEPA 1991	
Ingestion	Recreational User	Child	Incidental Ingestion while Wading	CW	Chemical Concentration	chemical-specific	mg/L	Site-specific	
				IR-W	Water Ingestion Rate-Child	0.05	L/day	USEPA 1989	Chronic Daily Intake (CDI) (mg/gk-day) = CW x IR-W x EF x ED x 1/BW 1/AT
				EF	Exposure Frequency	52	days/year	Site-specific	
				ED	Exposure Duration-Child	10	years	Site-specific	
				BW	Body Weight - Child	43	kg	USEPA 1997	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	3650	days	USEPA 1991	

USEPA. 1989. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A). Interim Final. EPA/5401/1-89/002. Office of Emergency and Remedial Response. U.S. EPA. Washington, DC.

USEPA. 1991. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Supplemental Guidance Standard Default Exposure Factors. OSWER Directive 9285.6-03. Office of Emergency and Remedial Response. U.S. EPA. Washington, D.C.

USEPA. 1997. Exposure Factors Handbook. Volume 1. General Factors. Office of Research and Development. EPA/600/P-95/002Fa. August 1997.

USEPA. 2004d. Risk Assessment Guidance for Superfund, Volume I. Human Health Evaluation Manual. (Part E, Supplemental Guidance for Dermal Risk Assessment). Final. Office of Emergency and Remedial Response. EPA/540/R/99/005. OSWER 9285.7-02EP. PB99-963312.

a- Calculated from USEPA 1997 based on the a total body surface area to individual body part ratio for hands, feet, lower arms, and legs of adults. Proportion of body surface is assumed to be the same for children ages 7-16.

Table 4-6 Exposure Parameters Used in the Adult Lead Model

Exposure Parameter	Definition	Parameter Value	Reason for Variable Selection	Reference
PbB- Fetal	Target fetal blood lead – no more than 5% should exceed	10 µg/dL	Recommended by USEPA	USEPA 1996b
IR	Soil ingestion rate			
	Construction Worker	100 mg/day	Recommended by USEPA	USEPA 2005e
	Recreational User, Adolescent	50 mg/day	Recommended by USEPA	USEPA 1997a
R fetal/maternal	Ratio of fetal to maternal blood lead	0.9	Recommended by USEPA	USEPA 1996b
PbB adult, 0	Background adult blood lead concentration			
	Adult Receptors	1.7 –2.2 µg/dL	USEPA Range	USEPA 1996b
	Adult (Construction Worker)	1.53 µg/dL	NHANES III Survey data	USEPA 2002
	Recreational User, Adolescent	1.53 µg/dL	NHANES III Survey data	USEPA 2002
BKSF	Biokinetic slope factor	0.4 µg/dL/µg/day	Recommended by USEPA	USEPA 1996b
GSD	Geometric standard deviation	1.8-2.1	USEPA recommended range	USEPA 1996b
	GSD Used in Assessment	2.18	NHANES III Survey data	USEPA 2002
EF	Exposure Frequency			
	Construction Worker	132 days/year	Site-specific	Professional Judgment
	Recreational User	27, 52 and 132 days/year	Site-specific	Professional Judgment
AT	Averaging time			
	Construction Worker	182 days/year	Recommended by USEPA	USEPA 1996b
	Recreational User	182 days/year	Site-specific	Professional Judgment
AF	Absorption Fraction	0.12	Recommended by USEPA	USEPA 1996b

µg/dL = micrograms per deciliter
mg/day = milligrams per day
µg/day = micrograms per day

Section 5
Toxicity Assessment

The purpose of a toxicity assessment is to review and summarize available information on the potential for each COPC to cause adverse effects in exposed individuals. Adverse effects include both carcinogenic and noncarcinogenic health effects in humans as well as animals. COPCs for the ALS include arsenic, iron, lead, manganese, and thallium.

For most adverse effects caused by chemicals, a positive relationship exists between dose (intake of a chemical through a particular exposure pathway, such as ingestion) and response. Generally, as dose increases, type and severity of adverse response also increases. Furthermore, time of onset of toxic responses often shortens.

A key facet of any toxicity assessment is the use of dose-response information to describe a quantitative relationship between human exposure and potential for adverse health effects. Quantitative toxicity criteria are generally numerical expressions developed by USEPA of the relationship between chronic average daily dose (exposure) and toxic response (adverse health effects). As described below, separate toxicity criteria are developed for assessment of carcinogenic and noncarcinogenic health effects.

The USEPA has developed a hierarchy for reviewing human health toxicity values. This hierarchy has three tiers: (1) USEPA's Integrated Risk Information System (IRIS); (2) USEPA's Provisional Peer Reviewed Toxicity Values; and (3)other toxicity criteria (e.g. toxicity criteria developed by California EPA). For this document, toxicity values were obtained following USEPA's hierarchy, beginning with IRIS. Since dermal toxicity criteria are not available, oral toxicity criteria were used to evaluate risks and hazards from dermal exposure. Differences in absorption between oral and dermal exposure were corrected using absorption estimates obtained from USEPA RAGS Part E guidance (2004f). No toxicity criteria have been developed for lead. Instead, risks associated with lead exposure are evaluated for residential receptors using USEPA's IEUBK model (version 1.0, Build 261) and USEPA's adult lead methodology (ALM) (USEPA 1996b). Section 5.3 discusses lead modeling.

The following sections briefly outline how toxicity criteria for carcinogens and noncarcinogens are developed and expressed, and summarize toxicity values for COPCs. The general basis for the development of toxicity values for carcinogens and noncarcinogens is presented in Section 5.1 and 5.2, respectively. Sections 5.1 and 5.2 also present toxicity criteria for COPCs. Toxicity profiles for arsenic, iron, lead, manganese, and thallium are included in Appendix C.

5.1 Chemical Carcinogens

5.1.1 Evidence of Carcinogenicity

USEPA has developed a classification system for carcinogens to characterize overall weight of evidence of carcinogenicity based on the availability of human, animal, and other supportive data. Three major factors are considered:

- The quality of evidence from human studies;
- The quality of evidence from animal studies; and,
- Other supportive data that are assessed to determine whether the overall weight of evidence should be modified.

The USEPA classification system for the characterization of the overall weight of carcinogenicity has the following five categories:

- **Carcinogenic to Humans (formerly Group A – Human Carcinogen).** This category indicates that there is sufficient evidence from epidemiological studies to support a causal association between an agent and cancer. This descriptor may also be used if there is a lesser weight of epidemiological evidence strengthened by other evidence.
- **Likely to be Carcinogenic to Humans (formerly Group B – Probable Human Carcinogen).** This category generally indicates that there is at least limited evidence from epidemiological studies of potential carcinogenicity to humans. However, the weight of evidence does not reach that required for "Carcinogenic to Humans".
- **Suggestive Evidence of Carcinogenic Potential (formerly Group C – Possible Human Carcinogen).** This category indicates that the potential for carcinogenicity to humans has been raised, but the weight of evidence is not strong enough for a more definitive conclusion.
- **Inadequate Information to Assess Carcinogenic Potential (formerly Group D - Not Classified).** This category indicates that the weight of evidence for carcinogenicity is not adequate to use one of the other descriptors described above.
- **Not Likely to be Carcinogenic to Humans (formerly Group E – Evidence of Noncarcinogenicity to Humans).** This category indicates that the weight of evidence is strong enough to declare a chemical not likely to be carcinogenic to humans.

5.1.2 Cancer Slope Factors

The USEPA IRIS Work Group has used a variety of specialized models to estimate the upper bound risk of carcinogens for numerous compounds. Data from animal or epidemiological studies are used to determine slope factors, which are expressed as

$(mg/kg\text{-}day)^{-1}$. The cancer slope factor (CSF) describes the increase in an individual's risk of developing cancer over a 70-year lifetime per unit of exposure where the unit of exposure is expressed as milligrams per kilogram per day (mg/kg-day).

CSFs are calculated using methods intended to be protective of human health, and are based on the assumption that cancer risks decrease linearly with decreasing dose. The 95 percent upper confidence limit estimate for the slope is used in most cases to compensate for animal to human extrapolation and other uncertainties. The resulting CSFs are considered to be upper bound estimates, which are unlikely to underestimate carcinogenic potential in humans.

When the upper-range CSF is multiplied by the lifetime average daily dose of a potential carcinogen, the product is an estimate of the upper-bound lifetime individual cancer risk associated with exposure at that dose. The calculated risk is an estimate of the increased likelihood of cancer resulting from exposure to a chemical. For example, if the product of the CSF and the average daily dose is 1×10^{-6}, the predicted upper-bound cancer risk for the exposed population is one million, or 0.0001 percent. This risk is in addition to any "background" risk of cancer not related to the chemical exposure.

Calculation of carcinogenic risk relies on data derived from human epidemiological studies or chronic animal bioassays. The likelihood that a chemical is a human carcinogen is a function of the following factors:

- The number of tissues affected by the chemical;
- The number of animal species, strains, sexes, and number of experiments and doses showing a carcinogenic response;
- The occurrence of clear-cut dose-response relationships as well as a high level of statistical significance of the increased tumor incidence in treated, compared to control groups;
- A dose-related decrease in time-to-tumor occurrence or time-to-death with tumor; and
- A dose-related increase in the proportion of tumors that are malignant.

The USEPA prefers that data of sufficient quality from epidemiologic studies are used for estimating risks. However, animal studies can be drawn upon and are typically conducted using relatively high doses in order to observe adverse effects. Because humans are expected to be exposed at lower doses, data are adjusted by using a mathematical model. Data from animal studies are fitted to an appropriate model to extrapolate the dose-response to lower doses. The low-dose slope of the dose-response curve is subjected to various adjustments (e.g., calculation of 95 percent upper confidence limit), and inter-species scaling factors may be applied to derive slope factors for humans. Dose-response data derived from human epidemiological studies are fitted to dose-time-response curves on an individual basis. These models provide conservative but plausible estimates of upper limits on lifetime risk. Although the actual risk is unlikely to be higher than the estimated risk, it could be considerably lower, and may even be zero.

Table 5-1 presents oral CSFs for the ALS COPCs.

5.2 Systemic Toxicants

Oral reference doses (RfDs) and reference concentrations for inhalation (RfCs) are toxicity values developed by USEPA for chemicals exhibiting noncarcinogenic effects. RfDs and RfCs are usually derived from no-observable-adverse-effect levels (NOAELs) taken either from human studies, often involving workplace exposures, or from animal studies and are adjusted downward using uncertainty or modifying factors. Uncertainty factors are generally applied to adjust for the possibility that humans are more sensitive than experimental animals and that there may be sensitive subpopulations (e.g., children, pregnant women, individuals with hay fever or asthma). In addition, modifying factors are applied to address uncertainties related to the database. For example, a modifying factor of 2 to 10 may be applied in instances where the database on a particular chemical lacks information on possible reproductive or developmental toxicity.

RfDs and RfCs are intended as estimates of the daily exposure to a COPC that would not cause adverse effects even if exposure occurred continuously over a lifetime. These values are presented in units of mg/kg-day for comparison with estimated chronic daily intake into the body. Intakes that are less than the RfD or RfC are not likely to cause adverse health effects. Chronic daily intakes that are greater than the RfD or RfC indicate a possibility for adverse effects. The quantitative relationship between the estimated chronic daily intake (dose) and the RfD (or RfCs) is termed the hazard index (HI).

Oral RfDs and RfCs for the ALS COPCs are presented in Tables 5-2 and 5-3.

5.3 Lead Modeling

USEPA has not published conventional quantitative toxicity criteria for lead because available data suggest a very low or possible no threshold for adverse effects, even at exposure levels that might be considered background. Any significant increase above such background exposures could represent a cause for some concern. In lieu of evaluating risk using typical intake calculations and toxicity criteria, USEPA has developed a computer model (the Integrated Exposure Uptake Biokinetic [IEUBK] model) for prediction of blood-lead levels in children exposed to lead from a variety of sources, including soil, dust, air, diet, lead-based paint, and maternal blood. Estimated blood-lead levels are compared to target blood-lead concentrations to assess possible risks. The model can be used to assess risks to individual children or populations of children. For a single child, risk is calculated as the probability that the child's blood-lead level will exceed the level of concern (10 micrograms pre deciliter [µg/dL]).

USEPA has also developed an Adult Lead Methodology that assesses lead exposure to the fetus of a pregnant woman. This methodology is used to predict blood lead concentrations in adults and in fetuses for exposure scenarios that do not involve residential exposure of young children. Therefore, this model is not directly applicable to the older child (ages 7 to 16 years) that is evaluated for intermittent lead exposure. However, this model should be conservative for this age group and is the only methodology that can be applied to older children.

Both the IEUBK and ALM approaches are discussed in detail in Section 4, Exposure Assessment.

Table 5-1 Cancer Toxicity Values for COPCs

Chemical of Potential Concern	Carcinogen	Oral Cancer Slope Factor	Oral to Dermal Adjustment Factor[1]	Adjusted Dermal Cancer Slope Factor[2]	Inhalation Slope factor	Units	Weight of Evidence/ Cancer Guideline Description	Source	Date (MM/DD/YY) (Date Checked)[3]
Arsenic	C	1.5	NA	NA	15.1	(mg/kg /day)-1	A	IRIS	7/15/2005
Iron	NA	NA	NA	NA	NA	(mg/kg /day)-1	NA	NA	NA
Lead	C	[4]	NA	[4]	[4]	(mg/kg /day)-1	B2	IRIS	7/15/2005
Manganese	NC	NA	NA	NA	NA	(mg/kg /day)-1	D	IRIS	7/15/2005
Thallium (as thallium chloride)	NA	NA	NA	NA	NA	(mg/kg /day)-1	NA	NA	NA

1 Oral to Dermal Adjustment Factor from Exhibit 4-1, RAGS Part E, Supplemental Guidance for Dermal Risk Assessment. Final. EPA/540/R/99/005. July 2004.
2 Adjusted Dermal Cancer Slope Factor (1/mg/kg/day) = Oral Cancer Slope Factor (1/mg/kg/day) / Oral to Dermal Adjustment Factor.
3 Toxicity values were obtained from USEPA online toxicity database, IRIS, July 2005.
4 Lead was evaluated using the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children, Version 1.0
IRIS EPA online toxicity database, http://www.epa.gov/IRIS
NA = not available/ not applicable
NC = noncarcinogen
USEPA Weight of Evidence:
A – Human Carcinogen
B1 – Probable human carcinogen – indicates that limited human data are available
B2 - Probable human carcinogen – indicates sufficient evidence in animals.
C – Possible human carcinogen
D – Not classified as human carcinogen

Table 5-2 Non-Cancer Oral Toxicity Values for COPCs

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD Value	Units	Oral to Dermal Adjustment Factor[1]	Adjusted Dermal RfD[2]	Units	Primary Target Organ	Combined Uncertainty/ Modifying Factors	Sources of RfD	Date of RfD (MM/DD/YY) (Date Checked)[3]
Arsenic	Chronic	3.00E-04	mg/kg-day	NA	NA	mg/kg-day	Hyperpigmentation, Keratosis, and Vascular System	3/1	IRIS	7/15/05
Iron[5]	Chronic	3.00E-01	mg/kg-day	NA	NA	NA	GI tract	NA	NCEA	7/22/05
Lead	NA	[4]	NA	NA	[4]	NA	Central Nervous System, Developmental	NA	NA	NA
Manganese[6]	Chronic	2.40E-02	mg/kg-day	4%	9.6E-04	mg/kg-day	Central Nervous System	NA	USEPA Region 9	8/1/05
Thallium (as thallium chloride)	Chronic	7.0E-05	mg/kg-day	NA	NA	NA	GI Tract and Central Nervous System	3000/1	IRIS	7/15/05

1 Oral to Dermal Adjustment Factor from Exhibit 4-1, RAGS Part E, Supplemental Guidance for Dermal Risk Assessment. Final. EPA/540/R/99/005. July 2004.
2 Adjusted Dermal Reference Dose (mg/kg-day) = Oral Reference Dose (mg/kg-day) x Oral to Dermal Adjustment Factor.
3 Toxicity values were obtained from USEPA online toxicity database, *IRIS*, July 2005.
4 Lead was evaluated using the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children, Version 1.0.
5 The oral RfD for iron is an outdated value that may overestimate potential hazards. This RfD is further discussed in Section 7, Uncertainties.
6 The oral RfD for manganese used in this HHRA is the oral RfD from the current Region 9 PRG table; this value is more conservative than the oral RfD on IRIS of 1.4E-01 mg/kg-day.

Note: There are no non-cancer inhalation toxicity criteria available for the above COPCs on *IRIS* USEPA online toxicity database, http://www.epa.gov/IRIS
NCEA = National Center for Environmental Assessment
NA = not available/ not applicable

Table 5-3 Non-Cancer Inhalation Toxicity Values for COPCs

Chemical of Potential Concern	Inhalation Reference Dose	Units	Primary Target Organ	Combined Uncertainty/ Modifying Factors	Sources of RfC	Date of RfC (MM/DD/YY) (Date Checked)
Arsenic	NA	NA	NA	NA	NA	NA
Iron	NA	NA	NA	NA	NA	NA
Lead	NA	NA	NA	NA	NA	NA
Manganese	5E-05	mg/m^3-day	Central Nervous System	1E+03	IRIS	7/15/05
Thallium (as Thallium chloride)	NA	NA	NA	NA	NA	NA

IRIS USEPA online toxicity database, http://www.epa.gov/IRIS
NA = not available/ not applicable

Section 6
Risk Characterization

In this section, exposure assessments (Section 4) are integrated with results of the toxicity assessment (Section 5) to produce quantitative expressions of carcinogenic risk and noncarcinogenic hazards. These quantitative risk and hazard estimates are presented along with a qualitative analysis of their meaning for people living, working or recreating in the study area.

Potential health hazards due to exposure to lead were evaluated independently because toxicity criteria, such as cancer slope factors and reference dose, are not available for this contaminant. Instead of standard risk and/or hazard calculations, the IEUBK model was used to estimate potential lead exposures for young children living in the study area and the Adult Lead Methodology is used to evaluate exposures for older children recreating in the area and adult workers. Quantitative results from the IEUBK model and Adult Lead Methodology and their interpretation for people living, working or recreating in the study area are presented separately.

6.1 Overview of Risk Characterization

Health hazards associated with exposure to lead are assessed using exposure models developed by USEPA. These models, the IEUBK model for young children and the Adult Lead Methodology for adolescents and construction workers, estimate the probability that a child exposed to given concentrations of lead in site media will have a blood lead concentration exceeding 10 μg/dL. When this probability falls below a health protection goal of 5 percent, lead exposures are typically considered to be acceptable.

Carcinogenic risks are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. The upper-bound excess lifetime cancer risk is estimated by multiplying the lifetime exposure (Section 4) by the cancer slope factor (Section 5). Excess lifetime cancer risks are generally expressed in scientific notation and are probabilities. An excess lifetime cancer risk of 1×10^{-6} (one in one million), for example, represents the incremental probability that an individual will develop cancer as a result of exposure to a carcinogenic chemical over a 70-year lifetime under specified exposure conditions.

The potential for noncarcinogenic effects is evaluated by comparing an exposure level over a specified time period with a reference dose derived for a similar exposure period. This ratio of exposure to toxicity is referred to as a hazard quotient (HQ). A hazard index (HI) is the sum of the HQs from individual chemicals of potential concern. Where an HI is equal to or less or less than one, potential exposures are at or below a "safe" level as defined by USEPA reference doses. Where HI's are greater than one, exposure may be sufficient to imply a hazard to human health. However, this conclusion is generally reached only where such an HI is based on exposure to chemicals that affect the same target organ or system. Chemicals are assumed to have additive toxicity only when they display similar toxicity profiles at low levels of exposure.

To gain perspective on estimates of risks and hazards, EPA uses targets that help to define when remediation or mitigation may be warranted. Typically, cancer risks that do not exceed 1 in ten thousand are considered acceptable, but decisions on the need for remediation are made on a case-by-case basis. Cancer risks below 1 in one million are typically considered *de minimus.* In addition, protection of young children for health effects of lead exposure is considered achieved if the odds of a typical or hypothetical child (or group of similarly exposed children) with blood lead levels of 10 µg/dL or greater is no more than 5 percent (USEPA 1994b). The results of risk calculations are compared to these target values to aid in determining whether additional response action is necessary at the site.

Cancer risk and noncancer hazard calculations for COPCs are discussed in the following sections. Potential health risks associated with lead are discussed separately in Section 6.2. Cancer risks for other COPCs are presented in Section 6.3. Estimated noncancer health hazards are presented for each of the receptors in Section 6.4. Separate estimates are presented for each of the exposure scenarios, including:

- Future Residents
- Construction Workers
- Recreational Visitors

For the Annapolis Lead Mine, the basic approach to the characterizing risks and hazards is twofold. First, for the portion of the site north of Highway 49, the assessment focuses on residual risks associated with lead contamination left in place following a recently completed removal action. Second, for floodplain areas, particularly those areas south of Highway 49, the assessment addresses potential risks from existing contamination eroded from the mine site and deposited during flood events.

6.2 Estimates of Lead Exposure

The main concern for the ALS is potential exposure to lead in mine wastes generated and released at the site. Although other COPCs were identified in this and previous reports, the "risk driver" for the site appears to be lead.

Potential health risks due to exposure to lead were assessed using USEPA's IEUBK model for lead exposure of young children, ages 0 to 84 months of age. USEPA's Adult Lead Methodology was used to assess non-residential exposures to lead. Results of these analyses are discussed in the following sections.

6.2.1 Residential Lead Exposures

The approach to evaluating the mine operations area was to assume that future residential development might occur and that such development would bring contaminated materials to the surface where future residents might be exposed. Although, unlikely, such a scenario is not specifically excluded.

Residential blood lead levels were calculated using site-specific (e.g. soil lead concentrations) and default exposure assumptions. The approach used site-specific information where available to evaluate key inputs to the USEPA's IEUBK Model for estimating lead exposure in young children. If site-specific information was sufficient, default inputs to the model were replaced with ones more applicable to the site. Otherwise, default parameters provided with the model were retained.

The focus of the IEUBK Model for lead in children is the prediction of blood lead concentrations in young children exposed to lead from several sources and by several routes. The model utilizes four interrelated modules (exposure, uptake, biokinetic, and probability distribution) to estimate blood lead levels in children exposed to lead contaminated media. The IEUBK Model can be used to predict the probability that a child exposed to given set of concentrations of lead in environmental media will have blood lead concentrations exceeding a health protection goal of concern (typically 10 µg/dL). For this assessment, estimates for blood lead concentrations were calculated for the former mining operations area and for identified hotspot areas, using the IEUBK model. The model was run using a combination of default and site-specific parameters. For this assessment the only non-default site-specific parameters available were media concentrations. IEUBK modeling results are based on updated dietary uptake values, a GSD of 1.6, and an assumed soil to dust transfer factor of 0.70 for residential children from birth to seven years (84 months) of age.

Recent studies have indicated that some model default parameters may overestimate exposures to lead. Additional realizations of the model were evaluated to illustrate the range of possible blood lead levels in children exposed in identical exposure conditions using non-default model parameters. These additional analyses are discussed in Section 7, Uncertainties. IEUBK model results for all model variations are presented in Appendix F.

Most soils in the mining operations area of the site that were sampled during post removal activities have lead concentrations that are below levels of potential concern. Young children that might live or play in these areas would not be expected to have greater than a 5 percent chance of having their blood lead concentrations exceed 10 µg/dL; when this criterion is met, lead exposures are unlikely to represent a significant hazard. In fact for many areas the probability that a child's blood lead concentrations would exceed 10 µg/dL is less than 1 percent. Since children receive more exposure than adults in the same setting, and are more sensitive to the harmful effects of lead, lead concentrations at these locations will not represent a significant hazard for adults either.

For the identified hotspots in the former mining operations area, average lead concentrations could be high enough to represent a hazard to young children, if residential development where to occur. Two such hotspots where identified, one near the former Clark residence (Clark hotspot) and one located north of the

Mayberry residence (Mayberry hotspot). [NOTE: The Mayberry hotspot lies outside of the yard of this residence and does not imply any source of lead on the current Mayberry property.] In hotspot areas, lead exposures are predicted to be very high and lead concentrations in soil and dust could theoretically cause the majority of children living in these areas to have blood lead concentrations exceeding 10 µg/dL. A child living at and playing in a yard characterized by average hotspot lead concentrations could have much greater than a 5 percent chance of having blood lead levels that exceed 10 µg/dL.

This result assumes that the current 18 inch clean soil cover is disturbed such that residual lead contamination beneath the cover is brought to and remains at the surface. A child living in the area could then be exposed directly to contaminated soils. The probability that a child's blood lead level will exceed the level of concern (10 µg/dL) is 99% and 91% at the former Clark residence hot spot and at the hotspot north of the Mayberry residence, respectively, assuming that a child is exposed to the average lead concentrations in these areas.

Locations with average lead concentrations that could represent a hazard for young children occur near the former Clark residence, the former Mayberry residence, near Sutton Branch Creek southwest of the former Clark residence, and at the toe of the tailings cap. No modeling estimates are provided for the latter two hotspots because the spot southwest of the former Clark residence is in the floodplain and residential development is not anticipated and because the hotspot at the toe of the cap is anticipated to fall under the requirement of the State of Missouri to maintain the integrity of the waste depository.

Results of the IEUBK modeling are presented in Table 6-1.

Table 6-1 Summary of IEUBK Model Runs
Annapolis Lead Mine Site

Future Residential Scenario		
Exposure Area	**Exposure Point Concentration (mean of dataset) (mg/kg)**	**Probability of a Child (Birth to 84 Months in Age) Expected to have a Blood Lead Concentration above 10 µg/dL**
Former Mining Operations Area, Surface Soil	159	0.2%
Hot Spot Areas		
Former Clark Residence	6960	99.4%
North of Mayberry Residence	2640	89%
Note: Recommended (TRW) New Dietary Intakes were Used		

6.2.2 Construction Worker Lead Exposures

Future development of the mine operations area would require some excavation that would penetrate the 18" cover placed on the site and construction workers could be exposed to residual lead contamination beneath this cover. No exposure for construction workers is anticipated for floodplain areas because no development is expected within areas subject to periodic flooding.

USEPA's Adult Lead Methodology was used to assess lead exposures for adult workers in the former mining operations area. For a majority of the site, lead concentrations are below levels of potential concern; however, in areas identified as hotspots, lead concentrations could be of concern for future construction workers. For areas not identified as hotspots, the average PbB is estimated to be 2.1 µg/dL for a construction worker exposed to average lead residual lead concentrations and the probability of fetal blood lead levels above 10 µg/dL is 2 percent for these individuals.

Estimated PbB levels for a construction worker exposed to average lead concentrations, and the probability of fetal blood lead levels above 10 µg/dL for these individuals are substantially higher for excavation activities in hotspot areas. For the Clark hotspot, these estimates are 26 µg/dL and 86 percent, respectively. Analogous estimates for the Mayberry hotspot are 11 µg/dL and 48 percent. These estimates suggest that exposures in hotspot areas could be unacceptable for future construction workers. Estimates of lead exposures for the construction worker based on USEPA's Adult Lead Methodology are summarized on Table 6-2 and calculation worksheets are presented in Appendix F.

Table 6-2 Summary of Estimated Lead Exposures for the Construction Worker Based on USEPA Adult Lead Methodology

Receptor	Construction Worker		
Exposure Area	Exposure Point Concentration (mean) mg/kg)	Probability that fetal PbB will be greater than 10 µg/dl	PbB of adult worker (µg/dL)
Former Mining Operations Area, Surface Soil	159	2%	2.1
Hot Spot Areas, Former Mining Operations Area			
Former Clark Residence	6960	86%	25.8
North of Mayberry Residence	2640	48%	10.7

PbB = blood lead level

6.2.3 Recreational User Lead Exposures

Recreational visitors to the site may contact existing surface contamination in much of the floodplain for Sutton Branch Creek. No exposure to subsurface contamination is anticipated for the mine operations area or areas within the floodplain where the removal occurred. In the former mine operations area, a cover of 18" has been placed over residual contamination. Part of the removal action is to maintain and repair this cover until it is fully vegetated and stabilized. Thus, residual contamination in these areas is not expected to be brought to the surface where they might represent a source of exposure. All estimates of lead exposure to soil are for existing surface contamination in the floodplain south of Highway 49.

USEPA's Adult Lead Methodology was used to assess lead exposures for adolescents recreating in the floodplain area. There is significant uncertainty associated with the recreational scenario; therefore, a range of exposures were evaluated. Lead exposures were estimated for a range of exposure frequencies, from one, two and five visits per week. The central estimate PbB for a recreational adolescent exposed to average lead concentrations in the floodplain ranged from 2 µg/dL to 3 µg/dL. Estimates for potential effects on the fetus are provided in the Table 6-3. The age range that is evaluated in this assessment is not typically associated with child-bearing; however, pregnancy is possible toward the upper end of the age range. Based on USEPA's Adult Lead Methodology the probability of fetal blood levels exceeding 10 µg/dL would range from 1 to 5 percent, again based on an individual exposed to average soil lead concentrations in the area. Percentages are at or below the USEPA health protection goal of no more than 5 percent probability of exceeding 10 µg/dL.

Note that the estimate of a 5 percent chance of exceeding the health protection goal is based on an exposure frequency of 5 events per week. This frequency is an extremely high estimate for an area with poor access and low attractiveness. The estimate shows that even extreme exposure parameters do not result in significantly elevated estimates of lead exposure for recreational visitors.

Separate estimates for exposure to sediments were not developed for potential recreational exposures, since the EPC for lead in sediment (330 mg/kg) is lower than that for floodplain soils. Exposure to sediments alone or in combination with floodplain soils would not be expected to cause impacts greater than those for soils alone. Also, exposure to lead in surface water was not quantified since this pathway would be negligible in comparison to the soil ingestion pathway. Estimates of lead exposures for the adolescent recreating in the floodplain area based on USEPA's Adult Lead Methodology are summarized on Table 6-3 and calculation worksheets are presented in Appendix F.

Table 6-3 Summary of Estimated Lead Exposures for the Recreational Adolescent Based on USEPA Adult Lead Methodology

Receptor	Recreational Adolescent		
Exposure Area	Exposure Point Concentration (mean) mg/kg)	Probability that fetal PbB will be greater than 10 µg/dl	PbB of recreational adolescent (µg/dL)
Flood Plain Area	912.4		
Exposure Frequency			
1 visit per week		1.1%	1.8
2 visits per week		1.8%	2.2
5 visits per week		5.0%	3.1

PbB = blood lead level

6.3 Cancer Risks

Cancer risks at the site are due to exposure to arsenic; potential health risks due to exposure to arsenic in soil were assessed using standard USEPA exposure equations and a combination of site-specific and USEPA default exposure assumptions. Cancer risk estimates were assessed for future residents in the former mining operations area (groundwater exposure only) and for recreational users visiting the floodplain area or playing in Sutton Branch Creek. Results from cancer risk calculations are discussed below.

6.3.1 Cancer Risk for Future Residents

Cancer risks for future residents were estimated using assumptions for an RME. Thus, all risk estimates are expected to fall in the upper range of those possible. In some cases, as discussed below and in Section 7, Uncertainties, the estimates can be interpreted as upper bounds. All potential cancer risks at the site are associated with exposure to arsenic in groundwater used for domestic purposes. Post-removal analytical data for arsenic in soil are not available; therefore, potential exposures associated with soil conditions are not evaluated.

The maximum detected concentration of arsenic in groundwater was used as the exposure point concentration; this exposure point concentration may overestimate potential for exposure. Cancer risk estimates for residential exposure to groundwater may represent the upper bound for the site. Cancer risk for ingestion of groundwater is 2×10^{-5}. Cancer risk associated with dermal contact with arsenic during bathing is 1×10^{-7}. Total cancer risk associated with groundwater exposures is 2×10^{-5}. Cancer risks for future residents based on RME therefore fall within USEPA's acceptable risk range. Cancer risk for the resident is presented in Table 6-4. Cancer risk calculations for residents are presented in Appendix E.

6.3.2 Cancer Risks for Future Construction Workers

Construction workers are only assessed for exposure to residual contamination in soils in the mine operations area. Since post-removal data for arsenic are not available for this medium, no cancer risk estimates were developed for these receptors.

6.3.3 Cancer Risks for Recreational Users

Cancer risks for recreational users were estimated for ingestion of and dermal contact with surface soils, sediment, and surface water. There is significant uncertainty associated with the recreational scenario; therefore, a range of exposures were evaluated. Cancer risk associated with incidental ingestion and dermal contact of surface soil is 5×10^{-6}, with incidental ingestion and dermal contact of sediment is 4×10^{-6}; and with incidental ingestion and dermal contact of surface water is 5×10^{-7}, based on 2 visits per week during the warmest months of the year. Total cancer risks for the recreationist are therefore 1×10^{-5}. This estimate falls in the middle of USEPA's risk management range. These risk estimates may overstate actual potential risks for the site. The greatest potential risks are associated with incidental ingestion of soils and sediments. For estimation of risks, maximum detected concentrations were used as exposure point concentrations for sediment, which may result in overestimate potential risk associated with this medium. Since people recreating at the site are unlikely to consistently visit only the most contaminated areas and since sediment contamination is likely to change substantially over time, actual exposure point concentrations, and, hence, cancer risks, may be less than those calculated.

Cancer risk for the recreational user is presented in Table 6-4 at the end of this section. Cancer risk calculations for the recreational users are presented in Appendix E.

6.4 Noncancer Hazards

Assessment of noncancer hazards followed the same basic approach used for assessment of cancer risks. As previously discussed, HQs for individual COPCs are added together to produce an HI. When such an HI exceeds one, HIs are then recalculated separately by adding individual HQs for COPCs that affect the same target organ or system.

6.4.1 Noncancer Hazards for Future Residents

No non-cancer hazards are estimated for exposure to COPCs in soils for future residents because of the lack of post-removal concentrations of metals other than lead. Thus, the only hazard estimates are those for exposure to groundwater used for domestic purposes.

Maximum detected concentrations were used to estimate hazards associated with the groundwater exposure pathway. The use of these concentrations most likely overestimates potential exposures associated with groundwater. The HI associated with ingestion of groundwater is 11 for a child resident and 6 for an adult. The individual HIs for iron are 9 and 2 for iron and thallium, respectively for the child resident. The individual HQs should be emphasized because iron and thallium affect different target organs, and additive effects may not be expected. Similarly, the individual HQs for the adult resident are 5 and 1 respectively. All of these estimates exceed the target HQ of 1.

6.4.2 Noncancer Hazards for Construction Workers

Non-cancer hazards are not estimated for construction workers because of lack of post-removal data for metals other than lead in soils in the mine operations area. The only exposures that are quantified are those associated with use of groundwater for domestic purposes.

6.4.3 Noncancer Hazards for Recreational Users

The noncancer health hazard index for recreational users associated with incidental ingestion and dermal contact of surface soil in the floodplain area is 0.1 , which is based on 2 visits per week to the site during the warmest 6 months of the year. The HI associated with the ingestion of and dermal contact with sediment are all less than one. The HI associated with incidental ingestion of dermal contact with surface water is less than one. The majority of the HI is associated with ingestion of thallium in surface water. As discussed previously, maximum detected COPC concentrations were used as exposure point concentrations for surface water and sediment, and likely these concentrations may overestimate any actual exposures that may take place in the study area. Noncancer hazards for the recreational users are presented in Table 6-4. Calculations for noncancer health hazards for recreational users are presented in Appendix E.

Table 6-4 Summary of Cancer Risks and Non Cancer Hazards for Receptors for the ALS

Exposure Area	Exposure Scenario	Receptor	Cancer Risk Estimate (1)	Non Cancer Hazard Index
Former Mine Operations Area	Domestic Use of Groundwater (Ingestion and Dermal Contact during bathing/showering)	Future Resident, Adult, Cancer Risk	2×10^{-5} (2)	6
		Future Resident, Child	Not Calculated	11
	Ingestion of and Dermal Contact with Soil	Future Resident	Exposures associated with soil in the former mining area are evaluated for lead only in the IEUBK model	
	Ingestion of and Dermal Contact with Soil	Future Construction Worker	Exposures associated with soil in the former mining area are evaluated for lead only using USEPA's Adult Lead Methodology	
Sutton Branch Floodplain	Incidental Ingestion of and Dermal Contact with Surface Soil	Recreational Visitor	5×10^{-6}	0.1
Sutton Branch Creek	Incidental Ingestion of and Dermal Contact with Surface Water	Recreational Visitor	5×10^{-7}	0.3
	Incidental Ingestion of and Dermal Contact with Sediment	Recreational Visitor	4×10^{-6}	0.06

(1) Cancer risk for resident includes exposure for 6 years as a child and 24 years as an adult.
(2) Cadmium in groundwater could contribute to cancer risks about equally with arsenic (Appendix B). This estimate is based on an oral slope factor from California EPA that is not widely accepted and is subject to much uncertainty. If hypothetical risks due to oral exposure to cadmium were added to those associated with arsenic, resulting risks would still be within EPA's risk management range.

Section 7 Uncertainties

Uncertainties can arise from several sources in a HHRA including data collection and interpretation, assumptions used to characterize exposures, and toxicity values. To compensate for uncertainty surrounding input variables, conservative assumptions are often made that tend to overestimate rather than underestimate risk. In cases where data are limited, assumptions may be based on professional judgment or subjective estimates that may under- or overestimate risks.

7.1 Types of Uncertainty

Three primary sources of uncertainty include:

- Scenario uncertainty
- Parameter uncertainty
- Model uncertainty

Scenario uncertainty results from missing or incomplete information needed to fully define exposure and dose. This uncertainty may include errors or gaps in site characterization, professional judgment, assumptions regarding exposed populations, and steady-state conditions. Sources of parameter uncertainty include measurement and sampling errors, inherent variability in environmental and exposure-related parameters, and the use of generic surrogate data or default assumptions when site-specific data are not available. Parameter uncertainty often leads to model uncertainty. One source of modeling uncertainty is relationship errors, such as errors in correlations among chemical properties or limitations in mathematical expressions used to define environmental processes. Errors due to the use of mathematical or conceptual models as simplified representations of reality are also sources of modeling uncertainty.

Often analysis of uncertainties is divided into "true uncertainty" and "variability." The former is uncertainty due to lack of knowledge of data. Variability is uncertainty due to irresolvable variation in physical, chemical, and biological process, human behavioral patterns, seasonal changes, and data for site characterization. An example of uncertainty in this HHRA involves selection of an exposure frequency for recreational site users. Little site-specific information is available and this parameter is based on professional judgment. An example of variability in this HHRA involves estimates of exposure concentrations. These estimates are upper range estimates of mean concentrations based on variability in data used in the calculations.

These three types of uncertainty have been identified in each of the four parts of this risk assessment: data evaluation, exposure assessment, toxicity assessment and risk characterization. Uncertainty within each of these components is discussed below.

7.2 Uncertainties Associated with Data Evaluation

Uncertainty is present in the data before it is even evaluated for risk assessment. Such uncertainty includes potential sampling bias, errors in laboratory extraction and analysis, and the protocol employed to assess contaminants identified as nondetected. Where COPCs are reported above detection limits, a higher level of confidence is placed on the analytical results. Sampling errors and biases and assumptions for use of nondetect data are almost always more important from uncertainty considerations.

The impact of errors in laboratory analysis can be assessed to some extent by examining results from independent chemical analyses. An analytical XRF instrument was used to measure soil concentrations of metals and metalloids during the recent removal action in the former mine operational area. The instrument was apparently well calibrated for measuring lead that was the focus of the removal action in the former mine operational area. Confirmation samples for some sampling locations were sent to an independent analysis using standard Contract Laboratory Program (CLP) methods. The correlation in findings of these two analyses is extremely good, implying that both methods produced consistent results. However, the slope of the regression line is about 0.8, indicating that the XRF values were consistently lower by about 20 percent than the concentrations reported from the off-site laboratory (Figure 7-1). Laboratory analyses are generally regarded as more accurate than those from field instruments. Thus, the data on which the risk assessment are based may be biased low, but by no more than 20 percent. Such a bias would not have any substantive impact on the results and conclusions of the risk assessment.

Soil data used to assess risks for the mine operational area were collected in the latter half of 2004. Data were collected using a grid system to systematically measure lead concentrations throughout the site. This systematic data collection for grids measuring only about 50 feet on a side provide a very complete site characterization, and exposure point concentrations based on these data are likely to accurately represent the potential for exposure.

Soil samples were not sieved, however, as suggested by USEPA's Technical Review Group for Lead (USEPA 2005c) to obtain the soil fraction most likely to adhere to skin and be subsequently ingested by young children. Some enrichment of lead in small soil particle sizes has been seen in past investigations, although this is not a universal finding. Thus, lead concentrations measured using unsieved soil could somewhat under or overestimate lead concentrations in the soil fraction that is expected to contribute most to exposure. This uncertainty cannot be resolved with currently available information. However, even significant enrichment in small particles would not materially change the basic conclusions of the risk assessment. In most of the mine operations area, for example, lead concentrations average much less than the screening level of 400 mg/kg. An enrichment "error" is unlikely to be sufficiently large to cause average concentrations to exceed 400 mg/kg. Further, average concentrations in hotspot areas appear to be much higher than those that might be acceptable for surface soils in residential developments. Enrichment would only further support the conclusion of potential excess lead exposure if residual contamination below the current 18 inch cover was brought to the surface and made available for direct contact exposure.

In the floodplain area south of Highway 49, data were collected in what appears to be a stratified random manner. Although the sampling was not as dense for this area as in the north, the manner in which contaminants were deposited suggests that contamination should be spread relatively evenly over the area. Thus, fewer samples would be necessary to characterize contaminant distribution than would be the case if contamination was spottier as is often the case when dealing with mining source areas. Available data are likely to represent actual exposure concentrations for the floodplain area accurately. For both the mine operational and the floodplain areas, uncertainties are likely to be associated mainly with measured variability.

Finally, data for soil constituents other than lead are not available to characterize post-removal conditions in the former mine operations area. Lack of these data and any associated quantitative exposure assessment suggests that risks and hazards to hypothetical future residents and construction workers are likely to be underestimated. Available data suggest, however, that such underestimation may not greatly affect the results and conclusions of the risk assessment. Two COPCs, besides lead, were identified for soils in the ALS, arsenic and manganese.

Arsenic was detected in most soil samples at concentrations above its Region 9 residential soil PRG. However, because of very high toxicity of arsenic, most background concentrations of arsenic exceed the PRG. Overall, the concentrations of arsenic observed at the site are not greatly elevated. For example, the exposure concentration for arsenic in the floodplain soils was less than 40 mg/kg. In many areas of the country, background arsenic concentrations can be in the range of a few up to 15 or 20 mg/kg. In contrast, the highest concentrations of lead at the site may be in the range of 20,000 mg/kg, while background concentrations may be less than 100 mg/kg. The amount of arsenic in the galena ore found at the ALS was apparently relatively low. Further, the highest concentrations seem to occur in areas where higher concentrations of lead are also found. Figure 7-2 shows this correlation between arsenic and lead in soils for the floodplain area. Probably, risk management decisions based on potential for lead exposure will also address any risks associated with residual arsenic. However, data are not available to directly support this conclusion.

The manganese concentration at one location slightly exceeded its residential soil PRG. Since almost all concentrations of manganese are below screening levels for soils, the level of contamination associated with past mining activities does not appear to be substantial. The moderate levels of manganese observed in soils suggest little potential for substantial exposure or hazard. Lack of data for manganese is not likely to have any significant impact on conclusions of the risk assessment.

7.3 Uncertainties Associated with Exposure Parameters

The combination of exposure assumptions and exposure point concentrations used in the assessment is expected to provide conservative estimates for exposure of individuals living near the ALS. However, uncertainties and their potential impacts on use of risk results for risk management should be understood. The exposure assessment relies on assumptions for a variety of exposure parameters. Assumptions used are variously based on:

- Site-specific information
- USEPA guidance
- Professional judgment

Choices made for adult exposure parameters are within the ranges suggested by USEPA and should be conservative for assessing adult exposure.

7.3.1 Soil Ingestion Rate

Soil ingestion rates are particularly important for the IEUBK model. Soil ingestion rates have been assessed and reassessed multiple times. Some recent information suggests that default soil ingestion rates may somewhat overestimate the average daily ingestion rates for young children. Uncertainty in this parameter was addressed by estimating possible lead exposure using both default and updated soil ingestion rates. These estimates bracket the range of plausible exposures based on available soil ingestion information.

Alternate soil and dust intake estimates provided by USEPA Region 8 (e-mail from Wendy O'Brien June 1, 2005 based on soil ingestion estimates from a study conducted in Anaconda, MT) are summarized below:

Age Range (years)	Soil and Dust Intake (g/d)
0-1	0.024
1-2	0.038
2-3	0.038
3-4	0.038
4-5	0.028
5-6	0.026
6-7	0.024

g/d = grams per day

Alternative estimates for possible lead exposure are provided in Table 7-1. This table also addresses uncertainties in soil-to-dust transfer coefficient, as discussed in Section 7.4.

Table 7-1 Summary of IEUBK Model Runs

Results for Child 0 to 84 months in age
Note: New Dietary Intakes were Used
Results presented are the probability in percent that a child exposed to soil at the EPC would have a blood lead concentration above 10 μg/dL

Exposure Area	Exposure Point Concentration (mean of dataset) mg/kg)	Soil to Dust Transfer Factor of 70%		Soil to Dust Transfer Factor of 24%	
		Alternate Soil and Dust Intake (1)	Default Soil and Dust Intake	Alternate Soil and Dust Intake (1)	Default Soil and Dust Intake
Former Mining Operations Area, Surface Soil	159.4	0.001%	0.2%	0.001%	0.04%
Hot Spot Areas					
Former Clark Residence	6959.7	79%	99.4%	61%	98%
North of Mayberry Residence	2639.7	25%	89%	10%	77%
(1) EPA 1996. Baseline Human Health Risk Assessment. Anaconda Smelter NPL Site. Anaconda, Montana.					

7.3.2 Exposure Frequency

Frequency and duration of exposure are also important determinants of exposure that are characterized by USEPA default values. No site-specific information on frequency of exposure or residence times is available for the ALS.

Exposure frequency for residents (groundwater ingestion) is estimated at the high end of possible frequencies, allowing only for a 2-week-per-year vacation. Most individuals may spend more time than this away from home and/or may spend limited time at home on most weekdays because of work commitments. These individuals may receive less exposure than that estimated in this assessment. However, a significant number of individuals (for example non-working parents) may spend significant amounts of time each day at their homes. The exposure frequency used in this assessment is not expected to be appropriate for most individuals in the potentially exposed population. However, the exposure frequency is reasonable for the most heavily exposed individuals and will be protective for the population as a whole.

Exposure frequency for construction workers and recreational visitors are very uncertain and are based completely on professional judgment. It is not possible to predict beforehand how long excavation activities would last during construction, and no data are available to estimate how frequently people might visit the site recreationally. Some quantitative sense of the range of lead exposure associated with recreational use of the floodplain was gained by comparing scenarios with a range of plausible exposure frequencies. Even an exposure frequency up to 5 days per week, an extremely high estimate given the lack of accessibility and attractiveness of the site for recreation still produced estimates of exposure that were below levels of potential concerns. It seems highly unlikely that recreational exposure could lead to unacceptable lead exposures under any foreseeable circumstances.

7.3.3 Exposure Duration

Exposure duration can also have a significant impact on exposure estimates. National norms suggest that the 90th percentile for time at one residence is about 30 years. If the population near the ALS is either more sedentary or more mobile than the nation as a whole, risks could be either under- or overestimated. In many cases, small rural communities have many residents that stay in the community for long periods of time, and some information suggests that this may be true for Annapolis.

Uncertainties in exposure duration are, however, unlikely to be of great significance in evaluation of residential exposure. For example, if a more reasonable upper range estimate for time at one residence was either 20 or 40 years, RME estimates would go down or up by only 33 percent.

Exposure duration for construction workers and recreational visitors are subject to significant uncertainties much like those for exposure frequencies. Exposure durations used in this assessment could either under- or overestimate potential risks and hazards for these receptors.

7.3.4 Evaluation of Inhalation Exposure

The risk assessment did not include estimates of risk and hazard due to exposure via inhalation of COPCs in the quantitative analysis. Since this pathway is at least potentially complete currently and/or in the future, this approach may lead to some underestimation of potential risks and hazards. However, such underestimation is probably negligible in terms of its impact on the conclusions of the risk assessment.

A screening level calculation using generic exposure parameters for inhalation exposure suggests that risks and hazards due to inhalation of arsenic will be a small fraction of those associated with incidental soil ingestion and dermal contact of arsenic (Table 7-2). The potential small contribution of the inhalation pathway would not change the reported risks or hazards, which are presented with only 1 or 2 significant figures. The screening calculation supports the decision to exclude the inhalation pathway from consideration in the quantitative assessment. Note also that the calculation used arsenic as an example COPC. The inhalation slope factor for arsenic is 10 times higher than the oral slope factor. Thus, the relative contribution of the inhalation pathway to overall cancer risk should be larger than that for many chemicals for which inhalation and oral toxicity criteria are similar. Even so, the inhalation pathway contributes only about 0.5 percent to total cancer risk from arsenic in the example calculation.

Table 7-2 Potential relative contribution of inhalation exposure to potential cancer risks for residents.

