AMAX Arizona, Inc.

Anaconda Arizona, Inc.

Probabilistic Risk Assessment

Former Eagle Picher Mill Site on Parcel 30, Sahuarita, Arizona

VRP 512782

July 2021, Revision July 2022

Probabilistic Risk Assessment

Former Eagle Picher Mill Site on Parcel 30, Sahuarita, Arizona

July 2021, Revision July 2022

Prepared By:
Arcadis U.S., Inc.
410 N. 44th Street Suite 1000
Phoenix, Arizona 85008

Phone: 602 438 0883
Fax: 602 438 0102

Prepared For:
AMAX Arizona, Inc.
Phoenix, Arizona
Anaconda Arizona, Inc.
Houston, Texas

Our Ref:
30084240

Anne Thatcher

Anne Thatcher
Technical Expert/Risk Assessor

Version Control

Issue	Revision No.	Date Issued	Description
	1	March 2022	Based on comments from ADEQ
	2	May 2022	Based on comments from ADEQ
	3	July 2022	Based on comments from ADEQ

Contents

Acronyms and Abbreviations vi
Executive Summary ES1
1 Introduction 1
2 Site Background 2
2.1 Previous Site Investigations 3
2.1.1 Hydrometrics, Inc 3
2.1.2 Golder Associates 4
2.1.3 Clear Creek Associates 4
2.1.4 Brown and Caldwell 5
2.1.5 Data Usability 5
2.1.5.1 Hydrometrics, Inc 5
2.1.5.2 Golder Associates 5
2.1.5.3 Clear Creek Associates 6
2.1.5.4 Brown and Caldwell 7
2.1.5.5 Comparability of Data 7
2.2 Exposure Area 8
2.3 Selection of Constituents of Concern 10
2.4 Probabilistic Risk Assessment 10
3 Exposure Assessment 11
3.1 Potential Receptors 11
3.2 Potentially Complete Exposure Routes 11
3.3 Exposure Assumptions 11
3.3.1 Exposure Point Concentrations 12
3.3.2 Exposure Duration 12
3.3.3 Body Weight 13
3.3.4 Exposure Frequency 13
3.3.5 Incidental Ingestion of Soil 13
3.3.6 Bioavailability of Metals in Soil 14
3.3.7 Dermal Exposure to Metals in Soil 15
3.3.8 Inhalation Exposure Time 17
3.3.9 Averaging Time 17
3.4 Dose (Intake) Estimation 17

3.5 Exposure to Lead 19
4 Toxicity Assessment 22
4.1 Arsenic 22
4.2 Cadmium 22
4.3 Lead 23
4.4 Manganese 23
4.5 Zinc 24
5 Risk Characterization 25
5.1 Cancer Risk Characterization 25
5.2 Noncancer Hazard Characterization 25
5.3 Risk Characterization Results 26
5.4 Lead Evaluation 26
5.5 Site-Specific Soil Remediation Levels 27
6 Uncertainties in the Risk Assessment 30
6.1 Uncertainties Associated with COC Selection 30
6.2 Uncertainties Associated with PRA Distributions 31
6.3 Uncertainties Associated with Lead Exposure 33
6.4 Uncertainties Associated with Critical Effects System Adjustments to SSRLs 34
7 Summary and Conclusions 35
8 References 36

Tables

Table 2.1 Summary of Available Soil Data for Metals

Table 2.2 Statistical Summary and Selection of Chemical Constituents of Potential Concern

Table 2.3 Surface Soil Data Summary

Table 3.1 Probabilistic Risk Assessment Input Parameters

Table 6.1 Summary of Tailings Data (Area 1) from 0 to 5 ft and Calculated Hazard Indices

Table 6.2 Comparison of Detected Concentrations in Areas 2, 3, and 4 and Area 1 (Tailings)

Table 6.3 Projected Concentrations and Hazard Indices for A2-36

Figures

Figure 1 Site Location Map

Figure 2 Historical Sample Locations

Figure 3 Arsenic Concentrations in Soil

Figure 4 Cadmium Concentrations in Soil

Figure 5 Lead Concentrations in Soil

Figure 6 Manganese Concentrations in Soil

Figure 7 Zinc Concentrations in Soil

Figure 8 Arsenic Thiessen Polygons

Figure 9 Lead Thiessen Polygons

Figure 10 Manganese Thiessen Polygons

Figure 11 Uncertainty Analysis for Lead

Appendices

Appendix A.	**@Risk Report**
Appendix B.	**IEUBK Model Output and Lead Distribution**
Appendix C.	**EPC Data Sets**
Appendix D.	**Box Plots and Statistics**
Appendix E.	**Area 1 Metal/Lead Ratio Calculation**
Appendix F.	**ADEQ Correspondence**

Acronyms and Abbreviations

A.A.C.	Arizona Administrative Code
ABSd	dermal absorption factor
ADD	average daily dose
ADEQ	Arizona Department of Environmental Quality
ADHS	Arizona Department Health Services
AMAX	AMAX Arizona, Inc.
AWQS	Arizona Water Quality Standard
BC	Brown and Caldwell
BLRV	blood lead reference value
CalEPA	California Environmental Protection Agency
CDC	Centers for Disease Control and Prevention
COC	constituent of concern
CSF	cancer slope factor
cm^2	square centimeter
CVAA	cold vapor atomic absorption
DPT	direct-push technology
DTSC	Department of Toxic Substances Control
DUER	Declaration of Environmental Use Restriction
EA	exposure area
ED	exposure duration
EFH	Exposure Factors Handbook
ELCR	excess lifetime cancer risk
EPC	exposure point concentration
ft bgs	foot below ground surface
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
hr	hour
HSA	hollow-stem auger

ICP/AES	inductively coupled plasma/atomic emission spectroscopy
ICP/MS	inductively coupled plasma/mass spectrometry
IEUBK	Integrated Exposure Uptake Biokinetic
IRIS	Integrated Risk Information System
IUR	inhalation unit risk factor
kg	kilogram
LADD	lifetime average daily dose
LIU	Lampbright Investigation Unit
m^3	cubic meter
mg	milligram
µg	microgram
µm	micron
NHANES	National Health and Nutrition Examination Survey
ODEQ	Oregon Department of Environmental Quality
OLEM	Office of Land and Emergency Management
PbB	blood lead
PRA	probabilistic risk assessment
QA/QC	quality assurance/quality control
RBA	relative bioavailability
RfC	reference concentration
RfD	reference dose
rSRL	residential soil remediation level
SHEDS	Stochastic Human Exposure and Dose Simulation
SRLs	soil remediation levels
SSRL	site-specific soil remediation level
TAL	Target Analyte List
TRW	Bioavailability Technical Review Work Group
UCL	upper confidence limit
USEPA	United States Environmental Protection Agency
USGS	U.S. Geological Survey
VRP	Voluntary Remediation Program

XRF	x-ray fluorescence
yr	year

Executive Summary

Arcadis U.S., Inc. (Arcadis) has prepared this Probabilistic Human Health Risk Assessment (PRA) on behalf of AMAX Arizona, Inc. and Anaconda Arizona, Inc. for the Former Eagle Picher Mill site on Parcel 30 in Sahuarita, Arizona as part of the Arizona Department of Environmental Quality's (ADEQ's) Voluntary Remediation Program (VRP). Parcel 30 was entered into the VRP in 2016 (Site Code 512782). The results of the PRA will be used in the risk management decision making process for the portion of Parcel 30 currently enrolled in the VRP, and the outcome of the PRA complies with risk-based remedial goals of Arizona Revised Statutes (A.R.S.) §49-175(B).

Lead-zinc ores were milled at the Eagle Picher Mill site from 1943 to 1959. Ore was processed at the former mill site and tailing impoundment between West Twin Buttes Road and the northern property boundary. In the late 1960s, the mill buildings were demolished down to their concrete foundations, and the tailing impoundment was capped with a vegetated soil cover. The 238-acre Parcel 30 property has been previously subdivided into five areas for assessment purposes:

- Area 1 - Tailings Impoundment;
- Area 2 - Former Mill Site;
- Area 3 - Former Pole Area;
- Area 4 - North Area;
- Area 5 - South Area.

Parcel 30 is located in an area of potential future growth for the Town of Sahuarita. Based on conversations with Town representatives, planned uses of Parcel 30 exclude residential and commercial uses, but include the following:

- Area 1 will be recapped with two feet of clean soil to contain the waste material and pollinator gardens will be constructed on a portion of the new cap.
- A small portion of Areas 1, 2, 3, and 4 will contain light hiking trails with periodic benches.
- Area 4 will also contain a mixed-use area.
- Area 5 has been withdrawn from the VRP.

Based on the planned uses described above, the PRA evaluated the potential cancer risk and non-cancer hazards from exposure to soils in Areas 2, 3, and 4 (defined as the Exposure Area [EA]). Area 1 (tailings impoundment) will be capped with two feet of clean soil and revegetated as part of reclamation, thereby preventing potential exposure to the waste material by recreators. The remaining exposed, impacted materials in areas outside of Area 1 will be consolidated into a smaller footprint more centrally located and provide cover material and improved stormwater drainage management features for the resulting footprints of impacted material in Areas 2 and 4 (Arcadis 2022). As part of the planned Declaration of Environmental Use Restriction (DEUR), pollinator gardens will be placed on a portion of the cap in Area 1 where they can be observed from interpretive trails constructed in Areas 1, 2, 3, and 4. Area 5 was not used for historical mill operations and was not impacted from adjacent operations; consequently, it was removed from the VRP in April 2021. Therefore, only Areas 2, 3 and 4 are evaluated in this PRA[1] (referred to hereinafter as the "Site"). For purposes of this PRA, and to align with the intended future use of the Site by AMAX Arizona, Inc. and Anaconda Arizona, Inc., recreational use is

[1] Although portions of Areas 2 and 4 will be remediated, all available data for Areas 2, 3 and 4 were evaluated in the PRA.

assumed for Areas 1, 2, 3, and 4. The relevant receptor population for a recreational use risk assessment are adult and child recreators.

Potential cancer risks and non-cancer hazards to future recreators that could result from exposure to soil containing arsenic, cadmium, manganese, and zinc at the Site were assessed using probabilistic methods. Exposure estimates based on a combination of parameter distributions and point estimates were then combined with toxicity values to provide distributions of risk and hazard estimates that consider both variability and uncertainty. The resulting 95th percentile cancer risk estimate of 4×10^{-7} is below both the ADEQ and the United States Environmental Protection Agency (USEPA) acceptable risk range of 1×10^{-6} to 1×10^{-4} and the resulting 95th percentile hazard index (HI) estimate of 0.24 is below the target HI of 1.

For comparison, Site-specific soil remediation levels (SSRLs) resulting in an excess lifetime cancer risk (ELCR) of 1×10^{-5}, which has been accepted by ADEQ as the target risk level for cleanup level development at other VRP sites, and an HI of 1 were also identified. The SSRLs are used in the remedial action plan (RAP) to guide the civil design for remedial activities at the Site so residual concentrations in soil are protective of recreational land use. The SSRL for arsenic based on the target risk level of 1×10^{-5} is 150 mg/kg. SSRLs based on an HI of 1 are 73.6 mg/kg for cadmium, 18,500 mg/kg for manganese, and 236,000 mg/kg for zinc. The SSRL for manganese was adjusted to 9,250 mg/kg based on an HI of 0.5, as it can potentially affect the same critical effect system (i.e., central nervous system) as one of the other constituents of concern (i.e., lead). The maximum detected concentrations of arsenic, manganese, and zinc do not exceed their respective SSRL values in Areas 2, 3, and 4. The EA-wide area-weighted 95% upper confidence limits (UCLs) for arsenic and manganese are 8.23 mg/kg and 837 mg/kg, respectively (Appendix A). The EA-wide 95% UCL for zinc is 5,245 mg/kg. The maximum cadmium concentration of 75 mg/kg in Area 2 marginally exceeds the SSRL of 73.6 mg/kg; however, no action is required since the EA-wide 95% UCL (18.18 mg/kg; Appendix A) is below the SSRL.

The USEPA's Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK v2.0 model) was used to evaluate the potential for adverse health effects from exposure to lead. Based on the results of the IEUBK model, exposure to lead in soil at Areas 2, 3, and 4 is not likely to result in adverse health effects in future child recreators and, by extension, in future adult recreators.

The IEUBK model was also used to derive an SSRL for lead. Based on a goal of no more than 5 percent of the child resident population having a blood lead (PbB) concentration greater than 10 micrograms per deciliter (μg/dL), and accounting for time spent at the EA and time spent away from the EA (e.g., at home) in accordance with USEPA (2003b) guidance, the lead SSRL is 2,100 mg/kg. The average lead concentrations in surface soil (i.e., EA-wide average; EA-wide area-weighted average) calculated for the exposure area evaluated in this PRA do not exceed the lead SSRL.

The results of the PRA indicate that adverse effects to human health from exposure to constituents of concern in soil are not expected if Areas 2, 3, and 4 are developed for recreational use. These conclusions are based on a robust dataset and a scientifically defensible process that can support risk management decisions for this Site.

That said, remedial action is required to consolidate eroded material and any visible tailing. The published ADEQ residential Soil Remediation Levels (rSRLs) for arsenic, lead, and manganese were used to design the planned consolidation (Arcadis 2022).

1 Introduction

Arcadis U.S., Inc. (Arcadis) prepared this Probabilistic Human Health Risk Assessment (PRA) on behalf of AMAX Arizona, Inc. (AMAX) and Anaconda Arizona, Inc. (Anaconda) for the portion of the Former Eagle Picher Mill site on Parcel 30 in Sahuarita, Arizona (Figure 1) enrolled in the Arizona Department of Environmental Quality's (ADEQ's) Voluntary Remediation Program (VRP), referred to hereinafter as the "Site". Arcadis conducted the PRA in accordance with ADEQ's VRP to conservatively evaluate whether residual concentrations of Site-related constituents in soil pose adverse health effects to current and hypothetical future users at the Site. The Site was entered into the VRP in 2016 (Site Code 512782). The results of the PRA will be used in the risk management decision making process for the Site.

The PRA was developed based on the results of previous Site investigations, evaluation of anticipated Site uses (including historical, current, and long-term future land uses), and applicable United States Environmental Protection Agency (USEPA) and state agency guidance. This PRA assesses cancer risks and non-cancer hazards associated with metals detected at the Site and proposes Site-specific soil remediation levels (SSRLs) to support a reclamation program planned for the Site.

The former mill site and tailing impoundment were reclaimed in the late 1960s by removing the buildings and capping the impoundment with a vegetated soil cover. AMAX and Anaconda seek a letter of completion from ADEQ or an alternative no further action document for the property. The conceptual remediation approach for the Eagle Picher Mill Site, as discussed with ADEQ, is to integrate future land use planned with the Town of Sahuarita (i.e., walking trails, ball fields) with the engineering controls of capping and surface water management at the former impoundment and a Declaration of Environmental Use Restriction (DEUR) that will restrict the property to non-residential land use. As part of the DEUR, pollinator gardens will be placed on a portion of the newly-installed cap in Area 1 where they can be observed from interpretive trails to be constructed in Areas 1, 2, 3, and 4 and a frisbee golf course to be constructed in Area 4.

The remainder of this PRA is organized as follows:

- Section 2 - Site Background;
- Section 3 - Exposure Assessment;
- Section 4 - Toxicity Assessment;
- Section 5 - Risk Characterization;
- Section 6 - Uncertainties in the Risk Assessment;
- Section 7 - Summary and Conclusions;
- Section 8 - References.

2 Site Background

Parcel 30 is located in Sections 13 and 14 of Township 17 South, Range 13 East in Pima County and consists of four contiguous parcels (Pima County Assessor Parcels 303-33-012C, 303-33-012D, 303-36-009A, and 303-36-009B). Pima Tax Assessor's records list AMAX Arizona, Inc. and Anaconda Arizona, Inc. as the owners of Parcel 30. AMAX Arizona, Inc. is an indirect subsidiary of Freeport Minerals Corporation. Anaconda Arizona, Inc. is an indirect subsidiary of BP.

Parcel 30 is located in the Santa Cruz Valley, a wide alluvial basin between the Santa Rita Mountains to the east and the Sierrita Mountains to the west. The Santa Cruz River is approximately 1,200 to 2,000 feet to the east of the eastern property boundary (Figure 1). The property slopes gently to the east towards the river channel. The Site elevation is approximately 2,780 feet above mean sea level on the west and 2,740 feet above mean sea level on the east. Several dry washes cross the property from west to east.

Parcel 30 is currently vacant. The property is bounded to the east by South Villita Road (Figure 2). West Twin Buttes Road and the Southern Pacific Railroad line cross the property from northeast to southwest. Interstate 19 is approximately 0.5 mile west of the western property boundary. The portion of the property north of West Twin Buttes Road contains the former Eagle Picher Mill Site, which is fenced and has signage indicating that it is a mine waste reclamation project.

Parcel 30 south of West Twin Buttes Road is undeveloped land. Nearby property uses include residential land approximately 0.5 mile south of West Twin Buttes Road, vacant land and agricultural land to the east, vacant land to the west, and recent development for the Town of Sahuarita (e.g., school, church, police department) on the adjacent property to the north.

Lead-zinc ores were milled at the Eagle Picher Mill Site from 1943 to 1959. Ore was processed at the former mill site and tailing impoundment between West Twin Buttes Road and the northern property boundary (Figure 2). In the late 1960s, the mill buildings were demolished down to their concrete foundations, and the tailing impoundment was capped with a vegetated soil cover. There is no information indicating that the portion of Parcel 30 south of West Twin Buttes Road was used for ore processing.