Exposure Parameters	Cancer Risk
Soil Ingestion Rate -- 100 mg/d	Soil Ingestion 7.0×10^{-6}
Inhalation Rate -- 20 m^3/day	
Particle Emission Factor - 1.32E-09 m^3/kg	Inhalation 3.6×10^{-8}
Exposure Frequency – 350 days/year	
Exposure Duration -- 24 years	
Body Weight – 70 kg	

Averaging Time – 25550 days	
Slope Factor (oral) -- 1.5 per mg/kg-d	
Slope Factor (inhalation) -- 15 per mg/kg-d	

Calculations assume an arsenic concentration in soil of 10 mg/kg.

7.3.5 Evaluation of Dermal Exposure to Sediment

The risk assessment assumed that hands, forearms, lower legs and feet would be exposed to sediments in Sutton Branch Creek during recreational activities. This assumption may be a significant overestimate, since water play would likely wash off sediment from much exposed skin area fairly rapidly. Probably, the actual area of exposed skin would be much smaller for children wading in the creek. Risk and hazard estimates due to dermal exposure may be over 20 percent of total risks and hazards, and overestimation of exposed skin surface could result in some overestimation of total risk or hazard. A contribution of 20 percent is, however, relatively small and would be unlikely to alter the conclusions of the risk assessment.

Note: Uncertainties in the approach to dermal exposure applies only to arsenic in sediments. No other COPCs were evaluated for dermal exposure.

7.4 Uncertainties Associated with the Soil-to-Dust Transfer Factor (IEUBK Model)

Transfer of COPCs in soils to indoor dust is an important process for estimation of exposure. The default soil-to-dust transfer factor in the IEUBK model is 0.7. To estimate potential exposures for the ALS, the soil-to-dust transfer default factor of 0.7 was used. In recent studies of soil-to-dust transfer in Butte and Anaconda, Montana, measured dust concentrations of lead and arsenic, respectively, have been 24 and 43 percent of outdoor soil concentrations (USEPA 1994, 1996a). The estimate from Butte, Montana is based on data from homes in a community that was very dusty with large amounts of uncovered and unvegetated mine wastes when the data were collected. The estimate from Anaconda, Montana is based on data from a community where most of the arsenic released was in the form of very small particulate matter from a smelter. The ALS does not have large amounts of uncovered or unvegetated mine wastes and no smelting of ores was conducted in the town in the past. Thus, these two conditions that would seem to favor transfer of outdoor contamination indoors may not have been as important in determining soil-to-dust transfer for the ALS. Further, other estimates of soil-to-dust transfer are also much less than the default of 0.7. At another milling/smelting site in Utah, arsenic soil-to-dust transfer was estimated to be about 20 percent at Winchester Estates near the Midvale NPL site (CDM 2002). Even though fine particulates were released at this site during smelting operations, soil-to-dust transfer was still low.

Overall, available data from mining/milling/smelting sites appear to indicate that soil-to-dust transfer may be less than the default of 0.7. For this risk assessment, the range of soil-to-dust transfer from 0.24 to 0.7 was used to bracket the plausible range of transfer coefficients. Likely, even the estimates based on the lower value can be considered within the reasonable range for risk management decisions.

A comparison of lead exposure estimates for young children using default and alternative inputs to the IEUBK model are summarized in Table 7-1. Generally, the alternative inputs would have little impact on conclusions of the risk assessment. Concentrations of lead in hotspot areas are high and would represent unacceptable exposures regardless of choice of input parameters. Else where in the mine operations area, lead concentrations are below levels of concerns, and choice of input parameters would, again, not change this finding.

7.5 Uncertainties Associated with Uptake of COPCs into Garden Vegetables

Potential exposures and risks due to consumption of home-grown produce raised in contaminated soil were not quantitatively characterized. Potentially, this approach could lead to underestimation of possible risks and hazards. The decision not to evaluate exposure via garden vegetables is based on a study report of uptake of arsenic and lead into garden vegetables at the Kennecott mine site in Utah (EPA 1995). In this study, the uptake of arsenic and lead was low. Slopes of regression lines for vegetable concentrations versus soil concentrations ranged from a low of 0.000089 for lead uptake into zucchini to 0.0068 for lead uptake into beet greens. Regression slopes were less than those suggested in Baes et al (1984) who present generic uptake values for arsenic, lead and other metals. For some commonly grown vegetables (tomatoes, zucchini, leafy vegetables), results from Kennecott were 10 to 100 times lower than the Baes estimates. Results suggest that uptake into root crops may be greatest and that uptake into fruits (tomatoes and zucchini for example) is extremely limited. For example, arsenic could not be detected, using methods with detection limits in the 0.1 μg/mg range, in tomatoes.

Further, correlation coefficients for regressions in the study were generally low, suggesting a poor correlation between constituents in soil and those in vegetables. Soil concentrations may be overall poor predictors of concentrations in home grown vegetables. Vegetable data were not collected at the ALS site, making any attempt at quantification of the pathway very uncertain.

In addition, some fraction of arsenic taken up into vegetables is converted to less toxic organic forms (ATSDR 2000). The fraction of arsenic that is converted reduces exposure to the more toxic inorganic forms and therefore reduces potential risks at the site. Given that arsenic concentrations at the site are moderate (the EPC for As in flood plain soils is 34 mg/kg), that uptake is poor especially into some of the most popular types of vegetables, and that some fraction of arsenic taken up into plants will be detoxified, the potential for significant exposure and risk due to consumption of contaminated vegetables appear to be small.

Finally, gardens soils are typically amended, often on a yearly basis, with top soil, manure, etc., which would serve to dilute concentrations of arsenic and lead. These organic amendments might also reduce bioavailability of COPCs through binding to acid and sulfur groups. Further, continued harvest of crops from the same plot would reduce COPC concentrations over time. Overall, the garden vegetable consumption pathway would seem to be of minor concern for the ALS site.

7.6 Uncertainties Associated with Toxicity Assessment

7.6.1 Uncertainties in Cancer and Noncancer Toxicity Criteria

A potentially large source of uncertainty is inherent in the derivation of the USEPA toxicity criteria (i.e., RfDs and cancer slope factors). In many cases, data must be extrapolated from animals to sensitive humans by the application of uncertainty factors to an estimated NOAEL or LOAEL for noncancer effects. While designed to be protective, it is likely in many cases that uncertainty factors overestimate the magnitude of differences that may exist between human and animals, and among humans.

In some cases, however, toxicity criteria may be based on studies that did not detect the most sensitive adverse effects. For example, many past studies have not measured possible toxic effects on the immune system. Moreover, some chemicals may cause subtle effects not easily recognized in animal studies. The effects of lead on cognitive function and behavior at very low levels of exposure serve as examples.

In addition, derivation of cancer slope factors often involves linear extrapolation of effects at high doses to potential effects at lower doses commonly seen in environmental exposure settings. Currently, it is not known whether linear extrapolation is appropriate. Probably, the shape of the dose response curve for carcinogenesis varies with different chemicals and mechanisms of action. It is not possible at this time, however, to describe such differences in quantitative terms.

It is likely that the assumption of linearity is conservative and yields slope factors that are unlikely to lead to underestimation of risks. Yet, for specific chemicals, current methodology could cause slope factors, and, hence, risks to be underestimated.

Use of USEPA toxicity criteria could either over- or underestimate potential risks, but it is difficult to determine either the direction or magnitude of any errors. In general, however, it is likely that the criteria err on the side of protectiveness for most chemicals.

The RfD for iron is particularly uncertain. This criterion is an outdated provisional value from 1993 that does not reflect the latest research conducted by the Institute of Medicine (IOM), which published its revised iron dietary intake in 2001. The IOM report specified an upper tolerable intake for iron in children as 40 mg/per day for infants and children up to 13 years. This equates to a dose of 2.7 mg/kg-day for a 15 kg child and an even higher value for infants. Based on this IOM analysis, the risk assessment may be overestimating the HQ for iron by about 10-fold. A ten-fold reduction in hazard quotients for iron would mean that potentially significant impacts associated with ingestion of groundwater would be reduce to levels below the target

HQ of 1. Thus, newer information suggests that hazards identified in the risk assessment in Section 6, may be in error.

7.6.2 Bioavailability of Arsenic and Lead

Bioavailability of arsenic and lead are important issues for accurate assessment of possible risks and hazard associated with these common mine-site contaminants. Bioavailability of both arsenic and lead have been shown to be much lower than default estimates used in this risk assessment at several mine sites. For example, measured bioavailability of arsenic has ranged from less than 10 percent to perhaps 50 percent for several mine and smelter wastes tested in juvenile swine (Henningsen et al. 1999). However, extrapolation among mining sites is difficult, because results of bioavailability assays have varied over a wide range and are apparently affected significantly by such factors as ore type(s), soil geochemistry, and milling and smelting operations. Detailed information that would be necessary to estimate bioavailability of arsenic and lead in mine wastes at the ALS are not available, and no site-specific estimate of bioavailability of either contaminant can be made at this time. Risk and hazard estimates for arsenic and lead may be overestimated as a result of this data gap. Bioavailability of either arsenic or lead could be revisited if better support is needed in the future for risk management decisions.

7.7 Uncertainties Associated with Risk Characterization

Risk assessment guidance (USEPA 1989) stresses the importance of considering uncertainties in interpreting and applying results of any risk assessment. Assumptions are made using professional judgment and the scientific literature on site-specific risk assessments. In general, assumptions made throughout this risk assessment are conservative in that they would tend to overestimate exposure and resultant risk rather than underestimate it. In some instances, a range of plausible exposure estimates for lead were included in the risk assessment to better reflect the range of reasonable exposure estimates based on most recent information and recognized uncertainties.

A key uncertainty in the risk assessment is the assumption that parts of the site may be developed for residential exposure in the future. Although theoretically possible, the former mine operational area would not seem to be a particularly attractive site for building and it seems unlikely that such development would completely reverse the current cover and bring residual contamination, without dilution, to the surface. Part of the site, the repository of mine wastes, must be maintained in perpetuity by the State of Missouri. Other parts of the site could be developed, but such development would likely involve excavation of limited areas, and would not necessarily result in spreading of contaminated subsurface soils over all of the soils in the immediate yard of any residence. Thus, the assumption of residential exposure to currently covered residual contamination is likely a very conservative assumption for evaluating the removal area.

The risk characterization is also uncertain because of some basic assumptions made concerning the removal action recently completed for the site. Specifically, the assessment concluded that development on the repository in the former mine operational area would be excluded in perpetuity because of the requirement that the State of Missouri maintain the integrity of the cap on this repository. Furthermore, the assessment assumed that repair and maintenance of the 18" clean fill cover over the site would continue until the site was completely revegetated and the soil cover was stable.

While both of these assumptions concerning the removal action seem reasonable, one cannot be completely certain that the repository and soil cover will always remain uncompromised. For future residents and construction workers, this uncertainty applies only to the repository, since the assessment assumed that residential development could be possible on the rest of the mine operational area. However, no exposure was assumed for recreational visitors to any subsurface source of residual mine-related contamination. Since integrity of the cover material may be the least certain of the two assumptions regarding the removal action, uncertainties are greater for recreational visitors.

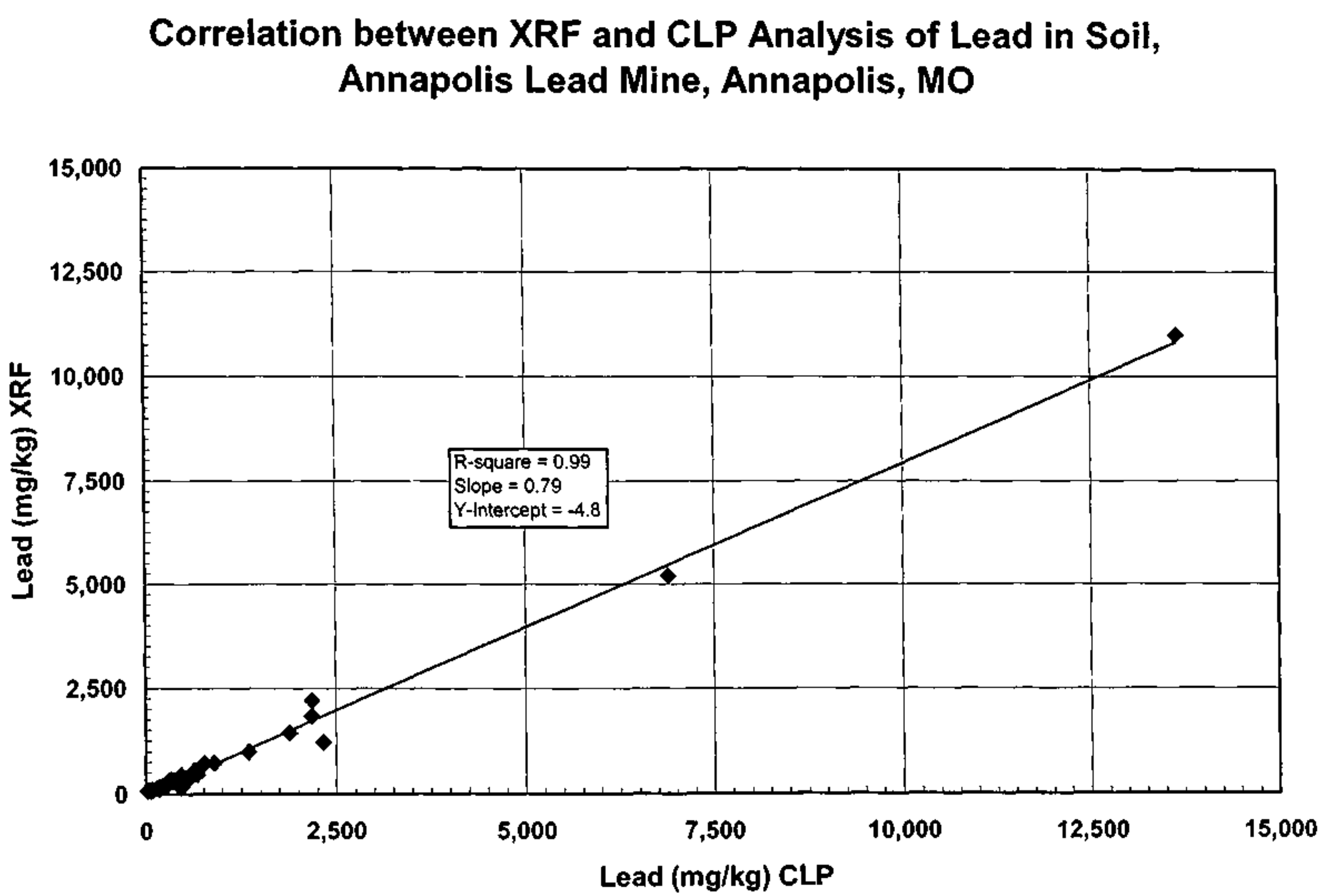

Figure 7-1: Correlation between XRF and CLP Analysis of Lead in Soil.

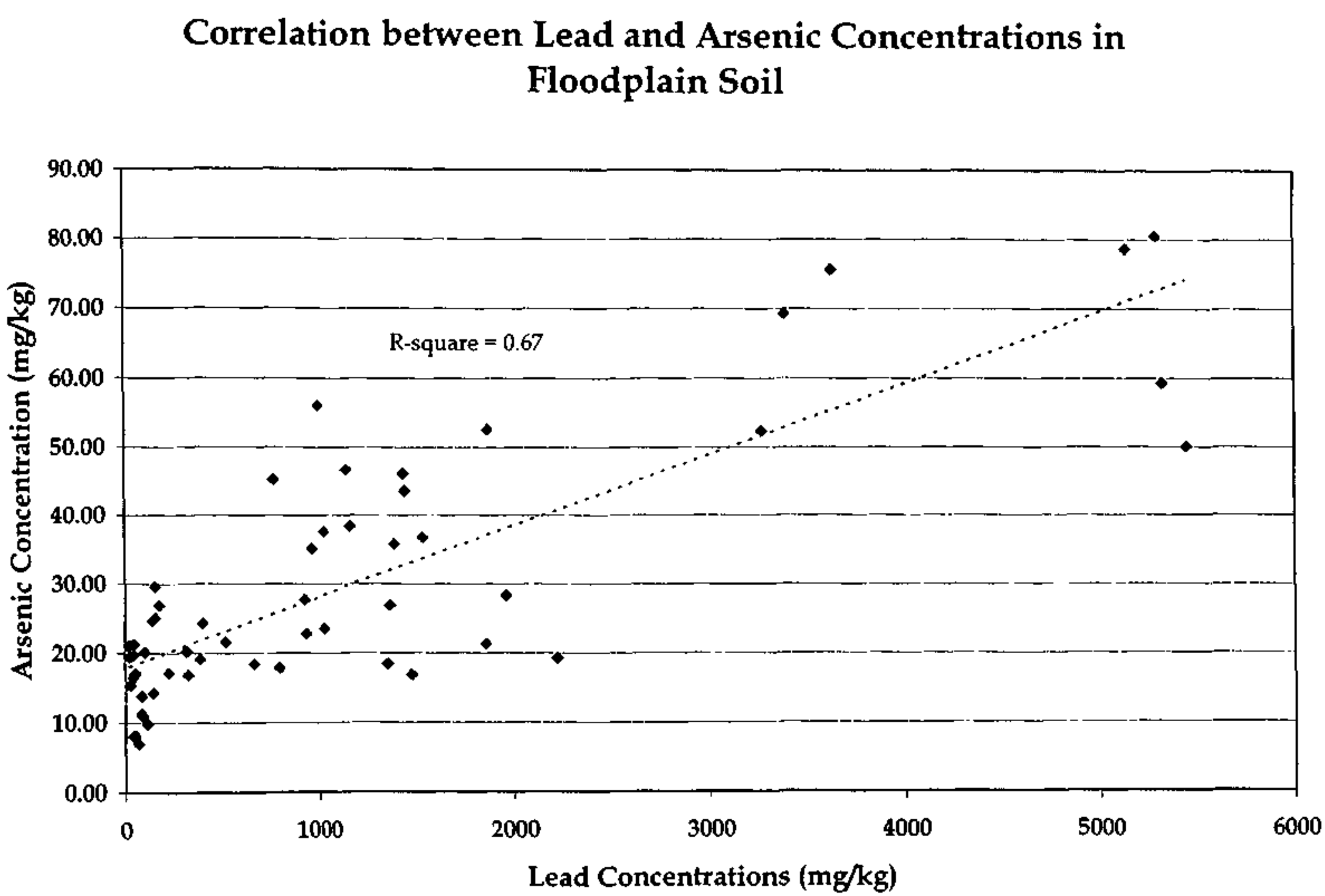

Figure 7-2: Correlation between Lead and Arsenic Concentrations in Floodplain Soil.

Section 8
Summary and Conclusions

The HHRA for the Annapolis Lead Mine used standard USEPA guidance along with both default and site-specific information to assess potential health risks for people living, working, or recreating in the area. The assessment focused on evaluating potential exposure to lead and other mine-related materials under existing conditions. For the former mine operations area, this focus requires estimation of potential risks and hazards following a recently completed removal action. In this area, the risk assessment provides information on residual risk and hazard posed by contamination left in subsurface soils after the removal. In the floodplain of the Sutton Branch, no removal activities have taken place. The risk assessment for this area provides a basic baseline risk assessment that can be used to help assess the need for remediation. Throughout the assessment, evaluation of mine operations area and the floodplain is kept separate to aid risk managers in understanding the different risk scenarios and focus employed.

The approach, results, and uncertainties of the risk assessment are summarized below, followed by a listing of conclusions supported by these results.

8.1 Summary of HHRA Approach

A HHRA was conducted for the site based on basic USEPA guidance (USEPA 1989), supplemented with more recent guidance and policy as appropriate. Site characterization data collected in recent field investigations and during the removal action in the former mine operations area were used in this HHRA to evaluate the possible exposure concentrations for residual contamination in the mine operations area and existing contamination in the Sutton Branch floodplain. Exposure concentrations help define risks and hazards due to exposure to metals and arsenic detected in site media (soil, surface water, sediment, and groundwater). Assumptions, methods, and results are summarized below.

Potentially Exposed Populations. Risks and hazards for three potential receptor groups were evaluated in the HHRA including current and future residents, current and future recreationists, and future construction workers. Future residents and construction workers were used to assess residual risks in areas of the mine operations area that are above the floodplain. Current and future recreationists were used to assess potential risks and hazards associated with existing contamination in the floodplain of the Sutton Branch.

Media of Concern and Exposure Pathways. Based on site data, media of concern are soil, indoor dust, air, vegetation, fish, groundwater, surface water, and sediment. Only a subset of these media was, however, assessed quantitatively in the risk assessment. Current and future residents and future construction workers were evaluated for direct contact with surface or subsurface soils and indoor dust (incidental ingestion and dermal contact (arsenic only)). Current and future residents were also evaluated for ingestion and dermal contact with potable water derived from shallow groundwater beneath the mine operations area. Recreationists were evaluated for incidental ingestion of surface soil, surface water and sediment and for dermal contact with soil, sediment, and surface water.

RME exposures were evaluated for the above receptors for all COPCs except lead. USEPA guidance generally defines RME as an exposure well above the average, but within the range of those possible. Estimates of central tendency exposures (CTE) were not included in the assessment. Risk and hazard estimates based on CTE were not thought to be essential because virtually all unacceptable exposures for the site were lead. This metal is evaluated using alternative methodology and the concepts of RME and CTE do not apply. Exposures to other COPCs, evaluated using RME estimates, were at or below levels of concern. CTE estimates would be less and therefore would not be highly informative.

Chemicals of Potential Concern. COPCs were selected for the ALS using comparisons of maximum concentrations of metals and arsenic detected in soil with residential PRGs developed by USEPA Region 9. Constituents with maximum concentrations above their PRGs were selected as COPCs. COPCs for surface soil included arsenic, lead, and manganese. COPCs selected for subsurface soil are the same as those selected for surface soil. COPCs selected for sediment include arsenic and lead. Surface water COPCs selected were arsenic, lead, manganese, and thallium. Groundwater COPCs selected were arsenic, iron, lead, and thallium. These COPCs are likely to represent all mining-related contaminants at the site that could be of concern for human health.

Evaluation of Exposure to Lead. Lead exposure is not assessed using standard risk assessment methods. Instead, exposures in residential settings are typically evaluated using USEPA's IEUBK model. Other exposure scenarios can be assessed using the Adult Lead Methodology, also developed by USEPA. For the ALS, the IEUBK model was used to assess risks to hypothetical future residents at the mine operations area, under the assumption that future residential development would transfer subsurface residual contamination to the surface. The Adult Lead Methodology was used to characterize potential lead exposures for construction workers involved in residential development in the mine operations area and to characterize potential lead exposures for recreational visitors to floodplain areas of the Sutton Branch.

8.2 Summary of HHRA Results

Quantitative risk and hazard estimates were developed for residents, construction workers and recreational users.

Residential Lead Exposures. The IEUBK model was used to assess lead exposures for young children. Lead exposures for future residential children were assessed for exposure to soil in the former mine site. Hot spots in this area were evaluated separately. To illustrate the range for possible impacts to blood lead levels both default and alternative values for key parameters in the model were assessed in the uncertainties section.

Most soils in the former mining operations area of the site that were sampled during post-removal activities have lead concentrations that are below levels of potential concern. A young child that might live or play in these areas and be exposed to average soil and dust concentrations would not be expected to have greater than a 5 percent chance of having their blood lead concentrations exceed the health protection goals of 10 µg/dL; when this criterion is met, lead exposures are unlikely to represent a significant hazard. This conclusion would apply to the current Mayberry residence and any residences outside of the floodplain south of Hwy 49. Lead concentrations in yards of these residences are below the screening value of 400 mg/kg.

For identified hotspots in the former mining operations area that were sampled, average lead concentrations could be high enough to represent a hazard to young children. In hotspot areas, lead exposures are predicted to be very high and lead concentrations in soil and dust could theoretically cause a young child exposed to average soil and dust concentrations in these areas to have a high probability of having a blood lead concentration exceeding the health protection goal of 10 µg/dL. Such exposures would only occur if residual lead contamination that exists below the 18 inch clean cover were to be brought to and left on the surface after residential development at the site. Currently, no exposure pathways exist for residual lead beneath the clean soil cover.

Nonresidential Lead Exposures. USEPA's Adult Lead Methodology (ALM) (USEPA 1996b) was used to assess intermittent or variable exposures to lead at the site by recreational users (older children) and construction workers. The current and future recreational user was evaluated based on an older child/adolescent scenario (7 to 16 years) for exposures to lead in soil while recreating in the Sutton Branch floodplain. Lead exposure for these individuals is not expected to cause more than a 5 percent chance of blood lead concentrations in a fetus exceeding 10 µg/dL for recreational visitors exposed to average floodplain soil or sediment concentrations.

Lead exposures for a construction worker were assessed for exposure to soil in the former mine operations area. Hot spots were evaluated separately. The predicted blood lead level for a construction worker exposed to average concentrations of lead in soil outside of hotspot areas was 2.1 µg/dL; the probability that fetal blood lead concentrations would exceed the health protection goal of 10 µg/dL was 2 percent for such an individual. This finding suggests that hazards associated with lead exposure are not expected for construction workers in most areas of the former mine site; however, only surface soil data were available to evaluate potential exposures after the removal action occurred. Construction workers would most likely be exposed to contamination in subsurface soil during construction activities and lack of subsurface data for some areas of the site where no removal took place may cause underestimation of potential exposure for future workers in the former mine area. Potential exposure was also evaluated for construction workers working in two hot spot areas; near the former Clark residence and north of the Mayberry residence. Exposures at these areas are above levels of concern for both the worker and the fetus. The central estimate worker blood lead levels could range from 10.7 µg/dL to 25.8 µg/dL for individuals exposed to average lead concentrations in soil. Probabilities that fetal blood lead concentrations would exceed USEPA's health protection goal of 10 µg/dL are 48 to 86 percent for a fetus of a construction worker exposed to average concentrations of lead in soils in these hotspots.

Total Carcinogenic Risks for Residents. Cancer risks at the site are due to exposure to arsenic; potential health risks due to exposure to arsenic were assessed using standard USEPA exposure equations and a combination of site-specific and USEPA default exposure assumptions. Post removal analytical data for arsenic in soil are not available; therefore, potential exposures associated with soil are not evaluated. Cancer risk for the groundwater exposure pathway was 2×10^{-5}; this estimate is based on ingestion of arsenic in groundwater and dermal contact with arsenic during bathing or showering. The groundwater dataset was small and maximum concentrations were used to estimate cancer risks. Cancer risks for future residents based on RME fall within USEPA's acceptable risk range. The lack of soil data for COPCs other than lead may underestimate risk for the future residential scenario.

Total Carcinogenic Risks for Workers. Cancer risks could not be estimated for the construction workers because data for soil constituents other than lead are not available to characterize post-removal conditions for the mine operations area. This data gap could result in some underestimation of risk for the site.

Total Carcinogenic Risks for Recreational Users. Cancer risk for recreational visitors to the floodplain (1×10^{-5}) falls within the USEPA's risk management range of 1×10^{-6} to 1×10^{-4}.

Noncancer Hazards for Residents. Noncancer hazards were estimated using standard USEPA exposure equations and a combination of site-specific and USEPA default exposure assumptions. Post removal analytical data for arsenic in soil are not available; therefore, potential exposures associated with soil are not evaluated. HI's for the groundwater exposure pathway were greater than one for both adults and children. These HI's, 6 and 11 for adults and children, respectively, are due mainly (80%) to potential exposure to iron. As discussed in Section 7, Uncertainties, the RfD for iron is outdated and subject to considerable uncertainty. Recent information suggests that the RfD could be too conservative by an order of magnitude. If the RfD that was used in the assessment was replaced by one ten times higher, HQs for iron would fall at or below the target of 1. Given available evidence, HQs for iron seem likely to fall into the acceptable range.

The HQ associated with ingestion of thallium in groundwater was also greater than one for the child (HI of 2). Maximum analytical results from three groundwater wells in the area were used to evaluate residential exposures to groundwater; thallium concentration was elevated in one of the residential drinking water wells sampled. Maximum concentrations used as exposure point concentrations may overestimate potential hazards.

Noncancer Hazards for Workers. Noncancer hazards could not be estimated for the construction workers because data for soil constituents other than lead are not available to characterize post-removal conditions for the mine operations area. This data gap could result in some underestimation of hazards for the site.

Noncancer Hazards for Recreational Users. Noncancer health hazards for all COPCs and pathways for recreational users were less than one, even when exposure frequency was assumed to be 5 days per week. This finding suggests that adverse noncancer health effects for recreational users at the site are not expected.

8.3 Conclusions

Based on the results of field investigations and the HHRA, the following conclusions are appropriate concerning human health risks and hazards associated with mine wastes in the ALS. Note that all risk and hazard estimates for COPCs other than lead are based on RME.

- Residual contamination in the mine operations area is generally below levels of concern for lead. However, hotspots exist in limited areas that could be associated with unacceptable exposures to lead. Unacceptable exposure could be realized for both future construction workers and future residents.

- Lead exposures for the mine operations area would be realized only if residual contamination beneath the 18" soil cover is excavated into or is brought to the surface in a residential yard. In the absence of development of the area, no complete exposure pathways for residual soil contamination would exist, provided that the cover remains intact.

- Lead is the only COPC that was assessed for the mine operations area; post-removal data was not available for other constituents. Some information suggests that higher concentrations of arsenic co-exist with elevated concentrations of lead. Thus, appropriate management of lead exposures is also expected to address risks due to exposure to arsenic. However, data are insufficient to demonstrate that this conclusion holds for all portions of the site. The other COPC, manganese, is present at concentrations above its screening criterion in only one sample in the floodplain. Manganese contamination does not appear to be sufficiently high to cause significant health impacts.

- Lead exposures for recreational visitors to the floodplain are not expected to reach unacceptable levels. These exposure estimates are based on frequent visits to an area that appears to be unattractive for recreation. The floodplain areas are heavily vegetated which may limit exposure to contaminated soils. The conclusion that risks and hazards for recreational visitors fall below levels of concern can be accepted with confidence.

- Lead exposures due to recreational contact with surface water and sediment in Sutton Branch Creek appear to be too low to cause unacceptable risk.

- Cancer risk due to exposure to arsenic in groundwater falls within USEPA's risk management range. However, hazards due to exposure to iron and thallium do fall above the target hazard of one and may imply some potential for unacceptable noncancer hazards. Groundwater risk and hazard estimates are based on maximum detected concentrations in a limited data set. Additional data would have to be collected to determine if these estimates are accurate and widespread in shallow groundwater. Further, the high HQ for iron is based on an outdated RfD and newer information suggests that the HQ could be overestimated by a factor of 10. If so, the major source of potential noncancer hazard would be eliminated.

- Cancer risks and noncancer hazards for recreational exposures in the floodplain and creek fall within the risk management range for cancer risk and below one for hazards. These results suggest that recreational exposure to COPCs other than lead may be in an acceptable range.

Section 9
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ANNAPOLIS LEAD MINE

HUMAN HEALTH RISK ASSESSMENT

APPENDIX A

Sampling Results

Table A-1: Surface Water Sampling Results

Sample #	Sampling Location	Comment	Al (ug/L)		Sb (ug/L)		As (ug/L)		Ba (ug/L)		Be (ug/L)		Cd (ug/L)		Ca (ug/L)		Cr (ug/L)		Co (ug/L)		Cu (ug/L)		Fe (ug/L)		PB (ug/L)		Mg (ug/L)		Mn (ug/L)		Mo (ug/L)		Ni (ug/L)		K (ug/L)		Se (ug/L)		Ag (ug/L)		Na (ug/L)		Tl (ug/L)		Ti (ug/L)		V (ug/L)		Zn (ug/L)	
2340-1	Big Creek upstream grover smelter	Instream pore water	17.00	U	8.50	U	3.50	U	37.50		0.50	U	0.50	U	0.011		2.00	U	1.50	U	1.00	U	14.50	U	5.00	U	0.006		10.50		2.50	U	3.00	U	0.001		20.00	U	3.50	U)	0.002		18.50	U	2.00	U	1.50	U	2.00	U
2340-2	Big Creek downstream grover smelter	Instream pore water	17.00	U	8.50	U	3.50	U	269.00		0.50	U	0.50	U	0.051		6.14		43.20		1.00	U	9180		14.00		0.019		6620		2.50	U	25.50		0.004		20.00	U	3.50	U	0.004		18.50	U	2.00	U	1.50	U	23.90	
2340-3	Sutton Branch above PPE northern most site	Instream pore water	17.00	U	8.50	U	3.50	U	35.30		0.50	U	0.50	U	0.009		2.00	U	1.50	U	1.00	U	14.50	U	5.00	U	0.005		6.03		2.50	U	3.00	U	0.001	U	20.00	U	3.50	U	0.001	U	18.50	U	2.00	U	1.50	U	2.00	U
2340-4	Sutton Branch above PPE ds sample #3	Instream pore water	17.00	U	8.50	U	3.50	U	42.80		0.50	U	0.50	U	0.019		2.00	U	1.50	U	1.00	U	14.50	U	5.00	U	0.010		6.51		8.28		3.00	U	0.001	U	20.00	U	3.50	U	0.001	U	18.50	U	2.00	U	1.50	U	2.00	U
2340-5	Sutton Branch	Pore Water	94.30		8.50	U	3.50	U	73.20		0.50	U	0.50	U	0.089		9.49		14.20		1.00	U	473.00		274.00		0.045		139.00		26.80		45.80		0.002		20.00	U	3.50	U	0.002		18.50	U	2.00	U	1.50	U	75.80	
2340-6	Sutton Branch below PPE above 49	Instream pore water	17.00	U	8.50	U	3.50	U	25.20		0.50	U	0.50	U	0.031		2.00	U	1.50	U	1.00	U	14.50	U	10.70		0.017		2.09		7.65		7.57		0.001	U	20.00	U	3.50	U	0.001	U	18.50	U	2.00	U	1.50	U	2.00	U
2340-7	Sutton Branch below 49	Pore Water	17.00	U	8.50	U	3.50	U	32.30		0.50	U	0.50	U	0.018		2.00	U	1.50	U	1.00	U	14.50	U	5.00	U	0.010		4.79		9.29		3.00	U	0.001	U	20.00	U	3.50	U	0.001	U	18.50	U	2.00	U	1.50	U	2.00	U
2340-8	Sutton Branch just us confluence Big Creek	Stream pore sample	17.00	U	8.50	U	3.50	U	21.60		0.50	U	0.50	U	0.013		2.00	U	1.50	U	1.00	U	14.50	U	5.00	U	0.007		2.36		2.50	U	3.00	U	0.001	U	20.00	U	3.50	U	0.002		18.50	U	2.00	U	1.50	U	2.00	U
2340-9	Sutton Branch btwn 7&8	Pore Water	37.00		8.50	U	3.50	U	37.20		0.50	U	0.50	U	0.021		2.00	U	16.70		1.00	U	14.50	U	14.40		0.011		93.60		9.59		15.40		0.001	U	20.00	U	3.50	U	0.001	U	18.50	U	2.00	U	1.50	U	2.00	U
2340-10	Big Creek ds Sutton Branch	Instream pore water	17.00	U	8.50	U	3.50	U	34.60		0.50	U	0.50	U	0.024		2.00	U	1.50	U	1.00	U	14.50	U	5.00	U	0.013		1.00	U	8.21		3.00	U	0.001		20.00	U	3.50	U	0.003		18.50	U	2.00	U	1.50	U	2.00	U
2340-10FD	Big Creek ds Sutton Branch	Instream pore water	17.00	U	8.50	U	3.50	U	34.70		0.50	U	0.50	U	0.025		2.00	U	1.50	U	1.00	U	14.50	U	5.00	U	0.013		1.00	U	2.50	U	7.96		0.001		20.00	U	3.50	U	0.003		18.50	U	2.00	U	1.50	U	2.00	U
2340-11	Big Creek us Sutton Branch	Instream pore water	17.00	U	8.50	U	3.50	U	46.40		0.50	U	0.50	U	0.057		2.00	U	1.50	U	1.00	U	14.50	U	5.00	U	0.030		1.00	U	13.20		16.30		0.001	U	20.00	U	3.50	U	0.012		18.50	U	2.00	U	1.50	U	2.00	U
2340-22	Big Creek below grover smelter	Water column	17.00	U	8.50	U	3.50	U	35.80		0.50	U	0.50	U	0.017		2.00	U	1.50	U	1.00	U	14.50	U	5.00	U	0.009		5.49		2.50	U	3.00	U	0.002		20.00	U	3.50	U	0.004		18.50	U	2.00	U	1.50	U	33.70	
2340-23	Sutton Branch NMP	Water column	17.00	U	8.50	U	3.50	U	32.10		0.50	U	0.50	U	0.009		2.00	U	1.50	U	1.00	U	14.50	U	5.00	U	0.005		2.06		2.50	U	3.00	U	0.001	U	20.00	U	3.50	U	0.001	U	18.50	U	2.00	U	1.50	U	2.00	U
2340-24	Sutton Branch NMP below PPE	Water column	17.00	U	8.50	U	3.50	U	32.40		0.50	U	0.50	U	0.015		2.00	U	1.50	U	1.00	U	14.50	U	5.00	U	0.008		3.14		5.41		3.00	U	0.001	U	20.00	U	3.50	U	0.001	U	18.50	U	2.00	U	1.50	U	2.00	U
2340-25		Water column	37.80		8.50	U	3.50	U	32.40		0.50	U	0.50	U	0.016		2.00	U	1.50	U	1.00	U	14.50	U	5.00	U	0.009		3.27		7.51		3.00	U	0.001	U	20.00	U	3.50	U	0.002	U	18.50	U	2.00	U	1.50	U	2.00	U
2340-26		Water column	17.00	U	8.50	U	3.50	U	33.50		0.50	U	0.50	U	0.018		2.00	U	1.50	U	9.12		14.50	U	5.00	U	0.010		5.99		2.50	U	3.00	U	0.001	U	20.00	U	3.50	U	0.001	U	18.50	U	2.00	U	1.50	U	2.00	U
2340-27		Water column	17.00	U	8.50	U	19.90		32.40		0.50	U	0.50	U	0.018		2.00	U	1.50	U	1.00	U	14.50	U	5.00	U	0.010		4.94		5.14		3.00	U	0.001	U	20.00	U	3.50	U	0.001	U	18.50	U	2.00	U	1.50	U	2.00	U
2340-28		Water column	17.00	U	8.50	U	7.95		29.70		0.50	U	0.50	U	0.015		2.00	U	1.50	U	1.00	U	14.50	U	5.00	U	0.009		1.00	U	2.50	U	3.00	U	0.001	U	20.00	U	3.50	U	0.001	U	18.50	U	2.00	U	1.50	U	2.00	U
2340-29		Water column	17.00	U	8.50	U	3.50	U	32.20		0.50	U	0.50	U	0.018		2.00	U	1.50	U	1.00	U	14.50	U	5.00	U	0.010		11.50		6.52		7.86		0.001	U	20.00	U	3.50	U	0.001	U	18.50	U	2.00	U	1.50	U	2.00	U
2340-30		Water column	17.00	U	8.50	U	12.40		31.00		0.50	U	0.50	U	0.019		2.00	U	1.50	U	1.00	U	14.50	U	5.00	U	0.010		10.90		6.13		7.70		0.001		20.00	U	3.50	U	0.003		18.50	U	2.00	U	1.50	U	2.00	U
2340-30FD		Water column	17.00	U	8.50	U	3.50	U	30.40		0.50	U	0.50	U	0.019		2.00	U	1.50	U	1.00	U	14.50	U	5.00	U	0.010		5.27		2.50	U	3.00	U	0.001		20.00	U	3.50	U	0.003		18.50	U	2.00	U	1.50	U	2.00	U
2340-31		Water column	17.00	U	8.50	U	18.70		32.30		0.50	U	0.50	U	0.019		2.00	U	1.50	U	1.00	U	14.50	U	5.00	U	0.010		3.44		5.37		7.64		0.001		20.00	U	3.50	U	0.003		18.50	U	2.00	U	1.50	U	2.00	U
2340-32	Big Creek us grover smelter	bank pore water - bckgrnd	57.40		8.50	U	3.50	U	104.00		0.50	U	0.50	U	0.012		2.00	U	1.50	U	1.00	U	14.50	U	5.00	U	0.007		1.00	U	2.50	U	3.00	U	0.001		20.00	U	3.50	U	0.004		18.50	U	2.00	U	1.50	U	6.28	
2340-33	Big Creek below grover smelter	bank pore water	17.00	U	8.50	U	3.50	U	118.00		0.50	U	0.50	U	0.022		2.00	U	1.50	U	1.00	U	14.50	U	5.00	U	0.012		30.50		2.50	U	6.93		0.001		20.00	U	3.50	U	0.003		18.50	U	2.00	U	1.50	U	70.30	
2340-34		bank pore water	17.00	U	8.50	U	3.50	U	35.40		0.50	U	0.50	U	0.014		2.00	U	1.50	U	1.00	U	14.50	U	5.00	U	0.008		1.00	U	2.50	U	3.00	U	0.001	U	20.00	U	3.50	U	0.001	U	18.50	U	2.00	U	1.50	U	2.00	U
2340-35	Sutton Branch	bank pore water	17.00	U	8.50	U	3.50	U	44.70		0.50	U	0.50	U	0.031		2.00	U	1.50	U	1.00	U	14.50	U	5.00	U	0.016		1.00	U	7.50		8.20		0.001		20.00	U	3.50	U	0.001	U	18.50	U	2.00	U	1.50	U	2.00	U
2340-36		bank pore water	17.00	U	8.50	U	3.50	U	82.50		0.50	U	0.50	U	0.075		8.19		51.00		1.00	U	735.00		31.30		0.037		883.00		18.60		40.60		0.002		20.00	U	3.50	U	0.002		18.50	U	2.00	U	1.50	U	27.50	
2340-37		bank pore water	17.00	U	8.50	U	18.90		30.00		0.50	U	0.50	U	0.033		2.00	U	1.50	U	1.00	U	14.50	U	35.70		0.018		2.39		7.91		5.50		0.001	U	20.00	U	3.50	U	0.001	U	18.50	U	2.00	U	1.50	U	5.23	
2340-38		bank pore water	17.00	U	8.50	U	3.50	U	25.00		0.50	U	0.50	U	0.024		2.00	U	1.50	U	1.00	U	14.50	U	11.00		0.013		1.00	U	5.90		14.20		0.001	U	20.00	U	3.50	U	0.001	U	18.50	U	2.00	U	1.50	U	2.00	U
2340-39		bank pore water	17.00	U	8.50	U	3.50	U	23.70		0.50	U	0.50	U	0.014		2.00	U	1.50	U	1.00	U	14.50	U	5.00	U	0.008		2.41		8.56		3.00	U	0.001	U	20.00	U	3.50	U	0.002		18.50	U	2.00	U	1.50	U	2.00	U
2340-40		bank pore water	17.00	U	8.50	U	12.40		29.00		0.50	U	0.50	U	0.021		2.00	U	1.50	U	1.00	U	14.50	U	12.80		0.011		15.90		2.50	U	12.00		0.001	U	20.00	U	3.50	U	0.001	U	18.50	U	2.00	U	1.50	U	2.00	U
2340-41		bank pore water	17.00	U	8.50	U	10.80		35.70		0.50	U	0.50	U	0.024		2.00	U	1.50	U	1.00	U	14.50	U	5.00	U	0.013		1.00	U	7.41		3.00	U	0.001		20.00	U	3.50	U	0.003		18.50	U	2.00	U	1.50	U	2.00	U
2340-41FD		bank pore water	17.00	U	8.50	U	3.50	U	34.10		0.50	U	0.50	U	0.024		2.00	U	1.50	U	1.00	U	14.50	U	5.00	U	0.013		1.00	U	2.50	U	6.76		0.001		20.00	U	3.50	U	0.003		18.50	U	2.00	U	1.50	U	2.00	U
2340-42		bank pore water	17.00	U	8.50	U	3.50	U	43.60		0.50	U	0.50	U	0.044		2.00	U	1.50	U	1.00	U	14.50	U	5.00	U	0.023		1.00	U	9.15		12.50		0.001		20.00	U	3.50	U	0.009		18.50	U	2.00	U	1.50	U	2.00	U
2293-101 (SW-01)	Big Creek us Sutton Branch		25.00	U	25.00	U	29.00		28.30		1.50	U	1.50	U	0.020		7.50	U	5.00	U	2.50	U	25.00	U	25.00	U	0.009		10.20		7.50	U	10.00	U	0.001	U	25.00	U	12.50	U	0.003	U	25.00	U	10.00	U	5.00	U	12.50	U
2293-102 (SW-02)	Big Creek ds Sutton Branch		25.00	U	25.00	U	12.50	U	28.00		1.50	U	1.50	U	0.020		7.50	U	5.00	U	2.50	U	25.00	U	25.00	U	0.009		7.75		7.50	U	10.00	U	0.001	U	25.00	U	12.50	U	0.003	U	25.00	U	10.00	U	5.00	U	12.50	U
2293-103 (SW-03)	Sutton Branch below 49		25.00	U	25.00	U	12.50	U	30.20		1.50	U	1.50	U	0.019		7.50	U	5.00	U	2.50	U	25.00	U	25.00	U	0.009		2.50	U	7.50	U	10.00	U	0.001	U	25.00	U	12.50	U	0.003	U	101.00		10.00	U	5.00	U	12.50	U
2293-104 (SW-04)	Sutton Branch below 49		25.00	U	25.00	U	12.50	U	31.10		1.50	U	1.50	U	0.020		7.50	U	5.00	U	2.50	U	25.00	U	25.00	U	0.010		11.50		7.50	U	10.00	U	0.001	U	25.00	U	12.50	U	0.003	U	25.00	U	10.00	U	5.00	U	12.50	U
2293-105 (SW-05)	Sutton Branch below 49		25.00	U	25.00	U	12.50	U	31.30		1.50	U	1.50	U	0.020		7.50	U	5.00	U	2.50	U	25.00	U	25.00	U	0.010		9.98		7.50	U	10.00	U	0.001	U	59.30		12.50	U	0.003	U	25.00	U	10.00	U	5.00	U	12.50	U

	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	PB	Mg	Mn	Mo	Ni	K	Se	Ag	Na	Tl	Ti	V	Zn
Std Dev	14.12	5.53	6.13	41.56	0.33	0.33	0.02	2.33	10.35	1.35	1450.32	42.64	0.01	1050.80	4.79	9.40	0.00	6.32	3.01	0.00	13.09	2.68	1.17	16.68
Avg	21.96	10.56	6.95	44.97	0.63	0.63	0.02	3.13	4.92	1.39	274.43	16.60	0.01	198.20	6.48	8.81	0.00	21.48	4.63	0.00	21.21	3.00	1.94	9.03
Min	17.00	8.50	3.50	21.60	0.50	0.50	0.01	2.00	1.50	1.00	14.50	5.00	0.01	1.00	2.50	3.00	0.00	20.00	3.50	0.00	18.50	2.00	1.50	2.00
Max	94.30	25.00	29.00	269.00	1.50	1.50	0.09	9.49	51.00	9.12	9180.00	274.00	0.05	6620.00	26.80	45.80	0.00	59.30	12.50	0.01	101.00	10.00	5.00	75.80
Location of Max	2340-5	ND	2340-27	2340-2	ND	ND	2340-5	2340-5	2340-36	2340-26	2340-2	2340-5	2340-5	2340-2	2340-5	2340-5	2340-2	2293-105 (SW-05)	ND	2340-11	2293-103 (SW 03)	ND	ND	2340-5
Reg. 9 PRG	36000	14.60	0.04	2554.99	73.00	18.25	na	109.50	730.00	1460.00	10949.88	15.00	na	876.00	182.50	730.00	na	182.50	182.50	na	2.41	145979	36.50	10949.9
c/nc	nc	nc	ca	nc	nc	nc	na	nc	nc	nc	nc	na	na	nc	nc	nc	na	nc	nc	na	nc	nc	nc	nc
retain as coc	no	no	yes	no	no	no	no	no	no	no	no	yes	no	yes	no	no	no	no	no	no	yes	no	no	no
n	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
# of Detects	4	0	8	40	0	0	40	3	4	1	3	8	40	28	20	17	16	1	0	18	1	0	0	7