The tailing impoundment thickness was estimated to range from approximately 4 to 23 feet, with an average thickness of 13 feet (Golder 2009). Native alluvium was encountered directly beneath the tailing material. Impoundment thickness is greatest on the southern and eastern flanks. An estimated 421,121 cubic yards (11,370,267 cubic feet) of historical tailing is present at Parcel 30 (Golder 2009).

The Parcel 30 tailing impoundment is covered by a soil cover averaging 1 foot thick. While this cover has withstood approximately 20 years of exposure to the elements, minor erosion was observed at isolated points along the edges of the footprint, with exposed tailing material visible as washout among the riprap of some of the French drains on the north side of the impoundment. To prevent similar degradation in the future, the new cap will be graded to promote drainage to newly installed interceptor drainage channels that will be armored with 3-inch rip rap to prevent erosion in low-gradient areas such as the top of the impoundment and along the east toe. The surface drainage will be conveyed from the interceptor drainage channels to down drains armored with a combination of 12- to 18-inch (depending on the gradient and length of the downdrain) to further protect against erosion prior to discharging to the wash on the north side of the impoundment.

As discussed in the Remedial Work Plan (RWP; Arcadis 2022), the remedial alternative will also relocate and consolidate impacted materials in outlying areas to a more central location further from the property boundaries and allow for more efficient long-term monitoring of the remedy to confirm long-term protectiveness. Visible tailing and other impacted material will be excavated from Area 2 and Area 4 and consolidated on Area 1. Excavations will be performed to meet design grades and to allow for placement of a 2-foot clean cover system in excavated areas. Post-excavation soil samples will be collected for documentation purposes and to verify that excavation activities have met the objectives stated in the RWP. The planned remediation is discussed in detail in the RWP (Arcadis 2022).

Parcel 30 has previously been subdivided into the following five areas for assessment purposes (Figure 2):

- Area 1 - Tailings Impoundment (Pima County Assessor Parcel 303-33-012C (portion));
- Area 2 - Former Mill Site (Pima County Assessor Parcel 303-33-012C (portion));
- Area 3 - Former Pole Area (Pima County Assessor Parcel 303-33-012C (portion));
- Area 4 - North Area (Pima County Assessor Parcel 303-33-012C (portion));
- Area 5 - South Area (Pima County Assessor Parcels 303-36-009A, 303-36-009B, 303-33-012D, and 303-33-012C (portion)).

Area 5 was removed from the VRP because it was not impacted by historical mineral processing operations. AMAX and Anaconda withdrew Area 5 from the VRP in a letter to ADEQ dated April 7, 2021. Therefore, Area 5 is not evaluated in this PRA.

2.1 Previous Site Investigations

Four previous investigations have been conducted at the Site. A brief summary of each investigation is provided below, followed by an evaluation of data usability for the PRA.

2.1.1 Hydrometrics, Inc

In 1999, Hydrometrics evaluated a series of 52 soil grab samples from two shallow depth intervals (i.e., 0 to 6 inches and 6 to 12 inches) from across the entire Parcel 30 property. These samples were analyzed for arsenic, cadmium, lead, and zinc. Surface (0 to 6 inches) concentrations of these metals in the tailings remedial cap did not exceed ADEQ residential Soil Remediation Levels (rSRLs). ADEQ rSRLs for arsenic and lead were exceeded in deeper (6 to 12 inches) cap samples. Elsewhere on the Site, soil concentrations of metals were below rSRLs except at the following locations: lead, arsenic, and cadmium exceed rSRLs in one or more samples collected from 6 to 12 inches in the former mill site (Area 2) and lead exceeds its rSRL in one surface (0 to 6 inches) sample and one deeper (6 to 12 inches) sample in the former pole area (Area 3). Sample data are presented in Figures 3, 4, 5 and 7.

Hydrometrics collected 11 soil grab samples from Area 5 located in the southern portion of Parcel 30. These samples were analyzed for arsenic, cadmium, lead, and zinc. During the December 1, 2021 teleconference call with ADEQ, it was agreed AMAX would evaluate the potential to develop Site-specific background concentrations based on data for soil samples collected from Area 5. That evaluation was summarized in an email to ADEQ on December 10, 2021 and ADEQ responded on December 28, 2021 requesting that the background lead concentration for the IEUBK model be based on seven of the 11 data points available from Area 5 (i.e., S-1A, S-2A, S-3A, S-4A, S-5A, R-3A and R-3B).

2.1.2 Golder Associates

In 2009, Golder Associates (Golder) conducted an investigation of the Site that focused on the tailings impoundment and included spatial extent of the tailings, approximate volume of the tailings, metal concentrations of the tailings cap, tailings materials, and the soil underlying the tailings. These extents and material properties were determined by drilling 20 boreholes through the remaining cap, tailings, and the underlying soil material. Samples were collected from 0 to 5 feet, 5 to 10 feet, 5 to 15 feet, 10 to 15 feet, 15 to 20 feet, 20 to 25 feet, and 25 to 30 feet below ground surface (ft bgs). Additionally, 10 test pits were dug using a backhoe to expose and delineate the lateral extent of the tailings material to facilitate an estimate of the volume/quantity of this material within the tailings impoundment area.

Total metals results indicate that concentrations of arsenic, lead, and manganese were higher than ADEQ rSRLs in most samples. Concentrations of cadmium and thallium were higher than the rSRL in isolated samples. Concentrations were less than rSRLs in samples collected from below 25 ft bgs, and exceedances were rare in samples collected from below 15 ft bgs. After a comparison of exceedance patterns with impoundment depth, Golder concluded that the underlying native alluvium has not been appreciably affected by the tailing material. Golder sample data are presented in Figures 3 through 7.

2.1.3 Clear Creek Associates

In June 2014, Clear Creek Associates (Clear Creek) conducted a soil investigation to characterize the nature and extent of soils in Area 1 (Tailings Impoundment), Area 2 (Mill Site), Area 3 (Pole Area), and Area 4 (North Area) impacted by former ore processing. Groundwater quality was also investigated.

In Area 1 (tailings impoundment), the goal of sampling was to identify the western extent of affected soil between the tailing impoundment and the former mill site (Area 2). Samples were collected from Areas 2 and 3 to identify impacts from the mill operations. In Area 4, samples were collected to evaluate the extent of arsenic, lead, and manganese concentrations north of the impoundment. Sample data are presented in Figures 3, 5 and 6.

The arsenic, lead, and manganese concentrations of soil samples were screened in the field by x-ray fluorescence (XRF). The top 2 feet of soil were sampled at each location (i.e., 0 to 12 inches and 12 to 24 inches). If the field screening did not detect concentrations above rSRLs in the top 2 feet of soil (using the XRF's margin of error), sampling at the location was terminated. Soil sample concentrations exceeded rSRLs for arsenic, lead, and manganese in the following areas:

- Area 1 west of the estimated extent of tailing and east of Area 2;
- The mill area (Area 2) east of the rail spur;
- The eastern portion of the pole area (Area 3);
- Three borings in the eastern portion of Area 4 north of the tailing impoundment.

Three temporary wells were installed to investigate groundwater conditions. Depth to groundwater ranged from 157 to 205 ft bgs. Groundwater samples were collected from the three wells on June 17, 2014 and analyzed for dissolved arsenic, dissolved lead, total nitrate, and total nitrite. Dissolved arsenic, dissolved lead, and total nitrite concentrations were lower than their respective Arizona Water Quality Standards (AWQS). Total nitrate marginally exceeded its AWQS of 10 milligrams per liter (mg/L) in one sample with a concentration of 11 mg/L.

2.1.4 Brown and Caldwell

In 2018, Brown and Caldwell (BC) sampled the abandoned rail spur berm material using a direct-push rig. The intent of the investigation was to determine whether the rail berm material was impacted or was suitable for use as cover material. A total of 59 soil samples were collected from nine locations along the rail spur berm and analyzed for arsenic, barium, cadmium, chromium, lead, manganese, selenium, silver, and mercury. Detected constituent concentrations were compared to the SRLs for residential land use. Arsenic, cadmium, and lead concentrations exceeded rSRLs at one surface sample location (BH9 from 0 to 1 foot in Area 2). Sample data are presented in Figures 3 through 6.

2.1.5 Data Usability

Laboratory analytical data used in this PRA were subject to a review to verify the data completeness, accuracy, and usability. The key components of the data review are consistent with USEPA (1989, 1992) risk assessment guidance. The review evaluated the appropriateness of sample locations, adequacy of Site characterization (relative to nature and extent), and comprehensiveness of the data collected to date. Concentrations of metals are not expected to significantly vary in the short term in soil; therefore, no temporal data needs were identified for the soil data collection program.

Table 2.1 contains information on the soil sampling and analytical methods used during the investigations described above. A variety of sampling methods have been used including surficial soil sampling using plastic hand tools and metal hand augers (Hydrometrics 1999; Clear Creek 2015); and sampling from boreholes drilled using direct-push technology (DPT) and hollow-stem auger (HSA) technology (Golder 2009; Clear Creek 2015; BC 2018).

Soil samples were collected from the historical tailings impoundment area (Area 1), mill site (Area 2), pole area (Area 3), and the northern area (Area 4) using HSA and DPT drill rigs. In general, HSA rigs are capable of reaching greater depths than DPT rigs. The DPT rigs were used to collect soil samples from less than 10 ft bgs (Clear Creek 2015; BC 2018), whereas Golder (2009) used an HSA rig to reach as deep as 30 ft bgs and collect samples with a split-spoon barrel (Golder 2009).

2.1.5.1 Hydrometrics, Inc

Hydrometrics conducted a soil sampling investigation in 1999 in four areas: the wash and property boundary, the mill site and gate keeper's house, the historical tailings impoundment, and the southern tract of Parcel 30. Soil was sampled primarily from 0 to 6 inches bgs and 6 to 12 inches bgs at 26 separate locations. The recorded soil sample locations are only approximations due to map scale irregularities (Clear Creek 2015). Samples were submitted for analysis of arsenic, cadmium, lead, and zinc by USEPA Method 6010 (Hydrometrics 1999). Sample data are presented in Figures 3, 4, 5 and 7.

2.1.5.2 Golder Associates

Golder (2009) focused on the tailings impoundment area. Split-spoon composite soil samples were collected from continuous 5- or 10-foot intervals within the top 30 feet. In total, 66 samples were collected from 20 separate boreholes arranged across the tailings impoundment area. The edges of the tailings material were delineated with the excavation of 10 test pits, which confirmed that all 20 boreholes were located within the tailings impoundment area. The borehole locations were well distributed throughout the tailings. Biased sampling increases the likelihood that analytical data are adequately protective of potential current and future exposures. The vertical extent of the tailings material was determined by drilling deeper into the underlying soil. The selection of deep boring locations contributes to the suitability of the analytical data for characterizing metal concentrations at varying depths. Soil samples were submitted for analysis of a wide suite of metals (including arsenic, cadmium, lead, antimony, and manganese) by USEPA Method 6010, fluoride by USEPA Method 300.0, and mercury by USEPA Method 7471A (Golder 2009).

Soil samples collected during drilling at the presumed footprint of the historical tailing impoundment area (Golder 2009) were sieved with a size 60 mesh (250 microns [µm]) before laboratory analysis. While the process of sieving soil samples could theoretically result in greater metals concentrations due to the greater surface area on fine soil particles to which metals could adhere, 250 µm sieves are intended to eliminate very coarse sand, gravel, and other larger particles. Considering that the Site soils are predominantly fine-grained (Golder 2009), most of the material would pass through the sieve. Thus, it is reasonable to conclude that any potential differences in sample sieving for this Site (sieved versus potentially not sieved) is not a material issue with respect to data usability.

The analytical data for samples collected from the impoundment were not quantitatively evaluated in the PRA but were considered representative of potential 'source' conditions for Site-related metals to the other areas in Parcel 30 (i.e., Areas 2, 3, and 4). The Golder data (0 to 5 feet bgs) were used to estimate concentrations for metals that were not analyzed in Areas 2, 3 and 4 (Section 6) and to confirm that no other metals should be further evaluated in the PRA. The Golder 2009 data were used because these samples were analyzed for the entire Target Analyte List (TAL) metals list plus molybdenum and tin, whereas the remaining datasets used a focused analyte list with fewer metals. It is important to note that the Golder data for composite samples collected from 0 to 5 feet included cap material and may be biased slightly low. Golder data are presented in Figures 3 through 7.

2.1.5.3 Clear Creek Associates

Clear Creek Associates conducted a drilling investigation in 2015 that focused on the mill site, pole area, and northern areas of Parcel 30. Soil samples were collected using DPT from 1-foot intervals within the top 8 feet of soil. The soil cores were screened for arsenic, lead, and manganese in the field by XRF to determine total depth and sampling intervals for each boring. Locations at which the top two sample intervals (0 to 1 and 1 to 2 feet depth) did not exceed SRLs based on the field XRF analysis were considered unimpacted, sampling was terminated, and the top two sample intervals were submitted for laboratory analysis. Locations where the XRF field screening detected an SRL exceedance in the top two feet of soil were sampled until there were two consecutive sample intervals that met SRLs. If there was no sample recovery between two intervals that were less than SRLs, the missing interval was assumed to also meet SRLs and considered to constitute two consecutive sample intervals meeting the SRLs. Field XRF screening was implemented with quality assurance and quality control (QA/QC) procedures per USEPA Method 6200. In total, 154 samples were collected from 53 separate boreholes, with two to five samples collected per boring depending on the XRF screening and recovery. The soil samples were analyzed for arsenic, lead, and manganese by USEPA Method 6020A. The data were validated in terms of completeness, case narratives, delivery conditions and holding times, analytical precision, and representativeness (Clear Creek 2015). Clear Creek (2015) concluded that 100 percent of the data in the report are usable. Sample data are presented in Figures 3, 5 and 6.

2.1.5.4 Brown and Caldwell

BC conducted a drilling investigation in 2018 that focused on the rail berm in the mill site and pole areas on the western side of Parcel 30. Soil samples were collected using DPT from 1 foot intervals within the top 10 feet of soil (boring BH1 – 6 samples to 6 feet; boring BH2 – 3 samples to 6 feet; boring BH3 – 6 samples to 6 feet; boring BH4 – 5 samples to 8 feet; boring BH5 – 10 samples to 10 feet; boring BH6 – 6 samples to 6 feet; boring BH7 – 4 samples to 5 feet; boring BH8 – 3 samples to 3 feet; boring BH9 – 10 samples to 10 feet). Five samples were collected from larger (greater than 1 ft) intervals (e.g., 0 to 4 ft, 6 to 8 ft) due to poor recovery. In total, 59 samples were collected from nine separate boreholes. Soil samples were submitted for analysis of a wide suite of metals (including arsenic, cadmium, lead, and manganese) by USEPA Method 6010 and mercury by USEPA Method 7471A (BC 2018). Sample data are presented in Figures 3 through 6.

2.1.5.5 Comparability of Data

Sampling methods and laboratories have varied, but the requested analytical methods for metals have remained largely the same across different investigations (USEPA Method 6020 inductively coupled plasma-mass spectrometry [ICP-MS] or USEPA Method 6010 inductively coupled plasma-atomic emission spectroscopy [ICP-AES], USEPA Method 7471A cold vapor atomic absorption [CVAA] for mercury). This contributes to the comparability of data from different Site investigations. It was assumed that historical data quality assessments (i.e., data validation) performed by previous consultants were accurate, and no additional assessments were completed by Arcadis. Additionally, as requested by ADEQ in comments received November 1, 2021, the data across the three sampling campaigns (i.e., Hydrometrics, Clear Creek and BC) were compared using side-by-side box plots to support combining the data into one dataset and the calculation of site wide exposure point concentrations (EPCs). As seen in Appendix D, the box plots give graphical information on the location, the dispersion, and the skewness of the datasets. The 2014 Clear Creek data sets for arsenic, lead, and manganese contain the most data points and thus have the largest ranges in all three areas; however, the 1999 Hydrometrics data and 2018 BC data generally fall within 1.5 times the Clear Creek interquartile range (IQR). The box plots for cadmium (1999 and 2018) show similarity between medians and overlapping IQRs. For barium and chromium which were only analyzed in 2018, and zinc which was only analyzed in 1999, medians are similar and IQRs are generally overlapping between the three areas. Based on this graphical analysis, it is appropriate to combine the data sets for the three areas and three campaigns in determining EPCs for the Site.

Lastly, hypothesis testing was conducted to confirm there is not a significant difference between data populations for 0 to 1 ft, 0 to 6 inch, and 6 to 12 inch samples from Areas 2, 3, and 4. The USEPA Unified Guidance (USEPA 2009) recommends using the Kruskal-Wallis (KW) test (Gilbert 1987; Helsel and Hirsch 1995) to determine if there are statistically significant differences in median concentrations among datasets. The KW test is a nonparametric test that does not require an assumption of normality. To perform the test, the concentration data are ranked from smallest to largest and an average rank is calculated for each group and the overall dataset. If the average rank is similar for each group and to the average rank of the overall dataset, then the null hypothesis of no difference among groups is true. Conversely, if the average rank for some groups differ, then the alternative hypothesis is true.

A test statistic is computed based on the average group rank and the average rank of the overall dataset. A test statistic of zero implies that all groups have identical average ranks, whereas a positive test statistic implies that the average group ranks are different (USEPA 2009). The test statistic is compared to a critical value based on a chosen confidence level ($1 - \alpha$) in order to accept or reject the null hypothesis of no difference. A 95 percent confidence level was chosen (α = 0.05); therefore, probability values (p-values) for the test statistic that are less than 0.05 indicate a statistically significant difference.