Table A-2: Sediment Sampling Results

Sample #	Sampling Location	Comment	Al (mg/kg)		Sb (mg/kg)		As (mg/kg)		Ba (mg/kg)		Be (mg/kg)		Cd (mg/kg)		Ca (mg/kg)		Cr (mg/kg)		Co (mg/kg)		Cu (mg/kg)		Fe (mg/kg)	
2340-102	Big Creek below grover smelter						14.20						4.17											
2340-103	Sutton Branch NPM						18.60						1.00	U										
2340-104	Sutton Branch below NMP above PPE						14.90						1.00	U										
2340-105							5.00	UJ					1.00	UJ										
2340-106							5.04						1.00	U										
2340-107							10.60						1.00	U										
2340-108							8.79						1.00	U										
2340-109							7.69						1.00	U										
2340-110							6.69						1.00	U										
2340-110-FD							7.13						1.00	U										
2340-111	Big Creek us Sutton Branch						10.70						1.62											
2293-50 (SED-01)	Big Creek us Sutton Branch	SED-01	888.00		1.00	U	10.40		10.90		0.50	U	0.50	U	498.00		16.60		2.85		4.82		5510.00	
2293-51 (SED-02)	Big Creek ds Sutton Branch	SED-02	1250.00		1.00	U	2.50	U	29.40		0.50	U	0.50	U	9270.00		7.09		7.05		6.80		4730.00	
2293-52 (SED-03)	Sutton Branch below 49	SED-03	812.00		1.00	U	2.50	U	17.80		0.50	U	0.50	U	46900		1.00	U	21.70		13.40		5740.00	
2293-53 (SED-04)	Sutton Branch below 49	SED-04	1450.00		1.00	U	25.60		18.50		0.50	U	0.50	U	73900		1.00	U	40.20		45.50		8400.00	
2293-54 (SED-05)	Sutton Branch below 49	SED-05	610.00		1.00	U	2.50	U	8.32		0.50	U	0.50	U	64100		1.00	U	22.10		52.10		4580.00	
		Std Dev	340.94		0.00		6.33		8.20		0.00		0.88		32698.18		6.83		14.75		22.51		1539.54	
		Avg	1002.00		1.00		9.55		16.98		0.50		1.08		38933.6		5.34		18.78		24.52		5792.00	
		Min	610.00		1.00		2.50		8.32		0.50		0.50		498.00		1.00		2.85		4.82		4580.00	
		Max	1450.00		1.00		25.60		29.40		0.50		4.17		73900		16.60		40.20		52.10		8400.00	
		Location of Max	2293-53 (SED-04)		ND		2340-103		2293-51 (SED-02)		ND		2340-102		2293-53 (SED-04)		2293-50 (SED-01)		2293-53 (SED-04)		2293-54 (SED-05)		2293-53 (SED-04)	
		Reg. 9 PRG	76141.951		31.29		0.39		5374.91		154.37		37.03				210.68		902.89		3128.55		23463.185	
		c/nc	nc		nc		ca*		nc		nc		nc				ca		ca**		nc		nc	
		retain as coc	no		no		yes		no		no		no		no		no		no		no		no	
		n	5		5		16		5		5		16		5		5		5		5		5	
		# of Detects	5		0		12		5		0		2		5		2		5		5		5	

Sample #	PB (mg/kg)		Mg (mg/kg)		Mn (mg/kg)		Mo (mg/kg)		Ni (mg/kg)		K (mg/kg)		Se (mg/kg)		Ag (mg/kg)		Na (mg/kg)		Tl (mg/kg)		Ti (mg/kg)		V (mg/kg)		Zn (mg/kg)	
2340-102	115.00								8.25																108.00	
2340-103	22.50								20.40																27.50	
2340-104	9.62								5.01																16.50	
2340-105	19.70	J							2.00	UJ															5.00	UJ
2340-106	365.00								2.00	UJ															41.50	
2340-107	721.00								4.70																55.90	
2340-108	164.00								5.16																37.50	
2340-109	962.00								3.19																49.80	
2340-110	10.10								2.44																8.36	
2340-110-FD	40.26								3.61																13.30	
2340-111	24.30								4.82																23.20	
2293-50 (SED-01)	7.25		290.00		124.00		1.00	U	3.23		70.70		5.00	U	1.00	U	25.00	U		DR			8.39			
2293-51 (SED-02)	80.00		5100.00		464.00		1.00	U	5.54		121.00		5.00	U	1.00	U	25.00	U		DR			8.11			
2293-52 (SED-03)	280.00		26200.00		754.00		1.00	U	14.40		202.00		5.00	U	1.00	U	112.00			DR			5.52			
2293-53 (SED-04)	1070.00		42200.00		1090.00		1.00	U	32.20		409.00		5.00	U	1.00	U	168.00			DR			6.66		92.70	
2293-54 (SED-05)	268.00		36400.00		868.00		1.00	U	13.70		194.00		5.00	U	1.00	U	156.00			DR			2.50	U	40.40	
Std Dev	350.48		18641.13		375.07		0.00		8.26		129.11		0.00		0.00		69.13						2.39		31.21	
Avg	259.92		22038.00		660.00		1.00		8.17		199.34		5.00		1.00		97.20		0.00				6.24		39.97	
Min	7.25		290.00		124.00		1.00		2.00		70.70		5.00		1.00		25.00		0.00				2.50		5.00	
Max	1070.00		42200.00		1090.00		1.00		32.20		409.00		5.00		1.00		168.00		0.00				8.39		108.00	
Location of Max	2293-53 (SED-04)		2293-53 (SED-04)		2293-53 (SED-04)		ND		2340-103		2293-53 (SED-04)		ND		ND		2293-53 (SED-04)		ND		ND		2293-50 (SED-01)		2340-102	
Reg. 9 PRG	400.00				1762.35		391.07		1564.28				391.07		391.07				5.16				78.21		23463.18	
c/nc	nc				nc		nc		nc				nc		nc				nc		max		nc		nc	
retain as coc	yes		no		no		no		no		no		no		no		no		no				no		no	
n	16		5		5		5		16		5		5		5		5		0				5		13	
# of Detects	16		5		5		0		14		5		0		0		3		0		0		4		12	

Table A-3: Soil Sampling Results

Sample #	Sampling Location	Depth (ft.)	Comment	Al (mg/kg)	Sb (mg/kg)	As (mg/kg)	Ba (mg/kg)	Be (mg/kg)	Cd (mg/kg)	Ca (mg/kg)	Cr (mg/kg)	Co (mg/kg)	Cu (mg/kg)	Fe (mg/kg)	Pb (mg/kg)	Mg (mg/kg)	Mn (mg/kg)	Hg (mg/kg)	Ni (mg/kg)	K (mg/kg)	Se (mg/kg)	Ag (mg/kg)	Na (mg/kg)	Tl (mg/kg)	Tl (mg/kg)	V (mg/kg)	Zn (mg/kg)
2340-121	121		Big Creek bridge soil			15.50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2340-122	122					23.80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2340-123	123		soil/green zone by pond			35.70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2340-120	120					79.60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2340-124-FD	124-FD		soil/"hot" spot by house			45.90	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-1	GP10	4.0-4.5	RI/FS area, see figure 2	2320.00	1.00 U	21.30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-2	GP04	0.0-1.0	RI/FS area, see figure 2	2210.00	1.00 U	35.20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-3	GP04	1.0-3.0	RI/FS area, see figure 2	5270.00	2.04	20.10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-4	GP05	1.5-1.75	RI/FS area, see figure 2	3360.00	1.00 U	18.40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-5	GP06	1.5-3.0	RI/FS area, see figure 2	1070.00 J	1.00 U	37.60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-6	GP06	7.0-4.0	RI/FS area, see figure 2	7400.00	1.00 U	28.60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-7	GP11	4.0-6.0	RI/FS area, see figure 2	3260.00	1.00 U	28.30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-8	GP07	2.5-3.5	RI/FS area, see figure 2	2680.00	1.00 U	50.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-9	GP14	4.0-5.0	RI/FS area, see figure 2	6830.00	1.00 U	36.60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-10	GP16	5.5-6.5	RI/FS area, see figure 2	1120.00	1.00 U	19.20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-11	GP14	0.5-2.5	RI/FS area, see figure 2	1060.00	1.00 U	52.50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-12	GP12	2.0-4.0	RI/FS area, see figure 2	695.00	1.00 U	33.60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-13	GP11	4.0-5.5	RI/FS area, see figure 2	3610.00	1.00 U	17.80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-14	GP08	0.0-2.0	RI/FS area, see figure 2	2420.00	1.00 U	52.30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-15	GP09	0.0-2.0	RI/FS area, see figure 2	2220.00	1.00 U	78.60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-16	GP15	0.0-1.0	RI/FS area, see figure 2	5370.00	3.49	38.30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-17	GP17	0.0-3.0	RI/FS area, see figure 2	1760.00	1.00 U	59.30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-18	GP01	0.0-1.5	RI/FS area, see figure 2	1140.00	1.00 U	43.50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-19	GP02	0.0-1.5	RI/FS area, see figure 2	1590.00	1.00 U	26.90	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-20	GP02	1.5-3.0	RI/FS area, see figure 2	6130.00	1.00 U	17.10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-21	GP01	0.0-1.5	RI/FS area, see figure 2	5360.00	3.97	46.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-22	GP21	0.0-2.5	RI/FS area, see figure 2	6440.00	1.00 U	19.40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-23	GP30	0.0-2.0	RI/FS area, see figure 2	4260.00 J	1.00 U	31.30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-24	GP22	4.0-5.0	RI/FS area, see figure 2	1190.00	1.00 U	15.30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-25	GP31	0.5-2.0	RI/FS area, see figure 2	1950.00	1.00 U	13.80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-26	GP23	0.0-3.0	RI/FS area, see figure 2	1090.00	1.00 U	16.80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-27	GP23	3.0-4.0	RI/FS area, see figure 2	4440.00	1.41	37.70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-28	GP24	0.0-7.5	RI/FS area, see figure 2	7200.00	1.00 U	80.90	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-29	GP34	0.5-2.5	RI/FS area, see figure 2	6240.00	1.00 U	20.20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-30	GP33	2.0-3.5	RI/FS area, see figure 2	668.00	1.00 U	16.40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-31	GP38	1.5-3.5	RI/FS area, see figure 2	751.00	1.00 U	46.10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-32	GP39	3.5-6.0	RI/FS area, see figure 2	3010.00	2.70	56.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-33	GP31	4.0-5.5	RI/FS area, see figure 2	752.00	1.00 U	22.80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-34	GP32	5.5-7.5	RI/FS area, see figure 2	2970.00	1.14 U	24.30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-35	GP29	0.0-3.25	RI/FS area, see figure 2	3680.00	1.00 U	35.80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-36	GP26	0.0-2.25	RI/FS area, see figure 2	3200.00	1.00 U	69.30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-37	GP27	0.0-2.25	RI/FS area, see figure 2	3200.00	1.00 U	75.60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-38	GP28	0.0-2.25	RI/FS area, see figure 2	4220.00	5.72	21.60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-39	GP25	0.0-1.75	RI/FS area, see figure 2	2770.00	1.73	14.30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-40	GP36	0.0-2.5	RI/FS area, see figure 2	5870.00	1.00 U	24.70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-41	GP37	0.0-2.25	RI/FS area, see figure 2	3780.00	2.10	26.90	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-42	GP36	0.0-3.0	RI/FS area, see figure 2	4810.00	1.00 U	17.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-43	GP35	2.5-3.5	RI/FS area, see figure 2	4860.00	2.15	45.20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-44	GP19	3.5-4.0	RI/FS area, see figure 2	2340.00	1.00 U	16.50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-45	GP20	0.0-1.25	RI/FS area, see figure 2	4060.00	1.00 U	18.10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-46	GP19	0.0-1.5	RI/FS area, see figure 2	3320.00	1.00 U	14.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-47	GP16	0.0-1.5	RI/FS area, see figure 2	4640.00	1.00 U	19.70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-48	GP09	7.0-4.0	RI/FS area, see figure 2	5913.00	4.15	28.10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2293-49	GP21	4.0-8.0	RI/FS area, see figure 2	5910.00	4.56	21.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	GP43	0.0-1.0	RI/FS area, see figure 4, 5, 6	3250.00 J	6.01 UJ	9.00 UJ	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	GP44	0.0-1.0	RI/FS area, see figure 4, 5, 6	5800.00 J	5.98 UJ	7.22 UJ	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	GP48	0.0-1.0	RI/FS area, see figure 4, 5, 6	6290.00 J	6.07 UJ	9.24 UJ	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	GP50	3.0-1.0	RI/FS area, see figure 4, 5, 6	5440.00 J	6.04 UJ	5.41 UJ	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	GP57	0.0-1.0	RI/FS area, see figure 4, 5, 6	3150.00 J	5.91 UJ	4.07 UJ	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	GP61	3.0-1.0	RI/FS area, see figure 4, 5, 6	4000.00 J	6.04 UJ	6.90 UJ	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	GP65	3.0-1.0	RI/FS area, see figure 4, 5, 6	3950.00 J	6.11 UJ	4.16 UJ	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	GP67	2.0-1.0	RI/FS area, see figure 4, 5, 6	3940.00 J	6.02 UJ	6.44 UJ	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	GP78	0.0-1.5	RI/FS area, see figure 4, 5, 6	10900.00 J	6.06 UJ	10.90 UJ	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	GP73	0.0-2.0	RI/FS area, see figure 4, 5, 6	10900.00 J	6.03 UJ	11.20 UJ	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	GP75	0.0-3.0	RI/FS area, see figure 4, 5, 6	6730.00 J	6.09 UJ	8.10 UJ	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	GP77	0.0-1.0	RI/FS area, see figure 4, 5, 6	6280.00 J	6.01 UJ	8.00 UJ	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	GP76	0.0-0.5	RI/FS area, see figure 4, 5, 6	5670.00 J	6.02 UJ	9.80 UJ	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	GP81	0.0-0.5	RI/FS area, see figure 4, 5, 6	2460.00 J	5.82 UJ	6.99 UJ	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	GP82	0.0-1.0	RI/FS area, see figure 4, 5, 6	3220.00 J	6.02 UJ	8.59 UJ	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	GP91	0.0-1.0	RI/FS area, see figure 4, 5, 6	2660.00 J	5.96 UJ	9.63 UJ	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	GP94	3.0-1.0	RI/FS area, see figure 4, 5, 6	2860.00 J	5.92 UJ	8.85 UJ	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	GP96	0.0-1.0	RI/FS area, see figure 4, 5, 6	3560.00 J	6.05 UJ	6.79 UJ	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			Std Dev	2240.16	2.22	20.22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			Avg	3952.18	2.17	27.44	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			Min	664.00	1.00	4.16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			Max	10900.00	6.12	86.40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			Location of Max	2293-6	2293-38	2340-126	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			Reg. 9 PRG	76141.95	31.29	0.39	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			c/nc	nc	nc	ca*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			>Reg. 9 PRG	no	no	yes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			n	67	67	77	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			# of Detects	67	11	54	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table A-4: Surface Soil Sampling Results

Sample #	Sampling Location	Depth (ft.)	Comment	Al (mg/kg)	Sb (mg/kg)	As (mg/kg)	Ba (mg/kg)	Be (mg/kg)	Cd (mg/kg)	Ca (mg/kg)	Cr (mg/kg)	Co (mg/kg)	Cu (mg/kg)	Fe (mg/kg)	PB (mg/kg)
	GP78	0.0-0.5	RI/FS area; see figure 4, 5, 6	5670.00 J	6.02 UJ	9.80 UJ	225.00	0.889 J	0.50 UJ	1840.00	13.60	12.90 J	34.60 J	15000.00 J	112.00 J
	GP81	0.0-0.5	RI/FS area; see figure 4, 5, 6	2460.00 J	5.92 UJ	6.95 UJ	508.00	0.505 J	0.75 UJ	4590.00	10.40	7.85 J	22.20 J	8790.00 J	66.50 J
2293-2	GP04	0.0-1.0	RI/FS area; see figure 2	1210.00	1.00 U	35.10	8.71	0.500 U	0.50 U	121000.00	1.00 U	54.60	66.20	10800.00	961.00
2293-16	GP15	0.0-1.0	RI/FS area, see figure 2	5370.00	3.69	38.30	112.00	1.240	1.37	20300.00	5.42	42.80	38.30	12400.00	1170.00
	GP43	0.0-1.0	RI/FS area; see figure 4, 5, 6	3250.00 J	6.01 UJ	9.80 UJ	127.00	0.771 J	1.65 UJ	21900.00	10.50	24.20 J	89.90 J	12000.00 J	706.00 J
	GP44	0.0-1.0	RI/FS area; see figure 4, 5, 6	5800.00 J	5.98 UJ	7.33 UJ	301.00	1.420 J	0.50 UJ	1210.00	8.50	18.90 J	15.40 J	12800.00 J	42.30 J
	GP48	0.0-1.0	RI/FS area; see figure 4, 5, 6	6290.00 J	6.07 UJ	5.24 UJ	171.00	0.769 J	0.51 UJ	1500.00	15.70	14.00 J	11.70 J	10800.00 J	46.30 J
	GP50	0.0-1.0	RI/FS area; see figure 4, 5, 6	5440.00 J	6.04 UJ	5.41 UJ	248.00	1.110 J	0.50 UJ	1120.00	15.50	13.50 J	8.54 J	10500.00 J	36.00 J
	GP57	0.0-1.0	RI/FS area; see figure 4, 5, 6	5150.00 J	5.91 UJ	4.82 UJ	140.00	0.771 J	0.49 UJ	731.00	9.61	16.00 J	8.59 J	9530.00 J	30.70 J
	GP61	0.0-1.0	RI/FS area; see figure 4, 5, 6	4000.00 J	6.04 UJ	6.98 UJ	88.10	0.731 J	2.23 UJ	18600.00	14.70	16.00 J	191.00 J	10900.00 J	623.00 J
	GP65	0.0-1.0	RI/FS area; see figure 4, 5, 6	3950.00 J	6.12 UJ	4.16 UJ	128.00	0.661 J	0.51 UJ	1220.00	14.10	9.65 J	9.91 J	8110.00 J	41.30 J
	GP67	0.0-1.0	RI/FS area; see figure 4, 5, 6	3940.00 J	6.02 UJ	8.44 UJ	123.00	0.669 J	4.49 J	23500.00	16.50	28.30 J	200.00 J	13100.00 J	951.00 J
	GP77	0.0-1.0	RI/FS area; see figure 4, 5, 6	6280.00 J	6.03 UJ	8.00 UJ	160.00	1.040 J	0.50 UJ	1470.00	11.50	12.80 J	17.30 J	13700.00 J	39.20 J
	GP82	0.0-1.0	RI/FS area; see figure 4, 5, 6	3220.00 J	6.02 UJ	8.59 UJ	131.00	0.610 J	0.61 J	41700.00	10.10	52.30 J	120.00 J	17600.00 J	6370.00 J
	GP91	0.0-1.0	RI/FS area; see figure 4, 5, 6	2660.00 J	5.96 UJ	9.63 UJ	73.20	0.677 J	0.68 J	47400.00	14.70	22.60 J	254.00 J	13600.00 J	1630.00 J
	GP94	0.0-1.0	RI/FS area; see figure 4, 5, 6	2860.00 J	5.90 UJ	8.85 UJ	88.20	0.561 J	0.56 J	40800.00	14.60	17.50 J	137.00 J	11800.00 J	822.00 J
	GP96	0.0-1.0	RI/FS area; see figure 4, 5, 6	3560.00 J	6.05 UJ	8.79 UJ	94.90	0.658 J	0.66 J	65000.00	13.00	9.40 J	139.00 J	12200.00 J	607.00 J
2293-45	GP20	0.0-1.25	RI/FS area; see figure 2	4060.00	1.00 U	19.10	83.40	0.500 U	2.81	23000.00	7.90	19.30	27.90	10900.00	385.00
2293-18	GP03	0.0-1.5	RI/FS area; see figure 2	1140.00	1.00 U	43.50	21.30	0.500 U	2.28	135000.00	1.00 U	44.90	80.40	14500.00	1450.00
2293-19	GP02	0.0-1.5	RI/FS area; see figure 2	1550.00	1.00 U	26.90	31.30	0.500 U	1.74	118000.00	1.00 U	44.50	50.20	11800.00	1370.00
2293-21	GP01	0.0-1.5	RI/FS area; see figure 2	5360.00	3.97	46.60	90.90	1.030	1.47	16000.00	9.07	58.30	39.60	12100.00	1150.00
2293-46	GP19	0.0-1.5	RI/FS area; see figure 2	3320.00	1.00 U	16.80	90.70	0.500 U	0.50 U	14900.00	10.30	18.30	19.60	10500.00	324.00
	GP70	0.0-1.5	RI/FS area; see figure 4, 5, 6	10900.00 J	6.06 UJ	10.90 UJ	189.00	1.910 J	0.51 UJ	4100.00	18.30	17.00 J	24.30 J	20800.00 J	86.30 J
2293-39	GP29	0.0-1.75	RI/FS area; see figure 2	2770.00	3.72	14.30	85.00	0.500 U	2.02	2980.00	9.69	10.20	13.80	7870.00	141.00
2293-14	GP08	0.0-2.0	RI/FS area; see figure 2	2420.00	1.00 U	52.30	35.90	0.500 U	2.40	100000.00	1.00 U	68.00	72.10	12500.00	3270.00
2293-15	GP09	0.0-2.0	RI/FS area; see figure 2	2220.00	1.00 U	78.60	30.80	0.500 U	3.48	115000.00	1.00 U	81.60	96.40	14000.00	5140.00
2293-23	GP30	0.0-2.0	RI/FS area; see figure 2	6280.00 J	1.00 U	21.20	233.00	1.200	0.50 U	1660.00	9.58	12.50	16.30	11100.00	45.70
2293-25	GP31	0.0-2.0	RI/FS area; see figure 2	3950.00	1.00 U	13.80	115.00	0.500 U	0.50 U	2230.00	10.30	11.90	14.60	9910.00	82.30
	GP73	0.0-2.0	RI/FS area; see figure 4, 5, 6	10900.00 J	6.03 UJ	11.20 UJ	160.00	1.670 J	0.50 UJ	2310.00	14.50	17.60 J	25.90 J	19100.00 J	81.60 J
2293-3	GP04	1.0-2.0	RI/FS area; see figure 2	5270.00	2.84	20.10	121.00	0.500 U	1.40	3080.00	10.90	47.20	9.21	9500.00	101.00
2293-4	GP05	1.5-1.75	RI/FS area; see figure 2	3360.00	1.00 U	18.40	36.10	0.500 U	1.28	103000.00	1.00 U	43.00	53.50	11500.00	1360.00

Sample #	Sampling Location	Depth (ft.)	Mg (mg/kg)	Mn (mg/kg)	Mo (mg/kg)	Ni (mg/kg)	K (mg/kg)	Se (mg/kg)	Ag (mg/kg)	Na (mg/kg)	Tl (mg/kg)	Ti (mg/kg)	V (mg/kg)	Zn (mg/kg)
	GP78	0.0-0.5	729.00	949.00 J		11.30 J	626.00 J	3.51 UJ	1.00 UJ	502.00 U	2.51 UJ		23.20	55.70 J
	GP81	0.0-0.5	2320.00	511.00 J		7.85 J	493.00 UJ	3.45 UJ	0.99 UJ	493.00 UJ	2.47 UJ		14.10	46.70 J
2293-2	GP04	0.0-1.0	67500.00	1450.00	1.00 U	38.90	424.00	10.70	1.00 U	224.00			2.50 U	199.00
2293-16	GP15	0.0-1.0	10200.00	1620.00	1.00 U	35.40	647.00	5.00 U	1.00 U	25.00 U			16.40	113.00
	GP43	0.0-1.0	11500.00	1270.00 J		10.80 J	501.00 UJ	3.51 UJ	1.00 UJ	509.00 J	2.51 UJ		15.50	986.00 J
	GP44	0.0-1.0	498.00 U	2760.00 J		15.60 J	498.00 UJ	3.49 UJ	1.00 UJ	498.00 U	2.49 UJ		21.00	38.20 J
	GP48	0.0-1.0	537.00	1870.00 J		7.68 J	522.00 J	3.54 UJ	1..01 UJ	506.00 U	2.53 UJ		21.80	26.20 J
	GP50	0.0-1.0	504.00 U	2090.00 J		8.94 J	504.00 UJ	3.52 UJ	1.01 UJ	504.00 U	2.52 UJ		20.30	25.40 J
	GP57	0.0-1.0	493.00 U	1570.00 J		6.76 J	493.00 UJ	3.45 UJ	0.99 UJ	493.00 U	2.46 UJ		18.50	22.10 J
	GP61	0.0-1.0	9700.00	771.00 J		8.23 J	503.00 UJ	3.52 UJ	1.01 UJ	678.00 J	2.52 UJ		15.30	685.00 J
	GP65	0.0-1.0	510.00 U	1280.00 J		5.71 J	510.00 UJ	3.57 UJ	1.02 UJ	510.00 U	2.55 UJ		15.80	41.80 J
	GP67	0.0-1.0	12000.00	1020.00 J		11.90 J	502.00 UJ	3.51 UJ	1.00 UJ	826.00 J	2.51 UJ		15.40	1380.00 J
	GP77	0.0-1.0	687.00	1170.00 J		11.50 J	503.00 UJ	3.52 UJ	1.01 UJ	503.00 UJ	2.51 UJ		22.80	32.50 J
	GP82	0.0-1.0	20700.00	905.00 J		8.27 J	595.00 J	3.51 UJ	1.00 UJ	980.00 J	2.51 UJ		15.80	3090.00 J
	GP91	0.0-1.0	24300.00	1270.00 J		15.20 J	497.00 UJ	3.48 UJ	0.99 UJ	597.00 J	2.48 UJ		13.40	501.00 J
	GP94	0.0-1.0	21400.00	869.00 J		9.88 J	492.00 UJ	3.44 UJ	0.98 UJ	587.00 J	2.46 UJ		12.30	688.00 J
	GP96	0.0-1.0	35300.00	1150.00 J		10.70 J	599.00 J	3.53 UJ	1.01 UJ	758.00 J	2.52 UJ		11.90	567.00 J
2293-45	GP20	0.0-1.25	12300.00	1060.00	1.00 U	18.60	430.00	5.00 U	1.00 U	25.00 U			15.70	70.30
2293-18	GP03	0.0-1.5	75000.00	1680.00	1.00 U	40.20	372.00	5.00 U	1.00 U	235.00			2.50 U	267.00
2293-19	GP02	0.0-1.5	65600.00	1470.00	1.00 U	37.40	451.00	5.00 U	1.00 U	189.00			2.50 U	213.00
2293-21	GP01	0.0-1.5	8410.00	1070.00	1.00 U	55.30	635.00	5.00 U	1.00 U	25.00 U			17.60	128.00
2293-46	GP19	0.0-1.5	8140.00	1230.00	1.00 U	16.70	312.00	5.00 U	1.00 U	25.00 U			15.40	53.50
	GP70	0.0-1.5	1790.00	1760.00 J		18.70 J	1160.00 J	3.54 UJ	1.01 UJ	505.00 U	2.53 UJ		35.30	86.80 J
2293-39	GP29	0.0-1.75	1190.00	572.00	1.00 U	9.54	340.00	5.00 U	1.00 U	25.00 U			12.90	36.70
2293-14	GP08	0.0-2.0	56900.00	1530.00	1.00 U	56.90	648.00	11.00	1.00 U	166.00			6.26	305.00
2293-15	GP09	0.0-2.0	63300.00	1490.00	1.00 U	71.30	748.00	13.20	1.00 U	136.00			5.18	311.00
2293-23	GP30	0.0-2.0	724.00	1220.00	1.00 U	12.00	385.00	5.00 U	1.00 U	25.00 U			19.20	29.10
2293-25	GP31	0.0-2.0	927.00	812.00	1.00 U	10.00	333.00	5.00 U	1.00 U	25.00 U			14.50	44.60
	GP73	0.0-2.0	1290.00	1680.00 J		17.70 J	837.00 J	3.51 UJ	1.00 UJ	502.00 U	2.51 UJ		32.40	55.40 J
2293-3	GP04	1.0-2.0	1690.00	2280.00	1.00 U	91.50	440.00	5.00 U	1.00 U	51.60			17.90	103.00
2293-4	GP05	1.5-1.75	57700.00	1590.00	1.00 U	46.50	554.00	5.00 U	1.00 U	248.00			9.70	201.00

	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	PB
Std Dev	2301.11	2.31	17.25	98.73	0.37	1.02	43766.21	5.22	19.79	64.22	2912.36	1476.21
Avg	4342.26	4.08	18.71	130.66	0.79	1.24	34036.81	9.84	27.99	61.53	12248.71	943.26
Min	1140.00	1.00 UJ	4.16 UJ	8.71	0.50 U	0.49 UJ	731.00	1.00 U	7.85 J	8.54 J	7870.00	30.70 J
Max	10900.00 J	6.12 UJ	78.60	508.00	1.91 J	4.49 J	135000.00	18.30	81.60	254.00 J	20800.00 J	6370.00 J
Location of Max	GP70	GP65	2293-15	GP81	GP70	GP67	2293-18	GP70	2293-15	GP91	GP70	GP82
Reg. 9 PRG	76141.95	31.29	0.39	5374.91	154.37	37.03		210.68	902.89	3128.55	23463.18	400.00
c/nc	nc	nc	ca*	nc	nc	nc		ca	ca**	nc	nc	nc
retain as coc	no	no	yes	no	no	no	no	no	no	no	yes	yes
n	31	31	31	31	31	31	31	31	31	31	31	31
# of Detects	67	11	54	67	29	37	67	44	67	67	67	72

	Mg	Mn	Mo	Ni	K	Se	Ag	Na	Tl	Ti	V	Zn
Std Dev	24454.03	490.87	0.00	21.52	164.33	2.40	0.01	272.93	0.03		7.50	603.03
Avg	18510.94	1353.84	1.00	23.45	534.00	4.82	1.00	366.95	2.51		15.58	335.55
Min	493.00 U	511.00 J	1.00 U	5.71 J	312.00	3.44 UJ	0.98 UJ	25.00 U	2.46 UJ		2.50 U	22.10 J
Max	75000.00	2760.00 J	1.00 U	91.50	1160.00 J	13.20	1.02 UJ	980.00 J	2.55 UJ		35.30	3090.00 J
Location of Max	2293-18	GP44	ND	2293-3	GP70	2293-15	GP82	ND	GP65		GP70	GP82
Reg. 9 PRG		1762.35	391.07	1564.28		391.07	391.07				78.21	23463.18
c/nc		nc	nc	nc		nc	nc				nc	nc
retain as coc	no	yes	no	no	no	no	no	no			no	no
n	31	31	14	31	31	31	31	31	17		31	29
# of Detects	63	67	2	72	56	12	0	34	0		53	72

Table A-5: Subsurface Soil Sampling Results

Sample #	Sampling Location	Depth (ft.)	Comment	Al (mg/kg)	Sb (mg/kg)	As (mg/kg)	Ba (mg/kg)	Be (mg/kg)	Cd (mg/kg)	Ca (mg/kg)	Cr (mg/kg)	Co (mg/kg)	Cu (mg/kg)	Fe (mg/kg)	PB (mg/kg)	Mg (mg/kg)	Mn (mg/kg)	Mo (mg/kg)	Ni (mg/kg)	K (mg/kg)	Se (mg/kg)	Ag (mg/kg)	Na (mg/kg)	Tl (mg/kg)	Ti (mg/kg)	V (mg/kg)	Zn (mg/kg)
2293-36	GP26	0.0-2.25	RI/FS area; see figure 2	3200.00	1.00 U	69 30	43.30	0.500 U	2.09	79400.00	1.00 U	87.00	97 40	13100.00	3390.00	44500.00	1510.00	1.00 U	78.00	585.00	5.00 U	1.00 U	100.00			8.67	231.00
2293-37	GP27	0.0-2.25	RI/FS area; see figure 2	3300.00	1.00 U	75.60	42.50	0.500 U	2.59	85000 00	1 00 U	97.50	108 00	14000.00	3630.00	48900.00	1590.00	1.00 U	83.70	618.00	5.00 U	1.00 U	131.00			9.08	255.00
2293-38	GP28	0.0-2.25	RI/FS area; see figure 2	4220.00	5.72	21.60	57.70	0.500 U	0.50 U	34500.00	5 09	24.20	29.40	10400.00	516.00	19500.00	1070.00	1.00 U	22.30	449.00	5.00 U	1.00 U	71.30			13.40	78.50
2293-22	GP21	0.0-2.5	RI/FS area; see figure 2	6440.00	1.00 U	19.40	136.00	1.130	0.50 U	895.00	9.54	13.30	19.70	11300.00	23.10	471.00	1330.00	1.00 U	11.00	474.00	5.00 U	1.00 U	25.00 U			20.30	23.40
2293-28	GP24	0.0-2.5	RI/FS area; see figure 2	2200.00	1.00 U	80.40	44.90	0.500 U	0.50 U	105000.00	1.00 U	84.50	109.00	14300.00	5300.00	57500.00	1550.00	1 00 U	73.90	546.00	12.40	1.00 U	146.00			6.20	347.00
2293-29	GP34	0 0-2.5	RI/FS area; see figure 2	6240.00	1.00 U	20.20	147.00	1.150	0.50 U	12000.00	8.56	20.40	21.90	11500.00	316.00	5090.00	1440.00	1.00 U	19.10	480.00	5.00 U	1.00 U	25.00 U			18.50	58.30
2293-40	GP38	0.0-2.5	RI/FS area; see figure 2	5670.00	1.00 U	24.70	140.00	1.050	3.21	2910.00	10.10	13.80	19.90	11000.00	140.00	1160.00	1060.00	1.00 U	13.60	500.00	5.00 U	1.00 U	25.00 U			19.00	51.20
2293-47	GP18	0.0-2.5	RI/FS area; see figure 2	4640.00	1.00 U	19.70	136.00	0.500 U	0.50 U	1670.00	9.51	15.50	12.40	10700.00	43.80	715.00	1660.00	1.00 U	14.10	574.00	5.00 U	1.00 U	25.00 U			16.40	38.30
2293-17	GP17	0.0-3.0	RI/FS area; see figure 2	1760.00	1.00 U	59.30	23.90	0.500 U	3.08	111000.00	1.00 U	70.60	102.00	13600.00	5330.00	60800.00	1450.00	1.00 U	62.40	473.00	15.80	1.00 U	140.00			2.50 U	336.00
2293-26	GP23	0 0-3 0	RI/FS area; see figure 2	1090.00	1.00 U	16.80	16.40	0.500 U	1.86	128000.00	1.00 U	36.40	49.40	10300.00	1480.00	70000.00	1420.00	1.00 U	31.60	352.00	5.00 U	1.00 U	259.00			2.50 U	229.00
2293-42	GP36	0.0-3.0	RI/FS area; see figure 2	4810.00	1.00 U	17.00	93.40	0.500 U	0.50 U	1340.00	8.85	10.70	14.90	8330.00	51.80	649.00	973.00	1.00 U	9.38	378.00	5.00 U	1.00 U	25.00 U			14.60	25.40
	GP75	0.0-3.0	RI/FS area; see figure 4, 5, 6	6730.00 J	6.09 UJ	8.10 UJ	128.00	1.090 J	0.51 UJ	2380.00	12.50	12.90 J	18.70 J	14000.00 J	48.30 J	1210.00	1180.00 J		12.70 J	676.00 J	3.55 UJ	1.01 UJ	507.00 U	2.54 UJ		24.20	40.10 J
2293-35	GP25	0.0-3.25	RI/FS area; see figure 2	1680.00	1.00 U	35.80	29.00	0.500 U	1.42	105000.00	1.00 U	47.80	61.80	11600.00	1390.00	62000.00	1450.00	1.00 U	37.50	435.00	5.00 U	1.00 U	178.00			5.10	161.00
2293-41	GP37	0.0-3.25	RI/FS area; see figure 2	5780.00	2.18	26.90	129.00	1.080	3.05	4380.00	9.48	17.30	22.40	11200.00	176.00	2160.00	1170.00	1.00 U	15.00	449.00	5.00 U	1.00 U	25.00 U			18.80	50.10
2293-11	GP14	0.5-2.5	RI/FS area; see figure 2	1060.00	1.00 U	52.50	8.66	0.500 U	1.41	138000.00	1.00 U	50.00	79.10	12900.00	1870.00	76800.00	1570.00	1.00 U	40.60	549.00	18.30	1.00 U	236.00			2.50 U	219.00
2293-5	GP06	1.5-3.0	RI/FS area; see figure 2	1070.00 J	1.00 U	37.60	9.22 J	0.500 U	0.50 U	130000.00	1.00 U	45.70	56.80	10700.00	1030.00	72700.00	1520.00	1.00 U	35.70	435.00	5.00 U	1.00 U	224.00			2.50 U	155.00
2293-20	GP02	1.5-3.0	RI/FS area; see figure 2	6130.00	1.00 U	17.10	86.40	0.500 U	0.50 U	7460.00	1.00 U	15.80	18.40	11500.00	225.00	4020.00	1090.00	1.00 U	14.70	493.00	5.00 U	1.00 U	25.00 U			19.50	59.80
2293-31	GP39	1.5-3.5	RI/FS area; see figure 2	751.00	1.00 U	46.10	5.15	0.500 U	1.71	139000.00	1.00 U	39.70	71.90	11700.00	1440.00	76800.00	1510.00	1.00 U	41.70	417.00	5.00 U	1.00 U	226.00			2.50 U	205.00
2293-8	GP07	2.0-3.5	RI/FS area; see figure 2	2680.00	1.00 U	50.00	42.20	0.500 U	4.02	105000.00	1.00 U	72.90	89.20	12600.00	5450.00	57200.00	1430.00	1.00 U	50.60	715.00	18.60	1.00 U	199.00			6.99	326.00
2293-30	GP33	2.0-3.5	RI/FS area; see figure 2	668.00	1.00 U	18.40	4.85	0.500 U	1.51	132000.00	1.00 U	30.10	49.60	9360.00	665.00	72100.00	1420.00	1.00 U	22.80	377.00	14.60	1.00 U	261.00			2.50 U	180.00
2293-12	GP12	2.0-4.0	RI/FS area; see figure 2	695.00	1.00 U	23.60	8.90	0.500 U	1.93	117000.00	1.00 U	26.20	112.00	10200.00	1030.00	65900.00	1320.00	1.00 U	22.10	322.00	5.00 U	1.00 U	272.00			2.50 U	221.00
2293-48	GP09	2.0-4.0	RI/FS area; see figure 2	5930.00	4.15	25.10	145.00	1.310	0.50 U	2500.00	7.78	18.70	14.50	10900.00	153.00	1080.00	1720.00	1.00 U	19.30	391.00	5.00 U	1.00 U	25.00 U			18.70	56.10
2293-43	GP35	2.5-3.5	RI/FS area; see figure 2	4860.00	2.15	45.20	73.70	0.500 U	1.06	6810.00	9.64	44.90	27.50	10000.00	765.00	3800.00	1230.00	1.00 U	39.50	448.00	5.00 U	1.00 U	25.00 U			15.00	82.90
2293-6	GP06	3.0-4.0	RI/FS area; see figure 2	7480.00	1.00 U	29.60	77.60	1.100	0.50 U	2340.00	10.30	21.40	14.80	12800.00	154.00	1470.00	1340.00	1.00 U	16.80	489.00	5.00 U	1.00 U	25.00 U			22.20	38.70
2293-27	GP23	3.0-4.0	RI/FS area, see figure 2	4440.00	3.83	27.70	83.50	0.500 U	1.83	17900.00	6.28	41.60	28.90	10200.00	920.00	9290.00	1300.00	1.00 U	50.30	412.00	5.00 U	1.00 U	25.00 U			15.10	233.00
2293-44	GP35	3.5-4.0	RI/FS area; see figure 2	2340.00	1.00 U	16.50	41.70	0.500 U	0.50 U	463.00	17.30	6.88	5.60	9260.00	40.80	280.00	536.00	1.00 U	7.66	174.00	5.00 U	1.00 U	25.00 U			15.60	13.80
2293-32	GP39	3.5-6.0	RI/FS area; see figure 2	5010.00	2.70	56.00	53.00	0.500 U	1.64	6550.00	17.00	86.60	27.20	10500.00	999.00	3200.00	461.00	2.85	71.80	410.00	5.00 U	1.00 U	25.00 U			17.50	259.00
2293-1	GP10	4.0-4.5	RI/FS area; see figure 2	2320.00	1.00 U	21.30	29.80	0.500 U	2.72	109000.00	2.50	31.20	92.10	13000.00	1860.00	59800.00	1250.00	1.00 U	28.00	416.00	5.00 U	1.00 U	324.00			8.05	316.00
2293-9	GP16	4.0-5.0	RI/FS area; see figure 2	6830.00	1.00 U	36.80	127.00	1.460	1.04	29200.00	8.88	48.30	39.70	12800.00	1540.00	15900.00	1810.00	1.00 U	48.10	621.00	10.60	1.00 U	70.50			19.30	137.00
2293-24	GP22	4.0-5.0	RI/FS area; see figure 2	1190.00	1.00 U	15.30	14.70	0.500 U	5.80	121000.00	1.00 U	25.90	59.90	11200.00	21.60	65800.00	1320.00	1.00 U	21.90	397.00	5.00 U	1.00 U	276.00			2.50 U	456.00
2293-13	GP13	4.0-5.5	RI/FS area, see figure 2	3610.00	1.00 U	17.80	50.10	0.500 U	0.50 U	71900.00	6.44	25.80	62.80	11300.00	793.00	40400.00	1350.00	1.00 U	24.20	378.00	15.70	1.00 U	158.00			11.50	162.00
2293-33	GP32	4.0-5.5	RI/FS area; see figure 2	752.00	1.00 U	22.80	7.07	0.500 U	2.13	121000.00	1.00 U	35.70	75.80	11400.00	930.00	71000.00	1360.00	1.00 U	28.20	348.00	5.00 U	1.00 U	250.00			2.50 U	207.00
2293-7	GP11	4.0-6.0	RI/FS area; see figure 2	1260 00	1.00 U	28.30	14.70	0.500 U	1.71	129000.00	1.00 U	34.90	85.60	11900.00	1960.00	70200.00	1440.00	1.00 U	27.70	476.00	22.70	1.00 U	279.00			2.50 U	231.00
2293-10	GP16	5.5-6.5	RI/FS area; see figure 2	1120.00	1.00 U	19.20	16.80	0.500 U	2.28	115000.00	1.00 U	26.20	76.90	9610.00	2220.00	64800.00	1420.00	1.00 U	24.30	382.00	12.90	1.00 U	266.00			2.50 U	257.00
2293-34	GP32	5.5-7.0	RI/FS area; see figure 2	2970.00	1.00 U	24.30	34.90	0.500 U	0.50 U	15300.00	51.30	36.20	15.40	12700.00	399.00	8510.00	659.00	12.20	25.70	361.00	5.00 U	1.00 U	25.00 U			19.90	55.30
2293-49	GP22	6.0-8.0	RI/FS area; see figure 2	5910.00	4.56	21.00	62.50	1 160	0.50 U	1470.00	13.20	8.47	9.68	10300.00	19.70	815.00	401.00	1.00 U	9.89	344.00	5.00 U	1.00 U	25.00 U			18.00	21.50
			Std Dev	2185.17	1.41	18.23	47.65	0.30	1.23	55403.35	9.15	24.41	34.09	1451.74	1537.50	30929.14	332.79	1.91	20.74	107.36	5.06	0.00	121.76			7.41	115.39
			Avg	3523.22	1.65	31.86	60.13	0.67	1.54	60871.33	6.70	36.81	50.01	11448.89	1286.67	33792.22	1286.39	1.37	32.11	454.00	7.64	1.00	137.47			11.36	161.57
			Min	668.00	1.00 U	8.10 UJ	4.85	0.50 U	0.50 U	463.00	1.00 U	6.88	5.60	8330.00	19.70	280.00	401.00	1.00 U	7.66	174.00	3.55 UJ	1.00 U	25.00 U	2.54 UJ		2.50 U	13.80
			Max	7480.00	6.09 UJ	80.40	147.00	1.46	5.80	139000.00	51.30	97.50	112.00	14300.00	5450.00	76800.00	1810.00	12.20	83.70	715.00	22.70	1.01 UJ	507.00 U	2.54 UJ		24.20	456.00
			Location of Max	2293-6	GP75	2293-28	2293-29	2293-9	2293-24	2293-31	2293-34	2293-37	2293-12	2293-28	2293-8	2293-31	2293-9	2293-34	2293-37	2293-8	2293-7	GP75	GP75	GP75		GP75	2293-24
			Reg. 9 PRG	76141.95	31.29	0.39	5374.91	154.37	37.03		210.68	902.89	3128.55	23463.18	400.00		1762.35	391.07	1564.28		391.07	391.07				78.21	23463.18
			c/nc	nc	nc	ca*	nc	nc	nc		ca	ca**	nc	nc	nc		nc	nc	nc		nc	nc				nc	nc
			retain as coc	no	no	yes	no	no	no	no	no	no	no	yes	yes	no	yes	no	no	no	no	no	no			no	no
			n	36	36	36	36	36	36	36	36	36	36	36	36	36	36	35	36	36	36	36	36	1		36	36
			# of Detects	36	29	35	36	27	21	36	20	36	36	36	36	36	36	2	36	36	8	0	20	0		25	36

Table A-6: Groundwater Sampling Results

Well	Sample #	Al (ug/mL)	Sb (ug/mL)	As (ug/mL)	Ba (ug/mL)	Be (ug/mL)	Cd (ug/mL)	Ca (ug/mL)	Cr (ug/mL)	Co (ug/mL)	Cu (ug/mL)	Fe (ug/mL)	Pb (ug/mL)	Mg (ug/mL)	Mn (ug/mL)	Mo (ug/mL)	Ni (ug/mL)	K (ug/mL)	Se (ug/mL)	Ag (ug/mL)	Na (ug/mL)	Tl (ug/mL)	Ti (ug/mL)	V (ug/mL)	Zn (ug/mL)
Shallow Irrigation	CC104-001			2.6			1.845		7.1		4.16	2490	40.3				5.75			3.94		2			1210
Shallow Irrigation	CC104-001D			1.9			1.85		7.1		4.16	3590	40.8				5.75			3.94		3.2			1270
Artesian	CC104-003			0.83			1.85		7.1		4.16	32.95	2.5				5.75			3.94		2.3			5.4
Clark Residence	CC104-002			0.83			1.85		7.1		4.6	32.95	2.8				5.75			3.94		1.8			36.8
Rubble Residence	CC104-004			0.83			6.08		7.1		13.9	41500	3.8				43.5			3.94		2			27
	Std Dev			0.816			1.892		0		4.311	17940	20.6				16.88			0		0.555			667
	Avg			1.398			2.695		7.1		6.196	9529	18				13.3			3.94		2.26			509.8
	Min			0.83			1.845		7.1		4.16	32.95	2.5				5.75			3.94		1.8			5.4
	Max			2.6			6.08		7.1		13.9	41500	40.8				43.5			3.94		3.2			1270
	Location of Max			CC104-001			CC104-004		ND		CC104-004	CC104-001D	CC104-001D				CC104-004			ND		CC104-001D			CC104-001D
	Reg. 9 PRG			0.045			18		110		1500	11000					730			180		2.4			11000
	c/nc			ca			nc		nc		nc	nc					nc			nc		nc			nc
	retain as coc			yes			no		no		no	yes	yes				no			no		yes			no

APPENDIX B

COPCs
at
HI=0.1
or
Target Cancer Risk of 1 x 10^{-7}

Appendix B
COPCs at HI=0.1 or Target Cancer Risk of 1 x 10^{-7}

PRGs were used as screening criteria for comparison with maximum detected concentrations during the COPC screening process. COPCs were selected based on target cancer risk of 1 x 10^{-6} and a hazard index (HI) of 1. To ensure that the potential for cumulative effects was adequately addressed in the selection of COPCs, PRGs were divided by 10, consistent with a target cancer risk of 1 x 10^{-7} and a hazard index (HI) of 0.1. This appendix discusses the potential contribution of these additional COPCs to total risk and hazard estimates for the site.

Chemicals that exceeded EPA Region 9 PRGs based on either a target cancer risk of 1 x 10^{-7} or an HI of 0.1, but not those based on 1 x 10^{-6} or 1, were evaluated and are unlikely to be "drivers" for risk management decisions at the Site. These additional chemicals generally were infrequently detected and very few locations had concentrations above the adjusted screening criteria. For those chemicals where detection above the screening criteria was frequent, most exceedances of the adjusted screening criteria were observed at locations where elevated concentrations of lead or arsenic were reported. The contribution of these chemicals to total site hazards would therefore be expected to be minimal, and have no effect on risk management decisions for the site.

Additional COPCs which would be selected based on a target cancer risk of 1 x 10^{-7} and a hazard index (HI) of 0.1 are summarized on Table B-1.

Table B-1 Additional COPCs Based on a Target Cancer Risk of 1 x10^{-7} or a HI of 0.1

Surface Soil	Subsurface Soil	Groundwater	Surface Water	Sediment
Aluminum	Antimony	Cadmium	Iron	Cadmium
Antimony	Cadmium	Zinc	Molybdenum	Iron
Cadmium	Chromium		Selenium	Manganese
Iron	Cobalt		Thallium	Vanadium
Thallium	Iron		Vanadium	
Vanadium	Thallium			
Zinc	Vanadium			

A summary of cancer risk and hazard indices associated with additional COPCs for the floodplain area are presented in Table B-2. Total cancer risk for the adolescent recreating in the floodplain area was 1 x 10^{-7}; this cancer risk is associated with cadmium concentrations in surface soil and in sediment. Cancer risk associated with additional COPCs is two orders of magnitude less than cancer risk associated with primary COPCs (1 x 10^{-5}). Noncancer health hazard indices for all exposure pathways for the adolescent recreating in the floodplain area and in Sutton Brach Creek are less than one. The total HI associated with additional COPCs (0.09) is one fifth of the HI associated with primary COPCs (0.4). Moreover, the additional COPCs do not all affect the same target organs or tissues and generally would not be added to produce a single HI estimate. These results support the assumption that COPCs selected based on an HI 0.1 or a target cancer risk of 1 x 10^{-7} do not contribute significantly to risk at the site for this receptor.

Table B-2 Summary of Risks and Hazards for the Floodplain Area and Sutton Branch Creek Associated with Additional COPCs (Based on a Target Cancer Risk of 1 x10^{-7} or a HI of 0.1)

COPCs	Surface Soil		Sediment		Surface Water	
	Total Carcinogenic Risk	*Total Hazard Index*	*Total Carcinogenic Risk*	*Total Hazard Index*	*Total Carcinogenic Risk*	*Total Hazard Index*
Aluminum	NC	0.003	NC	NC	NC	NC
Antimony	NC	0.008	NC	NC	NC	NC
Cadmium	9 x 10^{-8}	0.002	2 x 10^{-8}	0.0004	NC	NC
Iron	NC	0.03	NC	0.009	NC	0.00001
Manganese	NC	NC	NC	0.003	NC	NC
Molybdenum	NC	NC	NC	NC	NC	0.0002
Selenium	NC	NC	NC	NC	NC	0.002
Thallium	NC	0.02	NC	NC	NC	NC
Vanadium	NC	0.01	NC	0.002	NC	0.0008
Zinc	NC	0.0004	NC	NC	NC	NC
NC = Not calculated because not a COPC for this media, or not a carcinogen						

Exposures associated with soil in the former mine operations area were estimated for lead only. Table B-3 summaries cancer risk and noncancer health hazards associated with groundwater; risk estimates associated with primary COPCs are shown in parentheses. The HI associated with ingestion of groundwater is 0.9 for a child resident and 0.5 for an adult. Cancer risk, attributable to cadmium in groundwater was 4 x 10^{-5}. This cancer risk estimate uses California's Office of Environmental Health Hazard Assessment (OEHHA) oral cancer slope factor for cadmium which is not an EPA peer-reviewed value. Even if cadmium induced risk was included in the analysis, risks would still fall within the range typically considered acceptable. The addition of risk and hazards estimates associated with additional COPCs based on an HI 0.1 or a target cancer risk of 1 x 10^{-7} would not contribute significantly to total risk and hazard estimates at the site. As discussed in Section 6 maximum detected concentrations of COPCs were used to estimate exposures and the use of these concentrations most likely overestimates potential exposures associated with groundwater.

Table B-3 Summary of Cancer Risks and Non Cancer Hazards for Receptors for the Former Mine Operations Area

Exposure Area	Exposure Scenario	Receptor	Cancer Risk Estimate (1)	Non Cancer Hazard Index
Former Mine Operations Area	Domestic Use of Groundwater (Ingestion and Dermal Contact during bathing)	Future Resident, Adult, Cancer Risk	4×10^{-5} (2×10^{-5})	0.5 (6)
		Future Resident, Child	Not Calculated	0.9 (11)
	Ingestion of and Dermal Contact with Soil	Future Resident	Exposures associated with soil in the former mining area are evaluated for lead only in the IEUBK model	
	Ingestion of and Dermal Contact with Soil	Future Construction Worker	Exposures associated with soil in the former mining area are evaluated for lead only using EPA's Adult Lead Methodology	

(1) Cancer risk for resident includes exposure for 6 years as a child and 24 years as an adult

APPENDIX C

Toxicity Profiles

Arsenic

Introduction

Arsenic (As) is a naturally occurring metalloid that can be present in a number of different valence states and as a constituent in both inorganic and organic compounds. Elemental arsenic is used in industry as an alloying agent; both inorganic and organic arsenic compounds have been used as pesticides and pharmaceuticals.

Toxicokinetics

Absorption of arsenic from the gastrointestinal tract is dependent on the solubility of the arsenic compound. Soluble forms of both As(III) and As(V) are completely absorbed in laboratory animals (Vahter 1981) and humans (EPA 1984). Insoluble forms may not be available for absorption in humans as indicated by the lack of increase in urinary excretion of arsenic in human volunteers administered arsenic selenide orally (Mappes 1977).

Following inhalation, absorption is dependent on particle size, with larger particles being quickly cleared from the lungs with little absorption. Smaller particles penetrate into alveolar spaces and may remain there for extended periods, increasing the chances for inhaled arsenic to be absorbed (EPA 1984). Absorption from the lung may be rapid for soluble arsenic forms, but is much slower for more insoluble forms (ATSDR 1989).

Arsenic is efficiently metabolized to methylated forms in the liver in both animals (ATSDR 1989) and humans (Buchet et al. 1980). Because acute toxicity of these methylated forms is much less than for inorganic arsenic, methylation is considered detoxification. At high arsenic doses, methylation pathways may become saturated (Lovell and Farmer 1985; Buchet et al. 1981). This may result in a "threshold" determined by the ability to metabolize arsenic, where low doses are relatively nontoxic due to conversion to methylated forms, and higher doses are more toxic since greater amounts of inorganic arsenic will be available for distribution to target tissues. This is especially important for carcinogenesis following oral exposure, where small daily intakes could be much less effective in inducing cancer than higher doses that saturate metabolism. Contrasting views on the impact of a threshold, if one exists, on toxicity criteria have been debated in the recent literature, with Carlson-Lynch et al. (1994) and Beck et al. (1995) arguing that the cancer slope factor for ingested arsenic is too high, and Mushak and Crocetti (1995) presenting reasonable counter arguments. The issue of a threshold has not been resolved, and no alteration to the quantitative assessment of arsenic risks is currently justified.

Arsenic is primarily excreted in the urine in both animals and humans (ATSDR 1989). This is true for both inorganic and methylated forms. Biliary excretion has been noted to be highly variable in animals, but due to reabsorption in the intestines, does not contribute significantly to overall excretion (Klassen 1974).

Qualitative Description of Health Effects

Toxicological information on arsenic has been reviewed by EPA in its ambient water quality criteria document (EPA 1980) and health assessment document (EPA 1984) and more recently by EPA's Risk Assessment Forum (EPA 1985) and ATSDR (1989). Acute poisoning of humans with arsenic may result in gastrointestinal effects, hemolysis, and neuropathy. Chronic exposure is associated with characteristic toxic effects on the peripheral nervous system and, in children, on the central nervous system. In humans, keratosis, hyperpigmentation, precancerous dermal lesions, and cardiovascular injury frequently follow chronic exposure to arsenic. Arsenic has been found to be embryotoxic, fetotoxic, and teratogenic in several animal species at high doses. One report suggests that children of women working in a Swedish copper smelter had lower birth weights than expected (Nordström et al. 1978). Though arsenic exposure was involved, women were also exposed to a variety of heavy metals and sulfur dioxide. Thus, it is not possible to link fetal effects with arsenic exposure.

Arsenic induces chromosome aberrations and impairs DNA repair but has not been shown to cause point mutations. Epidemiological studies have shown that inhalation of arsenic is strongly associated with lung cancer and perhaps with hepatic angiosarcoma, while ingestion has been linked to a form of skin cancer and more recently to bladder, liver, and lung cancer (Tseng et al. 1968; Chen et al. 1986). Although arsenic's potential as a human carcinogen has long been recognized, reliable induction of cancer in animal models has not yet been achieved. Arsenic exposure has been reported to increase the neurotoxic effects of lead in children as measured by aggressive behavior (Marlowe et al. 1985). Arsenic and aluminum may interact in similar fashion, promoting aggressive behavior (ATSDR 1989). Arsenic and cigarette smoke are reported to have multiplicative effects on lung cancer mortality in smelter workers (Pershagen et al. 1983). Arsenic and cadmium together had a greater effect on reduced weight gain in rats than expected from the simple sum of their individual effects (Mahaffey and Fowler 1977).

Quantitative Description of Health Effects

EPA (1984) has classified arsenic as a Group A -- Human Carcinogen. This category applies to chemical agents for which there is sufficient evidence of carcinogenicity in humans.

Oral Toxicity

To estimate risks posed by ingestion of arsenic, EPA (1980) used data obtained in Taiwan by Tseng et al. (1968) and Tseng (1977). Based on a study population of 40,421 individuals that had obtained drinking water from wells contaminated with varying levels of arsenic for 45 years, age-specific cancer prevalence rates were found to be correlated with both local arsenic concentrations and age (duration of exposure). Based on data reported in the 1977 study, EPA Risk Assessment Forum developed a unit risk based on the incidence of skin cancers in exposed individuals. The unit risk developed is 5 x 10^{-3} (μg/L)$^{-1}$ (EPA 1994). This unit risk is converted to an oral slope factor by the following calculation:

$$\frac{5 \times 10^{-5} \times 70\,\text{kg}}{(\mu\text{g/L}) \times \dfrac{0.001\,\text{mg}}{\mu\text{g}} \times 1.5\,\text{L/d}} = 1.5\,(\text{mg/kg-d})^{-1}$$

In the same area of Taiwan, Chen et al. (1986) reported an association between bladder, lung, and liver tumors and ingestion of arsenic-contaminated drinking water.

A recent study (Astolfi et al. 1981) has shown an association between the ingestion of arsenic in drinking water (at concentrations around 1 ppm) and skin cancer. Epidemiological studies conducted in the United States have not yet shown such an association, but the reported studies were generally too insensitive to have shown such an association if it had existed at the predicted magnitude (EPA 1984).

One possible complicating factor for risk assessment of ingested arsenic is potential variation in carcinogenic potency according to the chemical form of arsenic. Trivalent inorganic arsenic compounds are generally more toxic than pentavalent inorganic arsenic compounds or organic arsenic compounds (EPA 1980). However, recent studies have shown that water samples from the area of Taiwan, where Tseng et al.'s (1968) and Tseng (1977) studies were carried out, contain primarily pentavalent inorganic arsenic and no organic arsenicals (EPA 1984). EPA unit risk is therefore applicable to other circumstances in which pentavalent arsenic compounds are ingested.

As discussed above, the possibility of a metabolic threshold for arsenic at low doses cannot be resolved at this time, and remains a significant uncertainty in arsenic risk assessment.

EPA has developed an oral reference dose based on studies by Tseng et al. (1968) and Tseng (1977). Data in these studies show an increased incidence of blackfoot disease in arsenic exposed individuals in Taiwan. Hyperpigmentation and keratosis of the skin were also reported. Based on average arsenic concentrations in wells used by these individuals, a no-observable-adverse effects level (NOAEL) of 0.8 μg/kg-day has been estimated. An uncertainty factor of three was applied to the NOAEL to yield an RfD of 3 x 10^{-4} mg/kg-day (EPA 2005).

The interim primary drinking water standard for arsenic was 50 μg/L (CFR 1984) established in 1942 as a maximum allowable level for arsenic in drinking water by the U.S. Public Health Service. EPA's Office of Drinking Water present maximum contaminant level (MCL) is 0.01 mg/L for arsenic in municipal drinking water supplies (EPA 2004a).

Inhalation Toxicity

Health risks posed by airborne arsenic compounds have been reviewed in considerable detail by EPA (1984), and studies on the carcinogenicity of arsenic compounds were reviewed by the International Agency for Research on Cancer (IARC) in 1980. Risk assessments for exposure to airborne arsenic are presented by OSHA (1983) and EPA (1984). The following summary is based on these reviews and risk assessments and on review of the primary literature.

It is well established that inhalation of certain arsenic compounds can cause cancer in humans. Several studies of workers in smelters and plants that manufacture arsenical pesticides have shown that inhalation of arsenic is strongly associated with lung cancer and perhaps with hepatic angiosarcoma (EPA 1984).

EPA (1984) based its quantitative risk assessment for inhaled arsenic on five studies of three exposed worker populations (Lee-Feldstein 1983; Brown and Chu 1982, 1983a,b; Ott et al. 1974). All five studies showed excess risks of lung cancer that were related to the intensity and duration of exposure and the duration of follow-up (latency). The estimates of unit risk (unit risk is the risk associated with lifetime exposure to 1 unit (generally 1 mg/kg-day, 1 mg/L, or 1 $\mu g/m^3$) of a substance) obtained from the five studies were in reasonable good agreement, ranging from 1.2×10^{-3} to 1.36×10^{-2} $(\mu g/m^3)^{-1}$. EPA omitted the highest value, derived from the study of Ott et al. (1974) which was considered least reliable, and calculated the geometric mean for each of the two remaining populations and then an overall geometric mean to obtain a best estimate of 4.3×10^{-3} $(\mu g/m^3)^{-1}$ for the unit risk.

No reference concentration is available for inorganic arsenic. Extrapolation from the oral value is deemed inappropriate based on the following considerations. First, the relative sensitivity of various tissues to arsenic exposure via oral and inhalation routes is not clear. Certainly, the skin is the critical target for carcinogenic response following `oral exposure, while the lung is the target after inhalation. Since it cannot be determined if the target organ is the same for the two exposures, route-to-route extrapolation is not appropriate. Further, metabolism may influence relative doses by the two routes. Inorganic arsenic is methylated in vivo by a saturable process in the liver. Because of first pass effects, and differences in the rate and extent of absorption following exposure by the two routes, the concentrations of inorganic arsenic which reach critical targets may differ. Again, this suggests that route-to-route extrapolation is inappropriate. Lack of an RfC requires that inhalation exposures to arsenic be assessed qualitatively for systemic effects.

An oral RfD has been developed for arsenic by EPA (1994). The RfD is based on data for chronic oral exposure to arsenic in humans (Tseng 1977; Tseng et al. 1968). The data reported in Tseng (1977) show an increased incidence of blackfoot disease for humans exposed to arsenic in well water. The incidences of blackfoot disease increased with age and dose. The data in Tseng et al. (1968) also show increased incidences of hyperpigmentation and keratosis with age. A NOAEL was identified from the Tseng et al. (1968) study based on the absence of the critical effect (hyperpigmentation, keratosis, and possible vascular complications). The NOAEL corresponded to a dose of 8×10^{-4} mg/kg-day. An uncertainty factor of three was applied to account for both, the lack of data to preclude reproductive toxicity as a critical effect and to account for some uncertainty in whether the NOAEL of the critical study accounts for all sensitive individuals. The resulting oral Rfd for arsenic was rounded to 3×10^{-4} mg/kg-day.

The American Conference of Governmental Industrial Hygienists (ACGIH 1986) recommends a time-weighted average Threshold Limit Value (TLV) of 0.2 mg/m^3 for arsenic and soluble compounds of arsenic.

Summary of Criteria

Criterion	Value	Source
EPA carcinogen classification	Group A	EPA 2005
Oral slope factor	1.5 mg/kg-day^{-1}	EPA 2005
Inhalation slope factor	15 mg/kg-day^{-1}	EPA 2005
RfD	0.0003 mg/kg-day	EPA 2005
Maximum Contaminant Level (MCL)	0.01 mg/L	EPA 2004a
EPA Drinking Water Health Advisories		
DWEL	0.01 mg/L	EPA 2004a
Ambient Water Quality Criteria (AWQC) (concentration associated with a 10^{-6} excess lifetime cancer risk)		
Ingestion of water and aquatic organisms	0.018 µg/L	EPA 2004b
Ingestion of aquatic organisms	0.14 µg/L	EPA 2004b
Freshwater aquatic life chronic toxicity	0.15 mg/L	EPA 2004b

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Iron

Introduction

Iron is one of the more common elements on earth, making up about 5% of the Earth's crust. Iron is a metal extracted from iron ore, and is hardly ever found in free (elemental) state. Most iron is found in various iron oxides, such as hematite, magnetite and taconite. Iron is the most used of all metals, comprising 95 percent of all the metal tonnage produced worldwide. Iron is used predominantly in the manufacture of metal alloys, such as steel.

Iron is essential to all organisms, except for a few bacteria. Iron functions as a component of a number of proteins, including enzymes and hemoglobin, the latter being important for the transport of oxygen to tissues throughout the body for metabolism.

Toxicokinetics

Iron is absorbed gastrointestinally. Iron is absorbed in the ferrous state by cells of the intestinal mucous; gastric and intestinal secretions reduce ferric ions (unusable form of iron) to the ferrous state (absorbable). Iron balance is maintained by the regulation of absorption in the upper small intestine. The iron content of the body is highly conserved. In the absence of bleeding (including menstruation) or pregnancy, only a small quantity is lost each day. Adult men need to absorb only about 1 mg/day to maintain iron balance. The average requirement for menstruating women is somewhat higher, approximately 1.5 mg/day. Requirements are higher for young children during periods of rapid growth (6 to 24 months).

The primary function of iron in the body is the formation of hemoglobin, the essential oxygen-carrying component of the red blood cell. Almost two-thirds of iron in the body is found in hemoglobin present in circulating erythrocytes. In combination with protein, iron is carried in the blood to the bone marrow, where hemoglobin is formed. Iron movement between cells is primarily conducted via reversible binding of iron to the transport protein transferrin. Iron entering cells may be incorporated into functional compounds, stored as ferritin or hemosiderin, or used to regulate future cellular iron metabolism. While all cells are capable of storing iron, the cells of the liver, spleen and bone marrow are primary iron storage sites in humans. Nuetrophils (white blood cells) depend on iron to help generate superoxide to function as a bacteria-destroying agent; an inadequate iron level reduces the effectiveness of the immune system.

Elimination via the intestine is the predominant excretion mechanism for iron in humans.

Qualitative Description of Health Effects

Iron deficiency may cause impaired physical work performance, developmental delay, cognitive impairment, and adverse pregnancy outcomes. Once the degree of iron deficiency is sufficiently severe to cause anemia, functional disabilities become evident (IOM 2001).

Iron is a redox-active transition metal. If transport mechanisms are overwhelmed, the free iron will be chelated by cellular compounds catalyzing the formation of highly toxic free radicals or the initiation of lipid peroxidation. Iron toxicity is not always due to an increase in dietary iron. Several diseases can lead to a problem in iron absorption and in turn to iron toxicity. Excessive storage of iron and/or high blood levels of iron are associated with increased risk of free radical damage and cancer. Problems resulting from iron toxicity may include: nausea, vomiting, anorexia, diarrhea, hypothermia, diphasic shock, metabolic acidosis, and death. In addition to these, vascular congestion of the gastrointestinal tract, liver, kidneys, heart, brain, spleen, adrenals, and thymus may occur. As a result of iron storage disease, the liver becomes cirrhotic. Hepatoma, cancer of the liver, has become the most common cause of death among patients with hemochromatosis. When siderosis becomes severe in young people, myocardial disease is a common cause of death. (Cornell University 2005)

High intakes of iron supplements have been associated with reduced zinc absorption.

Impotence may occur in young men, and amenorrhea may occur in young women. Both of these sexual related problems are due to iron loading in the anterior pituitary.

Acute toxicity resulting from unintentional ingestion of large doses of iron supplements (3 grams) was shown to cause mortality in young children (Litovitz 1992). At doses, which were not fatal, mucosal damage was observed. The severity of iron toxicity is related to the amount of elemental iron absorbed. With acute iron poisoning, much of the damage to the gastrointestinal tract and liver may be a result of a high localized iron concentration and free radical production, leading to heptatoxicity via lipid peroxidation and the destruction of the hepatic mitochondria.

Quantitative Description of Health Effects

An oral Reference Dose (RfD) for iron RfD (0.3 mg/kg-day), available in the USEPA Region 9 PRG table, was derived in 1993 by the Superfund Technical Support Center. The Superfund Technical Support Center is in the process of updating this value. This RfD is an outdated provisional value that does not reflect the latest research conducted by the Institute of Medicine (IOM), which published its revised iron dietary intake in 2001. The IOM report specified an upper tolerable intake (UL) for iron in children as 40 mg/per day for infants and children up to 13 years. This equates to a dose of 2.7 mg/kg-day for a 15 kg child (& higher for infants). Based on this analysis, this risk assessment may be overestimating the HQ for iron by 10-fold. Gastrointestinal side effects were selected as the critical adverse effects on which the UL was based. High doses of iron are commonly associated with constipation and other gastrointestinal effects including nausea, vomiting, and diarrhea. Some individuals may be more susceptible to the adverse effects of excess iron intake and may not be protected by the UL for iron. This group includes individuals with conditions such as hereditary hemochromatosis, iron loading abnormalities, chronic alcoholism, alcoholic cirrhosis, and other liver diseases.

Summary of Iron Criteria

Criteria	Value	Source
Oral RfD	3×10^{-1} mg/kg-day	EPA 2005
Health Advisories		
Lifetime	Not Available	EPA 2004
Secondary Drinking Water Regulation	0.3 mg/L	EPA 2004

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Lead

Introduction

Lead is a naturally occurring, ubiquitous metal. Concentrations in rocks and soils in the western United States range from 10 to 700 mg/kg (Shacklette and Boerngen 1984). Lead ores are often found with cadmium, zinc, and silver ores. Lead is commercially important because it is very soft, highly malleable, ductile, and is a poor conductor. In addition, it is resistant to corrosion, as well as being an effective sound absorber and an excellent radiation shield. Historically, lead has been used as pigments in paint, solders, gasoline additives, and in battery casings. Because of its extensive use and its ubiquitous distribution, exposure to lead is common.

Qualitative Description of Health Effects

Oral absorption of inorganic lead in humans ranges from as low as 3 percent to as high as 80 percent (ATSDR 1991). The percentage of absorbed lead appears to be dependent on the solubility of the lead salt ingested, as well as age, nutritional status, and fasting time. Dietary absorption of lead in children has been reported at 50 percent as compared to 15 percent in adults (Chamberlain et al. 1978 in ATSDR 1991). Absorption from inhaled lead particles is thought to reach 100 percent; however, the particles must be deposited in the respiratory tract. Rate of deposition of lead-containing particles appears to be between 30 and 50 percent of the inhaled particles. Dermal absorption of lead is not considered a significant pathway.

Route of absorption does not affect distribution of lead. However, the toxicokinetics of lead alkyls are different from the toxicokinetics of inorganic lead and will not be discussed in this profile. After absorption, lead is distributed among several physiologically distinct compartments (ATSDR 1991). The compartments are blood, soft tissue (particularly brain, kidney, and liver), and bone. Estimates of elimination half-times for lead from blood range from 15 to 35 days and elimination half-times from other soft tissues are probably similar (Harley and Kneip 1985 in ATSDR 1991). Elimination half-times for lead from mineralized bone are expressed in years. Because metabolic stress, such as pregnancy, may result in increased bone turnover or demineralization, there is potential for a portion of the parental bone lead-burden to be transferred to the fetus. In adults, approximately 94 percent of the total body burden is in bone (ATSDR 1991). Absorbed lead that is not retained is excreted by the kidney or through biliary clearance into the gastrointestinal tract. Infants retain approximately 32 percent of the lead absorbed (Ziegler et al. 1978 in ATSDR 1991), whereas, adults retain only about 1 percent of absorbed lead (Rabinowitz et al. 1977 in ATSDR 1991). Most toxicity endpoints associated with exposure to lead can be correlated with blood lead levels. Blood lead levels are, therefore, a useful index of toxicity.

Cases of severe lead encephalopathy have resulted in death in both adults and children. Blood lead levels associated with death in children ranged from approximately 125 µg/dL to 750 µg/dL. Systemic effects associated with lead include increased systolic and diastolic blood pressure (Harlan 1988; Pocock et al. 1984, 1985 in ATSDR 1991). Harlan's work, based on an analysis of National Health and Nutrition Examination Survey (NHANES II) data, estimated an increase in blood pressure of 7 mm Hg at blood lead levels between 14 and 30 μg/dL. Pirkle et al. (1985 in ATSDR 1991) evaluated the same data set for white males (ages 40 to 59) and found no discernible threshold for increased blood pressure associated with increased blood lead levels across the range of 7 to 34 μg/dL. Gastrointestinal symptoms, such as colic, abdominal pain, constipation, and anorexia, are typically seen at blood lead levels of 100 to 200 μg/dL but have been reported at blood lead levels as low as 40 μg/dL. Lead is known to depress heme synthesis and this effect also has no discernible threshold. Cytochrome P450 formation is also inhibited in the presence of lead. Kidney damage occurs with both acute and chronic exposures to lead. Acute renal toxicity has been reported in lead-intoxicated children and is considered reversible, whereas, chronic renal toxicity has been observed in lead-exposed workers and is considered irreversible. Lead interferes with vitamin D metabolism and may have some effect on the cellular component of the immune system.

The lowest observed effect level (LOEL) for overt neurotoxic toxicity in adults is 40 μg/dL (ATSDR 1991). Early symptoms include dullness, irritability, poor attention span, headache, muscular tremor, loss of memory, and hallucinations. As the condition worsens, symptoms include delirium, convulsions, paralysis, and coma and may lead to death. Decreased peripheral nerve conduction velocities have been seen in workers at blood lead levels ranging from 30 to 48 μg/dL; however, these effects are probably reversible.

Neurotoxicity in children is seen at much lower blood lead levels. Lead encephalopathy has been seen at blood lead levels of 60 to 300 μg/dL. Several studies have demonstrated a statistically significant decrement in children's IQ when correlated with blood lead levels and in some of the studies, results supported that there was no threshold level for this effect. There are also several well-designed and well-executed studies in the literature that have reported no statistically significant effects of lead exposure in IQ or other neurobehavioral measures.

Maternal blood lead levels appear to be correlated with birth weight and infant neurobehavioral deficits or delays.

Studies on the association of occupational exposure to lead with increased cancer risks are insufficient to determine the carcinogenicity of lead in humans. Ingestion of lead acetate and lead phosphate produced renal tumors in laboratory rats and mice.

It is difficult to briefly summarize the literature on lead. The Toxicological Profile for Lead (ATSDR 1991) contains over 1,000 references, and much of the brief synopsis above is taken from that profile.

Quantitative Description of Health Effects

Oral ingestion of certain lead salts (lead acetate, lead phosphate, lead subacetate) has been associated with increased renal tumor frequency in rats (Azar et al. 1973; Koller et al. 1985 both in ATSDR 1991). The International Agency for Research on Cancer

(IARC) has determined that there is sufficient evidence from animal studies to classify lead and some lead compounds as possibly carcinogenic to humans (IARC 1987).However, applying the criteria described in EPA's Guidelines for Carcinogenic Risk Assessment (EPA 1986a in EPA 1989), these lead salts have been classified by EPA (1995b) in Group B2 - probable human carcinogen.

A treatment technique action level of 0.015 mg/L was recently finalized (EPA 1991b in ATSDR 1991) by the Office of Drinking Water. The maximum contaminant level goal (MCLG) for lead at the source and at the tap are both zero. No MCL is currently available. The EPA Office of Drinking Water issued a draft health advisory of 20 µg/day for all extended periods of lead exposure (EPA 1985 in ATSDR 1991)

A target blood lead level of 10 µg/dL is a multi-Agency goal that has been designated by the US Centers for Disease Control (CDC) and the Agency for Toxic Substances and Disease Registry (ATSDR) as a level of concern to protect sensitive populations (neonates, infants, and children). The protection of sensitive populations is assumed to also provide protection for adults. The EPA's stated goal for lead is that children (up to 84 months of age) exposed at a risk-based cleanup level would have no more than a 5% probability of exceeding the level of concern (U.S. EPA, 1994b; U.S. EPA, 1998). The adult lead methodology extends that same concept to develop cleanup goals preventive of fetal risk. As a statistical goal, a probability of exceedance of up to 5% of the goal is acceptable.

The National Primary and Secondary Ambient Air Quality Standard for lead is 1.55 $\mu g/m^3$. This standard is currently being evaluated for revision (40 CFR 50.12).

EPA has not published a reference dose (RfD) or acceptable intakes for chronic or subchronic periods of human exposure in IRIS (EPA 2005) or HEAST (EPA 1995a), because the general population is already accruing unavoidable background exposures through food, water, and dust. Any significant increase above background exposure would represent a cause for concern. In addition, EPA has decided that it would be inappropriate to develop a reference dose for inorganic lead (and lead compounds) because some of the health effects associated with exposure to lead occur at blood lead levels as low as to be essentially without a threshold (IRIS 2005).In lieu of an acceptable intake for chronic exposure or RfDs, the EPA IEUBK model is used for the prediction of blood lead levels in children exposed to lead from a variety of sources (EPA 1991a, 1994a, b, 2001).

OSWER Directive 9355.4-12, issued on July 14, 1994 established OSWER's current approach to addressing lead in soil at CERCLA and RCRA sites. The directive recommends a 400 ppm screening level for lead in soil at residential properties. OSWER's risk reduction goal is to attempt to limit exposure to soil lead levels such that a typical (or hypothetical) child or group of similarly exposed children would have an estimated risk of no more than 5% of exceeding a blood lead level of 10 µg/dL. The United Kingdom Directorate of the Environment has developed a tentative guideline of 550 ppm for lead in soil in residential areas (Smith et al. 1981 in ATSDR 1991). Vernon Houk of the Centers for Disease Control has been quoted as indicating that levels of 300 to 400 ppm lead in soil are acceptable based on studies of childhood lead poisoning (Mielke et al. 1984 in ATSDR 1991).

No reference concentration (RfC) is available for lead; and, as discussed above, it is not clear that there is a threshold below which there are no risks from exposure to lead. RfCs are based on the assumption that such a threshold exists; therefore, estimation of an RfC for lead is not appropriate at this time.

The impact of ingestion of lead in soils can be assessed using the IEUBK Lead Model, Version 1.0 (EPA 2001). This model allows for the impact of lead in air on blood lead levels in children to be estimated. Thus, estimated blood lead levels can then be compared to target blood lead concentrations to assess potential risks.

The Technical Review Workgroup for Metals and Asbestos (TRW) is an interoffice workgroup convened by the U.S. EPA Office of Solid Waste and Emergency Response/Office of Superfund Remediation and Technology Innovation (OSWER/OSRTI). *Its goal is to support and promote consistent application of the best* science in the field of risk assessment for metals and asbestos at contaminated sites nationwide. The TRW has developed an interim approach to assess risks associated with nonresidential adult exposures to lead in soil. The methodology consists of algorithms that concentrate on estimated fetal blood lead concentrations in pregnant women exposed to lead-contaminated soils on a daily basis. The EPA's stated goal for lead is that children (up to 84 months of age) exposed at a risk-based cleanup level would have no more than a 5% probability of exceeding the level of concern (target blood lead level of 10 μg/dL). The adult lead methodology extends that same concept *to develop cleanup goals preventive of fetal risk. As a statistical goal, a probability of* exceedance of up to 5% of the goal is acceptable. The adult lead methodology can be used to back-calculate soil-lead Preliminary Remediation Goals (PRGs) that are protective of the developing fetus, the most susceptible receptor with adult exposures.

Summary Criteria

Criterion	Value	Source
EPA carcinogen classification	Group B2	EPA 2005
National Ambient Air Quality Standard	1.55 μg/m3	40 CFR 50.12
Maximum Contaminant Level Goal (MCLG)	0 mg/L	40 CFR 141.11
Treatment Technique Action Level	0.015 mg/L	EPA 2004a
Blood Lead Level of Concern	10 μg/dL	CDC 1999
Ambient Water Quality Criteria (AWQC) (concentration associated with a 10^{-6} excess lifetime cancer risk)		
Ambient Water Quality for Protection of Human Health	50 μg/L	45 FR 79318
Ingestion of water and aquatic organisms	Not Available	EPA 2004b
Ingestion of aquatic organisms	Not Available	EPA 2004b
Freshwater aquatic life acute toxicity	82 μg/L	EPA 2004b

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Manganese

Introduction

Elemental manganese is a grey-white metal resembling iron, with atomic number 25 and an atomic weight of 55 g/mole. It is highly reactive and can be present in seven oxidation states. Manganese is often used as an alloy to impart hardness.

Toxicokinetics

Manganese compounds are practically insoluble in water or body fluids. Following inhalation, manganese in small particles, which deposit in the alveoli, may be slowly absorbed into the blood. The degree of such absorption is unknown. Absorption of manganese by the oral route is controlled by homeostatic mechanisms. The absorption rate will depend on the amount ingested and on tissue levels of manganese. Limited information on humans indicates that absorption is only about 3 percent of the administered dose (Saric 1986).

Absorbed manganese is rapidly eliminated from the blood and distributed to the liver. Manganese is distributed in the body at concentrations characteristic of the individual tissues. In blood, manganese is bound to proteins. Absorbed manganese is almost totally excreted in the feces (Saric 1986).

Qualitative Description of Health Effects

The toxic effects of manganese have been studied primarily in workers who have inhaled manganese-containing dust (EPA 1984). Exposure to high levels of manganese causes pneumonitis in exposed workers. Chronic exposure has also been associated with manganism — a progressive neurological disease similar to Parkinson's disease, manifested by speech disturbances, a masklike face, tremors, difficulties in walking, and sexual disturbances (EPA 1984). Although exposure in the cases of manganism reported by EPA (1984) was by inhalation, some of the manganese that is inhaled can be removed by mucociliary clearance and consequently swallowed (EPA 1984), becoming available for absorption from the gastrointestinal tract. One case study reported apparent manganism associated with extremely high levels of manganese in a drinking water well, further suggesting that ingestion, as well as inhalation is an important route of exposure (Kawamura et al. 1941). Chronic exposure to manganese also causes increased production of erythrocytes, with consequent increases in hemoglobin values and erythrocyte counts.

Quantitative Description of Health Effects

EPA has derived an oral RfD for manganese based on extensive studies by the National Research Council (NRC 1989), the World Health Organization (1973), and Schroeder et al. (1966). The World Health Organization reported no-observed-adverse-effects-levels (NOAELs) in humans consuming supplements of 0.11 to 0.13 mg manganese/kg-day. The NRC determined "safe and adequate" levels to be 0.03 to 0.07 mg/kg-day, and Schroeder et al. reported a chronic human NOAEL of 0.16 mg/kg-day. From these studies, EPA derived a NOAEL of 0.14 mg/kg-day and a

RfD of 0.14 mg/kg-day (EPA 2005). A separate RfD of 5×10^{-3} mg/kg-day is suggested for manganese dissolved in drinking water to account for the greater bioavailability of manganese in this form (EPA 1993a).

An inhalation RfC has also been developed based on the epidemiological study by Roels et al. (1987). In this cross-sectional study 141 male workers were exposed to manganese dioxide, tetroxide, and various salts. The median time-weighted average (TWA) was identified as a lowest-observed-adverse-effects-level (LOAEL), converted to a human equivalent concentration, and corrected by uncertainty/modifying factors of 300 and 3, respectively. The resulting RfC is 5×10^{-5} mg/m^3 (EPA 2005).

The maximum contaminant level goal (MCLG) for manganese is currently unavailable (EPA 2004a). The National Academy of Sciences (NAS 1972) recommended that 0.05 mg/L soluble manganese not be exceeded in public water sources to prevent staining of plumbing fixtures and spotting of laundered clothes.

Summary of Criteria

Criterion	Value	Source
EPA Carcinogen Classification	Group D	EPA 2004a
Inhalation RfC	5×10^{-5} mg/m^3	EPA 2005
Oral RfD	1.4×10^{-1} mg/kg-day (food)	EPA 2005
Inhalation slope factor	Not available	EPA 1993a
Oral slope factor	Not available	EPA 1993a
MCLG	Not available	EPA 2004a
EPA Drinking Water Health Advisories		EPA 2004a
10-kg Child (One-day and Ten-day)	1 mg/L	EPA 2004a
DWEL	1.6 mg/L	EPA 2004a
Life-time	0.3 mg/L	EPA 2004a
AWQC (Water and Fish Consumption)	100 µg/L	EPA 1993a

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Thallium

Introduction

Thallium is a metal, the salts of which were formerly used as active ingredients in rodenticides and insecticides until its sale was regulated due to its high toxicity. Thallium household formulations were banned in 1965. The metal is still used in the manufacture of optical lenses and imitation jewelry and by government agencies as a pesticide.

Toxicological information regarding thallium is limited. The following information has been summarized from the Tomes Medical Management and *Integrated Risk Information System (IRIS)* databases.

Toxicokinetics

Thallium is absorbed gastrointestinally. Following exposure, thallium is excreted in the urine for many weeks.

Qualitative Description of Health Effects

Thallium affects a wide variety of target organs in humans and experimental animals. Following ingestion, gastrointestinal, hepatitic, dermal, and neurological effects have been widely reported. Ingestion of large doses of thallium may result in death; the reported adult fatal dose is approximately 1 g of absorbed thallium.

Symptoms are usually delayed by 12 to 24 hours in acute poisoning and reach a maximum in the second and third week after exposure. Transient nausea and vomiting are generally seen first, followed by a peripheral sensory neuropathy with painful paresthesias in 1 to 5 days or more. Other early effects may include myalgias, headache, seizures, delirium, coma, peripheral neuropathy, severe pain, and muscle weakness and atrophy. Alopecia may develop 1 to 3 weeks after exposure. Later effects may include ataxia, dementia, depression, and psychosis. Neurological damage resolves slowly and may be permanent. There are isolated reports of neurological effects lasting more than 30 years.

Quantitative Description of Health Effects

EPA has developed oral reference doses (RfDs) for several salts of thallium. These values are presented in the *Integrated Risk Information System (IRIS)* (EPA 2005). All RfDs are based on the same study, conducted using thallium sulfate, and were adjusted according to compound by correcting for differences in molecular weight.

Derivation of the RfDs is based on the results of a 90-day subchronic study with Sprague-Dawley rats conducted by EPA (1986). In this study, groups of rats (20/sex/group) were treated by gavage with an aqueous solution of thallium sulfate containing approximately 0, 0.008, 0.04, or 0.20 mg of thallium per kg per day. Following treatment, the only grossly observed finding at necropsy was alopecia, especially in female rats; however, microscopic evaluations did not reveal any histopathologic alterations. Based on the results of this study, the highest dose (0.20 mg/kg-day) was considered a no-observed-adverse-effects-level (NOAEL). An uncertainty factor of 3,000 was applied to the NOAEL to extrapolate from subchronic to chronic data, 10 for intraspecies extrapolation, and 10 to account for interspecies variability, and a factor of 3 to account for lack of reproductive and chronic toxicity data. RfDs for different salts of thallium are summarized below.

Summary of Criteria

Criterion	Value	Source
EPA Carcinogen Classification	Not Available	EPA 2004a
Oral RfD Thallium	7.0×10^{-5} mg/kg-day	EPA 2004a
Oral RfD Thallium Acetate	9.0×10^{-5} mg/kg-day	EPA 2005
Oral RfD Thallium Carbonate	8.0×10^{-5} mg/kg-day	EPA 2005
Oral RfD Thallium Chloride	8.0×10^{-5} mg/kg-day	EPA 2005
Oral RfD Thallium Nitrate	9.0×10^{-5} mg/kg-day	EPA 2005
Oral RfD Thallium Sufate (I)	8.0×10^{-5} mg/kg-day	EPA 2005
Maximum Contaminant Level Goal (MCLG)	0.0005 mg/L	EPA 2004a
Maximum Contaminant Level (MCL)	0.002 mg/L	EPA 2004a
EPA Drinking Water Health Advisories		EPA 2004a
10-kg Child (One-day and Ten-day)	0.007 mg/L	EPA 2004a
DWEL	0.002 mg/L	EPA 2004a
Life-time	0.0005 mg/L	EPA 2004a
Ambient Water Quality Criteria (AWQC) (concentration associated with a 10^{-6} excess lifetime cancer risk)		
Ingestion of water and aquatic organisms	0.24 µg/L	EPA 2004b
Ingestion of aquatic organisms	0.47 µg/L	EPA 2004b

References

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APPENDIX D

ProUCL Input and Output Files

Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	K	Se	Ag	Na	Tl	Ti	V	Zn	Well	Sample #
		0.83			1.85		7.1		4.16	32.95	2.5				5.75			3.94		2.3			5.4	Artesian	CC104-003
		0.83			1.85		7.1		4.6	32.95	2.8				5.75			3.94		1.8			36.8	Clark Residence	CC104-002
		0.83			6.08		7.1		13.9	41500	3.8				43.5			3.94		2			27	Rubble Residence	CC104-004

Table D-1: ProUCL Groundwater Input

Table D-2: ProUCL Soil Input
Mine Area w/o hotspots

Pb_XRF	Grid Cell Number	Date Screened	Notes:
253	161	9/8/2004	
238	162	9/8/2004	
102	170	9/8/2004	
<96	171	9/8/2004	
304	177	9/8/2004	
136	178	9/8/2004	
327	179	9/16/2004	
322	185	9/8/2004	
308	186	9/8/2004	
311	187	9/8/2004	
341	194	9/8/2004	
145	195	9/8/2004	
291	196	9/8/2004	
224	202	9/10/2004	
137	203	9/10/2004	
266	211	9/12/2004	
107	212	9/12/2004	
314	220	9/12/2004	
398	221	9/12/2004	
182	229	9/12/2004	
79	230	9/12/2004	
205	238	9/15/2004	
66	239	9/15/2004	
173	241	9/15/2004	
269	251	9/15/2004	
<65	252	9/15/2004	
165	253	9/15/2004	
60	267	9/16/2004	
87	268	9/16/2004	
104	269	9/20/2004	
110	282	9/20/2004	
225	283	9/20/2004	
106	284	9/20/2004	
103	296	9/14/2004	
109	297	9/20/2004	
<91	298	9/20/2004	
<110	304	9/20/2004	
103	316	9/20/2004	
64	317	9/20/2004	
106	318	9/20/2004	
47	321	9/22/2004	
50	322	10/17/2004	
58	334	9/14/2004	
61	335	9/14/2004	
117	336	9/20/2004	
186	337	9/20/2004	
65	338	9/20/2004	
82	339	9/22/2004	
72	340	9/27/2004	
171	341	9/27/2004	
345	342	9/27/2004	
219	343	9/27/2004	
50	354	9/14/2004	
103	355	9/14/2004	
100	356	9/20/2004	
79	357	9/20/2004	
199	358	9/20/2004	
299	359	9/22/2004	
307	360	10/17/2004	
304	361	10/17/2004	
154	372	10/4/2004	Backfilled-Lower Sed
171	373	9/14/2004	
	374	NA	Backfilled-Upper Sed
	375	NA	Backfilled-Upper Sed
<160	376	9/20/2004	
49	377	9/20/2004	
184	390	9/15/2004	
217	390	9/14/2004	
	391	NA	Backfilled-Upper Sed
	392	NA	Backfilled-Upper Sed
72	393	9/15/2004	
238	394	9/15/2004	
	395	NA	Backfilled
	396	NA	Backfilled
	397	NA	Backfilled
610	406	10/18/2004	Backfilled-Lower Sed
989	407	10/18/2004	Backfilled-Lower Sed
275	408	9/14/2004	
	409	NA	Backfilled-Upper Sed
	410	NA	Backfilled-Upper Sed
171	411	9/15/2004	
	413	NA	Backfilled
	414	NA	Backfilled
340	423	10/18/2004	Backfilled-Lower Sed
424	424	10/18/2004	Backfilled-Lower Sed
288	426	6/4/2005	
<85	427 ppx		
74	428		
51	429		
826	440		Backfilled-Lower Sed
92	443		

Table C-2: ProUCL Soil Input Mine Area w/o hotspots

52		444		
<80		445		
74		446		
327		451	9/15/2004	
		460		Backfilled
		461		Backfilled
<100	462 ppx			Backfilled
460		463	9/2/2004	Backfilled
606		466	9/2/2004	Backfilled
88		467	9/2/2004	
301		471	9/15/2004	
356		479	9/14/2004	
116		486	9/2/2004	
316		487	9/22/2004	
455		489	9/15/2004	
71	489 ppx			
233		495	9/14/2004	
514		496	9/2/2004	Backfilled
155		505	8/4/2004	
185		506	8/4/2004	
		507	NA	Backfilled
		508	NA	Backfilled
		509	NA	Backfilled
		510	NA	Backfilled
		511	NA	Backfilled
150	512 ppx			
778		513	9/15/2004	
221	513 ppx			
187		516	9/2/2004	
237		517	9/2/2004	
147		521	8/10/2004	
377		525	8/4/2004	
182		526	8/4/2004	
<90		527	8/17/2004	
		528	NA	Backfilled
		529	NA	Backfilled
		530	NA	Backfilled
		531	NA	Backfilled
213	532 ppx			
89		533	9/30/2004	
119		537	9/2/2004	
64		538	9/2/2004	
235		539	9/2/2004	
188		540	9/2/2004	
53		543	8/24/2004	
97		544	8/4/2004	
149		545	7/29/2004	
82		546	7/29/2004	
329		548	8/4/2004	
73		549	8/4/2004	
71		550	8/17/2004	
<93		551	8/17/2004	
345		556	9/15/2004	
105		557	8/6/2004	
223		558	9/15/2004	
832		559	9/15/2004	
82	559 ppx			
260		560	9/15/2004	
56		565	8/28/2004	
72		566	8/28/2004	
49		567	8/28/2004	
362		568	9/2/2004	
182		569	8/28/2004	
63		570	8/28/2004	
67		571	8/23/2004	
232		572	7/29/2004	
224		573	7/29/2004	
67		574	7/29/2004	
122		575	7/29/2004	
60		584	9/15/2004	
188		585	8/6/2004	
<110		593	8/7/2004	
73		594	8/16/2004	
41		595	8/28/2004	
55		596	8/26/2004	
59		597	8/28/2004	
54		598	8/24/2004	
87		599	7/29/2004	
51		602	7/29/2004	
92		603	7/29/2004	
116		604	8/4/2004	
119		620	8/6/2004	
<69		621	8/7/2004	
<43		622	8/26/2004	
107		623	8/26/2004	
133		624	8/26/2004	
55		626	8/9/2004	
191		631	7/29/2004	
		632	NA	Removal and Clearing
		633	NA	Removal and Clearing
		634	NA	Removal and Clearing
		635	NA	Removal and Clearing
301		645	8/6/2004	

Table C-2: ProUCL Soil Input Mine Area w/o hotspots

56		646	8/6/2004	
55		647	8/6/2004	
88		648	8/6/2004	
136		649	8/9/2004	
94		650	8/9/2004	
133		651	8/9/2004	
283		662	8/6/2004	
<94		663	8/6/2004	
316		664	8/6/2004	
113		665	8/3/2004	
55		667	7/29/2004	
215		676	8/6/2004	
221		677	8/6/2004	
<150		678	8/6/2004	
108		679	8/6/2004	
219		680	8/4/2004	
101		681	8/3/2004	
121		688	8/6/2004	
95		689	8/6/2004	
91		690	8/6/2004	
<47		691	8/6/2004	
46		692	8/4/2004	
77		699	8/3/2004	
97		825	10/17/2004	
49		826	10/17/2004	
<98		827	10/17/2004	
55		828	10/17/2004	
47		829	10/17/2004	
58		830	10/17/2004	
<100		831	10/17/2004	
156		832	10/17/2004	
316		833	10/17/2004	
361		834	10/17/2004	
107		835	10/17/2004	
114		836	10/17/2004	
145		837	10/17/2004	
147		838	10/17/2004	
450		839	10/17/2004	
87	839 ppx		11/5/2004	
192		840	10/17/2004	
74		841	10/17/2004	
208		842	10/17/2004	
208		843	10/17/2004	
536		844	10/17/2004	
93	844 ppx		11/5/2004	
305		845	10/17/2004	
363		846	10/17/2004	
261		847	10/17/2004	
318		848	10/17/2004	
341	849 ppx		11/5/2004	
564		850	11/5/2004	Backfilled
<58		853	11/5/2004	
350		854	10/17/2004	
118		855	10/17/2004	
127		856	10/17/2004	
132		857	10/17/2004	
<95		858	10/17/2004	
994		863	10/17/2004	
71	863 ppx		11/2/2004	
280		864	10/17/2004	
<81		865	10/17/2004	
93		866	10/17/2004	
113		867	10/17/2004	
131		868	10/17/2004	
732		874	10/17/2004	
84	874 ppx		11/2/2004	
66		875	10/17/2004	
<76		876	10/17/2004	
87		877	10/17/2004	
92		878	10/17/2004	
300		879	10/17/2004	
98		886	10/17/2004	
97		887	10/17/2004	
718		889	10/17/2004	
45	889 ppx		11/2/2004	
111		897	10/17/2004	
123		898	10/17/2004	
74		899	10/17/2004	

Pb_XRF	Date Screened	Grid Cell Number	Notes:
1005	10/18/2004	422	Backfilled-Lower Sed
1290	6/4/2004	425	Backfilled
1825		427	
1220		442	Backfilled
2900	9/2/2004	462	Backfilled
4426	9/2/2004	464	Backfilled
1523	9/2/2004	465	Backfilled
5066	9/2/2004	480	Backfilled
4553	9/2/2004	481	Backfilled
9990	9/2/2004	482	Backfilled
13833	9/2/2004	483	Backfilled
14900	9/2/2004	484	Backfilled
14800	9/2/2004	485	Backfilled
6140	9/2/2004	497	Backfilled
11140	9/2/2004	498	Backfilled
19566	9/2/2004	499	Backfilled
12660	9/2/2004	500	Backfilled
1254	9/2/2004	501	Backfilled
5190	9/2/2004	518	Backfilled
5196	9/2/2004	519	Backfilled
10986	9/2/2004	520	Backfilled
1976	9/2/2004	541	Backfilled
8633	9/2/2004	542	Backfilled

Table D-3: ProUCL Surface Soil Input
Mine Area - Clark Hotspot

Pb_XRF	Date Screened	Grid Cell Numbe	Notes:
3,746	9/8/2004	140	Backfilled
2,890	9/8/2004	150	Backfilled
1283	9/8/2004	151	Backfilled