Soil samples were collected from three intervals (0 – 1 ft bgs, 0 – 6 inches bgs, and 6 – 12 inches bgs), therefore the analytical data sets for each analyte were split into three groups, representing these depths. Non-detect results were set equal to the laboratory reporting limits. The KW test was performed for data sets with a frequency of detection greater than 25 percent.

The KW test was calculated in ProUCL 5.1 (USEPA 2015) using equations from USEPA Unified Guidance (USEPA 2009). As seen in Appendix D, p-values range from 0.079 for lead to 0.0140 for zinc. Therefore, it can be concluded that there is no significant difference between sample depths, and it is appropriate to combine the data sets and evaluate the data as a single population.

2.2 Exposure Area

Parcel 30 has historically been divided into five separate areas. Those areas are shown on Figure 2 and briefly described in Exhibit A.

Exhibit A – The Five Divisions of Parcel 30

Area	Name	Acreage	Description
1	Impoundment Area	38	Historically used for ore processing. Tailing contains concentrations of arsenic, cadmium, lead, and manganese exceeding rSRLs. Area 1 is capped by soil with an average thickness of about 12 inches. The tailing thickness ranges from 0 at the edge of the impoundment to 23 feet.
2	Mill Site	7	Historically contained a mill used for ore processing. Proximal to former railroad spur for receiving ore and shipping products.
3	Pole Area	9	Historical ore processing use is uncertain; proximal to former mill and railroad spur.
4	North Area	34	Historical ore processing use is uncertain; contains disturbed ground/former borrow pit.
5	South Area	151	Undeveloped land with no history of ore processing use. Withdrew from VRP in April 2021.

Parcel 30 is in an area of potential future growth (residential, commercial, recreational) for the Town of Sahuarita (Sahuarita Square 2020). The General Plan for the Town of Sahuarita (2019) identifies the “Eagle Picher Mill Site” as land that should be considered for “commercial, employment, and improved open space serving as an amenity to neighboring communities and developments.” Based on conversations with Town representatives, planned uses of Parcel 30 exclude residential and commercial uses, but include the following:

- Area 1 will be capped with an additional two feet of clean soil and, therefore, is not evaluated in the PRA. Areas to the northeast and west of the impoundment that have experienced erosion will be reintegrated into Area 1 and contained with the new engineered vegetative cap. Pollinator gardens will be placed on a portion of the newly-installed cap in Area 1. New data associated with backfill will be submitted under separate cover.
- A small portion of Areas 1, 2, 3, and 4 will contain light hiking trails.
- Area 5 has been withdrawn from the VRP (not evaluated in this PRA).
- The area to the east of Parcel 30 (not evaluated in this PRA) will be developed for commercial use (e.g., brick-and-mortar shops).
- The area to the west of Parcel 30 (not evaluated in this PRA) will be developed for residential use.

Based on the planned uses described above, this PRA evaluates the potential cancer risk and non-cancer hazards from exposure to surface soils in Areas 2, 3, and 4 (defined as the Exposure Area [EA]), with surface soil defined as the top foot of soil (i.e., 0 to 1 ft bgs). As indicated above, Area 1 (tailings impoundment) will be capped with two feet of clean soil, thereby preventing potential exposure to the waste material by recreators. As discussed in Section 2, Area 5 was not used for historical mill operations and was not impacted from adjacent operations. Soil data collected from Area 5 are considered representative of background conditions. Based on these considerations, AMAX and Anaconda withdrew Area 5 from the VRP in a letter to ADEQ dated April 7, 2021. Therefore, Area 5 is not evaluated in this PRA.

2.3 Selection of Constituents of Concern

Arsenic, lead, and manganese are the primary metals present at concentrations exceeding residential and non-residential SRLs in the area in and around the former tailing impoundment and, therefore, have historically constituted the Site constituents of interest. For this investigation, maximum concentrations for all other metals analyzed in soil collected from Parcel 30 from 0 to 1 ft bgs were screened against USEPA Regional Screening Levels (RSLs) (Table 2.2). As seen in Table 2.2, besides arsenic, lead, and manganese, cadmium and zinc reported a maximum detected concentration above the residential RSL. Therefore, these five metals were retained as Site constituents of concern (COCs). Note that although remediation is planned for areas outside Area 1 (e.g., A2-36 in Area 2) to consolidate eroded material and any visible tailing, data from these areas were included in the evaluation as a conservative measure. Additional details on the planned remediation are provided in the RWP (Arcadis 2022).

A conservative evaluation of non-COC data for the Site was conducted so the PRA does not eliminate any metal that may be contributing appreciably to the potential cumulative risk for future receptors. This evaluation is presented in the Uncertainties Section (Section 6).

2.4 Probabilistic Risk Assessment

PRAs use probability distributions to evaluate variability and uncertainty in risk estimates. In a PRA, one or more of the variables in the risk equation are defined as a probability distribution rather than a single value. For example, instead of using a single point estimate for the soil ingestion rate, incidental soil ingestion can be evaluated using a distribution of values specified by a minimum value, various percentiles, and a maximum value. Similarly, the output of a PRA is a range or distribution of risk estimates. PRA can provide a quantitative description of the degree of variability or uncertainty (or both) in cancer risk estimates and non-cancer hazard estimates. A fuller, more complete characterization of risk can help risk managers make risk management decisions based on a specific percentile (or set of percentiles) of the distribution of potential risk rather than a point estimate derived from a deterministic risk assessment, in which one has no knowledge of what percentile of the range of potential risk the point estimate represents. The PRA methods used in this report are in accordance with Arizona Administrative Code [A.A.C.] R18-7-206.B regulations and are consistent with PRA guidance published by the USEPA (USEPA 2001) and Oregon Department of Environmental Quality (ODEQ 1998).

The @Risk software program (Palisade, Release 7.5) was used for this PRA. This software uses Monte Carlo simulation methods to select random values from exposure parameter distributions, repeating the process over many iterations to produce a distribution of risk estimates that represents the range of potential outcomes. A maximum of 10,000 iterations was selected to generate the potential cancer risk and non-cancer hazard distributions for arsenic, cadmium, manganese, and zinc in this PRA. Random seeds were used for all simulations. For verification, risks and hazards were also generated using 15,000 iterations and 20,000 iterations (Table 1 in Appendix A) and the uncertainty in the selection of 10,000 is discussed in the uncertainties Section 6.2. In terms of lead, potential exposure risk was evaluated using the USEPA's Integrated Exposure Uptake Biokinetic (IEUBK) model as discussed in Section 3.5 (Appendix B). The following section provides a discussion of the exposure assumptions and parameters used to evaluate the potential health risks associated with the proposed recreational use of Areas 2, 3, and 4.

3 Exposure Assessment

As discussed previously, the Site is vacant and fenced, which restricts current access. Therefore, the PRA focuses on future exposure conditions. The property will be transferred to the Town of Sahuarita, and future recreational land use (walking/hiking trails) is planned. Future property use will be restricted to recreational activity only, thereby preventing other land uses such as residential, commercial, or industrial. The COCs are arsenic, cadmium, lead, manganese and zinc. Exposure to surface soil is the only complete pathway for future use conditions, and thus exposure to subsurface soil (>1 ft bgs) is not relevant for this PRA. A discussion of the basis for the various exposure inputs and assumptions used in this PRA is provided below.

3.1 Potential Receptors

For purposes of this PRA, future recreational use is assumed for Parcel 30. Due to the proximity of the Site to the Town of Sahuarita, it is possible that individuals who access the property in the future for recreational activities could be local residents from Sahuarita or surrounding areas. Therefore, the relevant receptor population for a recreational use risk assessment is anticipated to be child and adult recreators (age groups 0 to <6 years, 6 to <12 years, and 12+ years).

Exposure data are available for parameters such as soil ingestion rate, skin surface area, and body weight that allow for the distinction of exposure assumptions by age. The future recreator receptors are characterized using the following three age categories: 0 to < 6 years, 6 to <12 years, and 12+ years. These age categories are based on groupings for which the USEPA provides recommended soil ingestion rates in an update for Chapter Five (Soil and Dust Ingestion) of the 2011 Exposure Factors Handbook (USEPA 2017a).

3.2 Potentially Complete Exposure Routes

Potential receptors may be exposed to metals in soil through the following exposure routes:

- Incidental ingestion;
- Dermal contact;
- Inhalation of particulates/dust.

These exposure routes were included in the exposure dose calculations and subsequent cancer risk and non-cancer hazard estimates for the recreational use scenario.

3.3 Exposure Assumptions

The data summary tables and recommendations in the USEPA Exposure Factors Handbook (USEPA 2011, 2017a) were the primary sources for exposure parameter distributions used in this PRA. In some cases, the exposure assumptions were based on information from literature sources (e.g., exposure frequency for outdoor trail use in Arizona and manganese oral bioavailability). The assumptions used in this PRA for potential exposure to arsenic, cadmium, manganese and zinc in surface soil at the EA are summarized in Table 3.1 and discussed below. The assessment of potential risk from exposure to lead in surface soil at the EA is evaluated using the IEUBK model as described in Section 3.5.