Table D-4: ProUCL Surface Soil Input
Mine Area - Mayberry Hotspot

Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	K	Se	Ag	Na	Tl	Tl	V	Zn	Sample Location	Sample Depth
5670.00	6.02	9.80	225.00	0.889	0.50	1840.00	13.60	12.90	34.60	15000.00	112.00	729.00	949.00		11.30	626.00	3.51	1.00	502.00	2.51		23.20	55.70	GP78	0.0-0.5
2460.00	5.92	6.95	508.00	0.505	0.75	4590.00	10.40	7.85	22.20	8790.00	66.50	2320.00	511.00		7.85	493.00	3.45	0.99	493.00	2.47		14.10	46.70	GP81	0.0-0.5
1210.00	1.00	35.10	8.71	0.500	0.50	121000.00	1.00	54.60	66.20	10800.00	961.00	67500.00	1450.00	1.00	38.90	424.00	10.70	1.00	224.00			2.50	199.00	GP04	0.0-1.0
5370.00	3.69	38.30	112.00	1.240	1.37	20300.00	5.42	42.80	38.30	12400.00	1170.00	10200.00	1620.00	1.00	35.40	647.00	5.00	1.00	25.00			16.40	113.00	GP15	0.0-1.0
6280.00	6.03	8.00	160.00	1.040	0.50	1470.00	11.50	12.80	17.30	13700.00	39.20	687.00	1170.00		11.50	503.00	3.52	1.01	503.00	2.51		22.80	32.50	GP77	0.0-1.0
4060.00	1.00	19.10	83.40	0.500	2.81	23000.00	7.90	19.30	27.90	10900.00	385.00	12300.00	1060.00	1.00	18.60	430.00	5.00	1.00	25.00			15.70	70.30	GP20	0.0-1.25
1140.00	1.00	43.50	21.30	0.500	2.28	135000.00	1.00	44.90	80.40	14500.00	1450.00	75000.00	1680.00	1.00	40.20	372.00	5.00	1.00	235.00			2.50	267.00	GP03	0.0-1.5
1550.00	1.00	26.90	31.30	0.500	1.74	118000.00	1.00	44.50	50.20	11800.00	1370.00	65600.00	1470.00	1.00	37.40	451.00	5.00	1.00	189.00			2.50	213.00	GP02	0.0-1.5
5360.00	3.97	46.60	90.90	1.030	1.47	16000.00	9.07	58.30	39.60	12100.00	1150.00	8410.00	1070.00	1.00	55.30	635.00	5.00	1.00	25.00			17.60	128.00	GP01	0.0-1.5
3320.00	1.00	16.80	90.70	0.500	0.50	14900.00	10.30	18.30	19.60	10500.00	324.00	8140.00	1230.00	1.00	16.70	312.00	5.00	1.00	25.00			15.40	53.50	GP19	0.0-1.5
10900.00	6.06	10.90	189.00	1.910	0.51	4100.00	18.30	17.00	24.30	20800.00	86.30	1790.00	1760.00		18.70	1160.00	3.54	1.01	505.00	2.53		35.30	86.80	GP70	0.0-1.5
2770.00	3.72	14.30	85.00	0.500	2.02	2980.00	9.69	10.20	13.80	7870.00	141.00	1190.00	572.00	1.00	9.54	340.00	5.00	1.00	25.00			12.90	36.70	GP29	0.0-1.75
2420.00	1.00	52.30	35.90	0.500	2.40	100000.00	1.00	68.00	72.10	12500.00	3270.00	56900.00	1530.00	1.00	56.90	648.00	11.00	1.00	166.00			6.26	305.00	GP08	0.0-2.0
2220.00	1.00	78.60	30.80	0.500	3.48	115000.00	1.00	81.60	96.40	14000.00	5140.00	63300.00	1490.00	1.00	71.30	748.00	13.20	1.00	136.00			5.18	311.00	GP09	0.0-2.0
6280.00	1.00	21.20	233.00	1.200	0.50	1660.00	9.58	12.50	16.30	11100.00	45.70	724.00	1220.00	1.00	12.00	385.00	5.00	1.00	25.00			19.20	29.10	GP30	0.0-2.0
3950.00	1.00	13.80	115.00	0.500	0.50	2230.00	10.30	11.90	14.60	9910.00	82.30	927.00	812.00	1.00	10.00	333.00	5.00	1.00	25.00			14.50	44.60	GP31	0.0-2.0
10900.00	6.03	11.20	160.00	1.670	0.50	2310.00	14.50	17.60	25.90	19100.00	81.60	1290.00	1680.00		17.70	837.00	3.51	1.00	502.00	2.51		32.40	55.40	GP73	0.0-2.0
5270.00	2.84	20.10	121.00	0.500	1.40	3080.00	10.90	47.20	9.21	9500.00	101.00	1690.00	2280.00	1.00	91.50	440.00	5.00	1.00	51.60			17.90	103.00	GP04	1.0-2.0
3360.00	1.00	18.40	36.10	0.500	1.28	103000.00	1.00	43.00	53.50	11500.00	1360.00	57700.00	1590.00	1.00	46.50	554.00	5.00	1.00	248.00			9.70	201.00	GP05	1.5-1.75

Table D-5: ProUCL Surface Soil Input Floodplain Area

Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	K	Se	Ag	Na	Tl	Ti	V	Zn	Sample #	Sampling Location	Comment
25.00	25.00	12.50	30.20	1.50	1.50	0.019	7.50	5.00	2.50	25.00	25.00	0.009	2.50	7.50	10.00	0.001	25.00	12.50	0.003	101.00	10.00	5.00	12.50	2293-103 (SW-03)	Sutton Branch below 49	
25.00	25.00	12.50	31.10	1.50	1.50	0.020	7.50	5.00	2.50	25.00	25.00	0.010	11.50	7.50	10.00	0.001	25.00	12.50	0.003	25.00	10.00	5.00	12.50	2293-104 (SW-04)	Sutton Branch below 49	
25.00	25.00	12.50	31.30	1.50	1.50	0.020	7.50	5.00	2.50	25.00	25.00	0.010	9.98	7.50	10.00	0.001	59.30	12.50	0.003	25.00	10.00	5.00	12.50	2293-105 (SW-05)	Sutton Branch below 49	

Table D-6: ProUCL Surface Water Input
Sutton Branch - Floodplain Area Column Water

Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	K	Se	Ag	Na	Tl	Ti	V	Zn	Sample #	Sample Location
812.00	1.00	2.50	17.80	0.50	0.50	46900.00	1.00	21.70	13.40	5740.00	280.00	26200.00	754.00	1.00	14.40	202.00	5.00	1.00	112.00			5.52		2293-52 (SED-03)	Sutton Branch below 49
1450.00	1.00	25.60	18.50	0.50	0.50	73900.00	1.00	40.20	45.50	8400.00	1070.00	42200.00	1090.00	1.00	32.20	409.00	5.00	1.00	168.00			6.66	92.70	2293-53 (SED-04)	Sutton Branch below 49
610.00	1.00	2.50	8.32	0.50	0.50	64100.00	1.00	22.10	52.10	4580.00	268.00	36400.00	868.00	1.00	13.70	194.00	5.00	1.00	156.00			2.50	40.40	2293-54 (SED-05)	Sutton Branch below 49

Table D-7: ProUCL Sediment Input
Sutton Branch - Floodplain Area

Table D-8: ProUCL Surface Soil Output		**Variable:**	**Pb**
Mine Area without hotspots			
EPC Used: Mean = 159.4084 mg/kg			
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	262	*Lilliefors Test Statisitic*	0.173726
Number of Unique Samples	151	Lilliefors 5% Critical Value	0.054737
Minimum	0	Data not normal at 5% significance level	
Maximum	994		
Mean	159.4084	95% UCL (Assuming Normal Distribution)	
Median	106	Student's-t UCL	176.7111
Standard Deviation	169.6656		
Variance	28786.4		
Coefficient of Variation	1.064345		
Skewness	2.149275		
Gamma Statistics Not Available			
Lognormal Statistics Not Available			
		95% Non-parametric UCLs	
		CLT UCL	176.6497
		Adj-CLT UCL (Adjusted for skewness)	178.1369
		Mod-t UCL (Adjusted for skewness)	176.9431
		Jackknife UCL	176.7111
		Standard Bootstrap UCL	176.5499
		Bootstrap-t UCL	178.2907
RECOMMENDATION		Hall's Bootstrap UCL	178.8075
Data are Non-parametric (0.05)		Percentile Bootstrap UCL	176.9198
		BCA Bootstrap UCL	179.3053
Use 95% Chebyshev (Mean, Sd) UCL		95% Chebyshev (Mean, Sd) UCL	205.0983
		97.5% Chebyshev (Mean, Sd) UCL	224.8683
		99% Chebyshev (Mean, Sd) UCL	263.7027

Table D-9: ProUCL Surface Soil Output		**Variable:**	**Pb**
Mine Area - Clark Hotspot			
EPC Used: Mean = 6959.652 mg/kg			
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	23	Shapiro-Wilk Test Statisitic	0.895662
Number of Unique Samples	23	Shapiro-Wilk 5% Critical Value	0.914
Minimum	1005	Data not normal at 5% significance level	
Maximum	19566		
Mean	6959.65217	95% UCL (Assuming Normal Distribution)	
Median	5190	Student's-t UCL	8923.588
Standard Deviation	5485.09764		
Variance	30086296.1	Gamma Distribution Test	
Coefficient of Variation	0.78812813	A-D Test Statistic	0.559403
Skewness	0.71291624	A-D 5% Critical Value	0.760536
		K-S Test Statistic	0.138312
Gamma Statistics		K-S 5% Critical Value	0.185014
k hat	1.47628596	Data follow gamma distribution	
k star (bias corrected)	1.31271243	at 5% significance level	
Theta hat	4714.29816		
Theta star	5301.73405	95% UCLs (Assuming Gamma Distribution)	
nu hat	67.909154	Approximate Gamma UCL	9658.48
nu star	60.3847716	Adjusted Gamma UCL	9894.594
Approx.Chi Square Value (.05)	43.5117122		
Adjusted Level of Significance	0.0389	Lognormal Distribution Test	
Adjusted Chi Square Value	42.4733966	Shapiro-Wilk Test Statisitic	0.920373
		Shapiro-Wilk 5% Critical Value	0.914
Log-transformed Statistics		Data are lognormal at 5% significance level	
Minimum of log data	6.91274282		
Maximum of log data	9.88154865	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	8.47244115	95% H-UCL	12506.05
Standard Deviation of log data	0.95564215	95% Chebyshev (MVUE) UCL	14496.75
Variance of log data	0.91325192	97.5% Chebyshev (MVUE) UCL	17591.87
		99% Chebyshev (MVUE) UCL	23671.64
		95% Non-parametric UCLs	
		CLT UCL	8840.907
		Adj-CLT UCL (Adjusted for skewness)	9022.574
		Mod-t UCL (Adjusted for skewness)	8951.924
		Jackknife UCL	8923.588
		Standard Bootstrap UCL	8784.004
		Bootstrap-t UCL	9143.956
RECOMMENDATION		Hall's Bootstrap UCL	8911.588
Data follow gamma distribution (0.05)		Percentile Bootstrap UCL	8820.913
		BCA Bootstrap UCL	9096.435
Use Approximate Gamma UCL		95% Chebyshev (Mean, Sd) UCL	11945.02
		97.5% Chebyshev (Mean, Sd) UCL	14102.19
		99% Chebyshev (Mean, Sd) UCL	18339.54

Table D-10: ProUCL Surface Soil Output					**Variable:**	**Pb**		
Mine Area - Mayberry Hotspot								
EPC Used: Mean = 2639.667 mg/kg								
Raw Statistics								
Number of Valid Samples			3					
Number of Unique Samples			3					
Minimum			1283					
Maximum			3746					
Mean			2639.667					
Median			2890					
	Too Few Observations To Calculate UCLs							

Table D-11: ProUCL Surface Soil Output Floodplain Area		**Variable:**	**As**
EPC Used: 95% UCL = 34.4558 mg/kg			
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	19	Shapiro-Wilk Test Statisitic	0.851486
Number of Unique Samples	19	Shapiro-Wilk 5% Critical Value	0.901
Minimum	6.95	Data not normal at 5% significance level	
Maximum	78.6		
Mean	25.88684	95% UCL (Assuming Normal Distribution)	
Median	19.1	Student's-t UCL	33.36106
Standard Deviation	18.78786		
Variance	352.9838	Gamma Distribution Test	
Coefficient of Variation	0.725769	A-D Test Statistic	0.397
Skewness	1.438436	A-D 5% Critical Value	0.750411
		K-S Test Statistic	0.162453
Gamma Statistics		K-S 5% Critical Value	0.200512
k hat	2.382836	Data follow gamma distribution	
k star (bias corrected)	2.041687	at 5% significance level	
Theta hat	10.86388		
Theta star	12.67915	95% UCLs (Assuming Gamma Distribution)	
nu hat	90.54778	Approximate Gamma UCL	34.4558
nu star	77.58409	Adjusted Gamma UCL	35.34183
Approx.Chi Square Value (.05)	58.28938		
Adjusted Level of Significance	0.03687	Lognormal Distribution Test	
Adjusted Chi Square Value	56.82805	Shapiro-Wilk Test Statisitic	0.971169
		Shapiro-Wilk 5% Critical Value	0.901
Log-transformed Statistics		Data are lognormal at 5% significance level	
Minimum of log data	1.938742		
Maximum of log data	4.364372	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	3.029464	95% H-UCL	37.25225
Standard Deviation of log data	0.682504	95% Chebyshev (MVUE) UCL	44.3856
Variance of log data	0.465812	97.5% Chebyshev (MVUE) UCL	52.45697
		99% Chebyshev (MVUE) UCL	68.31162
		95% Non-parametric UCLs	
		CLT UCL	32.97654
		Adj-CLT UCL (Adjusted for skewness)	34.49637
		Mod-t UCL (Adjusted for skewness)	33.59812
		Jackknife UCL	33.36106
		Standard Bootstrap UCL	32.99886
		Bootstrap-t UCL	35.70585
RECOMMENDATION		Hall's Bootstrap UCL	36.33094
Data follow gamma distribution (0.05)		Percentile Bootstrap UCL	32.83947
		BCA Bootstrap UCL	33.91053
Use Approximate Gamma UCL		95% Chebyshev (Mean, Sd) UCL	44.67471
		97.5% Chebyshev (Mean, Sd) UCL	52.80423
		99% Chebyshev (Mean, Sd) UCL	68.77311

Table D-12: ProUCL Surface Soil Output **Variable: Mn**

Floodplain Area

EPC Used: 95% UCL = 1497.025 mg/kg

Raw Statistics		Normal Distribution Test	
Number of Valid Samples	19	Shapiro-Wilk Test Statisitic	0.968554
Number of Unique Samples	18	Shapiro-Wilk 5% Critical Value	0.901
Minimum	511	Data are normal at 5% significance level	
Maximum	2280		
Mean	1323.368	95% UCL (Assuming Normal Distribution)	
Median	1450	Student's-t UCL	1497.025
Standard Deviation	436.5187		
Variance	190548.6	Gamma Distribution Test	
Coefficient of Variation	0.329854	A-D Test Statistic	0.505961
Skewness	-0.05483	A-D 5% Critical Value	0.741574
		K-S Test Statistic	0.175178
Gamma Statistics		K-S 5% Critical Value	0.198698
k hat	8.274993	Data follow gamma distribution	
k star (bias corrected)	7.003503	at 5% significance level	
Theta hat	159.9238		
Theta star	188.9581	95% UCLs (Assuming Gamma Distribution)	
nu hat	314.4497	Approximate Gamma UCL	1535.624
nu star	266.1331	Adjusted Gamma UCL	1555.852
Approx.Chi Square Value (.05)	229.348		
Adjusted Level of Significance	0.03687	Lognormal Distribution Test	
Adjusted Chi Square Value	226.3661	Shapiro-Wilk Test Statisitic	0.912738
		Shapiro-Wilk 5% Critical Value	0.901
Log-transformed Statistics		Data are lognormal at 5% significance level	
Minimum of log data	6.23637		
Maximum of log data	7.731931	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	7.126297	95% H-UCL	1589.91
Standard Deviation of log data	0.382083	95% Chebyshev (MVUE) UCL	1853.292
Variance of log data	0.145987	97.5% Chebyshev (MVUE) UCL	2078.409
		99% Chebyshev (MVUE) UCL	2520.607
		95% Non-parametric UCLs	
		CLT UCL	1488.091
		Adj-CLT UCL (Adjusted for skewness)	1486.745
		Mod-t UCL (Adjusted for skewness)	1496.815
		Jackknife UCL	1497.025
		Standard Bootstrap UCL	1483.715
		Bootstrap-t UCL	1484.067
RECOMMENDATION		Hall's Bootstrap UCL	1491.422
Data are normal (0.05)		Percentile Bootstrap UCL	1478.053
		BCA Bootstrap UCL	1473.368
Use Student's-t UCL		95% Chebyshev (Mean, Sd) UCL	1759.887
		97.5% Chebyshev (Mean, Sd) UCL	1948.769
		99% Chebyshev (Mean, Sd) UCL	2319.791

Table D-13: ProUCL Surface Soil Output		**Variable:**	**Pb**
Floodplain Area			
EPC Used: Mean = 912.4 mg/kg			
Raw Statistics		Normal Distribution Test	
Number of Valid Samples	19	Shapiro-Wilk Test Statisitic	0.686715
Number of Unique Samples	19	Shapiro-Wilk 5% Critical Value	0.901
Minimum	39.2	Data not normal at 5% significance level	
Maximum	5140		
Mean	912.4	95% UCL (Assuming Normal Distribution)	
Median	324	Student's-t UCL	1435.015
Standard Deviation	1313.692		
Variance	1725787	Gamma Distribution Test	
Coefficient of Variation	1.439821	A-D Test Statistic	0.896329
Skewness	2.288115	A-D 5% Critical Value	0.792225
		K-S Test Statistic	0.21823
Gamma Statistics		K-S 5% Critical Value	0.208273
k hat	0.61006	Data do not follow gamma distribution	
k star (bias corrected)	0.548823	at 5% significance level	
Theta hat	1495.589		
Theta star	1662.467	95% UCLs (Assuming Gamma Distribution)	
nu hat	23.1823	Approximate Gamma UCL	1657.161
nu star	20.85527	Adjusted Gamma UCL	1749.466
Approx.Chi Square Value (.05)	11.4825		
Adjusted Level of Significance	0.03687	Lognormal Distribution Test	
Adjusted Chi Square Value	10.87666	Shapiro-Wilk Test Statisitic	0.908685
		Shapiro-Wilk 5% Critical Value	0.901
Log-transformed Statistics		Data are lognormal at 5% significance level	
Minimum of log data	3.668677		
Maximum of log data	8.544808	95% UCLs (Assuming Lognormal Distribution)	
Mean of log data	5.805742	95% H-UCL	3978.838
Standard Deviation of log data	1.551587	95% Chebyshev (MVUE) UCL	2795.348
Variance of log data	2.407422	97.5% Chebyshev (MVUE) UCL	3580.36
		99% Chebyshev (MVUE) UCL	5122.363
		95% Non-parametric UCLs	
		CLT UCL	1408.129
		Adj-CLT UCL (Adjusted for skewness)	1577.172
		Mod-t UCL (Adjusted for skewness)	1461.382
		Jackknife UCL	1435.015
		Standard Bootstrap UCL	1406.61
		Bootstrap-t UCL	1892.601
		Hall's Bootstrap UCL	3913.658
		Percentile Bootstrap UCL	1428.484
		BCA Bootstrap UCL	1594.421
		95% Chebyshev (Mean, Sd) UCL	2226.092
		97.5% Chebyshev (Mean, Sd) UCL	2794.528
		99% Chebyshev (Mean, Sd) UCL	3911.11

Table D-14: ProUCL Groundwater Output					**Variable:**	**As**		
EPC Used: Maximum Concentration = 0.83 ug/l								
Raw Statistics								
Number of Valid Samples			3					
Number of Unique Samples			2					
Minimum			0.83					
Maximum			0.83					
Mean			0.83					
Median			0.83					
	Too Few Observations To Calculate UCLs							

Table D-15: ProUCL Groundwater Output		Variable: Fe
EPC Used: Maximum Concentration = 41500 ug/l		
Raw Statistics		
Number of Valid Samples	3	
Number of Unique Samples	2	
Minimum	32.95	
Maximum	41500	
Mean	13855.3	
Median	32.95	
Too Few Observations To Calculate UCLs		

Table D-16: ProUCL Groundwater Output		Variable:	Pb
EPC Used: Maximum Concentration = 3.8 ug/l			
Raw Statistics			
Number of Valid Samples	3		
Number of Unique Samples	3		
Minimum	2.5		
Maximum	3.8		
Mean	3.033333		
Median	2.8		
Too Few Observations To Calculate UCLs			

Table D-17: ProUCL Groundwater Output		Variable:	Tl
EPC Used: Maximum Concentration = 2.3 ug/l			
Raw Statistics			
Number of Valid Samples	3		
Number of Unique Samples	3		
Minimum	1.8		
Maximum	2.3		
Mean	2.033333		
Median	2		
Too Few Observations To Calculate UCLs			

Table D-18: ProUCL Surface Water Output					**Variable:**	**As**		
Sutton Branch Floodplain								
EPC Used: Maximum Concentration = 12.5 ug/l								
Raw Statistics								
Number of Valid Samples			3					
Number of Unique Samples			1					
Minimum			12.5					
Maximum			12.5					
Mean			12.5					
Median			12.5					
	Too Few Observations To Calculate UCLs							

Table D-19: ProUCL Surface Water Output					**Variable:**	**Mn**		
Sutton Branch Floodplain								
EPC Used: Maximum Concentration = 11.5 ug/l								
Raw Statistics								
Number of Valid Samples			3					
Number of Unique Samples			3					
Minimum			2.5					
Maximum			11.5					
Mean			7.993333					
Median			9.98					
	Too Few Observations To Calculate UCLs							

Table D-20: ProUCL Surface Water Output					Variable:	Pb		
Sutton Branch Floodplain								
EPC Used: Maximum Concentration = 25 ug/l								
Raw Statistics								
Number of Valid Samples			3					
Number of Unique Samples			1					
Minimum			25					
Maximum			25					
Mean			25					
Median			25					
	Too Few Observations To Calculate UCLs							

Table D-21: ProUCL Surface Water Output					**Variable:**	Tl		
Sutton Branch Floodplain								
EPC Used: Maximum Concentration = 101 ug/l								
Raw Statistics								
Number of Valid Samples			3					
Number of Unique Samples			2					
Minimum			25					
Maximum			101					
Mean			50.33333					
Median			25					
	Too Few Observations To Calculate UCLs							

Table D-22: ProUCL Sediment Output					**Variable:**	**As**		
Sutton Branch Floodplain								
EPC Used: Maximum Concentration = 25.6 mg/kg								
Raw Statistics								
Number of Valid Samples			3					
Number of Unique Samples			2					
Minimum			2.5					
Maximum			25.6					
Mean			10.2					
Median			2.5					
	Too Few Observations To Calculate UCLs							

Table D-23: ProUCL Surface Water Output	**Variable:**	**Pb**
Sutton Branch Floodplain		
EPC Used: Maximum Concentration = 1070 mg/kg		

Raw Statistics	
Number of Valid Samples	3
Number of Unique Samples	3
Minimum	268
Maximum	1070
Mean	539.3333
Median	280
Too Few Observations To Calculate UCLs	

Table D-23: ProUCL Sediment Output					**Variable:**	**Pb**		
Sutton Branch Floodplain								
EPC Used: Maximum Concentration = 1070 mg/kg								
Raw Statistics								
Number of Valid Samples			3					
Number of Unique Samples			3					
Minimum			268					
Maximum			1070					
Mean			539.3333					
Median			280					
	Too Few Observations To Calculate UCLs							

ANNAPOLIS LEAD MINE

HUMAN HEALTH RISK ASSESSMENT

APPENDIX E

RAGS Part D Planning Tables

TABLE 0

SITE RISK ASSESSMENT IDENTIFICATION INFORMATION

Annapolis Lead Mine

Site Name/OU:	Annapolis Lead Mine
Region:	EPA Region VII
EPA ID Number:	MO0000958611
State:	Missouri
Status:	
Federal Facility (Y/N):	N
EPA Project Manager:	Steve Kinser
EPA Risk Assessor:	
Prepared by (Organization):	CDM
Prepared for (Organization):	U.S. EPA, Region 7
Document Title:	Annapolis Lead Mine Human Health Risk Assessment
Document Date:	22-Jul-05
Probabilistic Risk Assessment (Y/N):	N
Comments:	

TABLE 1

SELECTION OF EXPOSURE PATHWAYS

Annapolis Lead Mine

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Future/Current	Surface Soil/ Interior Dust	Surface Soil/ Interior Dust	Hand-to-Mouth Contact with Surface Soil/ Interior Dust	Resident	Adult	Ingestion	Quantitative	Residents may incidentally ingest soil.
Future/Current	Surface Soil/ Interior Dust	Surface Soil/ Interior Dust	Hand-to-Mouth Contact with Surface Soil/ Interior Dust	Resident	Child	Ingestion	Quantitative	Residents may incidentally ingest soil.
Future/Current	Surface Soil/ Interior Dust	Indoor Air	Inhaling Dust from Indoor Air	Resident	Adult	Inhalation	Qualitative	Residents may inhale fugitive dust.
Future/Current	Surface Soil/ Interior Dust	Indoor Air	Inhaling Dust from Indoor Air	Resident	Child	Inhalation	Qualitative	Residents may inhale fugitive dust.
Future/Current	Surface Soil/ Interior Dust	Surface Soil/ Interior Dust	Direct Contact with Surface Soil/ Interior Dust	Resident	Adult	Dermal Contact	Quantitative	Residents may have exposed skin surfaces come into contact with soil.
Future/Current	Surface Soil/ Interior Dust	Surface Soil/ Interior Dust	Direct Contact with Surface Soil/ Interior Dust	Resident	Child	Dermal Contact	Quantitative	Residents may have exposed skin surfaces come into contact with soil.
Future/Current	Groundwater	Groundwater	Direct Contact with Groundwater while Showering	Resident	Adult	Dermal Contact	Quantitative	Residents may have exposed skin surfaces come into contact with groundwater.
Future/Current	Groundwater	Groundwater	Direct Contact with Groundwater while Bathing	Resident	Child	Dermal Contact	Quantitative	Residents may have exposed skin surfaces come into contact with groundwater.
Future/Current	Groundwater	Groundwater	Drinking Water	Resident	Adult	Ingestion	Quantitative	Residents may ingest groundwater.
Future/Current	Groundwater	Groundwater	Drinking Water	Resident	Child	Ingestion	Quantitative	Residents may ingest groundwater.
Future/Current	Surface Soil	Homegrown Vegetables	Consumption of Homegrown Vegetables	Resident	Adult	Ingestion	Qualitative	Residents may ingest produce containing contaminants accumulated from soil.
Future/Current	Surface Soil	Homegrown Vegetables	Consumption of Homegrown Vegetables	Resident	Child	Ingestion	Qualitative	Residents may ingest produce containing contaminants accumulated from soil.
Future/Current	Surface Water	Homegrown Vegetables	Consumption of Homegrown Vegetables	Resident	Adult	Ingestion	Qualitative	Residents may ingest produce containing contaminants accumulated from surface water used for watering.
Future/Current	Surface Water	Homegrown Vegetables	Consumption of Homegrown Vegetables	Resident	Child	Ingestion	Qualitative	Residents may ingest produce containing contaminants accumulated from surface water used for watering.
Future/Current	Groundwater	Homegrown Vegetables	Consumption of Homegrown Vegetables	Resident	Adult	Ingestion	Qualitative	Residents may ingest produce containing contaminants accumulated from groundwater used for watering.
Future/Current	Groundwater	Homegrown Vegetables	Consumption of Homegrown Vegetables	Resident	Child	Ingestion	Qualitative	Residents may ingest produce containing contaminants accumulated from groundwater used for watering.
Future/Current	Surface Soil	Particulates	Inhaling Particulates from Outdoor Air	Resident	Adult	Inhalation	Qualitative	Residents may inhale fugitive dust from outdoor air.

TABLE 1 (continued)
SELECTION OF EXPOSURE PATHWAYS
Annapolis Lead Mine

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Future/Current	Surface Soil	Particulates	Inhaling Particulates from Outdoor Air	Resident	Child	Inhalation	Qualitative	Residents may inhale fugitive dust from outdoor air.
Future/Current	Surface Soil	Particulates	Ingesting Particulates from Outdoor Air	Resident	Adult	Ingestion	Qualitative	Residents may incidentally ingest fugitive dust from outdoor air.
Future/Current	Surface Soil	Particulates	Ingesting Particulates from Outdoor Air	Resident	Child	Ingestion	Qualitative	Residents may incidentally ingest fugitive dust from outdoor air.
Future/Current	Surface Soil	Particulates	Particulates Contacting Skin from Outdoor Air	Resident	Adult	Dermal Contact	Qualitative	Residents may have exposed skin surfaces come into contact with fugitive dust in outdoor air.
Future/Current	Surface Soil	Particulates	Particulates Contacting Skin from Outdoor Air	Resident	Child	Dermal Contact	Qualitative	Residents may have exposed skin surfaces come into contact with fugitive dust in outdoor air.
Future	Surface Soil/ Interior Dust	Surface Soil/ Interior Dust	Hand-to-Mouth Contact with Surface Soil/ Interior Dust	Construction Worker	Adult	Ingestion	Quantitative	Workers may incidentally ingest soil.
Future	Surface Soil/ Interior Dust	Surface Soil/ Interior Dust	Inhaling Dust from Indoor Air	Construction Worker	Adult	Inhalation	Qualitative	Workers may inhale fugitive dust.
Future	Surface Soil/ Interior Dust	Surface Soil/ Interior Dust	Direct Contact with Surface Soil/ Interior Dust	Construction Worker	Adult	Dermal Contact	Quantitative	Workers may have exposed skin surfaces come into contact with soil.
Future	Surface Water/Sediment	Surface Water/Sediment	Direct Contact with Surface Water/Sediment	Construction Worker	Adult	Dermal Contact	Qualitative	Workers may have exposed skin surfaces come into contact with surface water or sediment.
Future	Surface Soil	Particulates	Inhaling Particulates from Outdoor Air	Construction Worker	Adult	Inhalation	Qualitative	Workers may inhale fugitive dust.
Future	Surface Soil	Particulates	Ingesting Particulates from Outdoor Air	Construction Worker	Adult	Ingestion	Qualitative	Workers may incidentally ingest soil.
Future	Surface Soil	Particulates	Particulates Contacting Skin from Outdoor Air	Construction Worker	Adult	Dermal Contact	Qualitative	Workers may have exposed skin surfaces come into contact with surface water or sediment.
Future/Current	Surface Soil	Surface Soil	Hand-to-Mouth Contact with Surface Soil	Recreational User	Child	Ingestion	Quantitative	Recreationists may incidentally ingest surface soil.
Future/Current	Surface Soil	Surface Soil	Direct Contact with Surface Soil	Recreational User	Child	Dermal Contact	Quantitative	Recreationists may have exposed skin surfaces come into contact with soil.
Future/Current	Surface Water/Sediment	Surface Water/Sediment	Consumption of Aquatic Organisms	Recreational User	Child	Ingestion	Qualitative	Recreationists may ingest contaminants accumulated in fish/crayfish.
Future/Current	Surface Soil	Particulates	Inhaling Particulates from Outdoor Air	Recreational User	Child	Inhalation	Qualitative	Recreationists may inhale fugitive dust from outdoor air.
Future/Current	Surface Soil	Particulates	Ingesting Particulates from Outdoor Air	Recreational User	Child	Ingestion	Qualitative	Recreationists may incidentally ingest fugitive dust from outdoor air.
Future/Current	Surface Soil	Particulates	Particulates Contacting Skin from Outdoor Air	Recreational User	Child	Dermal Contact	Qualitative	Recreationists may have exposed skin surfaces come into contact with fugitive dust from outdoor air.
Future/Current	Surface Water/Sediment	Surface Water/Sediment	Direct Contact while Wading	Recreational User	Child	Dermal Contact	Quantitative	Recreationists may have exposed skin surfaces come into contact with surface water or sediment during wading.
Future/Current	Surface Water/Sediment	Surface Water/Sediment	Incidental Ingestion while Wading	Recreational User	Child	Ingestion	Quantitative	Recreationists may incidentally ingest surface water or sediment while wading.

TABLE 2.1

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Annapolis Lead Mine, Annapolis Missouri

Scenario Timeframe:	Current/Future
Medium:	Surface water
Exposure Medium:	Surface water

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency (40 samples)	Range of Detection Limits	Concentration Used for Screening (2)	Background Value (3)	Screening Toxicity Value (N/C) (4)	Potential ARAR/TBC Value (ug/l)	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
Contact and ingestion of Sutton Branch surface water	7429-90-5	Al	17.00U	94.30	ug/L	2340-5	4	34 - 50	94.30	NA	36498.67 (nc)	750	10 CSR 20-7.03	no	<SV
Contact and ingestion of Sutton Branch surface water	7440-36-0	Sb	8.50U	25.00U	ug/L	ND	0	17 - 50	25.00U	NA	14.60 (nc)	6	10 CSR 20-7.03	no	ND
Contact and ingestion of Sutton Branch surface water	7440-38-2	As	3.50U	29.00	ug/L	2340-27	8	7 - 25	29.00	NA	0.04 (ca)	20	10 CSR 20-7.03	yes	>SV
Contact and ingestion of Sutton Branch surface water	7440-39-3	Ba	21.60	296.00	ug/L	2340-2	40	1.00	296.00	NA	2554.99 (nc)	2000	10 CSR 20-7.03	no	<SV
Contact and ingestion of Sutton Branch surface water	7440-41-7	Be	0.50U	1.50U	ug/L	ND	0	1 - 3	1.50U	NA	73.00 (nc)	4	10 CSR 20-7.03	no	ND
Contact and ingestion of Sutton Branch surface water	7440-43-9	Cd	0.50U	1.50U	ug/L	ND	0	1 - 3	1.50U	NA	18.25 (nc)	9.1	10 CSR 20-7.03	no	ND
Contact and ingestion of Sutton Branch surface water	7440-70-2	Ca	0.001U	0.01	ug/L	2340-5	40	0.001	0.01	NA	NA			no	NS, EN
Contact and ingestion of Sutton Branch surface water	18540-29-9	Cr	2.00U	9.49	ug/L	2340-5	3	4 - 15	9.49	NA	109.50 (nc)	42	10 CSR 20-7.03	no	<SV
Contact and ingestion of Sutton Branch surface water	7440-48-4	Co	1.50U	51.00	ug/L	2340-36	4	3 - 10	51.00	NA	730.00 (nc)	1000	11 CSR 20-7.03	no	<SV
Contact and ingestion of Sutton Branch surface water	7440-50-8	Cu	1.00U	9.12	ug/L	2340-26	1	1 - 5	9.12	NA	1460.00 (nc)	19	12 CSR 20-7.03	no	<SV
Contact and ingestion of Sutton Branch surface water	7439-89-6	Fe	14.50U	9180.00	ug/L	2340-2	3	29 - 50	9180.00	NA	10949.88 (nc)	300	13 CSR 20-7.03	no	<SV
Contact and ingestion of Sutton Branch surface water	7439-92-1	Pb	5.00U	274.00	ug/L	2340-5	28	10 - 50	274.00	NA	15.00 (nc)	19	14 CSR 20-7.03	yes	>SV
Contact and ingestion of Sutton Branch surface water	7439-95-4	Mg	0.001U	0.05	ug/L	2340-5	40	0.001	0.05	NA	NA			no	NS, EN
Contact and ingestion of Sutton Branch surface water	7439-96-5	Mn	1.00U	6620.00	ug/L	2340-2	28	2 - 5	6620.00	NA	876.00 (nc)	50	10 CSR 20-7.03	yes	>SV
Contact and ingestion of Sutton Branch surface water	7439-98-7	Mo	2.50U	26.80	ug/L	2340-5	20	5 - 15	26.80	NA	182.50 (nc)			no	<SV

TABLE 2.1 (continued)

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Annapolis Lead Mine, Annapolis Missouri

Scenario Timeframe:	Current/Future
Medium:	Surface water
Exposure Medium:	Surface water

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency (40 samples)	Range of Detection Limits	Concentration Used for Screening (2)	Background Value (3)	Screening Toxicity Value (N/C) (4)	Potential ARAR/TBC Value (ug/l)	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
Contact and ingestion of Sutton Branch surface water	7440-02-0	Ni	3.00U	45.80	ug/L	2340-5	17	6 - 20	45.80	NA	730.00 (nc)	100	10 CSR 20-7.03	no	<SV
Contact and ingestion of Sutton Branch surface water	9/7/7440	K	0.001U	0.004	ug/L	2340-2	16	0.001	0.00	NA	NA			no	NS, EN
Contact and ingestion of Sutton Branch surface water	7782-49-2	Se	20.00U	59.30	ug/L	2293-105	1	40 - 50	59.30	NA	182.50 (nc)	5	10 CSR 20-7.03	no	<SV
Contact and ingestion of Sutton Branch surface water	7440-22-4	Ag	3.50U	12.50U	ug/L	ND	0	7 - 25	12.50U	NA	182.50 (nc)	3.5	10 CSR 20-7.03	no	ND
Contact and ingestion of Sutton Branch surface water	7440-23-5	Na	0.001U	0.012	ug/L	2340-11	18	0.002	0.01	NA	NA			no	<SV, EN
Contact and ingestion of Sutton Branch surface water	7440-28-0	Tl	18.50U	101.00	ug/L	2293-103	0	37 - 50	101.00	NA	2.41 (nc)	2	10 CSR 20-7.03	no	ND
Contact and ingestion of Sutton Branch surface water	7440-32-6	Ti	2.00U	10.00U	ug/L	ND	0	4 - 20	10.00U	NA	145978.69 (nc)			no	ND
Contact and ingestion of Sutton Branch surface water	7440-62-2	V	1.50U	5.00U	ug/L	ND	0	3 - 10	5.00U	NA	36.50 (nc)			no	ND
Contact and ingestion of Sutton Branch surface water	7440-66-6	Zn	2.00U	75.80	ug/L	2340-5	7	4 - 25	75.80	NA	10949.88 (nc)	241	10 CSR 20-7.03	no	<SV

Footnotes:

(1) Qualifier Code Definitions:

J = The identification of the analyte is acceptable; the reported value is an estimate.

U = The analyte was not detected at or above the reporting limit.

UJ = The analyte was not detected at or above the reporting limit. The reporting limit is a estimate.

(2) The maximum detected concentration was used for screening

(3) NA = Not Applicable-no background values were used

(4) USEPA Region 9 PRGs--Tap Water PRG

(5) 10 CSR 20-7.031 "Water Quality Standards"-- viewed on 3/21/05 at http://www.sos.mo.gov/adrules/csr/current/10csr/10c20-7.pdf

(6) Define the codes used for the "Rationale for Selection or Deletion".

ND = not detected and not expected to be present in significant quantities

>SV = Maximum (or minimum) value is greater than risk-based screening level

<SV = Maximum (or minimum) value is less than risk-based screening level

NS = No toxicity screening level in the Reg. 9 PRGs--essential nutrient

EN = Essential Nutrient/Macronutrient

TABLE 2.2

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Annapolis Lead Mine, Annapolis Missouri

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (2)	Background Value (3)	Screening Toxicity Value (N/C) (4)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
Contact and ingestion of Sutton Branch sediment	7429-90-5	Al	610.00	1450.00	mg/kg	2293-53	5/5		1450.00	NA	76141.95 (nc)	76141.95 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of Sutton Branch sediment	7440-36-0	Sb	1.00U	1.00U	mg/kg	ND	0/5	2.00	1.00U	NA	31.29 (nc)	31.29 (nc)	EPA Region 9 Residential Soil PRGs	no	ND
Contact and ingestion of Sutton Branch sediment	7440-38-2	As	2.80UJ	25.60	mg/kg	2340-103	12/16	5.00	25.60	NA	0.69 (ca)	0.69 (ca)	EPA Region 9 Residential Soil PRGs	yes	>SV
Contact and ingestion of Sutton Branch sediment	7440-39-3	Ba	8.32	29.40	mg/kg	2293-51	5/5		29.40	NA	5371.91 (nc)	5371.91 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of Sutton Branch sediment	7440-41-7	Be	0.50UJ	0.50U	mg/kg	ND	0/5	1.00	0.50U	NA	154.37 (nc)	154.37 (nc)	EPA Region 9 Residential Soil PRGs	no	ND
Contact and ingestion of Sutton Branch sediment	7440-43-9	Cd	0.50U	4.17	mg/kg	2340-102	2/16	1.00	4.17	NA	37.03 (nc)	37.03 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of Sutton Branch sediment	7440-70-2	Ca	498.00	73900.00	mg/kg	2293-53	5/5		73900.00	NA	NA	NA	EPA Region 9 Residential Soil PRGs	no	NS, EN
Contact and ingestion of Sutton Branch sediment	18540-29-9	Cr	1.00U	16.60	mg/kg	2293-50	2/5		16.60	NA	210.68 (nc)	210.68 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of Sutton Branch sediment	7440-48-4	Co	2.85	40.20	mg/kg	2293-53	5/5	2.00	40.20	NA	902.89 (ca)**	902.89 (ca)**	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of Sutton Branch sediment	7440-50-8	Cu	4.82	52.10	mg/kg	2293-54	5/5		52.10	NA	3128.55 (nc)	3128.55 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of Sutton Branch sediment	7439-89-6	Fe	4580.00	8400.00	mg/kg	2293-53	5/5		8400.00	NA	23463.18 (nc)	23463.18 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of Sutton Branch sediment	7439-92-1	Pb	7.25	1070.00	mg/kg	2293-53	16/16		1070.00	NA	400.00 (nc)	400.00 (nc)	EPA Region 9 Residential Soil PRGs	yes	>SV
Contact and ingestion of Sutton Branch sediment	7439-95-4	Mg	290.00	42200.00	mg/kg	2293-53	5/5		42200.00	NA	NA	NA	EPA Region 9 Residential Soil PRGs	no	NS, EN
Contact and ingestion of Sutton Branch sediment	7439-96-5	Mn	124.00	1090.00	mg/kg	2293-53	5/5		1090.00	NA	1762.35 (nc)	1762.35 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of Sutton Branch sediment	7439-98-7	Mo	1.00U	1.00U	mg/kg	ND	0/5	2.00	1.00U	NA	391.07 (nc)	391.07 (nc)	EPA Region 9 Residential Soil PRGs	no	ND

TABLE 2.2 (continued)

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Annapolis Lead Mine, Annapolis Missouri

Scenario Timeframe:	Current/Future
Medium:	Sediment
Exposure Medium:	Sediment

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (2)	Background Value (3)	Screening Toxicity Value (N/C) (4)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
Contact and ingestion of Sutton Branch sediment	7440-02-0	Ni	1.00UJ	32.20	mg/kg	2340-103	14/16	2.00	32.20	NA	1564.28 (nc)	1564.28 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of Sutton Branch sediment	9/7/7440	K	70.70	409.00	mg/kg	2293-53	5/5		409.00	NA	NA	NA	EPA Region 9 Residential Soil PRGs	no	NS, EN
Contact and ingestion of Sutton Branch sediment	7782-49-2	Se	5.00U	5.00U	mg/kg	ND	0/5	10.00	5.00U	NA	391.07 (nc)	391.07 (nc)	EPA Region 9 Residential Soil PRGs	no	ND
Contact and ingestion of Sutton Branch sediment	7440-22-4	Ag	1.00U	1.00U	mg/kg	ND	0/5	2.00	1.00U	NA	391.07 (nc)	391.07 (nc)	EPA Region 9 Residential Soil PRGs	no	ND
Contact and ingestion of Sutton Branch sediment	7440-23-5	Na	25.00U	168.00	mg/kg	2293-53	3/5	50.00	168.00	NA	NA	NA	EPA Region 9 Residential Soil PRGs	no	<SV, EN
Contact and ingestion of Sutton Branch sediment	7440-28-0	Tl	DR	DR	mg/kg	ND	0/5		DR	NA	5.16 (max)	5.16 (max)	EPA Region 9 Residential Soil PRGs	no	DR
Contact and ingestion of Sutton Branch sediment	7440-32-6	Ti	NA	NA	mg/kg	NA	0/5		NA	NA	100000.00 (nc)	100000.00 (nc)	EPA Region 9 Residential Soil PRGs	no	ND
Contact and ingestion of Sutton Branch sediment	7440-62-2	V	2.50U	8.39	mg/kg	2293-50	4/5	5.00	8.39	NA	78.21 (nc)	78.21 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of Sutton Branch sediment	7440-66-6	Zn	2.50UJ	108.00	mg/kg	2340-102	12/13	5.00	108.00	NA	23463.18 (nc)	23463.18 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV

Footnotes:

(1) Qualifier Code Definitions:

J = The identification of the analyte is acceptable; the reported value is an estimate.

U = The analyte was not detected at or above the reporting limit.

UJ = The analyte was not detected at or above the reporting limit. The reporting limit is a estimate.

(2) The maximum detected concentration was used for screening

(3) NA = Not Applicable-no background values were used

(4) USEPA Region 9 PRGs--Tap Water PRG

(5) 10 CSR 20-7.031 "Water Quality Standards"-- viewed on 3/21/05 at http://www.sos.mo.gov/adrules/csr/current/10csr/10c20-7.pdf

(6) Define the codes used for the "Rationale for Selection or Deletion".

ND = not detected and not expected to be present in significant quantities

>SV = Maximum (or minimum) value is greater than risk-based screening level

<SV = Maximum (or minimum) value is less than risk-based screening level

NS = No toxicity screening level in the Reg. 9 PRGs--essential nutrient

EN = Essential Nutrient/Macronutrient

DR = data rejected

TABLE 2.3

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Annapolis Lead Mine, Annapolis Missouri

Scenario Timeframe:	Current/Future
Medium:	Surface Soil
Exposure Medium:	Surface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (2)	Background Value (3)	Screening Toxicity Value (N/C) (4)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
Contact and ingestion of surface soils onsite	7429-90-5	Al	1140.00	10900.00J	mg/kg	GP70	31/31		10900.00J	NA	76141.95 (nc)	76141.95 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of surface soils onsite	7440-36-0	Sb	1.00U	6.12UJ	mg/kg	GP65	4/31	2.00	6.12UJ	NA	31.29 (nc)	31.29 (nc)	EPA Region 9 Residential Soil PRGs	no	ND
Contact and ingestion of surface soils onsite	7440-38-2	As	4.16UJ	78.60	mg/kg	2293-15	14/31		78.60	NA	0.69 (ca)*	0.69 (ca)*	EPA Region 9 Residential Soil PRGs	yes	>SV
Contact and ingestion of surface soils onsite	7440-39-3	Ba	8.71	508.00	mg/kg	GP81	31/31		508.00	NA	5371.91 (nc)	5371.91 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of surface soils onsite	7440-41-7	Be	0.50U	1.91J	mg/kg	GP70	20/31	1.00	1.91J	NA	154.37 (nc)	154.37 (nc)	EPA Region 9 Residential Soil PRGs	no	ND
Contact and ingestion of surface soils onsite	7440-43-9	Cd	0.49UJ	4.49J	mg/kg	GP67	15/31		4.49J	NA	37.03 (nc)	37.03 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of surface soils onsite	7440-70-2	Ca	731.00	135000.00	mg/kg	2293-18	31/31		135000.00	NA	NA	NA	EPA Region 9 Residential Soil PRGs	no	NS, EN
Contact and ingestion of surface soils onsite	18540-29-9	Cr	1.00U	18.30	mg/kg	GP70	25/31	2.00	18.30	NA	210.68 (nc)	210.68 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of surface soils onsite	7440-48-4	Co	7.85J	81.60	mg/kg	2293-15	31/31		81.60	NA	902.89 (ca)**	902.89 (ca)**	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of surface soils onsite	7440-50-8	Cu	8.54J	254.00J	mg/kg	GP91	31/31		254.00J	NA	3128.55 (nc)	3128.55 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of surface soils onsite	7439-89-6	Fe	7870.00	20800.00J	mg/kg	GP70	31/31		20800.00J	NA	23463.18 (nc)	23463.18 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of surface soils onsite	7439-92-1	Pb	30.70J	6370.00J	mg/kg	GP82	31/31		6370.00J	NA	400.00 (nc)	400.00 (nc)	EPA Region 9 Residential Soil PRGs	yes	>SV
Contact and ingestion of surface soils onsite	7439-95-4	Mg	493.00U	75000.00	mg/kg	2293-18	27/31		75000.00	NA	NA	NA	EPA Region 9 Residential Soil PRGs	no	NS, EN
Contact and ingestion of surface soils onsite	7439-96-5	Mn	511.00J	2760.00J	mg/kg	GP44	31/31		2760.00J	NA	1762.35 (nc)	1762.35 (nc)	EPA Region 9 Residential Soil PRGs	yes	>SV
Contact and ingestion of surface soils onsite	7439-98-7	Mo	1.00U	1.00UJ	mg/kg	ND	0/14	2.00	1.00UJ	NA	391.07 (nc)	391.07 (nc)	EPA Region 9 Residential Soil PRGs	no	ND

TABLE 2.3 (continued)

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Annapolis Lead Mine, Annapolis Missouri

Scenario Timeframe:	Current/Future
Medium:	Surface Soil
Exposure Medium:	Surface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (2)	Background Value (3)	Screening Toxicity Value (N/C) (4)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
Contact and ingestion of surface soils onsite	7440-02-0	Ni	5.71J	91.50	mg/kg	2293-3	31/31		91.50	NA	1564.28 (nc)	1564.28 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of surface soils onsite	9/7/7440	K	312.00	1160.00J	mg/kg	GP70	20/31		1160.00J	NA	NA	NA	EPA Region 9 Residential Soil PRGs	no	NS, EN
Contact and ingestion of surface soils onsite	7782-49-2	Se	3.44UJ	13.20	mg/kg	2293-15	3/31		13.20	NA	391.07 (nc)	391.07 (nc)	EPA Region 9 Residential Soil PRGs	no	ND
Contact and ingestion of surface soils onsite	7440-22-4	Ag	0.98UJ	1.02UJ	mg/kg	ND	0/31		1.02UJ	NA	391.07 (nc)	391.07 (nc)	EPA Region 9 Residential Soil PRGs	no	ND
Contact and ingestion of surface soils onsite	7440-23-5	Na	25.00U	980.00J	mg/kg	GP82	14/31	50.00	980.00J	NA	NA	NA	EPA Region 9 Residential Soil PRGs	no	<SV, EN
Contact and ingestion of surface soils onsite	7440-28-0	Tl	2.46UJ	2.55UJ	mg/kg	GP65	0/31		2.55UJ	NA	5.16 (max)	5.16 (max)	EPA Region 9 Residential Soil PRGs	no	DR
Contact and ingestion of surface soils onsite	7440-32-6	Ti	NA	NA	mg/kg	NA	NA		NA	NA	100000.00 (nc)	100000.00 (nc)	EPA Region 9 Residential Soil PRGs	no	ND
Contact and ingestion of surface soils onsite	7440-62-2	V	2.50U	35.30	mg/kg	GP70	28/31	5.00	35.30	NA	78.21 (nc)	78.21 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of surface soils onsite	7440-66-6	Zn	22.10J	3090.00J	mg/kg	GP82	31/31		3090.00J	NA	23463.18 (nc)	23463.18 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV

Footnotes:

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(2) The maximum detected concentration was used for screening

(3) NA = Not Applicable-no background values were used

(4) USEPA Region 9 PRGs--Tap Water PRG

(5) 10 CSR 20-7.031 "Water Quality Standards"-- viewed on 3/21/05 at http://www.sos.mo.gov/adrules/csr/current/10csr/10c20-7.pdf

(6) Define the codes used for the "Rationale for Selection or Deletion".