3.3.1 Exposure Point Concentrations

An EPC is the COC concentration to which a hypothetical receptor might be exposed through potentially complete exposure routes. A receptor will likely be exposed to a range of concentrations from not detected to the maximum concentration; therefore, over the entire exposure period, a concentration distribution was used to estimate exposure points. For this PRA, the 0 to 1 ft dataset for Areas 2, 3, and 4 were used to develop the EPCs. The dataset described in Tables 2.2 and 2.3 was modified for use in @Risk by selecting one concentration for sample locations that had co-located samples (Hydrometrics 1999). For those locations with both a 0 to 6 inch and 6- to 12-inch sample, the maximum detected concentration was selected for use in the development of the EPC distribution (note the lower concentration is struck out in Appendix C).

Thiessen polygons were developed in ArcGIS separately for the arsenic, , lead, and manganese datasets (Figures 8 through 10). Thiessen polygons are the boundary of the area that surrounds each unique sample location such that all locations within the polygon are closest to the unique sample. Thiessen polygon size and shape are determined by the proximity of the neighboring samples. The portion of the area of each polygon within the Site boundary is used to derive a weighting factor for each sample in the dataset. The sum of the weighting factors multiplied by the corresponding concentrations, equals the EA-wide area-weighted arithmetic mean concentration. The sample coverage for cadmium and zinc (Figures 4 and 7) was determined to be inadequate to support an EA-wide area weighting approach and therefore unweighted EPCs were developed for these two metals.

Bootstrap sampling with replacement was used to develop the normal distributions of the EA-wide arithmetic mean soil concentrations used to represent the EPCs for each metal. The final data sets from which EPCs were generated are provided in Appendix C. The EPC distributions developed from the soil arsenic, cadmium, manganese, and zinc data are presented in Appendix A. In terms of lead, the EPC concentrations used in the IEUBK lead model are described in Section 3.5 and presented in Appendix B.

EPCs assume exposure will occur at random across the entire EA (i.e., across all of Areas 2, 3, and 4). The potential for future exposures focused in smaller areas where residual concentrations of COCs are higher will be addressed by the application of ADEQ rSRLs and SSRLs (Section 5.5) to guide the remedial action (Arcadis 2022).

3.3.2 Exposure Duration

Exposure duration is the amount of time (in years) during which an individual is assumed to have contact with exposure media. The non-cancer exposure duration distribution was derived from percentile data for ages 3 to 11 years in Table 3-38 from ODEQ (1998). This dataset is the closest approximation for the standard child age range assumed in risk assessment for children of 0 to <6 years (USEPA 1989). In order to fit these data to the age 0 to <6 range used in this analysis, the distribution was capped at 6 years; the percentiles at and below 60 percent were equal to those in Table 3-38 (ODEQ 1998), and the 100th percentile of the distribution was set equal to 6. This is a conservative approach because a higher overall probability is assigned to the maximum exposure duration relative to those younger than 6 years.

To estimate cancer risks, continuous exposure beginning at birth was assumed, and a single distribution (for males and females, from Table 16-108 of the Exposure Factors Handbook [EFH; USEPA 2011]) was used to define the exposure duration. This distribution is based on a residential occupancy study (Johnson and Capel 1992). A minimum value of 0.01 year (from Table 3-38 of ODEQ 1998) was used for this PRA because a minimum value is not available in Table 16-108 (USEPA 2011). A residential exposure duration distribution was selected for the PRA as it is considered conservative and representative of reasonable maximum exposure (RME) for a recreational scenario. The non-cancer and cancer exposure distributions are presented in Appendix A.

3.3.3 Body Weight

The body weight distribution for age 0 to < 6 was derived from Table 8-3 (USEPA 2011). Separate distributions are available in this table for the following age groups: birth to <1 month, 1 to <3 months, 3 to <6 months, 6 to <12 months, 1 to <2 years, 2 to <3 years, and 3 to <6 years. A weighted average was calculated for each of the percentiles in these seven age groups to derive a single distribution for ages 0 to <6. A similar approach was used to define a body weight distribution for the age >12 group. A weighted average was calculated for each of the percentiles in seven age groups above age 12 years (11 to <16, 16 to <21, 21 to <30, 30 to <40, 40 to <50, 50 to <60, and 60 to <70). For the age 6 to <12 age group, a distribution was developed using the age 6 to <11 data in Table 8-3 (USEPA 2011). The selection of values for body weight are 100 percent correlated with skin surface area. The body weight distributions are presented in Appendix A.

3.3.4 Exposure Frequency

The exposure frequency is the number of days per year during which an individual is exposed to the affected medium. The exposure frequency for a future recreator accessing the EA was derived from a trail user survey from Sahuarita Parks and Recreation (PRCS 2021) which reports frequency of trail use as “a few times a week”. Therefore, a conservative point estimate equal to 100 days/year (i.e., twice a week for 50 weeks/year) was assumed to represent the frequency a recreator may visit the Site. This exposure frequency is considered a conservative representation of future conditions at the EA when it is redeveloped into public land/hiking trails. If the future hiking trails are improved with concrete, wood, or asphalt, the amount of soil contact assumed to occur at the future park/hiking trails likely overestimates exposure and risk for recreators.

3.3.5 Incidental Ingestion of Soil

Chapter 5 of the EFH was updated in 2017 to incorporate incidental soil ingestion data for children and adults from three recent studies that were unavailable for the 2011 EFH. The USEPA-recommended soil ingestion rates were revised in the 2017 EFH update (based on the more recent studies). The USEPA-recommended ingestion rates were developed by combining data distributions from several studies and are single-point estimates of central tendency and upper percentiles. In lieu of using the soil ingestion rate point estimates presented in Chapter 5 of the 2017 EFH (USEPA 2017a), the information presented in the recent studies was used in this PRA to develop soil ingestion rate distributions. Note, because recreational exposure occurs outdoors, ingestion of indoor settled dust was not considered in the PRA; the ingestion rate distributions pertain to soil and outdoor settled dust only.

The USEPA added three studies published since the release of the 2011 EFH to their soil ingestion evaluation presented in the updated Chapter 5 (USEPA 2017a). The studies used data from numerous studies for a wide range of parameters including location-specific exposure time, micro-activity data, soil/particle loading data for different surface types, and hand to mouth contact data (Ozkaynak et al. 2011; Wilson et al. 2013). These recent studies represent the most up-to-date evaluations of available data. Additionally, the most recent tracer element-based mass-balance study (Davis & Mirick 2006) was considered. The data from these three studies were then used to develop distributions of soil ingestion rates for the three age groups evaluated in this PRA. Percentiles from Ozkaynak et al. (2011) are provided by the USEPA in their updated EFH Chapter 5. For the other studies (Wilson et al. 2013, Davis & Mirick 2006), mean and standard deviations are provided. One distribution was generated from the data provided for each study as applicable for each age group. For the 12+ age group, distributions developed from two studies were combined to develop a single distribution for this age group. Additional information is provided below relative to the development of the age group-specific distributions.

Soil ingestion data are provided in Table 5-12 (USEPA 2017a) for children aged 3 to <6 years (hand to mouth data from Ozkaynak et al. 2011). For this PRA, the data from the 3 to <6 year age group (Table 5-12 of USEPA 2017a) were assumed to represent the 0 to <6 year age group, and a distribution was developed from the associated ingestion rate percentiles.

The soil ingestion rate distribution for the 6 to <12 age group was derived by assigning a normal distribution to the mean and standard deviation soil ingestion rates from the Wilson et al. (2013) data for children (aged 5 to 11 years) in Table 5-14 of USEPA (2017a). The 5 to 11 age group was assumed, for the purpose of this PRA, to represent the soil ingestion rates for the 6 to <12 age group. A forecast distribution was developed from the normal distribution (defined by the mean and standard deviation of the 5 to 11 age group data in Table 5-12 of USEPA 2017a). Several of the lower percentiles resulted in negative soil ingestion rates, which were replaced by zeros in the distribution, consistent with the USEPA (2017a) approach.

For the age >12 group, soil ingestion rate data were available for ages 12 to 19, 20 to 59, and 60+ from Table 5-14 (Wilson et al. 2013; USEPA 2017a). Normal distributions defined by the means and standard deviations for these three age groups were combined using a weighted average. This distribution was then combined with the adult data in Table 5-9 (Davis & Mirick 2006; USEPA 2017a) using the following approach. Four normal distributions were defined for mothers and fathers for aluminum and silicon tracer elements in Table 5-9 (Davis & Mirick 2006; USEPA 2017a). These four distributions were averaged to create a single combined soil ingestion rate distribution. Again, several of the lower percentiles resulted in negative soil ingestion rates, which were replaced by zeros in the distribution, consistent with the USEPA (2017a) approach. The averaged distribution developed from Table 5-14 and the averaged distribution developed from Table 5-9 were combined to derive a single adult soil ingestion distribution. The distributions developed for soil ingestion rates are presented in Appendix A.

3.3.6 Bioavailability of Metals in Soil

Oral bioavailability reflects the amount of a constituent absorbed into the body following ingestion. The typical assumption when calculating risks to humans is that oral bioavailability is 100 percent. In the case of arsenic, however, numerous studies that have measured site-specific oral bioavailability indicate that, especially for mine-related materials, the relative bioavailability of lead and arsenic is often much lower than 100 percent (e.g., Bradham et al. 2011; Drexler and Brattin 2007; USEPA 2010b; Casteel et al. 1997; Freeman et al. 1993). For example, relative bioavailability studies conducted with soils containing arsenic from mining sites have reported *in vivo* results of 18 to 52 percent (test species: swine), 18.3 percent (test species: monkey), 11 to 53 percent (test species: mouse), 10.7 to 24.7 percent (test species: monkey), and 11.2 percent (test species: mouse) (Brattin and Casteel 2013; Schoof 2003; Bradham et al. 2011; Roberts et al. 2002; Bradham et al. 2013). The USEPA's Bioavailability Technical Review Work Group (TRW) compiled an extensive dataset of arsenic bioavailability data from numerous published 'key' studies, and those data were used by the TRW to establish the national default soil relative bioavailability (RBA) value of 60 percent (USEPA 2012a, 2012b).

The key studies in the TRW evaluation included data from studies with swine (64 RBA values), monkeys (24 RBA values) and mice (15 RBA values) (USEPA 2012a,b). The TRW used these RBA values to generate distributions for the swine dataset, the monkey dataset, and a combined dataset. The combined dataset is summarized in two ways: 1) with each RBA value given equal weight, even if the sample was tested more than one time (referred to as the “unweighted” dataset), and 2) with sample-specific average RBA values that were used to calculate summary statistics (referred to as the “weighted” dataset). The distribution presented in Table 3 of USEPA (2012a) for the unweighted dataset (all soil samples and species) was used to define the arsenic RBA parameter for this PRA. This distribution was chosen for use because results from different species based on the same sample provide different estimates of RBA, and no species was expected to be more representative than another species. Thus, the RBA value for each sample was equally weighted. The bioavailability distribution for arsenic is presented in Appendix A.

The bioavailability of manganese in soil has not been studied as extensively as for arsenic or lead; consequently, there is a paucity of information for manganese. Studies of *in vivo* bioavailability of manganese from soil were not located in the scientific literature, while one study was found that measured *in vitro* bioaccessibility of manganese in soil (Sialelli et al. 2010). The bioaccessible fraction of a constituent is that which dissolves or desorbs from its matrix in the gastrointestinal tract of an organism and is available for absorption (ITRC 2011), while the bioavailable fraction is defined as the percentage of the constituent that is actually absorbed by that organism. Bioavailability of manganese in soil was included as an exposure parameter for a human health risk assessment (HHRA) for the Chino Mines Company Lampbright Investigation Unit (LIU) in 2012 (Neptune and Company, Inc. 2012). The LIU HHRA (Neptune and Company, Inc. 2012) used the results of an *in vitro* assay on urban soils conducted by Sialelli et al. (2010) as an estimate of manganese bioavailability. The Sialelli et al (2010) study found manganese bioaccessibility ranging from 0.12 to 0.41. In the absence of oral bioavailability values for manganese, a point estimate equal to the maximum bioaccessibility value of 0.41 or 41 percent was assumed to represent the absorption percentage and used as the RBA value for manganese in this PRA.

There is also a scarcity of bioavailability data for cadmium and zinc. Therefore, a conservative RBA of 1 was assumed for these two COCs.

Similar to arsenic, USEPA set a default RBA of lead to 60 percent in the IEUBK model, which is discussed in Section 3.5. USEPA published methods to test bioaccessibility, a surrogate for relative bioavailability, for arsenic and lead (USEPA 2017b, 2021b); however, this PRA relies on defaults at this time.

3.3.7 Dermal Exposure to Metals in Soil

A default dermal absorption factor (ABSd) of 0.03 is available from the USEPA for arsenic (USEPA 2004, 2022a). This default value is based on a study by Wester et al. (1993) that investigated the dermal absorption of arsenic in Rhesus monkeys from soil samples spiked with soluble arsenic. Arsenic was freshly mixed with soil and applied to the stomachs of restrained Rhesus monkeys, while monitoring arsenic excretion in urine. The study indicated that absorption of arsenic through the skin from freshly mixed soil was identical to that of soluble arsenic in water; equal to between 0.02 and 0.064 of the applied dose. Data from biomonitoring programs in human populations indicate that percutaneous absorption of arsenic does not contribute significantly to overall risk compared with other pathways (Walker and Griffin 1998). Based on this observation, Lowney et al. (2007) mimicked the experimental approach used by Wester et al. (1993). However, environmental samples from two different sites were used in addition to clean soil samples spiked with soluble arsenic. The authors found that spiked samples reproduced the results reported by Wester et al. (1993) with dermal absorption rates of 0.029 to 0.067 of applied arsenic. The environmental samples tested by Lowney et al. (2007) included soil from an orchard site in New York, where the dominant form of arsenic was iron oxides, and residential soil from a location in Colorado, where the dominant form of arsenic was arsenic trioxide. The soils were applied to skin on monkey's abdomens in dry preparations and wet preparations. The range of dermal absorption of dry environmental soil preparation ranged from 0.0018 to 0.0024, while application of wet environmental soil preparation had dermal absorption rates for arsenic of 0.0039 to 0.005. The dermal absorption of arsenic, therefore, was an order of magnitude lower for arsenic occurring in natural mineral forms in the environment compared to soluble arsenic spiked into clean soil.

The work by Lowney et al. (2007) demonstrates that arsenic speciation and soil matrix effects that reduce the oral RBA of arsenic in soil also reduce the availability of arsenic by the dermal route of exposure. The extremely low levels of arsenic absorption from soil reported by Lowney et al. (2007) are comparable to background uptake of arsenic from normal dietary sources. Monkeys tested as part of the Lowney et al. (2007) study were placed on low-arsenic diets in the attempt to control background exposures. The authors conclude that dermal absorption of arsenic from environmental sources of arsenic in soil cannot be distinguished from background exposures to arsenic.

Speciation of arsenic detected in Site soils has not been performed; however, based on information from ATSDR (2007) indicating that arsenic trioxide (As_2O_3) is a byproduct of the smelting process of lead ores, the dominant form of arsenic in Site soils is likely arsenic trioxide. This form is consistent with that used in the Lowney et al (2007) study, therefore for this PRA, the highest mean ABSd value measured in the Lowney et al. (2007) study of 0.5 percent (0.005) and the associated standard deviation (0.44 percent) were assigned to a normal distribution that was used to estimate dermal absorption of arsenic. The lower end of this distribution was truncated at zero. For manganese and zinc, a dermal absorption factor of 0.01 was selected consistent with the Chino Mine HHRA (Ontario MOE 2011). For cadmium a dermal absorption factor of 0.001 from the USEPA RSL table was selected (USEPA 2022a).

Skin surface area distributions for the age 0 to < 6 group were derived from Table 7-10 (USEPA 2011). Separate distributions are available in this table for the following age groups: birth to <1 month, 1 to <3 months, 3 to <6 months, 6 to <12 months, 1 to <2 years, 2 to <3 years, and 3 to <6 years. A weighted average was calculated for each of the percentiles in these seven age groups to derive a single distribution for ages 0 to <6. For the age 6 to < 12 age group, a distribution was developed using the age 6 to < 11 data in Table 7-10 (USEPA 2011). These distributions of total skin surface area were then adjusted by the proportion of the total body surface area composed of the head, legs, feet, lower arms, and hands. These are the surface areas most likely to be exposed during outdoor recreational activities. The individual body part fractions are available in Table 7- 10 (USEPA 2011). Data provided for male children within the age 0 to <6 and 6 to < 12 groups were used because males tend to be larger, providing a conservative estimate for male and female children. The most conservative (i.e., highest) fraction of surface area for each age group was used to adjust the whole body (35.5 percent for age 0 to <6 and 35.3 percent for age 6 to <12).

For the age >12 group, the sum of the skin surface area percentile data for the head, hands, forearms, and lower legs available in Table 7-12 (USEPA 2011) were combined to define a single surface area distribution. The surface area of feet was not included in the age >12 skin surface area dataset consistent with USEPA's recommendations stating that children are assumed to have more sensitive body parts (i.e., feet) exposed, whereas adults are not (USEPA 2002, 2014). Skin surface area distributions for each age group were correlated with the body weight distributions using a correlation coefficient of one. The skin surface area distributions are presented in Appendix A.