ND = not detected and not expected to be present in significant quantities

>SV = Maximum (or minimum) value is greater than risk-based screening level

<SV = Maximum (or minimum) value is less than risk-based screening level

NS = No toxicity screening level in the Reg. 9 PRGs--essential nutrient

EN = Essential Nutrient/Macronutrient

DR = data rejected

TABLE 2.4

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Annapolis Lead Mine, Annapolis Missouri

Scenario Timeframe:	Current/Future
Medium:	Subsurface Soil
Exposure Medium:	Subsurface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency (36 samples)	Range of Detection Limits	Concentration Used for Screening (2)	Background Value (3)	Screening Toxicity Value (N/C) (4)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
Contact and ingestion of subsurface soils onsite	7429-90-5	Al	668.00	7480.00	mg/kg	2293-6	36		7480.00	NA	76141.95 (nc)	76141.95 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of subsurface soils onsite	7440-36-0	Sb	1.00 (U)	6.09 (UJ)	mg/kg	GP75	29	2.00	6.09 (UJ)	NA	31.29 (nc)	31.29 (nc)	EPA Region 9 Residential Soil PRGs	no	ND
Contact and ingestion of subsurface soils onsite	7440-38-2	As	0.1 (UJ)	80.40	mg/kg	2293-28	35		80.40	NA	0.69 (ca)	0.69 (ca)	EPA Region 9 Residential Soil PRGs	yes	>SV
Contact and ingestion of subsurface soils onsite	7440-39-3	Ba	4.85	147.00	mg/kg	2293-29	36		147.00	NA	5371.91 (nc)	5371.91 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of subsurface soils onsite	7440-41-7	Be	0.5 (U)	1.46	mg/kg	2293-9	27	1.00	1.46	NA	154.37 (nc)	154.37 (nc)	EPA Region 9 Residential Soil PRGs	no	ND
Contact and ingestion of subsurface soils onsite	7440-43-9	Cd	0.5 (U)	5.80	mg/kg	2293-24	21	1.00	5.80	NA	37.03 (nc)	37.03 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of subsurface soils onsite	7440-70-2	Ca	463.00	139000.00	mg/kg	2293-31	36		139000.00	NA	NA	NA	EPA Region 9 Residential Soil PRGs	no	NS, EN
Contact and ingestion of subsurface soils onsite	18540-29-9	Cr	1.00 (U)	51.30	mg/kg	2293-34	20	2.00	51.30	NA	210.68 (nc)	210.68 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of subsurface soils onsite	7440-48-4	Co	6.68	97.50	mg/kg	2293-37	36		97.50	NA	902.89 (ca)**	902.89 (ca)**	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of subsurface soils onsite	7440-50-8	Cu	5.60	112.00	mg/kg	2293-12	36		112.00	NA	3128.55 (nc)	3128.55 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of subsurface soils onsite	7439-89-6	Fe	6330.00	14300.00	mg/kg	2293-28	36		14300.00	NA	23463.18 (nc)	23463.18 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of subsurface soils onsite	7439-92-1	Pb	19.70	6450.00	mg/kg	2293-8	36		5450.00	NA	400.00 (nc)	400.00 (nc)	EPA Region 9 Residential Soil PRGs	yes	>SV
Contact and ingestion of subsurface soils onsite	7439-95-4	Mg	280.00	76800.00	mg/kg	2293-31	36		76800.00	NA	NA	NA	EPA Region 9 Residential Soil PRGs	no	NS, EN
Contact and ingestion of subsurface soils onsite	7439-96-5	Mn	401.00	1810.00	mg/kg	2293-9	36		1810.00	NA	1762.35 (nc)	1762.36 (nc)	EPA Region 9 Residential Soil PRGs	yes	>SV
Contact and ingestion of subsurface soils onsite	7439-98-7	Mo	1.00 (U)	12.20	mg/kg	2293-34	2	2.00	12.20	NA	391.07 (nc)	391.07 (nc)	EPA Region 9 Residential Soil PRGs	no	ND

TABLE 2.4 (continued)

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Annapolis Lead Mine, Annapolis Missouri

Scenario Timeframe:	Current/Future
Medium:	Subsurface Soil
Exposure Medium:	Subsurface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency (36 samples)	Range of Detection Limits	Concentration Used for Screening (2)	Background Value (3)	Screening Toxicity Value (N/C) (4)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
Contact and ingestion of subsurface soils onsite	7440-02-0	Ni	7.66	83.70	mg/kg	2293-37	36		83.70	NA	1564.28 (nc)	1564.28 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of subsurface soils onsite	9/7/7440	K	174.00	715 (J)	mg/kg	2293-6	36		715 (J)	NA	NA	NA	EPA Region 9 Residential Soil PRGs	no	NS, EN
Contact and ingestion of subsurface soils onsite	7782-49-2	Se	3.55 (UJ)	22.70	mg/kg	2293-7	8		22.70	NA	391.07 (nc)	391.07 (nc)	EPA Region 9 Residential Soil PRGs	no	ND
Contact and ingestion of subsurface soils onsite	7440-22-4	Ag	1.00 (U)	1.01 (UJ)	mg/kg	GP75	0	2.00	1.01 (UJ)	NA	391.07 (nc)	391.07 (nc)	EPA Region 9 Residential Soil PRGs	no	ND
Contact and ingestion of subsurface soils onsite	7440-23-5	Na	25.00 (U)	507.00 (U)	mg/kg	GP75	20	50.00	507.00 (U)	NA	NA	NA	EPA Region 9 Residential Soil PRGs	no	<SV, EN
Contact and ingestion of subsurface soils onsite	7440-28-0	Tl	2.54 (UJ)	2.54 (UJ)	mg/kg	GP75	0		2.54 (UJ)	NA	5.16 (max)	5.16 (max)	EPA Region 9 Residential Soil PRGs	no	DR
Contact and ingestion of subsurface soils onsite	7440-32-6	Ti	NA	NA	mg/kg	NA	NA		NA	NA	100000.00 (nc)	100000.00 (nc)	EPA Region 9 Residential Soil PRGs	no	ND
Contact and ingestion of subsurface soils onsite	7440-62-2	V	2.50 (U)	24.20	mg/kg	GP75	25	5.00	24.20	NA	78.21 (nc)	78.21 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV
Contact and ingestion of subsurface soils onsite	7440-66-6	Zn	13.80	456.00	mg/kg	2293-24	36		456.00	NA	23463.18 (nc)	23463.18 (nc)	EPA Region 9 Residential Soil PRGs	no	<SV

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(2) The maximum detected concentration was used for screening

(3) NA = Not Applicable-no background values were used

(4) USEPA Region 9 PRGs--Tap Water PRG

(5) 10 CSR 20-7.031 "Water Quality Standards"-- viewed on 3/21/05 at http://www.sos.mo.gov/adrules/csr/current/10csr/10c20-7.pdf

(6) Define the codes used for the "Rationale for Selection or Deletion".

ND = not detected and not expected to be present in significant quantities

>SV = Maximum (or minimum) value is greater than risk-based screening level

<SV = Maximum (or minimum) value is less than risk-based screening level

NS = No toxicity screening level in the Reg. 9 PRGs--essential nutrient

EN = Essential Nutrient/Macronutrient

DR = data rejected

TABLE 2.5

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Annapolis Lead Mine, Annapolis Missouri

Scenario Timeframe:	Current/Future
Medium:	Groundwater
Exposure Medium:	Groundwater

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency (5 samples)	Range of Detection Limits	Concentration Used for Screening (2)	Background Value (3)	Screening Toxicity Value (N/C) (4)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
Contact and ingestion of groundwater onsite	7429-90-5	Al			ug/L				0.00	NA			MCL 2004 Drinking Water Standards	no	
Contact and ingestion of groundwater onsite	7440-36-0	Sb			ug/L				0.00	NA			MCL 2004 Drinking Water Standards	no	
Contact and ingestion of groundwater onsite	7440-38-2	As	1.90	2.60	ug/L	CC104-001	5		2.60	NA	0.045	10.00	MCL 2004 Drinking Water Standards	yes	>SV
Contact and ingestion of groundwater onsite	7440-39-3	Ba			ug/L				0.00	NA			MCL 2004 Drinking Water Standards	no	
Contact and ingestion of groundwater onsite	7440-41-7	Be			ug/L				0.00	NA			MCL 2004 Drinking Water Standards	no	
Contact and ingestion of groundwater onsite	7440-43-9	Cd	1.85 (U)	6.08	ug/L	CC104-004	1		6.08	NA	18.200	5.00	MCL 2004 Drinking Water Standards	no	<SV
Contact and ingestion of groundwater onsite	7440-70-2	Ca			ug/L				0.00	NA			MCL 2004 Drinking Water Standards	no	
Contact and ingestion of groundwater onsite	18540-29-9	Cr	7.10 (U)	7.10 (U)	ug/L	ND	0		7.10 (U)	NA	109.000	100.00	MCL 2004 Drinking Water Standards	no	<SV
Contact and ingestion of groundwater onsite	7440-48-4	Co			ug/L				0.00	NA			MCL 2004 Drinking Water Standards	no	
Contact and ingestion of groundwater onsite	7440-50-8	Cu	4.16 (U)	13.90	ug/L	CC104-004	1		13.90	NA	1460.000	1300 (TT)	MCL 2004 Drinking Water Standards	no	<SV
Contact and ingestion of groundwater onsite	7439-89-6	Fe	2490.00	41500.00	ug/L	CC104-004	5		41500.00	NA	10950.000		MCL 2004 Drinking Water Standards	yes	>SV

TABLE 2.5 (continued)

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Annapolis Lead Mine, Annapolis Missouri

Scenario Timeframe:	Current/Future
Medium:	Groundwater
Exposure Medium:	Groundwater

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency (5 samples)	Range of Detection Limits	Concentration Used for Screening (2)	Background Value (3)	Screening Toxicity Value (N/C) (4)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
Contact and ingestion of groundwater onsite	7439-92-1	Pb	2.50	40.80	ug/L	CC104-001D	5	[illegible]	40.80	NA	[illegible]	15 (TT)	MCL 2004 Drinking Water Standards	yes	[illegible]
Contact and ingestion of groundwater onsite	7439-95-4	Mg			ug/L				0.00	NA			MCL 2004 Drinking Water Standards	no	
Contact and ingestion of groundwater onsite	7439-96-5	Mn			ug/L				0.00	NA			MCL 2004 Drinking Water Standards	no	
Contact and ingestion of groundwater onsite	7439-98-7	Mo			ug/L				0.00	NA			MCL 2004 Drinking Water Standards	no	
Contact and ingestion of groundwater onsite	7440-02-0	Ni	5.75 (U)	43.50	ug/L	CC104-004	1		43.50	NA	730.000	NA	MCL 2004 Drinking Water Standards	no	<SV
Contact and ingestion of groundwater onsite	9/7/7440	K			ug/L				0.00	NA			MCL 2004 Drinking Water Standards	no	
Contact and ingestion of groundwater onsite	7782-49-2	Se			ug/L				0.00	NA			MCL 2004 Drinking Water Standards	no	
Contact and ingestion of groundwater onsite	7440-22-4	Ag	3.94 (U)	3.94 (U)	ug/L	ND	0		3.94 (U)	NA	182.000	NA	MCL 2004 Drinking Water Standards	no	<SV
Contact and ingestion of groundwater onsite	7440-23-5	Na			ug/L				0.00	NA			MCL 2004 Drinking Water Standards	no	
Contact and ingestion of groundwater onsite	7440-28-0	Tl	1.80	3.20	ug/L	CC104-001D	5	[illegible]	3.20	NA	2.409	2.00	MCL 2004 Drinking Water Standards	no	[illegible]SV
Contact and ingestion of groundwater onsite	7440-32-6	Ti			ug/L				0.00	NA			MCL 2004 Drinking Water Standards	no	

TABLE 2.5 (continued)

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Annapolis Lead Mine, Annapolis Missouri

Scenario Timeframe:	Current/Future
Medium:	Groundwater
Exposure Medium:	Groundwater

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency (5 samples)	Range of Detection Limits	Concentration Used for Screening (2)	Background Value (3)	Screening Toxicity Value (N/C) (4)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
Contact and ingestion of groundwater onsite	7440-62-2	V			ug/L				0.00	NA			MCL 2004 Drinking Water Standards	no	
Contact and ingestion of groundwater onsite	7440-66-6	Zn	5.40	1270.00	ug/L	CC104-001D	5		1270.00	NA	10950.000		MCL 2004 Drinking Water Standards	no	<SV

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J = The identification of the analyte is acceptable; the reported value is an estimate.

U = The analyte was not detected at or above the reporting limit.

UJ = The analyte was not detected at or above the reporting limit. The reporting limit is a estimate.

(2) The maximum detected concentration was used for screening

(3) NA = Not Applicable-no background values were used

(4) USEPA Region 9 PRGs--Tap Water PRG

(5) 10 CSR 20-7.031 "Water Quality Standards"-- viewed on 3/21/05 at http://www.sos.mo.gov/adrules/csr/current/10csr/10c20-7.pdf

(6) Define the codes used for the "Rationale for Selection or Deletion".

ND = not detected and not expected to be present in significant quantities

>SV = Maximum (or minimum) value is greater than risk-based screening level

<SV = Maximum (or minimum) value is less than risk-based screening level

NS = No toxicity screening level in the Reg. 9 PRGs--essential nutrient

EN = Essential Nutrient/Macronutrient

DR = data rejected

TABLE 3.1.RME
EXPOSURE POINT CONCENTRATION SUMMARY
REASONABLE MAXIMUM EXPOSURE
Annapolis Lead Mine, Annapolis Missouri

Scenario Timeframe: Current and Future
Medium: Surface Water - Sutton Branch
Exposure Medium: Surface Water - Sutton Branch

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution) (1)	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units	Statistic (2)	Rationale
Dermal contact or ingestion in the Floodplain Area	As	ug/l	8.9	18.51 (NP)	12.5	12.5	ug/l	Max	too few samples
Dermal contact or ingestion in the Floodplain Area	Pb	ug/l	17	38.35 (NP)	2.5E+01	25	ug/l	Max	too few samples
Dermal contact or ingestion in the Floodplain Area	Mn	ug/l	5.836	10.15 (N)	1.2E+01	11.5	ug/l	Max	too few samples
Dermal contact or ingestion in the Floodplain Area	Tl	ug/l	37.6	106.9487 (NP	1.0E+02	101	ug/l	Max	too few samples

Footnote Instructions:
(1) Qualifier Code Definitions:

N = Normal
NP = Non-parametric
T = Transformed
O = Other
(2) The maximum detected concentration was used for screening
Max = Maximum
95% UCL - N = 95% UCL of Normal Data
95% UCL - NP = 95% UCL of Non-parametric Data
95% UCL - T = 95% UCL of Transformed Data
95% UCL - O = 95% UCL of Gamma Distribution Data

TABLE 3.2.RME

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

Annapolis Lead Mine, Annapolis Missouri

Scenario Timeframe: Current and Future
Medium: Sediment - Sutton Branch
Exposure Medium: Sediment - Sutton Branch

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution) (1)	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units	Statistic (2)	Rationale
Dermal contact or ingestion	As	mg/kg	12.82	22.52 (N)	2.6E+01	25.6	mg/kg	Max	too few samples
Dermal contact or ingestion	Pb	mg/kg	330.02	743.17 (N)	1070.0	1070	mg/kg	Max	too few samples

Footnote Instructions:
(1) Qualifier Code Definitions:
N = Normal
NP = Non-parametric
T = Transformed
O = Other
(2) The maximum detected concentration was used for screening
Max = Maximum
95% UCL - N = 95% UCL of Normal Data
95% UCL - NP = 95% UCL of Non-parametric Data
95% UCL - T = 95% UCL of Transformed Data
95% UCL - O = 95% UCL of Gamma Distribution Data

TABLE 3.3.RME

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

Annapolis Lead Mine, Annapolis Missouri

Scenario Timeframe: Current and Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution) (1)	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units	Statistic (2)	Rationale
Dermal contact or ingestion	As	ug/l	1.165	1.93 (N)	8.3E-01	0.83	ug/l	Maximum	too few samples
Dermal contact or ingestion	Fe	ug/l	7940.98	37321.66 (NP)	41500.0	41500	ug/l	Maximum	too few samples
Dermal contact or ingestion	Pb	ug/l	15.03	50.28 (NP)	3.8E+00	4.0	ug/l	Default[a]	IEUBK Model
Dermal contact or ingestion	Tl	ug/l	1.88	2.75 (N)	2.3E+00	2.3	ug/l	Maximum	too few samples

Footnote Instructions:
a- Default value for IEUBK Model was chosen as the EPC concentration because the actual site value (3.8 ug/L) was not significantly different from the default (4 ug/L)
IEUBK = Integrated Exposure Uptake Biokinetic Mode
(1) Qualifier Code Definitions:
N = Normal
NP = Non-parametric
T = Transformed
O = Other
(2) The maximum detected concentration was used for screening
Max = Maximum
95% UCL - N = 95% UCL of Normal Data
95% UCL - NP = 95% UCL of Non-parametric Data
95% UCL - T = 95% UCL of Transformed Data
95% UCL - O = 95% UCL of Gamma Distribution Data

TABLE 3.4.RME

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

Annapolis Lead Mine, Annapolis Missouri

Scenario Timeframe: Current and Future
Medium: Surface Soil
Exposure Medium: Surface Soil, Floodplain Area

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution) (1)	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units	Statistic (2)	Rationale
Dermal contact and ingestion in the Floodplain Area	As	mg/kg	25.69	34.46 (O)	78.6	34.46	mg/kg	95% UCL - O	
Dermal contact and ingestion in the Floodplain Area	Mn	mg/kg	1323.37	1497.03 (N)	2.3E+03	1497.03	mg/kg	95% UCL - N	
Dermal contact and ingestion in the Floodplain Area	Pb	mg/kg	912.4	5122.36 (T)	5.1E+03	912.4	mg/kg	Arithmetic mean	

Footnote Instructions:
(1) Qualifier Code Definitions:
N = Normal
NP = Non-parametric
T = Transformed
O = Other
Max = Maximum
(2) The maximum detected concentration was used for screening
95% UCL - N = 95% UCL of Normal Data
95% UCL - NP = 95% UCL of Non-parametric Data
95% UCL - T = 95% UCL of Transformed Data
95% UCL - O = 95% UCL of Gamma Distribution Data

TABLE 3.5.RME
EXPOSURE POINT CONCENTRATION SUMMARY
REASONABLE MAXIMUM EXPOSURE
Annapolis Lead Mine, Annapolis Missouri

Scenario Timeframe: Current and Future
Medium: Soil (Below 18" clean fill)
Exposure Medium: Soil, Mine Area

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution) (1)	Maximum Concentration (Qualifier)	Exposure Point Concentration			
						Value	Units	Statistic (2)	Rationale
	Mine area								
Dermal contact or ingestion	Pb	mg/kg	159.4	205 (NP)	994.0	159.4	mg/kg	Arithemetic Mean	Mean is used for IEUBK
	Clark hotspot								
Dermal contact or ingestion	Pb	mg/kg	6959.7	9658 (NP)	19586.0	6959.7	mg/kg	Arithemetic Mean	Mean is used for IEUBK
	North of Mayberry hotspot								
Dermal contact or ingestion	Pb	mg/kg	2639.7	Too few samples	3746	2639.7	mg/kg	Arithemetic Mean	Mean is used for IEUBK

Footnote Instructions:
(1) Qualifier Code Definitions:
N = Normal
NP = Non-parametric
T = Transformed
O = Other
Max = Maximum
(2) The maximum detected concentration was used for screening
95% UCL - N = 95% UCL of Normal Data
95% UCL - NP = 95% UCL of Non-parametric Data
95% UCL - T = 95% UCL of Transformed Data
95% UCL - O = 95% UCL of Gamma Distribution Data

TABLE 4.1.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Scenario Timeframe: Future Exposure
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	RME Value	Units	Rationale/ Reference	Intake Equation Model Name
Dermal	Resident	Adult	Dermal Contact while Showering	DAa	Dermally Absorbed Dose per Event-Adult	chemical-specific	mg/cm^2-event	USEPA 2004	
				CW	Chemical Concentration	chemical-specific	mg/L	Site-specific	Dermally Absorbed Dose (DAD) (mg/kg-day) =
				CF	Water Conversion Factor	0.001	L/cm^3		((DAa x EDa x SAa x 1/BWa) +
				SAa	Skin Surface Area-Adult	18,000	cm^2	USEPA 2004	(DAc x EDc x SAc x 1/BWc)) x EF x EV x 1/AT
				Kp	Permeability Constant	chemical-specific	cm/hour	USEPA 2004	DAa = Kp x CW x CF x $t\text{-event}_a$
				EF	Exposure Frequency	350	days/year	USEPA 1991	DAc = Kp x CW x CF x $t\text{-event}_c$
				EV	Event Frequency	1	event/day	USEPA 2004	
				EDa	Exposure Duration - Adult	24	years	USEPA 1991	
				$t\text{-event}_a$	Event Duration-Adult Showering	0.58	hours/event	USEPA 2004	
				BWa	Body Weight - Adult	70	kg	USEPA 1991	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	10950	days	USEPA 1991	
				DAc	Dermally Absorbed Dose per Event-Child	chemical-specific	mg/cm^2-event	USEPA 2004	
				SAc	Skin Surface Area-Child	6,600	cm^2	USEPA 2004	
				EDc	Exposure Duration - Child	6	years	USEPA 1991	
				$t\text{-event}_c$	Event Duration-Child bathing	1.00	hours/event	USEPA 2004	
				BWc	Body Weight - Child	15	kg	USEPA 1991	
		Child	Dermal Contact while Bathing	DA	Dermally Absorbed Dose per Event-Child	chemical-specific	mg/cm^2-event	USEPA 2004	Dermally Absorbed Dose (DAD) (mg/kg-day) =
				Cw	Chemical Concentration	chemical-specific	mg/L	Site-specific	DA x EV x ED x EF x SA x 1/BW x 1/AT
				CF	Water Conversion Factor	0.001	L/cm^3		
				SA	Skin Surface Area-Child	6,600	cm^2	USEPA 2004	DA = Kp x CW x CF x $t\text{-event}_c$
				Kp	Permeability Constant	chemical-specific	cm/hour	USEPA 2004	
				EF	Exposure Frequency	350	days/year	USEPA 1991	
				EV	Event Frequency	1	event/day	USEPA 2004	
				ED	Exposure Duration-Child	6	years	USEPA 1991	
				$t\text{-event}_c$	Event Duration-Child bathing	1.00	hours/event	USEPA 2004	
				BW	Body Weight-Child	15	kg	USEPA 1991	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	2190	days	USEPA 1991	
Ingestion	Resident	Adult	Drinking Water	CW	Chemical Concentration	chemical-specific	mg/L	Site-specific	
				IR-Wa	Water Ingestion Rate-Adult	2	L/day	USEPA 1991	Chronic Daily Intake (CDI) (mg/gk-day) =
				EF	Exposure Frequency	350	days/year	USEPA 1991	CW x EF x ((IR-Wa x EDa x 1/BWa) +
				EDa	Exposure Duration-Adult	24	years	USEPA 1991	(IR-Wc x EDc x 1/BWc)) x 1/AT
				BWa	Body Weight - Adult	70	kg	USEPA 1991	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	10950	days	USEPA 1991	
				IR-Wc	Water Ingestion Rate-Child	1	L/day	USEPA 1991	
				EDc	Exposure Duration-Child	6	years	USEPA 1991	
				BWc	Body Weight - Child	15	kg	USEPA 1991	
		Child	Drinking Water	CW	Chemical Concentration	chemical-specific	mg/L	Site-specific	
				IR-W	Water Ingestion Rate-Child	1	L/day	USEPA 1991	Chronic Daily Intake (CDI) (mg/gk-day) =
				EF	Exposure Frequency	350	days/year	USEPA 1991	CW x IR-W x EF x ED x 1/BW 1/AT
				ED	Exposure Duration-Child	6	years	USEPA 1991	
				BW	Body Weight - Child	15	kg	USEPA 1991	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	2190	days	USEPA 1991	

USEPA. 1989. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A). Interim Final. EPA/5401/1-89/002. Office of Emergency and Remedial Response. U.S. EPA. Washington, DC.

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USEPA. 2004d. Risk Assessment Guidance for Superfund. Volume I. Human Health Evaluation Manual. (Part E. Supplemental Guidance for Dermal Risk Assessment). Final. Office of Emergency and Remedial Response. EPA/540/R/99/005. OSWER 9285.7-02EP. PB99-963312.

a- Calculated from USEPA 1997 based on the a total body surface area to individual body part ratio for hands, feet, lower arms, and legs of adults. Proportion of body surface is assumed to be the same for children ages 7-1

TABLE 4.2.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Scenario Timeframe: Current/Future Exposure
Medium: Soils
Exposure Medium: Soils

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	RME Value	Units	Rationale/ Reference	Intake Equation Model Name
Dermal	Resident	Adult	Dermal Contact with Soils/ Indoor Dust	DAa	Dermally Absorbed Dose per Event-Adult	chemical-specific	mg/cm^2-event	USEPA 2004	
				CS	Chemical Concentration	chemical-specific	mg/kg	Site-specific	Dermally Absorbed Dose (DAD) (mg/kg-day) =
				CF	Soil Conversion Factor	0.000001	kg/mg		((DAa x EDa x SAa x 1/BWa) +
				SAa	Skin Surface Area-Adult	5,700	cm^2	USEPA 2004	(DAc x EDc x SAc x 1/BWc)) x EF x EV x 1/AT
				ABSd	Dermal Absorption Factor	chemical-specific	percent	USEPA 2004	DAa = ABSd x CS x CF x AFa
				EF	Exposure Frequency	350	days/year	USEPA 1991	DAc = ABSd x CS x CF x AFc
				AFa	Adherence Factor-Adult	0.07	mg/cm^2	USEPA 2004	
				EDa	Exposure Duration - Adult	24	years	USEPA 1991	
				EV	Event Frequency	1.00	event/day	USEPA 2004	
				BWa	Body Weight - Adult	70	kg	USEPA 1991	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	10950	days	USEPA 1991	
				DAc	Dermally Absorbed Dose per Event-Child	chemical-specific	mg/cm^2-event	USEPA 2004	
				SAc	Skin Surface Area-Child	2,800	cm^2	USEPA 2004	
				AFc	Adherence Factor-Child	0.2	mg/cm^2	USEPA 2004	
				EDc	Exposure Duration - Child	6	years	USEPA 1991	
				BWc	Body Weight - Child	15	kg	USEPA 1991	
		Child	Dermal Contact with Soils/ Indoor Dust	DA	Dermally Absorbed Dose per Event	chemical-specific	mg/cm^2-event	USEPA 2004	Dermally Absorbed Dose (DAD) (mg/kg-day) =
				CS	Chemical Concentration	chemical-specific	mg/kg	Site-specific	DA x EV x ED x EF x SA x 1/BW x 1/AT
				CF	Soil Conversion Factor	0.000001	kg/mg		
				SA	Skin Surface Area	2,800	cm^2	USEPA 2004	DA = ABSd x CS x CF x AF
				ABSd	Dermal Absorption Factor	chemical-specific	percent	USEPA 2004	
				EF	Exposure Frequency	350	days/year	USEPA 1991	
				AF	Adherence Factor	0.2	mg/cm^2	USEPA 2004	
				ED	Exposure Duration	6	years	USEPA 1991	
				EV	Event Frequency	1.00	event/day	USEPA 2004	
				BW	Body Weight	15	kg	USEPA 1991	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	2190	days	USEPA 1991	
	Construction Worker	Adult	Dermal Contact with Soils/ Indoor Dust	DA	Dermally Absorbed Dose per Event	chemical-specific	mg/cm^2-event	USEPA 2004	
				CS	Chemical Concentration	chemical-specific	mg/kg	Site-specific	Dermally Absorbed Dose (DAD) (mg/kg-day) =
				CF	Soil Conversion Factor	0.000001	kg/mg		DA x EV x ED x EF x SA x 1/BW x 1/AT
				SA	Skin Surface Area	3,300	cm^2	USEPA 2004	
				ABSd	Dermal Absorption Factor	chemical-specific	percent	USEPA 2004	DA = ABSd x CS x CF x AF
				EF	Exposure Frequency	132	days/year	Site-specific	
				AF	Adherence Factor	0.3	mg/cm^2	USEPA 2004	
				ED	Exposure Duration	1	years	Site-specific	
				EV	Event Frequency	1.00	event/day	Site-specific	
				BW	Body Weight	70	kg	USEPA 1991	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	365	days	USEPA 1991	

TABLE 4.2.RME (continued)

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Scenario Timeframe: Current/Future Exposure
Medium: Soils
Exposure Medium: Soils

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	RME Value	Units	Rationale/ Reference	Intake Equation Model Name
Dermal (continued)	Recreational User	Child	Dermal Contact with Soils	DA	Dermally Absorbed Dose per Event	chemical-specific	mg/cm^2-event	USEPA 2004	Dermally Absorbed Dose (DAD) (mg/kg-day) =
				CS	Chemical Concentration	chemical-specific	mg/kg	Site-specific	DA x EV x ED x EF x SA x 1/BW x 1/AT
				CF	Soil Conversion Factor	0.000001	kg/mg		
				SA	Skin Surface Area	4,000	cm^2	USEPA 1997[a]	DA = ABSd x CS x CF x AF
				ABSd	Dermal Absorption Factor	chemical-specific	percent	USEPA 2004	
				EF	Exposure Frequency	52	days/year	Site-specific	
				AF	Adherence Factor	0.2	mg/cm^2	USEPA 2004	
				ED	Exposure Duration	10	years	Site-specific	
				EV	Event Frequency	1.00	event/day	USEPA 1991	
				BW	Body Weight	43	kg	USEPA 1997	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	3650	days	USEPA 1991	
Ingestion	Resident	Adult	Hand-to-Mouth Contact with Surface Soil/Indoor Dust	CS	Chemical Concentration	chemical-specific	mg/kg	Site-specific	
				IR-Sa	Ingestion Rate-Adult	100	mg/day	USEPA 1991	Chronic Daily Intake (CDI) (mg/gk-day) =
				EF	Exposure Frequency	350	days/year	USEPA 1991	CS x EF x (IR-Sa x EDa x 1/BWa) +
				EDa	Exposure Duration-Adult	24	years	USEPA 1991	(IR-Sc x EDc x 1/BWc) x 1/AT
				BWa	Body Weight-Adult	70	kg	USEPA 1991	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	10950	days	USEPA 1991	
				IR-Sc	Ingestion Rate-Child	200	mg/day	USEPA 1991	
				EDc	Exposure Duration-Child	6	years	USEPA 1991	
				BWc	Body Weight-Child	15	kg	USEPA 1991	
		Child	Hand-to-Mouth Contact with Surface Soil/Indoor Dust	CS	Chemical Concentration	chemical-specific	mg/kg	Site-specific	
				IR-S	Ingestion Rate	200	mg/day	USEPA 1991	Chronic Daily Intake (CDI) (mg/gk-day) =
				EF	Exposure Frequency	350	days/year	USEPA 1991	CS x IR-S x EF x ED x 1/BW x 1/AT
				ED	Exposure Duration	6	years	USEPA 1991	
				BW	Body Weight	15	kg	USEPA 1991	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	2190	days	USEPA 1991	
	Construction Worker	Adult	Hand-to-Mouth Contact with Surface Soil/Indoor Dust	CS	Chemical Concentration	chemical-specific	mg/kg	Site-specific	
				IR-S	Ingestion Rate	330	mg/day	USEPA 1997	Chronic Daily Intake (CDI) (mg/gk-day) =
				EF	Exposure Frequency	132	days/year	Site-specific	CS x IR-S x EF x ED x 1/BW x 1/AT
				ED	Exposure Duration	1	years	Site-specific	
				BW	Body Weight	70	kg	USEPA 1991	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	365	days	USEPA 1991	
	Recreational User	Child	Hand-to-Mouth Contact with Surface Soil	CS	Chemical Concentration	chemical-specific	mg/kg	Site-specific	
				IR-S	Ingestion Rate	100	mg/day	USEPA 1991	Chronic Daily Intake (CDI) (mg/gk-day) =
				EF	Exposure Frequency	52	days/year	Site-specific	CS x IR-S x EF x ED x 1/BW x 1/AT
				ED	Exposure Duration	10	years	Site-specific	
				BW	Body Weight	43	kg	USEPA 1997	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	3650	days	USEPA 1991	

USEPA. 1989. Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual (Part A). Interim Final. EPA/5401/1-89/002. Office of Emergency and Remedial Response. U.S. EPA. Washington, DC.

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a- Calculated from USEPA 1997 based on the a total body surface area to individual body part ratio for hands, feet, lower arms, and legs of adults. Proportion of body surface is assumed to be the same for children ages 7-16.

TABLE 4.3.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Scenario Timeframe: Current/Future Exposure
Medium: Sediment
Exposure Medium: Sediment

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	RME Value	Units	Rationale/ Reference	Intake Equation Model Name
Dermal	Recreational User	Child	Dermal Contact with Sediment while Wading	DA	Dermally Absorbed Dose per Event	chemical-specific	mg/cm^2-event	USEPA 2004	Dermally Absorbed Dose (DAD) (mg/kg-day) = DA x EV x ED x EF x SA x 1/BW x 1/AT DA = ABSd x CS x CF x AF
				CS	Chemical Concentration	chemical-specific	mg/kg	Site-specific	
				CF	Sediment Conversion Factor	0.000001	kg/mg		
				SA	Skin Surface Area	4,000	cm^2	USEPA 1997[a]	
				ABSd	Dermal Absorption Factor	chemical-specific	percent	USEPA 2004	
				EF	Exposure Frequency	52	days/year	Site-specific	
				AF	Adherence Factor	1	mg/cm^2	USEPA 2004	
				ED	Exposure Duration	10	years	Site-specific	
				EV	Event Frequency	1.00	event/day	USEPA 2004	
				BW	Body Weight	43	kg	USEPA 1997	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	3650	days	USEPA 1991	
Ingestion	Recreational User	Child	Incidental Ingestion of Sediment while Wading	CS	Chemical Concentration	chemical-specific	mg/kg	Site-specific	Chronic Daily Intake (CDI) (mg/gk-day) = CS x IR-S x EF x ED x 1/BW x 1/AT
				IR-S	Ingestion Rate	100	mg/day	USEPA 1991	
				EF	Exposure Frequency	52	days/year	Site-specific	
				ED	Exposure Duration	10	years	Site-specific	
				BW	Body Weight	43	kg	USEPA 1997	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	3650	days	USEPA 1991	

USEPA. 1989. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A). Interim Final. EPA/5401/1-89/002. Office of Emergency and Remedial Response. U.S. EPA. Washington, DC.

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a- Calculated from USEPA 1997 based on the a total body surface area to individual body part ratio for hands, feet, lower arms, and legs of adults. Proportion of body surface is assumed to be the same for children ages 7-16.

TABLE 4.4.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

Scenario Timeframe: Future Exposure
Medium: Surface Water
Exposure Medium: Surface Water

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	RME Value	Units	Rationale/ Reference	Intake Equation Model Name
Dermal	Recreational User	Child	Dermal Contact while Wading	DA	Dermally Absorbed Dose per Event-Child	chemical-specific	mg/cm^2-event	USEPA 2004	Dermally Absorbed Dose (DAD) (mg/kg-day) = DA x EV x ED x EF x SA x 1/BW x 1/AT
				Cw	Chemical Concentration	chemical-specific	mg/L	Site-specific	
				CF	Water Conversion Factor	0.001	L/cm^3	USEPA 1991	
				SA	Skin Surface Area-Child	4,000	cm^2	USEPA 1997[a]	DA = Kp x CW x CF x t-event
				Kp	Permeability Constant	chemical-specific	cm/hour	USEPA 2004	
				EF	Exposure Frequency	52	days/year	Site-specific	
				EV	Event Frequency	1	event/day	USPEA 2004	
				ED	Exposure Duration - Child	10	years	Site-specific	
				t-event	Event Duration-Child Wading	2.00	hours/event	Site-specific	
				BW	Body Weight - Child	43	kg	USEPA 1997	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	3650	days	USEPA 1991	
Ingestion	Recreational User	Child	Incidental Ingestion while Wading	CW	Chemical Concentration	chemical-specific	mg/L	Site-specific	
				IR-W	Water Ingestion Rate-Child	0.05	L/day	USEPA 1989	Chronic Daily Intake (CDI) (mg/gk-day) = CW x IR-W x EF x ED x 1/BW 1/AT
				EF	Exposure Frequency	52	days/year	Site-specific	
				ED	Exposure Duration-Child	10	years	Site-specific	
				BW	Body Weight - Child	43	kg	USEPA 1997	
				ATC	Averaging Time-Cancer	25550	days	USEPA 1991	
				ATN	Averaging Time-Non-Cancer	3650	days	USEPA 1991	

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a- Calculated from USEPA 1997 based on the a total body surface area to individual body part ratio for hands, feet, lower arms, and legs of adults. Proportion of body surface is assumed to be the same for children ages 7-16.

TABLE 6.2

CANCER TOXICITY DATA -- INHALATION

Annapolis Lead Mine NPL Site, Annapolis, MO

Chemical of Potential Concern	Unit Risk		Inhalation Cancer Slope Factor		Weight of Evidence/ Cancer Guideline Description	Unit Risk : Inhalation CSF	
	Value	Units	Value	Units		Source(s)	Date(s) (MM/DD/YYYY)
Arsenic	4.00E-03	per ug/m^3	1.51E+01	mg/kg-d	A	IRIS	7/22/2005
Iron	NA						
Lead	NA						
Manganese	NA						
Thallium (as Thallium chloride)	NA						

Weight of Evidence Classifications

A- Human Carcinogen, based on sufficient evidence from epidemiological studies

NA- Not available

Sources of References

I-Integrated Risk Information System (IRIS)

TABLE 6.1

CANCER TOXICITY DATA – ORAL/DERMAL

Annapolis Lead Mine NPL Site, Annapolis, MO

Chemical of Potential Concern	Oral Cancer Slope Factor		Oral Absorption Efficiency for Dermal	Absorbed Cancer Slope Factor for Dermal		Weight of Evidence/ Cancer Guideline Description	Oral CSF	
	Value	Units		Value	Units		Source(s)	Date(s) (MM/DD/YYYY)
Arsenic	1.5	per mg/kg-d	0.03	1.5	per mg/kg-d	A	IRIS	07/15/05
Iron	NA							
Lead	NA					B2	IRIS	07/15/05
Manganese	NA					D	IRIS	07/15/05
Thallium (as Thallium chloride)	NA							

Weight of Evidence Classifications

A- Human Carcinogen, based on sufficient evidence from epidemiological studies

B2- Probable Human Carcinogen, based on sufficient evidence of animal studies, but inadequate epidemiological data

D- Not Classifiable as to Human Carcinogenicity

NA- Not available

Sources of References

I-Integrated Risk Information System (IRIS)

TABLE 5.2

NON-CANCER TOXICITY DATA -- INHALATION

Annapolis Lead Mine NPL Site, Annapolis, MO

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation RfC		Extrapolated RfD		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfC : Target Organ(s)	
		Value	Units	Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
Arsenic	Chronic	3.0E-05	mg/m^3	8.6E-06	mg/kg-d	Skin	NA	CalEPA	7/22/2005
Iron		NA							
Lead		NA							
Manganese	Chronic	5.0E-05	mg/m^3	1.4E-05	mg/kg-d	Central Nervous System	1E+03	IRIS	7/22/2005
Thallium (as Thallium chloride)		NA							

NA- Not available

Sources of References
I-Integrated Risk Information System (IRIS)
CalEPA- California Environmental Protection Agency

TABLE 5.1
NON-CANCER TOXICITY DATA -- ORAL/DERMAL
Annapolis Lead Mine NPL Site, Annapolis, MO

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD		Oral Absorption Efficiency for Dermal (1)	Absorbed RfD for Dermal		Primary Target Organ(s)	Combined Uncertainty/ Modifying Factors	RfD:Target Organ(s)	
		Value	Units		Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
Arsenic	Chronic	3.0E-04	mg/kg-d	3.0E-02	3.0E-04	mg/kg-d	Skin (hyperpigmentation and keratosis) and vascular system	3/1	IRIS	7/22/2005
Iron	Chronic	3.0E-01	mg/kg-d	NA	NA		GI tract		NCEA	7/22/2005
Lead	NA						Central nervous system and developmental		IRIS	7/22/2005
Manganese	Chronic	2.4E-02	mg/kg-d	1.0E-03	9.6E-04	mg/kg-d	Central nervous system	NA	USEPA Region 9	8/8/2005
Thallium (as Thallium chloride)	Chronic	6.6E-05	mg/kg-d	NA	6.6E-05	mg/kg-d	Central nervous system and GI tract	3000/1	IRIS	7/22/2005

(1) Qualifier Code Definitions:

NA- Not available

Sources of References

I-Integrated Risk Information System (IRIS)

NCEA- National Center for Environmental Assessment, Superfund Technical Support Center, Provisional Peer Reviewed Toxicity Values Database

TABLE 7.1.RME

CALCULATION OF CHEMICAL RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Scenario Timeframe: Current/Future Exposure
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Contact while Showering	Dermal	Arsenic	0.00083	mg/L	7.07E-08	mg/kg-day	1.50E+00	1/mg/kg-day	1.06E-07	1.65E-07	mg/kg-day	3.00E-04	mg/kg-day	5.50E-04
				Iron	41.5	mg/L										
				Lead	0.0038	mg/L										
				Thallium	0.0023	mg/L										
			Exp. Route Total								1.06E-07					5.50E-04
		Exp. Point Total									1.06E-07					5.50E-04
		Drinking Water	Ingestion	Arsenic	0.00083	mg/L	1.23E-05	mg/kg-day	1.50E+00	1/mg/kg-day	1.85E-05	2.88E-05	mg/kg-day	3.00E-04	mg/kg-day	9.60E-02
				Iron	41.5	mg/L						1.44E+00	mg/kg-day	3.00E-01	mg/kg-day	4.80E+00
				Lead	0.0038	mg/L										
				Thallium	0.0023	mg/L						7.98E-05	mg/kg-day	6.60E-05	mg/kg-day	1.21E+00
			Exp. Route Total								1.85E-05					6.11E+00
		Exp. Point Total									1.85E-05					6.11E+00
	Exposure Medium Total										1.86E-05					6.11E+00
Groundwater Total											1.86E-05					6.11E+00
											1.86E-05					6.11E+00

TABLE 7.2.RME

CALCULATION OF CHEMICAL RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Scenario Timeframe: Current/Future Exposure
Receptor Population: Resident

Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Contact while Bathing	Dermal	Arsenic	0.00083	mg/L		mg/kg-day		1/mg/kg-day		3.50E-07	mg/kg-day	3.00E-04	mg/kg-day	1.17E-03
				Iron	41.5	mg/L										
				Lead	0.0038	mg/L										
				Thallium	0.0023	mg/L										
			Exp. Route Total													1.17E-03
		Exp. Point Total														1.17E-03
		Drinking Water	Ingestion	Arsenic	0.00083	mg/L		mg/kg-day		1/mg/kg-day		5.31E-05	mg/kg-day	3.00E-04	mg/kg-day	1.77E-01
				Iron	41.5	mg/L						2.65E+00	mg/kg-day	3.00E-01	mg/kg-day	8.84E+00
				Lead	0.0038	mg/L										
				Thallium	0.0023	mg/L						1.47E-04	mg/kg-day	6.60E-05	mg/kg-day	2.23E+00
			Exp. Route Total													1.12E+01
		Exp. Point Total														1.12E+01
	Exposure Medium Total															1.12E+01
Groundwater Total																1.12E+01
																1.12E+01

TABLE 7.3.RME

CALCULATION OF CHEMICAL RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

Scenario Timeframe: Current/Future Exposure
Receptor Population: Recreational User
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Surface Water	Surface Water	Contact while Wading	Dermal	Arsenic	0.0125	mg/L	4.73E-08	mg/kg-day	1.50E+00	1/mg/kg-day	7.10E-08	3.31E-07	mg/kg-day	3.00E-04	mg/kg-day	1.10E-03
				Lead	0.025	mg/L										
				Manganese	0.0115	mg/L										
				Thallium	0.101	mg/L										
			Exp. Route Total								7.10E-08					1.10E-03
		Exp. Point Total									7.10E-08					1.10E-03
		Contact while Wading	Ingestion	Arsenic	0.0125	mg/L	2.96E-07	mg/kg-day	1.50E+00	1/mg/kg-day	4.44E-07	2.07E-06	mg/kg-day	3.00E-04	mg/kg-day	6.90E-03
				Lead	0.025	mg/L										
				Manganese	0.0115	mg/L						1.91E-06	mg/kg-day	2.40E-02	mg/kg-day	7.94E-05
				Thallium	0.101	mg/L						1.67E-05	mg/kg-day	6.60E-05	mg/kg-day	2.54E-01
			Exp. Route Total								4.44E-07					2.60E-01
		Exp. Point Total									4.44E-07					2.60E-01
	Exposure Medium Total										5.15E-07					2.62E-01
Surface Water Total											5.15E-07					2.62E-01
Sediment	Sediment	Contact with Sediment while Wading	Dermal	Arsenic	25.60	mg/kg	1.45E-06	mg/kg-day	1.50E+00	1/mg/kg-day	2.18E-06	1.02E-05	mg/kg-day	3.00E-04	mg/kg-day	3.39E-02
				Lead	1070.00	mg/kg										
			Exp. Route Total								2.18E-06					3.39E-02
		Exp. Point Total									2.18E-06					3.39E-02
		Incidental Ingestion of Sediment while Wading	Ingestion	Arsenic	25.6	mg/kg	1.21E-06	mg/kg-day	1.50E+00	1/mg/kg-day	1.82E-06	8.48E-06	mg/kg-day	3.00E-04	mg/kg-day	2.83E-02
				Lead	1070	mg/kg										
			Exp. Route Total								1.82E-06					2.83E-02
		Exp. Point Total									1.82E-06					2.83E-02
	Exposure Medium Total										4.00E-06					6.22E-02
Sediment Total											4.00E-06					6.22E-02
Soil	Surface Soil	Contact with Surface Soil in the Floodplain Area	Dermal	Arsenic	34.4558	mg/kg	3.91E-07	mg/kg-day	1.50E+00	1/mg/kg-day	5.87E-07	2.74E-06	mg/kg-day	3.00E-04	mg/kg-day	9.13E-03
				Lead	5122.363	mg/kg										
				Manganese	1497.025	mg/kg										
			Exp. Route Total								5.87E-07					9.13E-03
		Exp. Point Total									5.87E-07					9.13E-03
		Hand-to-Mouth Contact with Surface Soil in the Floodplain Area	Ingestion	Arsenic	34.4558	mg/kg	3.26E-06	mg/kg-day	1.50E+00	1/mg/kg-day	4.89E-06	2.28E-05	mg/kg-day	3.00E-04	mg/kg-day	7.61E-02
				Lead	5122.363	mg/kg										
				Manganese	1497.025	mg/kg						9.92E-04	mg/kg-day	2.40E-02	mg/kg-day	4.13E-02
			Exp. Route Total								4.89E-06					1.17E-01
		Exp. Point Total									4.89E-06					1.17E-01
	Exposure Medium Total										5.48E-06					1.27E-01
Soil Total											5.48E-06					1.27E-01
											9.99E-06					4.50E-01

TABLE 9.1.RME

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS

REASONABLE MAXIMUM EXPOSURE

Scenario Timeframe: Future Exposure
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk			Non-Cancer Hazard Calculations			
				Ingestion	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal	Exposure Routes Total
Groundwater	Groundwater	Contact while Showering	Arsenic		1.06E-07	1.06E-07	Skin		5.50E-04	5.50E-04
			Iron							
			Lead							
			Thallium							
			Chemical Total		1.06E-07	1.06E-07			5.50E-04	5.50E-04
		Exp. Point Total				1.06E-07				5.50E-04
		Drinking Water	Arsenic	1.85E-05		1.85E-05	Skin	9.60E-02		9.60E-02
			Iron				Gastrointestinal	4.80E+00		4.80E+00
			Lead							
			Thallium				Central Nervous System	1.21E+00		1.21E+00
			Chemical Total	1.85E-05		1.85E-05		6.11E+00		6.11E+00
		Exp. Point Total				1.85E-05				6.11E+00
	Exposure Medium Total					1.86E-05				6.11E+00
Groundwater Total						1.86E-05				6.11E+00
Receptor Total						1.86E-05				6.11E+00

Total Risk Across All Media= 1.86E-05

Total Hazard Across All Media 6.11E+00

Total Skin HI Across All Media = 9.66E-02

Total Gastrointestinal HI Across All Media = 4.80E+00

Total Central Nervous System HI Across All Media = 1.21E+00

TABLE 9.2.RME

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS

REASONABLE MAXIMUM EXPOSURE

Scenario Timeframe: Future Exposure
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk			Non-Cancer Hazard Calculations			
				Ingestion	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal	Exposure Routes Total
Groundwater	Groundwater	Contact while Bathing	Arsenic				Skin		1.17E-03	1.17E-03
			Iron							
			Lead							
			Thallium							
			Chemical Total						1.17E-03	1.17E-03
		Exp. Point Total								1.17E-03
		Drinking Water	Arsenic				Skin	1.77E-01		1.77E-01
			Iron				Gastrointestinal	8.84E+00		8.84E+00
			Lead							
			Thallium				Central Nervous System	2.23E+00		2.23E+00
			Chemical Total					1.12E+01		1.12E+01
		Exp. Point Total								1.12E+01
	Exposure Medium Total									1.12E+01
Groundwater Total										1.12E+01
Receptor Total										1.12E+01

Total Risk Across All Media =

Total Hazard Across All Media 1.12E+01

Total Skin HI Across All Media= 1.78E-01

Total Gastrointestinal HI Across All Media= 8.84E+00

Total Central Nervous System HI Across All Media= 2.23E+00

TABLE 9.3.RME

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCS

REASONABLE MAXIMUM EXPOSURE

Scenario Timeframe: Current/Future Exposure
Receptor Population: Recreational User
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk			Non-Cancer Hazard Calculations			
				Ingestion	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal	Exposure Routes Total
Surface Water	Surface Water	Contact while Wading	Arsenic		7.10E-08	7.10E-08	Skin		1.10E-03	1.10E-03
			Lead							
			Manganese							
			Thallium							
			Chemical Total		7.10E-08	7.10E-08			1.10E-03	1.10E-03
		Exp. Point Total				7.10E-08				1.10E-03
		Incidental Ingestion while Wading	Arsenic	4.44E-07		4.44E-07	Skin	6.90E-03		6.90E-03
			Lead							
			Manganese				Central Nervous System	7.94E-05		7.94E-05
			Thallium				Central Nervous System	2.54E-01		2.54E-01
			Chemical Total	4.44E-07		4.44E-07		2.60E-01		2.60E-01
		Exp. Point Total				4.44E-07				2.60E-01
	Exposure Medium Total					5.15E-07				2.62E-01
Surface Water Total						5.15E-07				2.62E-01
Sediment	Sediment	Contact while Wading	Arsenic		2.18E-06	2.18E-06	Skin		3.39E-02	3.39E-02
			Lead							
			Chemical Total		2.18E-06	2.18E-06			3.39E-02	3.39E-02
		Exp. Point Total				2.18E-06				3.39E-02
		Incidental Ingestion while Wading	Arsenic	1.82E-06		1.82E-06	Skin	2.83E-02		2.83E-02
			Lead							
			Chemical Total	1.82E-06		1.82E-06		2.83E-02		2.83E-02
		Exp. Point Total				1.82E-06				2.83E-02
	Exposure Medium Total					4.00E-06				6.22E-02
Sediment Total						4.00E-06				6.22E-02
Soils	Surface Soils	Contact while Wading	Arsenic		5.87E-07	5.87E-07	Skin		9.13E-03	9.13E-03
			Lead							
			Manganese							
			Chemical Total		5.87E-07	5.87E-07			9.13E-03	9.13E-03
		Exp. Point Total				5.87E-07				9.13E-03
		Hand-to-Mouth Contact with	Arsenic	4.89E-06		4.89E-06	Skin	7.61E-02		7.61E-02
			Lead							
			Manganese				Central Nervous System	4.13E-02		4.13E-02
			Chemical Total	4.89E-06		4.89E-06		1.17E-01		1.17E-01
		Exp. Point Total				4.89E-06				1.17E-01
	Exposure Medium Total					5.48E-06				1.27E-01
Soils Total						5.48E-06				1.27E-01
Receptor Total						9.99E-06				4.50E-01

Total Risk Across All Media = 9.99E-06

Total Hazard Across All Media 4.50E-01

Total Skin HI Across All Media= 1.55E-01

Total Central Nervous System HI Across All Media= 2.95E-01

TABLE 10.1.RME

RISK SUMMARY FOR COPCS EXCEEDING 1 x 10^{-4} FOR CARCINOGENIC RISK AND 1.0 FOR NON-CARCINOGENIC RISK

REASONABLE MAXIMUM EXPOSURE

Scenario Timeframe: Future Exposure
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk			Non-Cancer Hazard Calculations			
				Ingestion	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal	Exposure Routes Total
Groundwater	Groundwater	Contact while Showering	Arsenic							
			Iron							
			Lead							
			Thallium							
			Chemical Total							
		Exp. Point Total								
		Drinking Water	Arsenic							
			Iron				Gastrointestinal	4.80E+00		4.80E+00
			Lead							
			Thallium				Central Nervous System	1.21E+00		1.21E+00
			Chemical Total					6.01E+00		6.01E+00
		Exp. Point Total								6.01E+00
	Exposure Medium Total									6.01E+00
Groundwater Total										6.01E+00
Receptor Total										6.01E+00

Total Risk Across All Media= [ ]

Total Hazard Across All Media: 6.01E+00

Total Gastrointestinal (Iron) HI Across All Media = 4.80E+00

Total Central Nervous System (Thallium) HI Across All Media = 1.21E+00

TABLE 10.2.RME

RISK SUMMARY FOR COPCS EXCEEDING 1 x 10^{-4} FOR CARCINOGENIC RISK AND 1.0 FOR NON-CARCINOGENIC RISK

REASONABLE MAXIMUM EXPOSURE

Scenario Timeframe: Future Exposure
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk			Non-Cancer Hazard Calculations			
				Ingestion	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal	Exposure Routes Total
Groundwater	Groundwater	Contact while Bathing	Arsenic							
			Iron							
			Lead							
			Thallium							
			Chemical Total							
		Exp. Point Total								
		Drinking Water	Arsenic							
			Iron				Gastrointestinal	8.84E+00		8.84E+00
			Lead							
			Thallium				Central Nervous System	2.23E+00		2.23E+00
			Chemical Total					1.11E+01		1.11E+01
		Exp. Point Total								1.11E+01
	Exposure Medium Total									1.11E+01
Groundwater Total										1.11E+01
Receptor Total										1.11E+01

Total Risk Across All Media =

Total Hazard Across All Media 1.11E+01

Total Gastrointestinal (Iron) HI Across All Media= 8.84E+00

Total Central Nervous System (Thallium) HI Across All Media= 2.23E+00

TABLE 10.3.RME

RISK SUMMARY FOR COPCS EXCEEDING 1 x 10^{-6} FOR CARCINOGENIC RISK AND 1.0 FOR NON-CARCINOGENIC RISK

REASONABLE MAXIMUM EXPOSURE

Scenario Timeframe: Future Exposure
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk			Non-Cancer Hazard Calculations			
				Ingestion	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal	Exposure Routes Total
Groundwater	Groundwater	Contact while Showering	Arsenic		1.06E-07	1.06E-07				
			Iron							
			Lead							
			Thallium							
			Chemical Total		1.06E-07	1.06E-07				
		Exp. Point Total				1.06E-07				
		Drinking Water	Arsenic	1.85E-05		1.85E-05				
			Iron				Gastrointestinal	4.80E+00		4.80E+00
			Lead							
			Thallium				Central Nervous System	1.21E+00		1.21E+00
			Chemical Total	1.85E-05		1.85E-05		6.01E+00		6.01E+00
		Exp. Point Total				1.85E-05				6.01E+00
	Exposure Medium Total					1.86E-05				6.01E+00
Groundwater Total						1.86E-05				6.01E+00
Receptor Total						1.86E-05				6.01E+00

Total Risk Across All Media= 1.86E-05

Total Hazard Across All Media 6.01E+00

Total Gastrointestinal (Iron) HI Across All Media = 4.80E+00

Total Central Nervous System (Thallium) HI Across All Media = 1.21E+00

TABLE 10.4.RME

RISK SUMMARY FOR COPCS EXCEEDING 1 x 10^{-6} FOR CARCINOGENIC RISK AND 1.0 FOR NON-CARCINOGENIC RISK

REASONABLE MAXIMUM EXPOSURE

Scenario Timeframe: Future Exposure
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk			Non-Cancer Hazard Calculations			
				Ingestion	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal	Exposure Routes Total
Groundwater	Groundwater	Contact while Bathing	Arsenic							
			Iron							
			Lead							
			Thallium							
			Chemical Total							
		Exp. Point Total								
		Drinking Water	Arsenic							
			Iron				Gastrointestinal	8.84E+00		8.84E+00
			Lead							
			Thallium				Central Nervous System	2.23E+00		2.23E+00
			Chemical Total					1.11E+01		1.11E+01
		Exp. Point Total								1.11E+01
	Exposure Medium Total									1.11E+01
Groundwater Total										1.11E+01
Receptor Total										1.11E+01

Total Risk Across All Media =	
Total Hazard Across All Media	1.11E+01
Total Gastrointestinal (Iron) HI Across All Media=	8.84E+00
Total Central Nervous System (Thallium) HI Across All Media=	2.23E+00

TABLE 10.5.RME

RISK SUMMARY FOR COPCS EXCEEDING 1 x 10^{-6} FOR CARCINOGENIC RISK AND 1.0 FOR NON-CARCINOGENIC RISK

REASONABLE MAXIMUM EXPOSURE

Scenario Timeframe: Current/Future Exposure
Receptor Population: Recreational User
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Cancer Risk			Non-Cancer Hazard Calculations			
				Ingestion	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Dermal	Exposure Routes Total
Surface Water	Surface Water	Contact while Wading	Arsenic							
			Lead							
			Manganese							
			Thallium							
			Chemical Total							
		Exp. Point Total								
		Incidental Ingestion while Wading	Arsenic							
			Lead							
			Manganese							
			Thallium							
			Chemical Total							
		Exp. Point Total								
	Exposure Medium Total									
Surface Water Total										
Sediment	Sediment	Contact while Wading	Arsenic		2.18E-06	2.18E-06				
			Lead							
			Chemical Total		2.18E-06	2.18E-06				
		Exp. Point Total				2.18E-06				
		Incidental Ingestion while Wading	Arsenic	1.82E-06		1.82E-06				
			Lead							
			Chemical Total	1.82E-06		1.82E-06				
		Exp. Point Total				1.82E-06				
	Exposure Medium Total					4.00E-06				
Sediment Total						4.00E-06				
Soils	Surface Soils	Contact with suface soils	Arsenic							
			Lead							
			Manganese							
			Chemical Total							
		Exp. Point Total								
		Hand-to-Mouth Contact with surface soils	Arsenic	4.89E-06		4.89E-06				
			Lead							
			Manganese							
			Chemical Total	4.89E-06		4.89E-06				
		Exp. Point Total				4.89E-06				
	Exposure Medium Total					4.89E-06				
Soils Total						4.89E-06				
Receptor Total						8.89E-06				

Total Risk Across All Media = 8.89E-06

Total Hazard Across All Media

Table 11

Chemical-specific exposure partition coefficient (Kp) and dermal absorption fraction (ABSd) used to calculate exposure in receptor populations for all chemicals except lead.

Chemical	Kp[a]	ABSd[a]
Aluminum	1.00E-03	1.00E-03
Antimony	NA	1.00E-03
Arsenic	1.00E-03	3.00E-02
Cadmium	1.00E-03	1.00E-03
Iron	1.00E-03	1.00E-03
Manganese	1.00E-03	1.00E-03
Molybdenum	1.00E-03	NA
Selenium	1.00E-03	NA
Thallium	1.00E-03	1.00E-03
Vanadium	1.00E-03	1.00E-03
Zinc	6.00E-04	1.00E-03

a-Dermally absorbed fraction and partition coefficient from USEPA 2004. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). Final. Office of Emergency and Remedial Response. EPA/540/R/99/005. OSWER 9285.7-02EP. PB99-963312. U.S. EPA. Washington, D.C. July 2004.

NA=Not applicable

APPENDIX F

IEUBK Model Runs
and
Adult Lead Calculation Worksheets

Table F-1A Summary of IEUBK Model Runs

Results for Child 0 to 84 months in age					
Note: New Dietary Intakes were Used					
Results presented are the percentage of children expected to have a blood lead concentration above 10 µg/dL					
	Exposure Point Concentration (mean of dataset) mg/kg)	**Soil to Dust Transfer Factor of 70%**		**Soil to Dust Transfer Factor of 24%**	
Exposure Area		**Alternate Soil and Dust Intake (1)**	**Default Soil and Dust Intake**	**Alternate Soil and Dust Intake (1)**	**Default Soil and Dust Intake**
Former Mining Operations Area, Surface Soil	159.4	0.001%	0.2	0.001%	0.04%
Hot Spot Areas					
Former Clark Residence	6959.7	79%	99.4%	61%	98%
North of Mayberry Residence	2639.7	25%	89%	10%	77%
(1) EPA 1996. Baseline Human Health Risk Assessment. Anaconda Smelter NPL Site. Anaconda, Montana.					

Table F-1
Annapolis Lead Mine Site
IEUBK MODEL Results
Former Mining Operations Area, Surface Soil

Soil to Dust Transfer Factor 70% , EPC = soil 159.4, dust-multiple source analysis (EPC does not include hot spot data)
New dietary intake values, other parameters are model defaults
LEAD MODEL FOR WINDOWS Version 1.0

==
Model Version: 1.0 Build 261
User Name:
Date:
Site Name:
Operable Unit:
Run Mode: Research
==
The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	3.160
1-2	2.600
2-3	2.870
3-4	2.740
4-5	2.610
5-6	2.740
6-7	2.990

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 ug Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 121.580 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	159.400	121.580
1-2	159.400	121.580
2-3	159.400	121.580
3-4	159.400	121.580
4-5	159.400	121.580
5-6	159.400	121.580
6-7	159.400	121.580

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

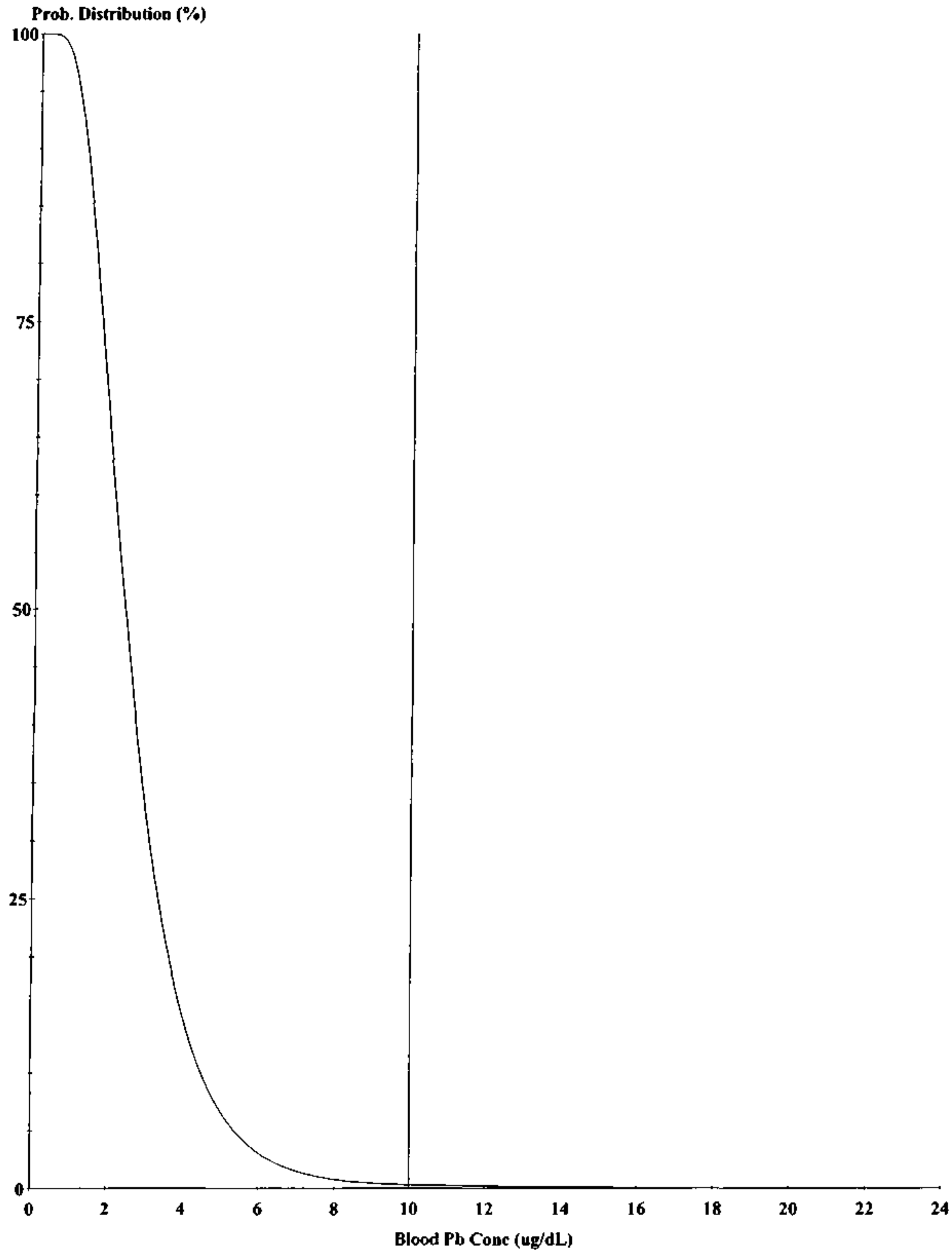
****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	1.489	0.000	0.377
1-2	0.034	1.218	0.000	0.937
2-3	0.062	1.356	0.000	0.983
3-4	0.067	1.305	0.000	1.010
4-5	0.067	1.261	0.000	1.063
5-6	0.093	1.330	0.000	1.126
6-7	0.093	1.455	0.000	1.149

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	3.331	5.219	2.8
1-2	5.260	7.450	3.1
2-3	5.303	7.703	2.9
3-4	5.347	7.728	2.7
4-5	4.016	6.406	2.3
5-6	3.633	6.183	2.0
6-7	3.441	6.138	1.8



Cutoff = 10.000 ug/dl
Geo Mean = 2.516
GSD = 1.600
% Above = 0.166

Age Range = 0 to 84 months
Time Step = Every 4 Hours
Run Mode = Research

Table F-2
Annapolis Lead Mine Site
IEUBK MODEL Results
Former Mining Operations Area, Surface Soil

Soil to Dust Transfer Factor 70% , EPC = soil 159.4, dust-multiple source analysis (EPC does not include hot spot data)
New dietary intake values, alternate soil and dust intake (EPA 1996)

LEAD MODEL FOR WINDOWS Version 1.0

==

Model Version: 1.0 Build 261
User Name:
Date:
Site Name:
Operable Unit:
Run Mode: Research

==

The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	3.160
1-2	2.600
2-3	2.870
3-4	2.740
4-5	2.610
5-6	2.740
6-7	2.990

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 ug Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 121.580 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	159.400	121.580
1-2	159.400	121.580
2-3	159.400	121.580
3-4	159.400	121.580
4-5	159.400	121.580
5-6	159.400	121.580
6-7	159.400	121.580

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

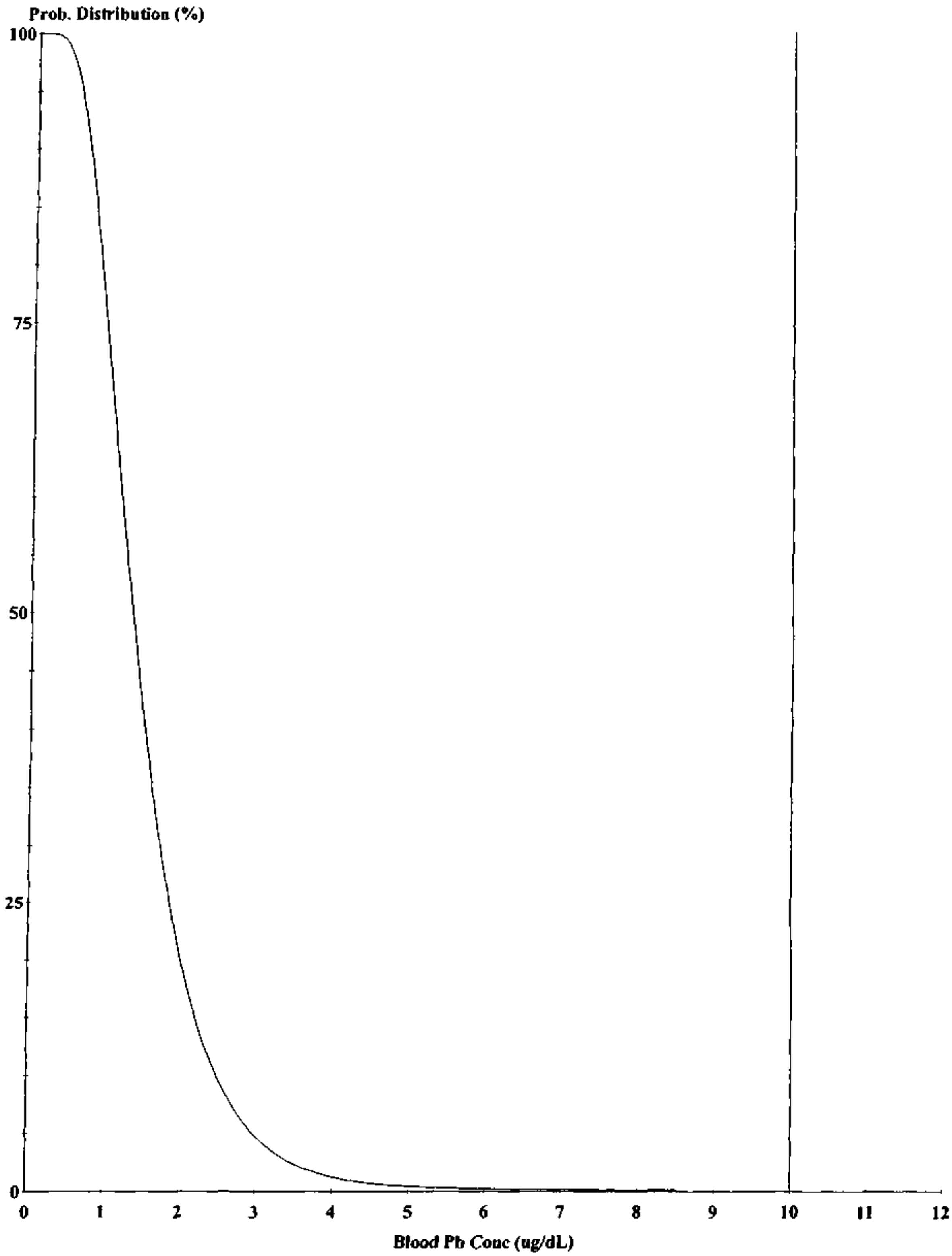
****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	1.529	0.000	0.387
1-2	0.034	1.258	0.000	0.968
2-3	0.062	1.394	0.000	1.010
3-4	0.067	1.337	0.000	1.034
4-5	0.067	1.280	0.000	1.079
5-6	0.093	1.347	0.000	1.140
6-7	0.093	1.471	0.000	1.161

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	0.966	2.903	1.6
1-2	1.529	3.790	1.6
2-3	1.535	4.001	1.5
3-4	1.541	3.979	1.4
4-5	1.142	3.569	1.2
5-6	1.063	3.643	1.1
6-7	0.982	3.708	1.1



Cutoff = 10.000 ug/dl
Geo Mean = 1.392
GSD = 1.600
% Above = 0.001

Age Range = 0 to 84 months
Time Step = Every 4 Hours
Run Mode = Research

Table F-3
Annapolis Lead Mine Site
IEUBK MODEL Results
Former Mining Operations Area, Surface Soil

Soil to Dust Transfer Factor 24% , EPC = soil 159.4, dust-multiple source analysis (EPC does not include hot spot data)
New dietary intake values, other parameters are model defaults
LEAD MODEL FOR WINDOWS Version 1.0

==
Model Version: 1.0 Build 261
User Name:
Date:
Site Name:
Operable Unit:
Run Mode: Research
==
The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	3.160
1-2	2.600
2-3	2.870
3-4	2.740
4-5	2.610
5-6	2.740
6-7	2.990

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 ug Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 48.256 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.240
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	159.400	48.256
1-2	159.400	48.256
2-3	159.400	48.256
3-4	159.400	48.256
4-5	159.400	48.256
5-6	159.400	48.256
6-7	159.400	48.256

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

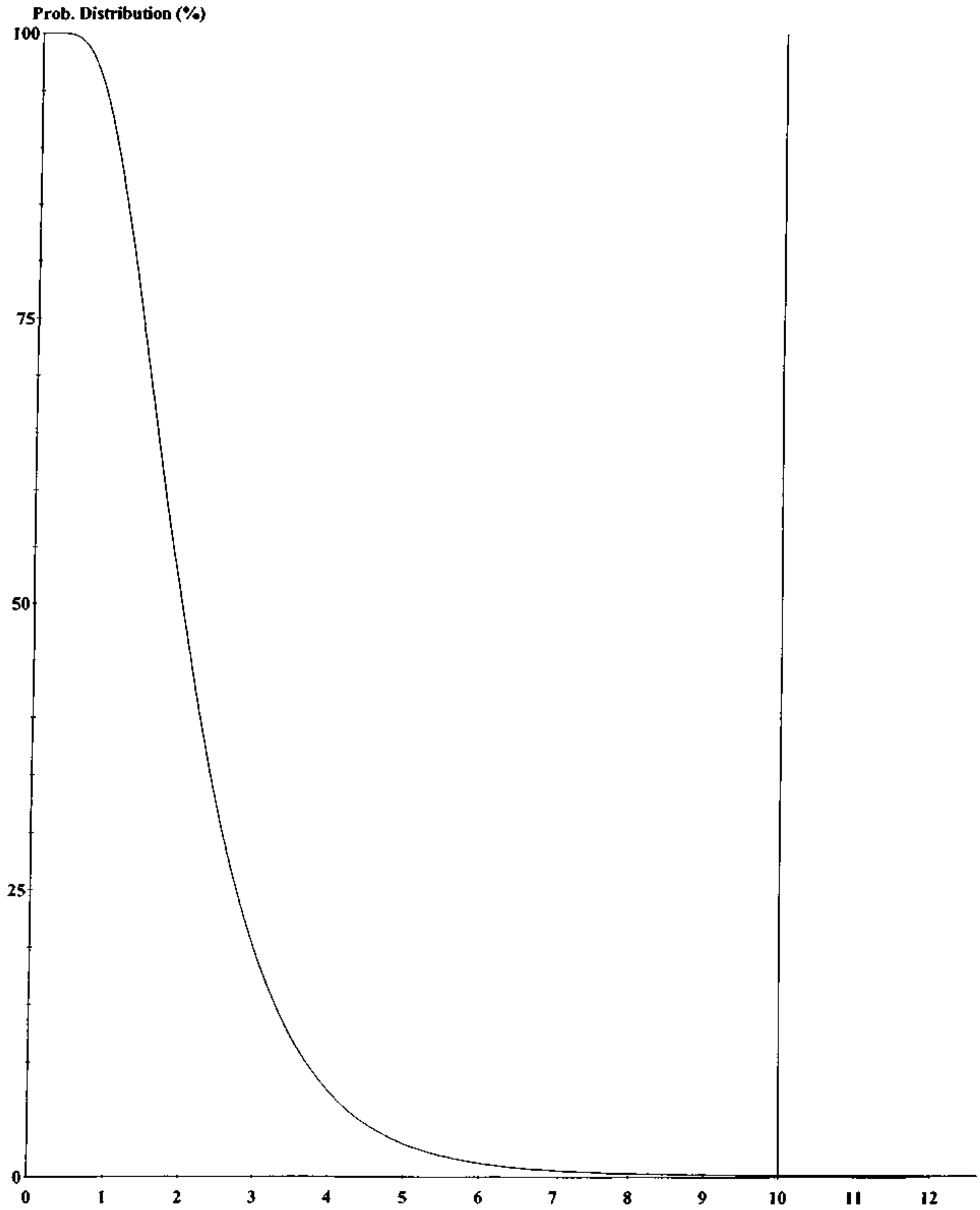
****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	1.505	0.000	0.381
1-2	0.034	1.234	0.000	0.949
2-3	0.062	1.371	0.000	0.993
3-4	0.067	1.318	0.000	1.019
4-5	0.067	1.268	0.000	1.069
5-6	0.093	1.337	0.000	1.132
6-7	0.093	1.462	0.000	1.154

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	2.387	4.294	2.4
1-2	3.778	5.995	2.5
2-3	3.802	6.228	2.3
3-4	3.828	6.231	2.2
4-5	2.866	5.270	1.9
5-6	2.589	5.151	1.6
6-7	2.450	5.159	1.5



Cutoff = 10.000 ug/dl
Geo Mean = 2.068
GSD = 1.600
% Above = 0.040

Age Range = 0 to 84 months
Time Step = Every 4 Hours
Run Mode = Research

Table F-4
Annapolis Lead Mine Site
IEUBK MODEL Results
Former Mining Operations Area, Surface Soil

Soil to Dust Transfer Factor 24% , EPC = soil 159.4, dust-multiple source analysis (EPC does not include hot spot data)
New dietary intake values, alternate soil and dust intake (EPA 1996)

LEAD MODEL FOR WINDOWS Version 1.0

==
Model Version: 1.0 Build 261
User Name:
Date:
Site Name:
Operable Unit:
Run Mode: Research
==
The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	3.160
1-2	2.600
2-3	2.870
3-4	2.740
4-5	2.610
5-6	2.740
6-7	2.990

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 ug Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 48.256 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.240
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	159.400	48.256
1-2	159.400	48.256
2-3	159.400	48.256
3-4	159.400	48.256
4-5	159.400	48.256
5-6	159.400	48.256
6-7	159.400	48.256

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

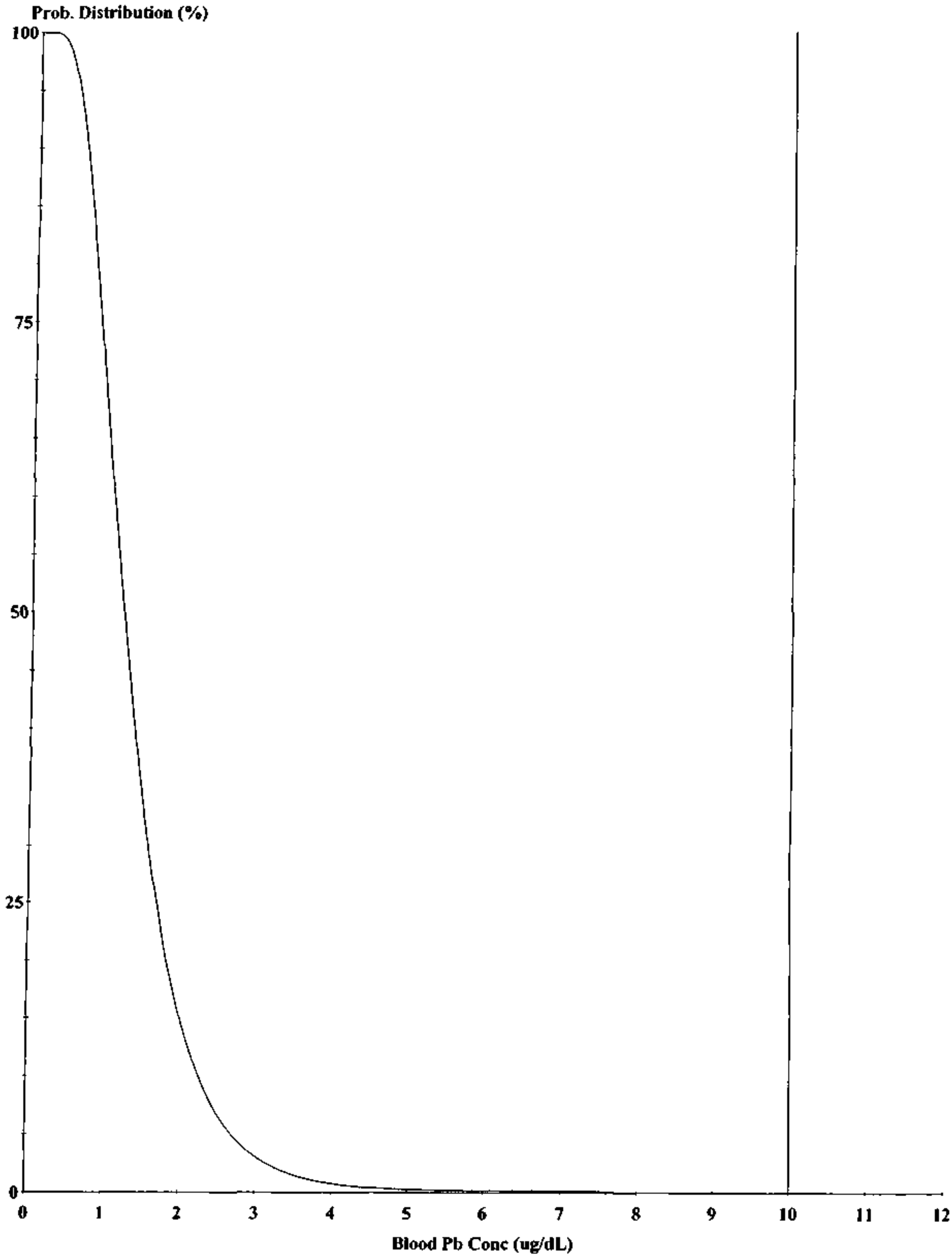
****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	1.534	0.000	0.388
1-2	0.034	1.263	0.000	0.972
2-3	0.062	1.398	0.000	1.013
3-4	0.067	1.340	0.000	1.037
4-5	0.067	1.283	0.000	1.081
5-6	0.093	1.349	0.000	1.142
6-7	0.093	1.473	0.000	1.163

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	0.687	2.630	1.5
1-2	1.088	3.357	1.4
2-3	1.092	3.565	1.3
3-4	1.096	3.540	1.3
4-5	0.811	3.242	1.1
5-6	0.755	3.339	1.0
6-7	0.697	3.426	1.0



Cutoff = 10.000 ug/dl
Geo Mean = 1.260
GSD = 1.600
% Above = 0.001

Age Range = 0 to 84 months
Time Step = Every 4 Hours
Run Mode = Research

Table F-5
Annapolis Lead Mine Site
IEUBK MODEL Results
Former Mining Operations Area, Surface Soil, Hot Spot near former Clark Residence

Soil to Dust Transfer Factor 70%, EPC = soil 6959.7, dust-multiple source analysis
New dietary intake values, other parameters are model defaults
LEAD MODEL FOR WINDOWS Version 1.0

==
Model Version: 1.0 Build 261
User Name:
Date:
Site Name:
Operable Unit:
Run Mode: Research
==
The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	3.160
1-2	2.600
2-3	2.870
3-4	2.740
4-5	2.610
5-6	2.740
6-7	2.990

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 ug Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 4881.790 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700

Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	6959.700	4881.790
1-2	6959.700	4881.790
2-3	6959.700	4881.790
3-4	6959.700	4881.790
4-5	6959.700	4881.790
5-6	6959.700	4881.790
6-7	6959.700	4881.790

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

****** Maternal Contribution: Infant Model ******

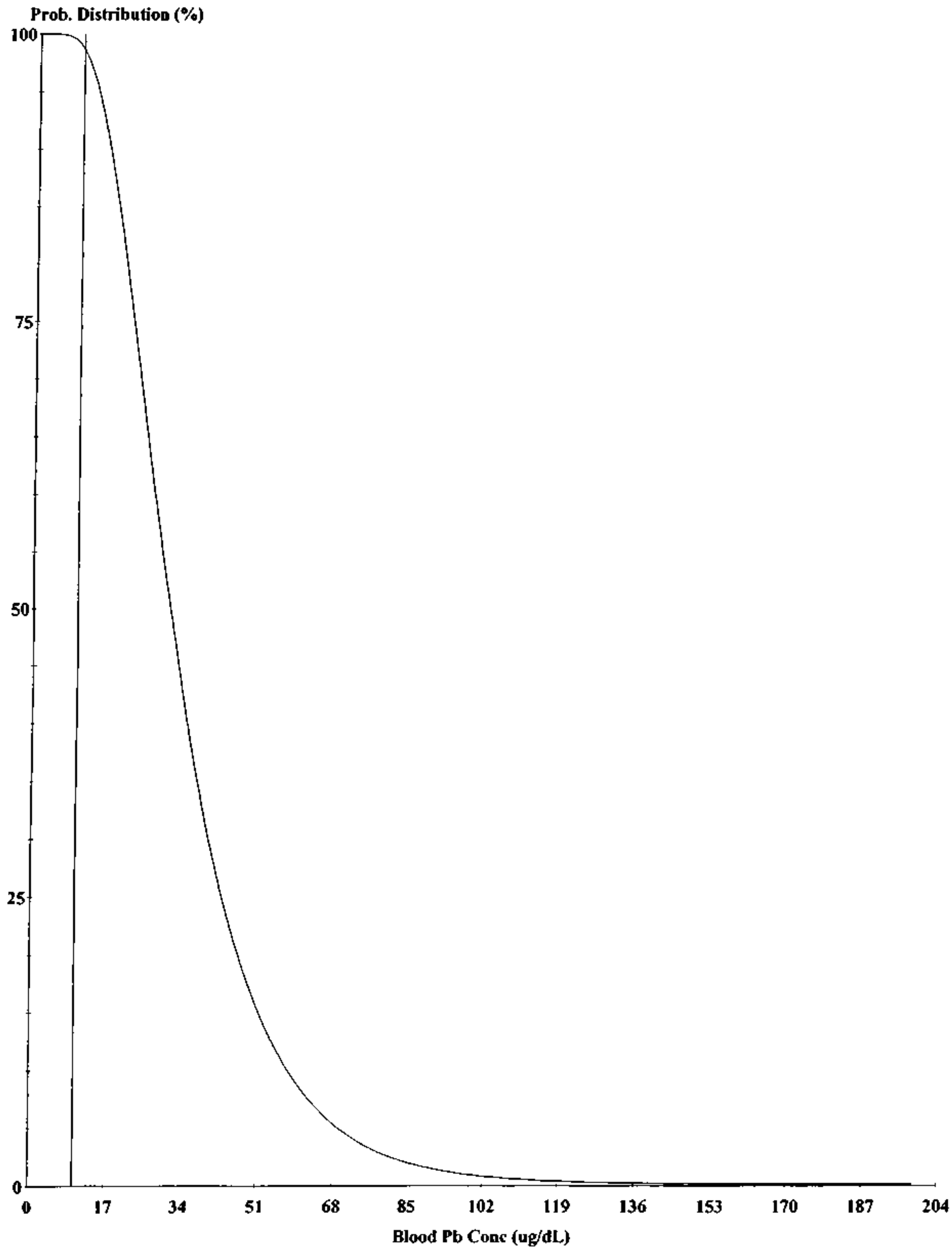
Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	0.724	0.000	0.183
1-2	0.034	0.552	0.000	0.425
2-3	0.062	0.648	0.000	0.470
3-4	0.067	0.657	0.000	0.508
4-5	0.067	0.736	0.000	0.621
5-6	0.093	0.834	0.000	0.706
6-7	0.093	0.952	0.000	0.751

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	68.012	68.941	33.5
1-2	100.018	101.029	38.4
2-3	106.352	107.532	36.7
3-4	112.916	114.147	36.5
4-5	98.443	99.866	32.4
5-6	95.557	97.189	28.8
6-7	94.415	96.211	26.2

Environmental exposures associated with blood lead levels above 30 µg/dl are above the range of values that have been used in the calibration and empirical validation of this model. (Zaragoza, L. and Hogan, K. 1998. The Integrated Exposure Uptake Biokinetic Model for Lead In Children: Independent Validation and Verification. Environmental Health Perspectives 106 (supplement 6). p. 1555)



Cutoff = 10.000 ug/dl
Geo Mean = 32.486
GSD = 1.600
% Above = 99.391

Age Range = 0 to 84 months
Time Step = Every 4 Hours
Run Mode = Research

Environmental exposures associated with blood lead levels above 30 µg/dl are above the range of values that have been used in the calibration and empirical validation of this model. (Zaragoza, L. and Hogan, K. 1998. The Integrated Exposure Uptake Biokinetic Model for Lead In Children: Independent Validation and Verification. Environmental Health Perspectives 106 (supplement 6). p. 1555)

Table F-6
Annapolis Lead Mine Site
IEUBK MODEL Results
Former Mining Operations Area, Surface Soil, Hot Spot near former Clark Residence

Soil to Dust Transfer Factor 70% , EPC = soil 6959.7, dust-multiple source analysis
New dietary intake values, alternate soil and dust intake (EPA 1996)
LEAD MODEL FOR WINDOWS Version 1.0

==
Model Version: 1.0 Build 261
User Name:
Date:
Site Name:
Operable Unit:
Run Mode: Research
==
The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	3.160
1-2	2.600
2-3	2.870
3-4	2.740
4-5	2.610
5-6	2.740
6-7	2.990

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 ug Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 4881.790 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700

Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	6959.700	4881.790
1-2	6959.700	4881.790
2-3	6959.700	4881.790
3-4	6959.700	4881.790
4-5	6959.700	4881.790
5-6	6959.700	4881.790
6-7	6959.700	4881.790

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

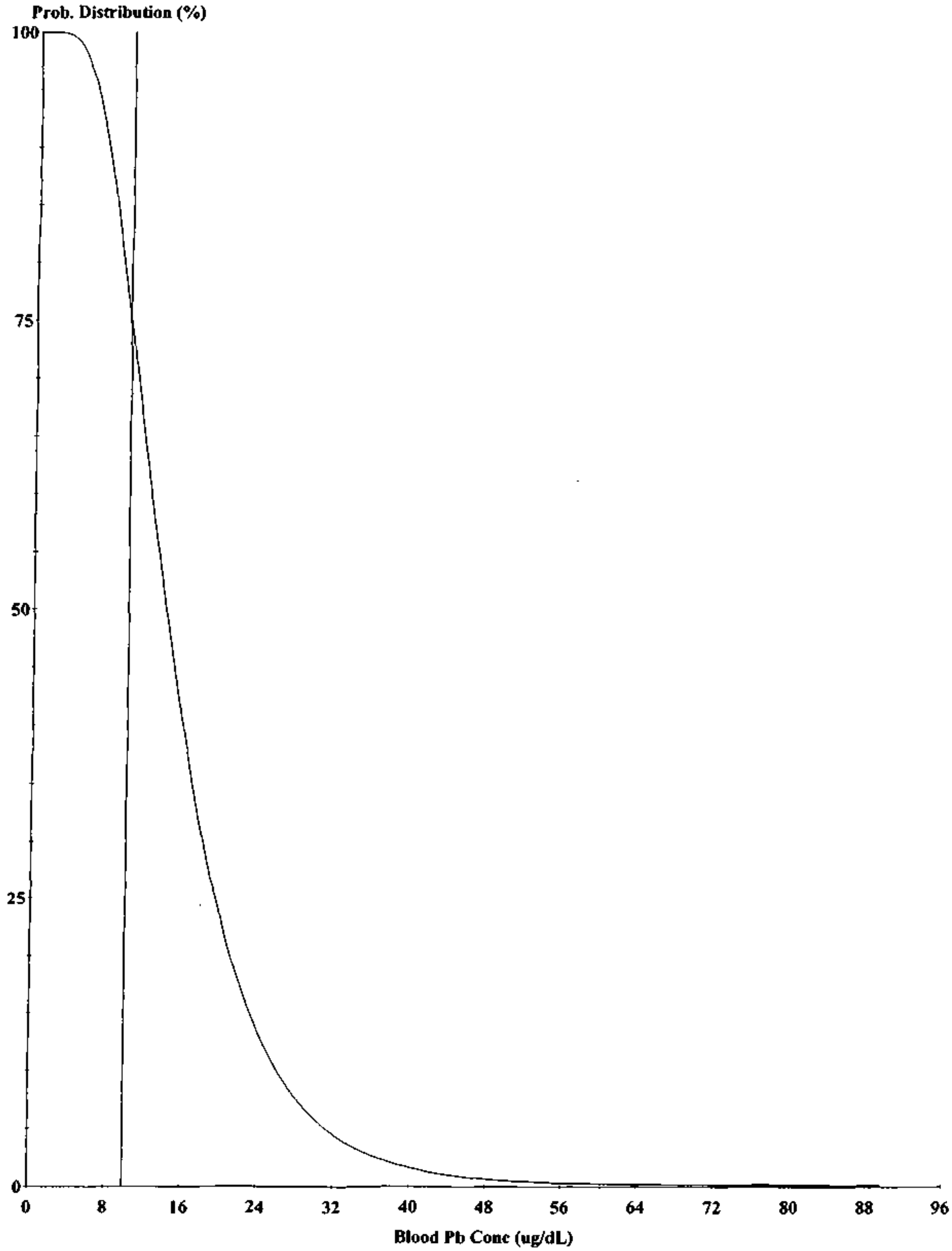
****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	1.100	0.000	0.278
1-2	0.034	0.858	0.000	0.660
2-3	0.062	0.991	0.000	0.718
3-4	0.067	0.986	0.000	0.763
4-5	0.067	1.036	0.000	0.873
5-6	0.093	1.125	0.000	0.953
6-7	0.093	1.259	0.000	0.994

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	29.146	30.544	15.7
1-2	43.755	45.307	18.1
2-3	45.793	47.564	17.1
3-4	47.738	49.554	16.7
4-5	38.791	40.767	14.1
5-6	37.259	39.430	12.2
6-7	35.272	37.619	10.8



Cutoff = 10.000 ug/dl
Geo Mean = 14.665
GSD = 1.600
% Above = 79.234

Age Range = 0 to 84 months
Time Step = Every 4 Hours
Run Mode = Research

Table F-7
Annapolis Lead Mine Site
IEUBK MODEL Results
Former Mining Operations Area, Surface Soil, Hot Spot near former Clark Residence

Soil to Dust Transfer Factor 24% , EPC = soil 6959.7, dust-multiple source analysis
New dietary intake values, other parameters are model defaults
LEAD MODEL FOR WINDOWS Version 1.0

==
Model Version: 1.0 Build 261
User Name:
Date:
Site Name:
Operable Unit:
Run Mode: Research
==
The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	3.160
1-2	2.600
2-3	2.870
3-4	2.740
4-5	2.610
5-6	2.740
6-7	2.990

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 ug Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 1680.330 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.240

Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	6959.700	1680.330
1-2	6959.700	1680.330
2-3	6959.700	1680.330
3-4	6959.700	1680.330
4-5	6959.700	1680.330
5-6	6959.700	1680.330
6-7	6959.700	1680.330

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

****** Maternal Contribution: Infant Model ******

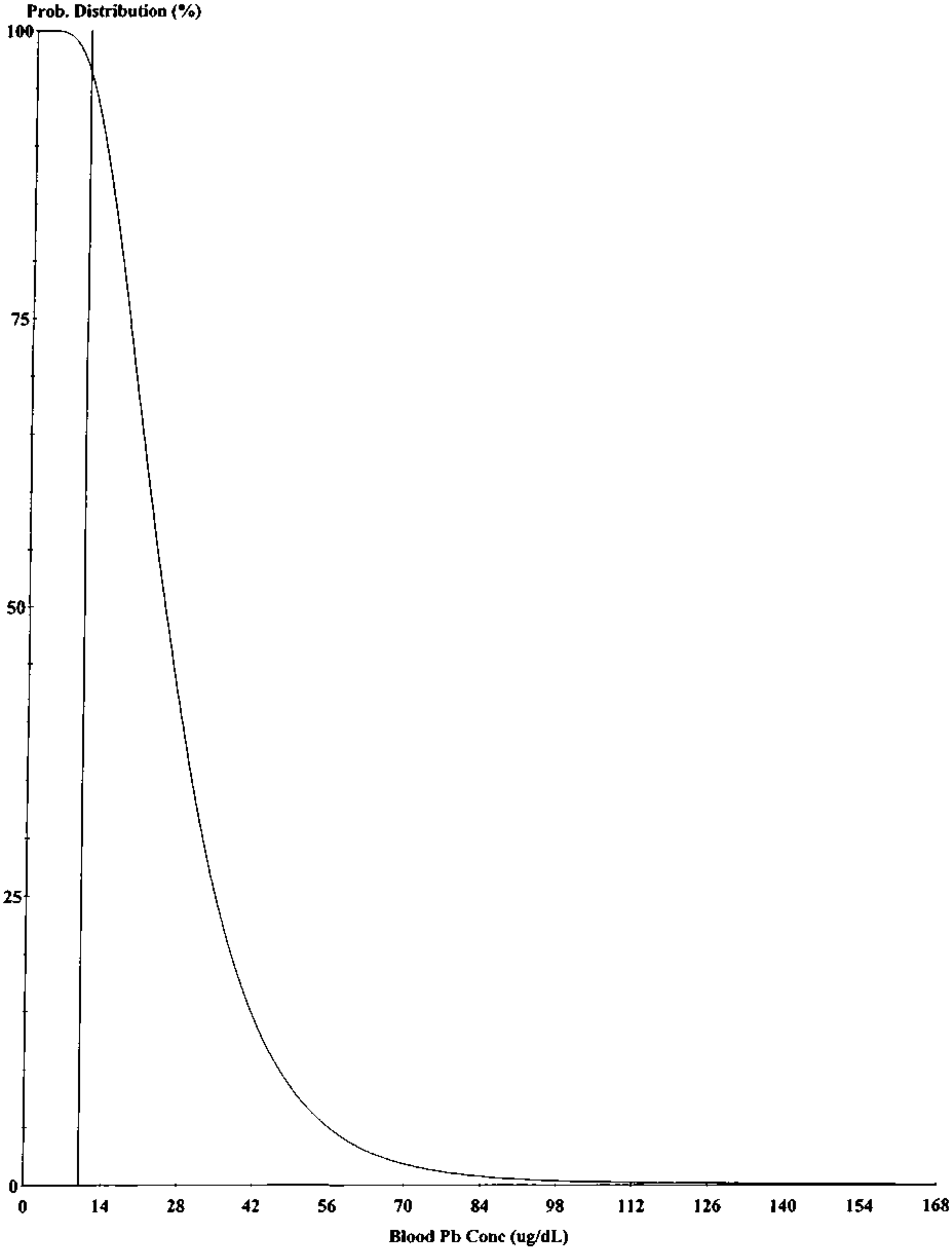
Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	0.828	0.000	0.210
1-2	0.034	0.632	0.000	0.486
2-3	0.062	0.741	0.000	0.537
3-4	0.067	0.749	0.000	0.580
4-5	0.067	0.828	0.000	0.698
5-6	0.093	0.929	0.000	0.787
6-7	0.093	1.054	0.000	0.832

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	54.183	55.241	27.3
1-2	79.876	81.029	31.3
2-3	84.831	86.171	30.0
3-4	89.845	91.240	29.7
4-5	77.249	78.842	26.1
5-6	74.265	76.074	23.0
6-7	72.887	74.865	20.7

Environmental exposures associated with blood lead levels above 30 µg/dl are above the range of values that have been used in the calibration and empirical validation of this model. (Zaragoza, L. and Hogan, K. 1998. The Integrated Exposure Uptake Biokinetic Model for Lead In Children: Independent Validation and Verification. Environmental Health Perspectives 106 (supplement 6). p. 1555)



Cutoff = 10.000 ug/dl
Geo Mean = 26.269
GSD = 1.600
% Above = 98.006

Age Range = 0 to 84 months
Time Step = Every 4 Hours
Run Mode = Research

Environmental exposures associated with blood lead levels above 30 μg/dl are above the range of values that have been used in the calibration and empirical validation of this model. (Zaragoza, L. and Hogan, K. 1998. The Integrated Exposure Uptake Biokinetic Model for Lead In Children: Independent Validation and Verification. Environmental Health Perspectives 106 (supplement 6). p. 1555)

Table F-8
Annapolis Lead Mine Site
IEUBK MODEL Results
Former Mining Operations Area, Surface Soil, Hot Spot near former Clark Residence

Soil to Dust Transfer Factor 24% , EPC = soil 6959.7, dust-multiple source analysis
New dietary intake values, alternate soil and dust intake (EPA 1996)
LEAD MODEL FOR WINDOWS Version 1.0

==
Model Version: 1.0 Build 261
User Name:
Date:
Site Name:
Operable Unit:
Run Mode: Research
==
The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	3.160
1-2	2.600
2-3	2.870
3-4	2.740
4-5	2.610
5-6	2.740
6-7	2.990

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 ug Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 1680.330 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.240

Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	6959.700	1680.330
1-2	6959.700	1680.330
2-3	6959.700	1680.330
3-4	6959.700	1680.330
4-5	6959.700	1680.330
5-6	6959.700	1680.330
6-7	6959.700	1680.330

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

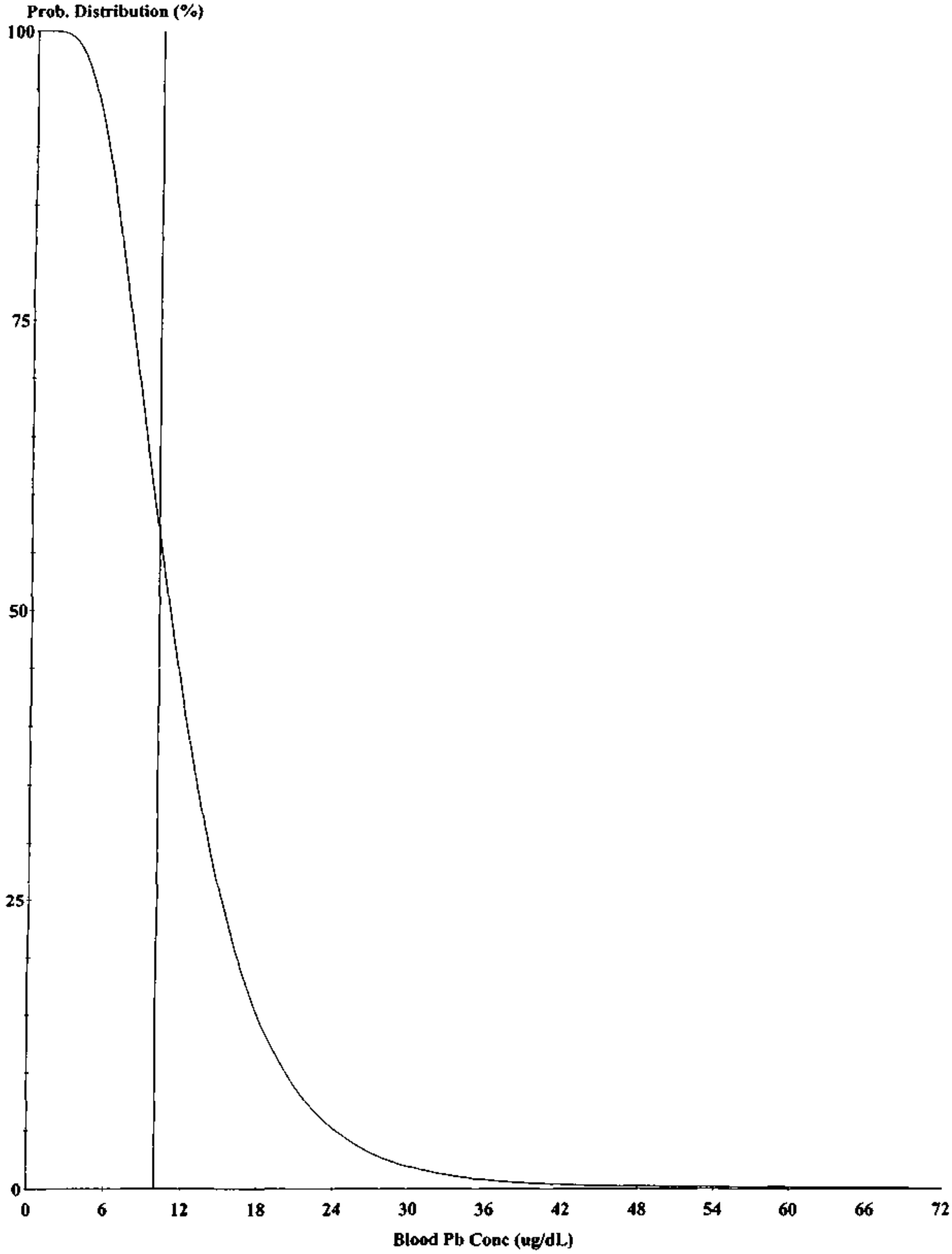
****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	1.196	0.000	0.303
1-2	0.034	0.943	0.000	0.725
2-3	0.062	1.080	0.000	0.783
3-4	0.067	1.067	0.000	0.826
4-5	0.067	1.098	0.000	0.926
5-6	0.093	1.183	0.000	1.002
6-7	0.093	1.316	0.000	1.039

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	22.106	23.626	12.3
1-2	33.529	35.231	14.2
2-3	34.816	36.742	13.4
3-4	36.024	37.984	12.9
4-5	28.673	30.764	10.8
5-6	27.326	29.604	9.3
6-7	25.710	28.159	8.1



Cutoff = 10.000 ug/dl
Geo Mean = 11.363
GSD = 1.600
% Above = 60.715

Age Range = 0 to 84 months
Time Step = Every 4 Hours
Run Mode = Research

Table F-9
Annapolis Lead Mine Site
IEUBK MODEL Results
Surface Soil , Hot Spot near Mayberry Residence

Soil to Dust Transfer Factor 70% , EPC = soil 2639.7, dust-multiple source analysis
New dietary intake values, other parameters are model defaults
LEAD MODEL FOR WINDOWS Version 1.0

==
Model Version: 1.0 Build 261
User Name:
Date:
Site Name:
Operable Unit:
Run Mode: Research
==
The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	3.160
1-2	2.600
2-3	2.870
3-4	2.740
4-5	2.610
5-6	2.740
6-7	2.990

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 ug Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 1857.790 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700

Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	2639.700	1857.790
1-2	2639.700	1857.790
2-3	2639.700	1857.790
3-4	2639.700	1857.790
4-5	2639.700	1857.790
5-6	2639.700	1857.790
6-7	2639.700	1857.790

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

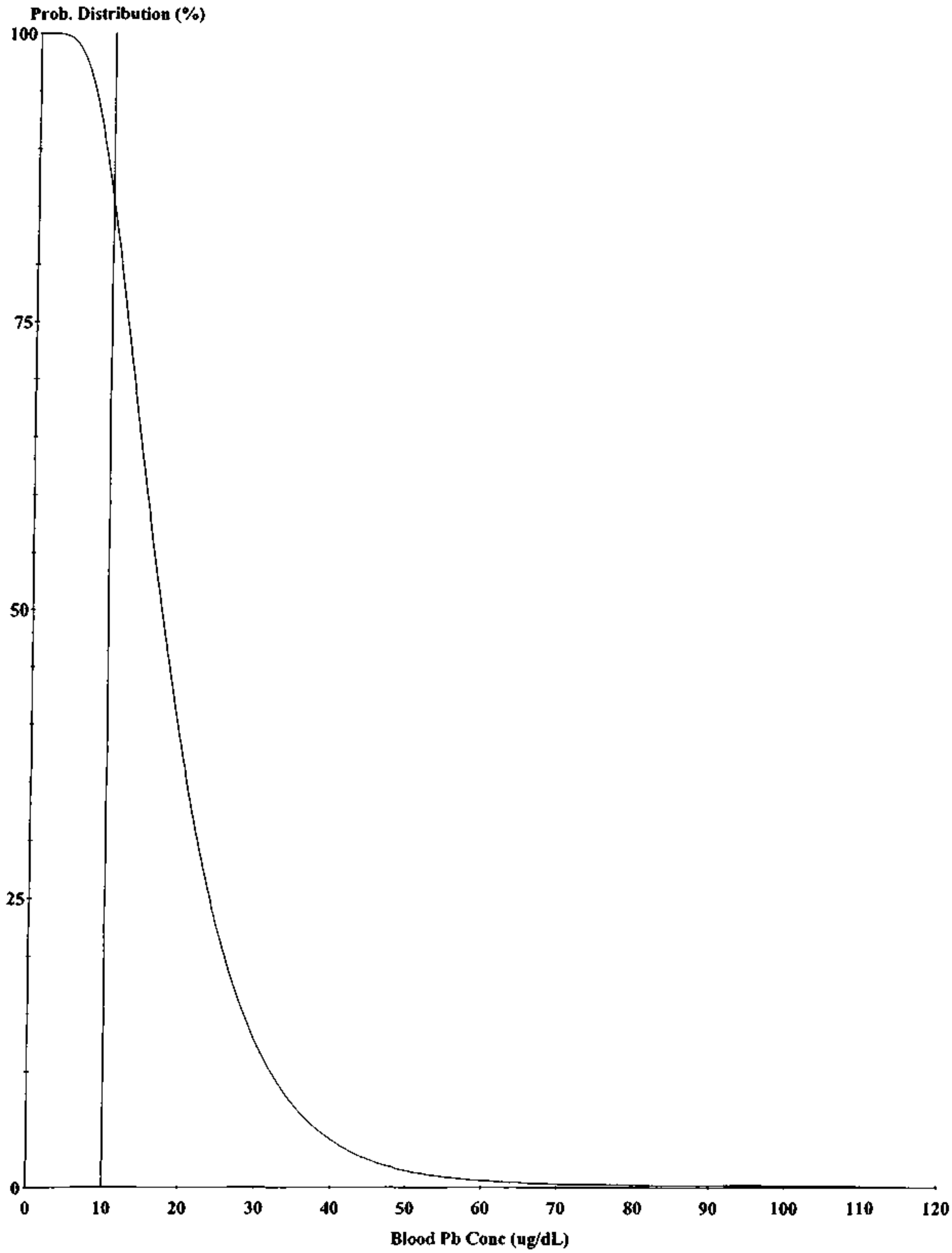
****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	1.012	0.000	0.256
1-2	0.034	0.783	0.000	0.602
2-3	0.062	0.910	0.000	0.659
3-4	0.067	0.911	0.000	0.705
4-5	0.067	0.974	0.000	0.821
5-6	0.093	1.072	0.000	0.908
6-7	0.093	1.201	0.000	0.948

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	36.108	37.397	19.0
1-2	53.884	55.304	21.9
2-3	56.740	58.371	20.8
3-4	59.514	61.197	20.4
4-5	49.457	51.318	17.5
5-6	46.677	48.750	15.1
6-7	45.277	47.520	13.4



Cutoff = 10.000 ug/dl
Geo Mean = 17.919
GSD = 1.600
% Above = 89.269

Age Range = 0 to 84 months
Time Step = Every 4 Hours
Run Mode = Research

Table F-10
Annapolis Lead Mine Site
IEUBK MODEL Results
Surface Soil , Hot Spot near Mayberry Residence

Soil to Dust Transfer Factor 70% , EPC = soil 2639.7, dust-multiple source analysis
New dietary intake values, alternate soil and dust intake (EPA 1996)
LEAD MODEL FOR WINDOWS Version 1.0

==
Model Version: 1.0 Build 261
User Name:
Date:
Site Name:
Operable Unit:
Run Mode: Research
==
The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	3.160
1-2	2.600
2-3	2.870
3-4	2.740
4-5	2.610
5-6	2.740
6-7	2.990

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 ug Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 1857.790 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700

Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	2639.700	1857.790
1-2	2639.700	1857.790
2-3	2639.700	1857.790
3-4	2639.700	1857.790
4-5	2639.700	1857.790
5-6	2639.700	1857.790
6-7	2639.700	1857.790

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

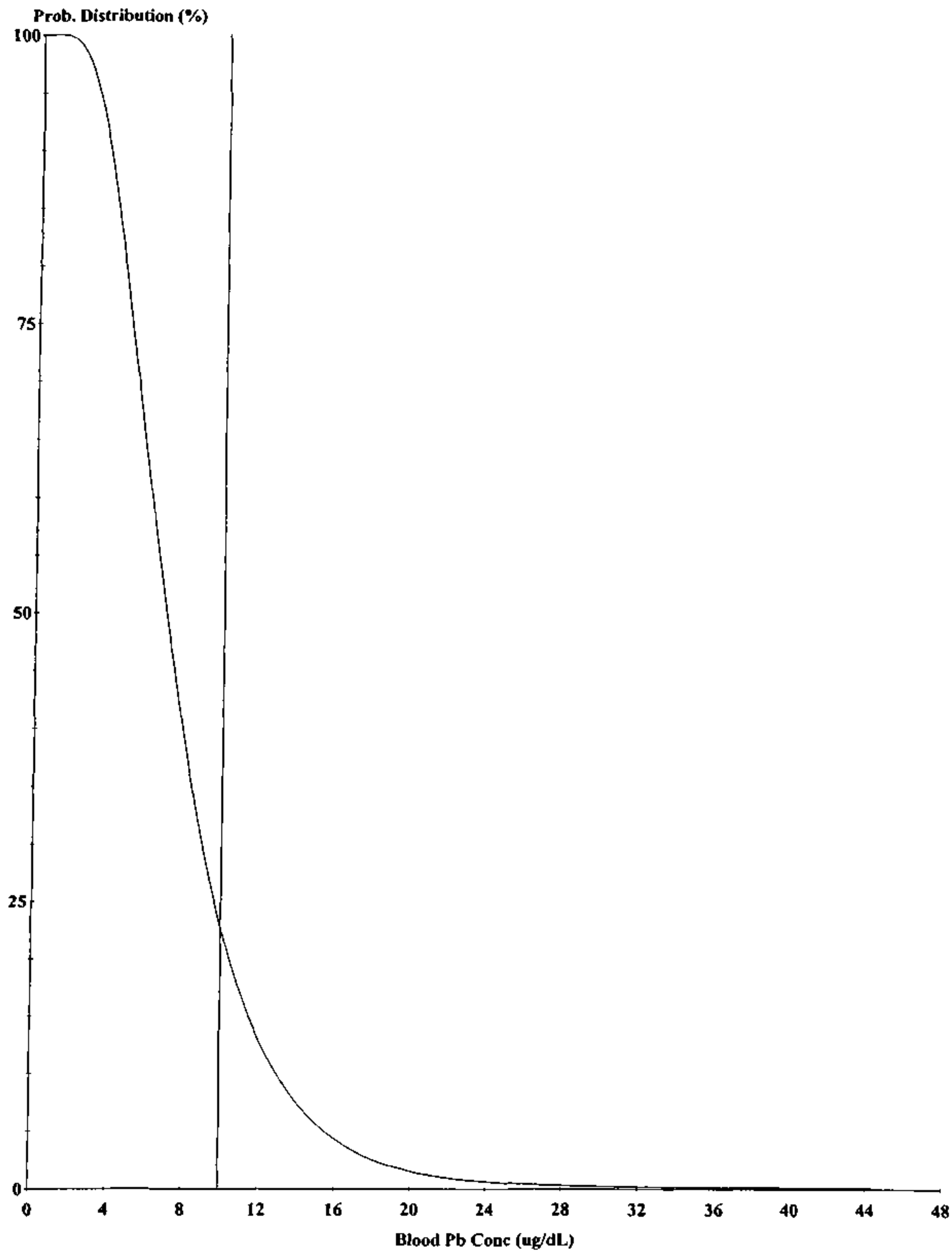
****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	1.327	0.000	0.336
1-2	0.034	1.062	0.000	0.817
2-3	0.062	1.203	0.000	0.872
3-4	0.067	1.175	0.000	0.909
4-5	0.067	1.175	0.000	0.991
5-6	0.093	1.254	0.000	1.061
6-7	0.093	1.384	0.000	1.092

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	13.359	15.043	8.0
1-2	20.581	22.494	9.2
2-3	21.111	23.247	8.6
3-4	21.603	23.754	8.2
4-5	16.715	18.948	6.8
5-6	15.771	18.180	5.7
6-7	14.726	17.296	5.0



Cutoff = 10.000 ug/dl
Geo Mean = 7.251
GSD = 1.600
% Above = 24.699

Age Range = 0 to 84 months
Time Step = Every 4 Hours
Run Mode = Research

Table F-11
Annapolis Lead Mine Site
IEUBK MODEL Results
Surface Soil , Hot Spot near Mayberry Residence

Soil to Dust Transfer Factor 24% , EPC = soil 2639.7, dust-multiple source analysis
New dietary intake values, other parameters are model defaults
LEAD MODEL FOR WINDOWS Version 1.0

==
Model Version: 1.0 Build 261
User Name:
Date:
Site Name:
Operable Unit:
Run Mode: Research
==
The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	3.160
1-2	2.600
2-3	2.870
3-4	2.740
4-5	2.610
5-6	2.740
6-7	2.990

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 ug Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 643.528 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.240

Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	2639.700	643.528
1-2	2639.700	643.528
2-3	2639.700	643.528
3-4	2639.700	643.528
4-5	2639.700	643.528
5-6	2639.700	643.528
6-7	2639.700	643.528

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

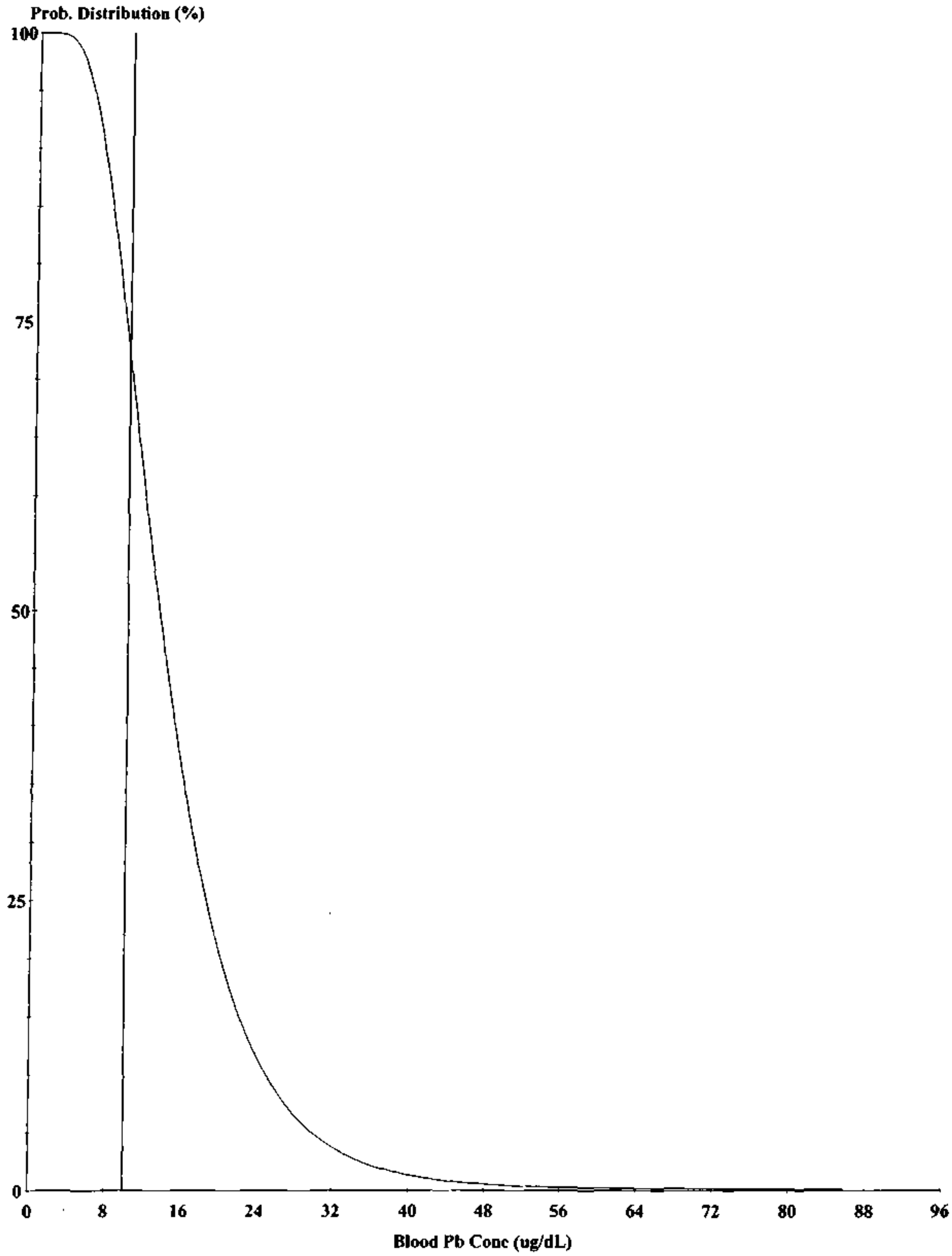
****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	1.117	0.000	0.283
1-2	0.034	0.872	0.000	0.671
2-3	0.062	1.007	0.000	0.730
3-4	0.067	1.001	0.000	0.774
4-5	0.067	1.046	0.000	0.882
5-6	0.093	1.140	0.000	0.965
6-7	0.093	1.270	0.000	1.003

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	27.802	29.224	15.0
1-2	41.907	43.485	17.4
2-3	43.802	45.600	16.4
3-4	45.605	47.447	16.0
4-5	37.085	39.080	13.6
5-6	34.645	36.844	11.5
6-7	33.402	35.768	10.2



Cutoff = 10.000 ug/dl
Geo Mean = 14.035
GSD = 1.600
% Above = 76.463

Age Range = 0 to 84 months
Time Step = Every 4 Hours
Run Mode = Research

Table F-12
Annapolis Lead Mine Site
IEUBK MODEL Results
Surface Soil , Hot Spot near Mayberry Residence

Soil to Dust Transfer Factor 24% , EPC = soil 2639.7, dust-multiple source analysis
New dietary intake values, alternate soil and dust intake (EPA 1996)
LEAD MODEL FOR WINDOWS Version 1.0

==
Model Version: 1.0 Build 261
User Name:
Date:
Site Name:
Operable Unit:
Run Mode: Research
==
The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	3.160
1-2	2.600
2-3	2.870
3-4	2.740
4-5	2.610
5-6	2.740
6-7	2.990

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 ug Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 643.528 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.240

Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	2639.700	643.528
1-2	2639.700	643.528
2-3	2639.700	643.528
3-4	2639.700	643.528
4-5	2639.700	643.528
5-6	2639.700	643.528
6-7	2639.700	643.528

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

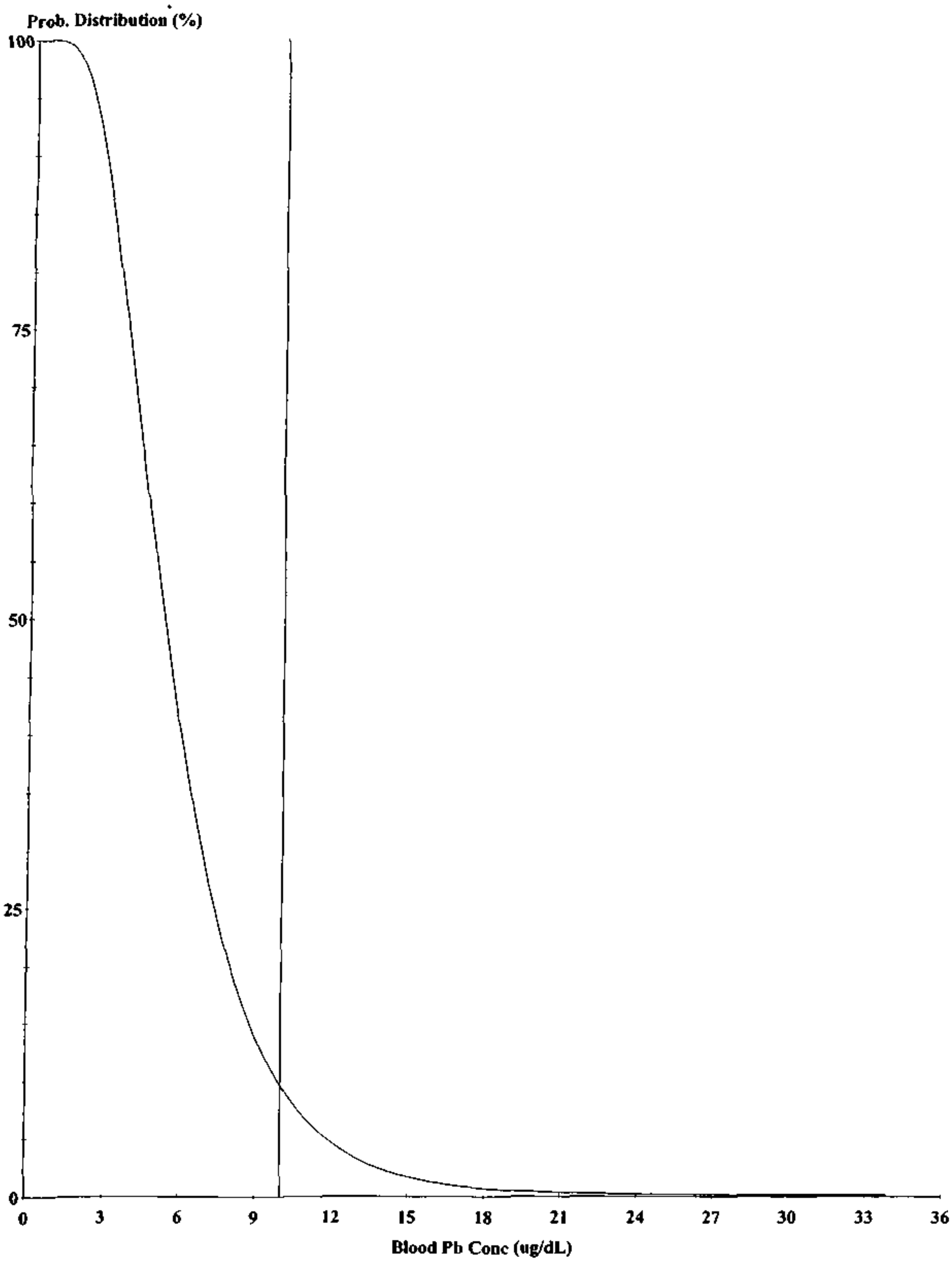
****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	1.384	0.000	0.350
1-2	0.034	1.116	0.000	0.859
2-3	0.062	1.257	0.000	0.911
3-4	0.067	1.221	0.000	0.945
4-5	0.067	1.207	0.000	1.017
5-6	0.093	1.282	0.000	1.085
6-7	0.093	1.411	0.000	1.113

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	9.725	11.481	6.1
1-2	15.094	17.103	7.0
2-3	15.392	17.621	6.5
3-4	15.670	17.903	6.2
4-5	11.975	14.266	5.1
5-6	11.252	13.713	4.3
6-7	10.474	13.091	3.8



Cutoff = 10.000 ug/dl
Geo Mean = 5.538
GSD = 1.600
% Above = 10.433

Age Range = 0 to 84 months
Time Step = Every 4 Hours
Run Mode = Research

Table F-13 Summary of Estimated Lead Exposures Based on EPA Adult Lead Methodology

Receptor	Construction Worker		
Exposure Area	Exposure Point Concentration (mean) mg/kg)	Probability that fetal PbB will be greater than 10 µg/dl	PbB of adult worker (µg/dL)
Former Mining Operations Area, Surface Soil	159.4	2%	2.1
Hot Spot Areas, Former Mining Operations Area			
Former Clark Residence	6959.7	86%	25.8
North of Mayberry Residence	2639.7	48%	10.7
Receptor	Recreational Adolescent		
Exposure Area	Exposure Point Concentration (mean) mg/kg)	Probability that fetal PbB will be greater than 10 µg/dl	PbB of recreational adolescent (µg/dL)
Flood Plain Area	912.4		
Exposure Frequency			
1 visit per week		1.1%	1.8
2 visits per week		1.8%	2.2
5 visits per week		5.0%	3.1

Table F-14

Estimates of Lead Exposures, Adult Lead Methodology

Annapolis Lead Mine Site, Former Mining Operations Area, Surface Soil, Construction Worker Scenario

Calculations of Blood Lead Concentrations (PbBs)

U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

[redacted]

Version date 05/19/03

Exposure Variable	PbB Equation[1]		Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario	
	1*	2**			Using Equation 1	Using Equation 2
					GSDi = Hom	GSDi = Hom
PbS	X	X	Soil lead concentration (Mean)	ug/g or ppm	159.4	159.4
$R_{fetal/maternal}$	X	X	Fetal/maternal PbB ratio	--	0.9	0.9
BKSF	X	X	Biokinetic Slope Factor	ug/dL per ug/day	0.4	0.4
GSD_i	X	X	Geometric standard deviation PbB	--	2.2	2.2
PbB_0	X	X	Baseline PbB	ug/dL	1.5	1.5
IR_S	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.100	--
IR_{S+D}		X	Total ingestion rate of outdoor soil and indoor dust	g/day	--	0.100
W_S		X	Weighting factor, fraction of IR_{S+D} ingested as outdoor soil	--	--	1.0
K_{SD}		X	Mass fraction of soil in dust	--	--	0.7
$AF_{S,D}$	X	X	Absorption fraction (same for soil and dust)	--	0.12	0.12
$EF_{S,D}$	X	X	Exposure frequency (same for soil and dust)	days/yr	132	132
$AT_{S,D}$	X	X	Averaging time (same for soil and dust)	days/yr	182	182
PbB_{adult}			PbB of adult worker, geometric mean	ug/dL	2.1	2.1
$PbB_{fetal,0.95}$			95th percentile PbB among fetuses of adult workers	ug/dL	6.8	6.8
PbB_t			Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	10.0	10.0
$P(PbB_{fetal} > PbB_t)$			Probability that fetal PbB > PbB_t, assuming lognormal distribution	%	1.6%	1.6%

[1] Equation 1 does not apportion exposure between soil and dust ingestion (excludes W_S, K_{SD}).
When $IR_S = IR_{S+D}$ and $W_S = 1.0$, the equations yield the same $PbB_{fetal,0.95}$.

***Equation 1, based on Eq. 1, 2 in USEPA (1996).**

PbB_{adult} =	$(PbS*BKSF*IR_{S+D}*AF_{S,D}*EF_S/AT_{S,D}) + PbB_0$
$PbB_{fetal,0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

****Equation 2, alternate approach based on Eq. 1, 2, and A-19 in USEPA (1996).**

PbB_{adult} =	$PbS*BKSF*([(IR_{S+D})*AF_S*EF_S*W_S]+[K_{SD}*(IR_{S+D})*(1-W_S)*AF_D*EF_D])/365+PbB_0$
$PbB_{fetal,0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

Table F-15

Estimates of Lead Exposures, Adult Lead Methodology

Annapolis Lead Mine Site, Former Mining Operations Area, Hot Spot, Near Former Clark Residence, Surface Soil, Construction Worker Scenario

Calculations of Blood Lead Concentrations (PbBs)

U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

[redacted]

Version date 05/19/03

Exposure Variable	PbB Equation 1*	PbB Equation 2**	Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario: Using Equation 1 (GSDi = Hom '96)	Values for Non-Residential Exposure Scenario: Using Equation 2 (GSDi = Hom '96)
PbS	X	X	Soil lead concentration (Mean)	ug/g or ppm	6959.7	6959.7
$R_{fetal/maternal}$	X	X	Fetal/maternal PbB ratio	--	0.9	0.9
BKSF	X	X	Biokinetic Slope Factor	ug/dL per ug/day	0.4	0.4
GSD_i	X	X	Geometric standard deviation PbB	--	2.2	2.2
PbB_0	X	X	Baseline PbB	ug/dL	1.5	1.5
IR_S	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.100	--
IR_{S+D}		X	Total ingestion rate of outdoor soil and indoor dust	g/day	--	0.100
W_S		X	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--	1.0
K_{SD}		X	Mass fraction of soil in dust	--	--	0.7
$AF_{S,D}$	X	X	Absorption fraction (same for soil and dust)	--	0.12	0.12
$EF_{S,D}$	X	X	Exposure frequency (same for soil and dust)	days/yr	132	132
$AT_{S,D}$	X	X	Averaging time (same for soil and dust)	days/yr	182	182
PbB_{adult}			PbB of adult worker, geometric mean	ug/dL	25.8	25.8
$PbB_{fetal,0.95}$			95th percentile PbB among fetuses of adult workers	ug/dL	83.5	83.5
PbB_t			Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	10.0	10.0
$P(PbB_{fetal} > PbB_t)$			Probability that fetal PbB > PbB_t, assuming lognormal distribution	%	86.0%	86.0%

[1] Equation 1 does not apportion exposure between soil and dust ingestion (excludes W_S, K_{SD}).
When IR_S = IR_{S+D} and W_S = 1.0, the equations yield the same $PbB_{fetal,0.95}$.

***Equation 1, based on Eq. 1, 2 in USEPA (1996).**

PbB_{adult} =	$(PbS*BKSF*IR_{S+D}*AF_{S,D}*EF_S/AT_{S,D}) + PbB_0$
$PbB_{fetal,0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

****Equation 2, alternate approach based on Eq. 1, 2, and A-19 in USEPA (1996).**

PbB_{adult} =	$PbS*BKSF*([(IR_{S+D})*AF_S*EF_S*W_S]+[K_{SD}*(IR_{S+D})*(1-W_S)*AF_D*EF_D])/365+PbB_0$
$PbB_{fetal,0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

Table F-16
Estimates of Lead Exposures, Adult Lead Methodology
Annapolis Lead Mine Site, Former Mining Operations Area, Hot Spot, North of Mayberry Residence, Surface Soil, Construction Worker Scenario
Calculations of Blood Lead Concentrations (PbBs)
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

[illegible]

Version date 05/19/03

Exposure Variable	PbB Equation[1] 1*	PbB Equation[1] 2**	Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario: Using Equation 1	
					GSDi = Hom	GSDi = Hom
PbS	X	X	Soil lead concentration (Mean)	ug/g or ppm	2639.7	2639.7
$R_{fetal/maternal}$	X	X	Fetal/maternal PbB ratio	--	0.9	0.9
BKSF	X	X	Biokinetic Slope Factor	ug/dL per ug/day	0.4	0.4
GSD_i	X	X	Geometric standard deviation PbB	-	2.2	2.2
PbB_0	X	X	Baseline PbB	ug/dL	1.5	1.5
IR_S	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.100	--
IR_{S+D}		X	Total ingestion rate of outdoor soil and indoor dust	g/day	--	0.100
W_S		X	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	-	--	1.0
K_{SD}		X	Mass fraction of soil in dust	-	--	0.7
$AF_{S,D}$	X	X	Absorption fraction (same for soil and dust)	-	0.12	0.12
$EF_{S,D}$	X	X	Exposure frequency (same for soil and dust)	days/yr	132	132
$AT_{S,D}$	X	X	Averaging time (same for soil and dust)	days/yr	182	182
PbB_{adult}			PbB of adult worker, geometric mean	ug/dL	10.7	10.7
$PbB_{fetal,0.95}$			95th percentile PbB among fetuses of adult workers	ug/dL	34.8	34.8
PbB_t			Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	10.0	10.0
$P(PbB_{fetal} > PbB_t)$			Probability that fetal PbB > PbB_t, assuming lognormal distribution	%	48.2%	48.2%

[1] Equation 1 does not apportion exposure between soil and dust ingestion (excludes W_S, K_{SD}).
When $IR_S = IR_{S+D}$ and $W_S = 1.0$, the equations yield the same $PbB_{fetal,0.95}$.

***Equation 1, based on Eq. 1, 2 in USEPA (1996).**

PbB_{adult} =	$(PbS*BKSF*IR_{S+D}*AF_{S,D}*EF_S/AT_{S,D}) + PbB_0$
$PbB_{fetal,0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

****Equation 2, alternate approach based on Eq. 1, 2, and A-19 in USEPA (1996).**

PbB_{adult} =	$PbS*BKSF*([(IR_{S+D})*AF_S*EF_S*W_S]+[K_{SD}*(IR_{S+D})*(1-W_S)*AF_D*EF_D])/365+PbB_0$
$PbB_{fetal,0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

Table F-17
Adult Lead Methodology
Annapolis Lead Mine Site, Floodplain Area, Surface Soil
Recreational Scenario (1 Visit per Week During Warmest 6 Months of the Year)
Calculations of Blood Lead Concentrations (PbBs)
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

[redacted]

Version date 05/19/03

Exposure Variable	PbB Equation[1] 1*	PbB Equation[1] 2**	Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario: Using Equation 1, GSDi = Hom	Values for Non-Residential Exposure Scenario: Using Equation 2, GSDi = Hom
PbS	X	X	Soil lead concentration (Mean)	ug/g or ppm	912.4	912.4
$R_{fetal/maternal}$	X	X	Fetal/maternal PbB ratio	--	0.9	0.9
BKSF	X	X	Biokinetic Slope Factor	ug/dL per ug/day	0.4	0.4
GSD_i	X	X	Geometric standard deviation PbB	--	2.2	2.2
PbB_0	X	X	Baseline PbB	ug/dL	1.5	1.5
IR_S	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050	--
IR_{S+D}		X	Total ingestion rate of outdoor soil and indoor dust	g/day	--	0.050
W_S		X	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--	1.0
K_{SD}		X	Mass fraction of soil in dust	--	--	0.7
$AF_{S,D}$	X	X	Absorption fraction (same for soil and dust)	--	0.12	0.12
$EF_{S,D}$	X	X	Exposure frequency (same for soil and dust)	days/yr	26	26
$AT_{S,D}$	X	X	Averaging time (same for soil and dust)	days/yr	182	182
PbB_{adult}			PbB of adult worker, geometric mean	ug/dL	1.8	1.8
$PbB_{fetal,0.95}$			95th percentile PbB among fetuses of adult workers	ug/dL	6.0	6.0
PbB_t			Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	10.0	10.0
$P(PbB_{fetal} > PbB_t)$			Probability that fetal PbB > PbB_t, assuming lognormal distribution	%	1.1%	1.1%

[1] Equation 1 does not apportion exposure between soil and dust ingestion (excludes W_S, K_{SD}).
When $IR_S = IR_{S+D}$ and $W_S = 1.0$, the equations yield the same $PbB_{fetal,0.95}$.

*Equation 1, based on Eq. 1, 2 in USEPA (1996).

PbB_{adult} =	$(PbS*BKSF*IR_{S+D}*AF_{S,D}*EF_S/AT_{S,D}) + PbB_0$
$PbB_{fetal,0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

**Equation 2, alternate approach based on Eq. 1, 2, and A-19 in USEPA (1996).

PbB_{adult} =	$PbS*BKSF*([(IR_{S+D})*AF_S*EF_S*W_S]+[K_{SD}*(IR_{S+D})*(1-W_S)*AF_D*EF_D])/365+PbB_0$
$PbB_{fetal,0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

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Table F-18

Estimates of Lead Exposures, Adult Lead Methodology

Annapolis Lead Mine Site, Floodplain Area, Surface Soil

Recreational Scenario (2 Visits per Week During Warmest 6 Months of the Year)

Calculations of Blood Lead Concentrations (PbBs)

U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

[redacted]

Version date 05/19/03

Exposure Variable	PbB Equation[1] 1*	PbB Equation[1] 2**	Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario: Using Equation 1 (GSDi = Hom)	Values for Non-Residential Exposure Scenario: Using Equation 2 (GSDi = Hom)
PbS	X	X	Soil lead concentration (Mean)	ug/g or ppm	912.4	912.4
$R_{fetal/maternal}$	X	X	Fetal/maternal PbB ratio	--	0.9	0.9
BKSF	X	X	Biokinetic Slope Factor	ug/dL per ug/day	0.4	0.4
GSD_i	X	X	Geometric standard deviation PbB	--	2.2	2.2
PbB_0	X	X	Baseline PbB	ug/dL	1.5	1.5
IR_S	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050	--
IR_{S+D}		X	Total ingestion rate of outdoor soil and indoor dust	g/day	--	0.050
W_S		X	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--	1.0
K_{SD}		X	Mass fraction of soil to dust	--	--	0.7
$AF_{S,D}$	X	X	Absorption fraction (same for soil and dust)	--	0.12	0.12
$EF_{S,D}$	X	X	Exposure frequency (same for soil and dust)	days/yr	52	52
$AT_{S,D}$	X	X	Averaging time (same for soil and dust)	days/yr	182	182
PbB_{adult}			PbB of adult worker, geometric mean	ug/dL	2.2	2.2
$PbB_{fetal,0.95}$			95th percentile PbB among fetuses of adult workers	ug/dL	7.0	7.0
PbB_t			Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	10.0	10.0
$P(PbB_{fetal} > PbB_t)$			Probability that fetal PbB > PbB_t, assuming lognormal distribution	%	1.8%	1.8%

[1] Equation 1 does not apportion exposure between soil and dust ingestion (excludes W_S, K_{SD}).
When $IR_S = IR_{S+D}$ and $W_S = 1.0$, the equations yield the same $PbB_{fetal,0.95}$.

***Equation 1, based on Eq. 1, 2 in USEPA (1996).**

PbB_{adult} =	$(PbS*BKSF*IR_{S+D}*AF_{S,D}*EF_S/AT_{S,D}) + PbB_0$
$PbB_{fetal,0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

****Equation 2, alternate approach based on Eq. 1, 2, and A-19 in USEPA (1996).**

PbB_{adult} =	$PbS*BKSF*([(IR_{S+D})*AF_S*EF_S*W_S]+[K_{SD}*(IR_{S+D})*(1-W_S)*AF_D*EF_D])/365+PbB_0$
$PbB_{fetal,0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

Table F-19
Estimates of Lead Exposures, Adult Lead Methodology
Annapolis Lead Mine Site, Floodplain Area, Surface Soil
Recreational Scenario (5 Visits per Week During Warmest 6 Months of the Year)
Calculations of Blood Lead Concentrations (PbBs)
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

Version date 05/19/03

[redacted]

Exposure Variable	PbB Equation¹ *1*	PbB Equation¹ *2**	Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario: Using Equation 1, GSDi = Hom	Using Equation 2, GSDi = Hom
PbS	X	X	Soil lead concentration (Mean)	ug/g or ppm	912.4	912.4
$R_{fetal/maternal}$	X	X	Fetal/maternal PbB ratio	--	0.9	0.9
BKSF	X	X	Biokinetic Slope Factor	ug/dL per ug/day	0.4	0.4
GSD_i	X	X	Geometric standard deviation PbB	-	2.2	2.2
PbB_0	X	X	Baseline PbB	ug/dL	1.5	1.5
IR_S	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.050	--
IR_{S+D}		X	Total ingestion rate of outdoor soil and indoor dust	g/day	--	0.050
W_S		X	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--	1.0
K_{SD}		X	Mass fraction of soil in dust	-	--	0.7
$AF_{S,D}$	X	X	Absorption fraction (same for soil and dust)	--	0.12	0.12
$EF_{S,D}$	X	X	Exposure frequency (same for soil and dust)	days/yr	130	130
$AT_{S,D}$	X	X	Averaging time (same for soil and dust)	days/yr	182	182
PbB_{adult}			PbB of adult worker, geometric mean	ug/dL	3.1	3.1
$PbB_{fetal,0.95}$			95th percentile PbB among fetuses of adult workers	ug/dL	10.0	10.0
PbB_t			Target PbB level of concern (e.g., 10 ug/dL)	ug/dL	10.0	10.0
$P(PbB_{fetal} > PbB_t)$			Probability that fetal PbB > PbB_t, assuming lognormal distribution	%	5.0%	5.0%

¹ *Equation 1 does not apportion exposure between soil and dust ingestion (excludes W_S, K_{SD}).*
When $IR_S = IR_{S+D}$ and $W_S = 1.0$, the equations yield the same $PbB_{fetal,0.95}$.

***Equation 1, based on Eq. 1, 2 in USEPA (1996).**

PbB_{adult} =	$(PbS*BKSF*IR_{S+D}*AF_{S,D}*EF_S/AT_{S,D}) + PbB_0$
$PbB_{fetal,0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$

****Equation 2, alternate approach based on Eq. 1, 2, and A-19 in USEPA (1996).**

PbB_{adult} =	$PbS*BKSF*([(IR_{S+D})*AF_S*EF_S*W_S]+[K_{SD}*(IR_{S+D})*(1-W_S)*AF_D*EF_D])/365+PbB_0$
$PbB_{fetal,0.95}$ =	$PbB_{adult} * (GSD_i^{1.645} * R)$