Single-point estimates for the dermal adherence factor were used to quantify the amount of soil assumed to adhere to the skin. The USEPA (2004) default value of 0.2 milligrams per square centimeter (mg/cm^2) was used for children in the 0 to <6 year age group. The default value of 0.07 mg/cm^2 (USEPA 2002) for receptors aged 7 to 31 years was assumed to adequately represent the age 6 to <12 and >12 groups.

3.3.8 Inhalation Exposure Time

A trail user survey from December 2020 to January 2021 for the Town of Sahuarita reported an average time spent on trails per use of 1 to 2 hours (Sahuarita PRCS 2021). *The Economic Value of Trails in Arizona* (Duval et al 2020) study results suggest that both non-motorized and motorized trail users in Arizona choose to access areas that have cooler average maximum and minimum temperatures. Since those cooler temperatures occur from late fall into early spring, the trail user surveys conducted in December and January 2021 are considered a reasonable representation of the peak season and as such are believed to be conservative data. Therefore, these data were used to define a distribution for all ages to quantify particulate inhalation exposures for this PRA. A uniform distribution with a mean of 1.5 hours and a standard deviation of 0.5 hour was defined for the exposure time.

3.3.9 Averaging Time

Averaging time was represented using point estimates, and no distribution was assumed for this exposure parameter. For evaluation of carcinogenic effects, the standard averaging time is 70 years or 25,550 days (USEPA 1989; ADHS 2003).

For the evaluation of non-cancer effects, the averaging time is equal to the exposure duration in years times 365 days per year (USEPA 1989). For each model iteration, the value randomly selected from the exposure duration distribution for the 0 to <6 year age group, therefore, was multiplied by 365 days/year to provide a non-cancer averaging time equal to the exposure duration for each iteration.

3.4 Dose (Intake) Estimation

For incidental ingestion and dermal contact with soil, when evaluating exposure to potential carcinogens, lifetime average daily doses (LADDs) were calculated by averaging exposure over an expected 70-year lifespan. When evaluating exposure to non-carcinogens, doses were estimated as average daily doses (ADDs), calculated as the average exposure for the time during which the receptor is assumed to be exposed to the COC. Exposures were calculated using the equations recommended by USEPA (1989, 2004) for the potentially complete routes identified for the EA.

The following sections describe the methods and inputs used to calculate LADDs for carcinogenic COCs and ADDs for non-carcinogenic COCs. Intake was calculated using age-adjusted factors, as contact rates and certain exposure factors vary among the three age groups evaluated (0 to <6, 6 to <12, and 12+ years).

The following equations were used for the ingestion pathway:

$$LADD_{ing}\ or\ ADD_{ing} = C_{soil} \times \frac{IFS_{adj} \times RBA \times FI \times EF \times CF}{AT}$$

If exposure duration (ED) is 12 years or greater (carcinogens only):

$$IFS_{adj} = \frac{6\,yr \times IR_{0-6}}{BW_{0-6}} + \frac{6\,yr \times IR_{6-12}}{BW_{6-12}} + \frac{(ED - 12\,yr) \times IR_{12+}}{BW_{12+}}$$

If exposure duration (ED) is greater than or equal to 6 years and less than 12 years (carcinogens only):

$$IFS_{adj} = \frac{6\,yr \times IR_{0-6}}{BW_{0-6}} + \frac{(ED - 6\,yr) \times IR_{6-12}}{BW_{6-12}}$$

If exposure duration (ED) is less than 6 years (carcinogens and non-carcinogens[2]):

$$IFS_{adj} = \frac{ED \times IR_{0-6}}{BW_{0-6}}$$

Where:

- *$LADD_{ing}$ = Lifetime average daily dose of the chemical via ingestion (mg/kg/day)*
- *ADD_{ing} = Average daily dose of the chemical via ingestion (mg/kg-day)*
- *C_{soil} = EPC in soil (mg/kg)*
- *IFS_{adj} = Age-adjusted ingested fraction of soil (mg-year/kg-day)*
- *RBA = Relative bioavailability (unitless)*
- *FI = Fraction of material ingested (unitless)*
- *EF = Exposure frequency (days/year)*
- *CF = Conversion factor (10^{-6} kg/mg)*
- *AT = Averaging time (days)*
- *IR = Soil ingestion rate (mg/day)*
- *BW = Body weight (kg)*
- *ED = Exposure duration (years)*

The following equations were used for the dermal pathway:

$$LADD_{derm}\ or\ ADD_{derm} = \frac{DFS_{adj} \times ABS_{derm} \times EV \times EF \times CF}{AT}$$

If exposure duration (ED) is 12 years or greater (carcinogens only):

$$DFS_{adj} = \frac{6\,yr \times SA_{0-6} \times AF_{0-6}}{BW_{0-6}} + \frac{6\,yr \times SA_{6-12} \times AF_{6-12}}{BW_{6-12}} + \frac{(ED - 12\,yr) \times SA_{12+} \times AF_{12+}}{BW_{12+}}$$

If exposure duration (ED) is greater than or equal to 6 years and less than 12 years (carcinogens only):

[2] The calculation of non-cancer health effects for the 0- to 6-year-old age group is protective of older children and adults, as the non-cancer health effects are highest for this age group.

$$DFS_{adj} = \frac{6\ yr\ \times\ SA_{0-6}\ \times AF_{0-6}}{BW_{0-6}} + \frac{(ED - 6\ yr) \times\ SA_{6-12}\ \times\ AF_{6-12}}{BW_{6-12}}$$

If exposure duration (ED) is less than 6 years (carcinogens only and non-carcinogens):

$$DFS_{adj} = \frac{ED\ \times\ SA_{0-6}\ \times AF_{0-6}}{BW_{0-6}}$$

Where:

- *$LADD_{derm}$ = Lifetime average daily dose of the chemical via dermal contact (mg/kg/day)*
- *ADD_{derm} = Average daily dose of the chemical via dermal contact (mg/kg-day)*
- *DFS_{adj} = Age-adjusted dermal fraction of soil (mg-year/kg)*
- *ABS_{derm} = Chemical-specific dermal absorption factor (unitless)*
- *EV = Events per day (day^{-1})*
- *SA = Skin surface area (cm^2)*
- *AF = Soil-to-skin adherence factor (mg/cm^2)*

The following equations were used for the particulate inhalation pathway:

$$EC = \left(C_{soil}\ \times\ \frac{1}{PEF}\right) \times \frac{ET\ \times EF\ \times\ ED}{24\frac{hr}{day} \times AT}$$

Where:

- *PEF = Particulate emission factor (m^3/kg)*
- *ET = Exposure time (hrs/day)*

3.5 Exposure to Lead

Lead can be harmful to humans when ingested or inhaled. Specifically, lead exposures can impair physical and mental development in children. The USEPA has not developed standard estimates representing a dose-response assessment for lead because a clear threshold for some of the more sensitive effects in humans from exposure to lead has not been identified (ATSDR 2007b). Rather, exposure to lead is typically evaluated in terms of the increase in blood lead (PbB) concentrations in exposed children or in the developing fetus of an exposed pregnant adult worker.

The evaluation of estimated PbB concentrations in the child recreator is facilitated through use of the USEPA's Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK model, version 2, USEPA 1994, 2007, 2021a). With the IEUBK model, concern is for an exposed child up to 6 years of age. The model predicts the risk, as a probability, that a typical child will exhibit a PbB concentration greater than a target PbB concentration when exposed to a combination of specified media concentrations of lead (USEPA 2021a). As discussed during a virtual meeting between ADEQ, Fehling and representatives from Freeport/AMAX, BP/Anaconda, and Arcadis on April 26, 2021, 10 micrograms per deciliter (µg/dL) is used in this PRA as the target PbB concentration in the IEUBK modeling for the EA. The goal is to limit the estimated portion of the child receptors' PbB distribution exceeding 10 µg/dL to less than 5 percent. This goal was established by USEPA in 1994 and was consistent with the Centers for Disease Control and Prevention's (CDC) blood lead action level at the time (USEPA 2016); it is also the basis of the current USEPA residential soil screening level of 400 mg/kg lead (USEPA 2022a). USEPA considered that a screening level developed using the IEUBK model and this goal would be protective for young children and "is expected to be protective for older population subgroups" as well (USEPA 1994). The health effects from lead exposure are further discussed in Section 4.3.

The IEUBK model includes three modules: exposure, uptake, and biokinetic. The exposure module calculates media-specific lead intake rates to estimate how much lead is taken into a child's body from soil and other media including indoor dust, particulates in ambient air, drinking water, and food. The uptake model incorporates absorption factors to estimate the fraction of lead intake that crosses into the bloodstream from the lungs or gastrointestinal tract. The IEUBK model default RBA of 60 percent for lead in soil was used in the absence of site-specific bioavailability data for lead; however, the bioavailability of lead in soil at a site can vary substantially from this default value. The transfer of lead between blood and other body tissues and through elimination pathways is addressed by the biokinetic module. The mother's PbB concentration at childbirth is incorporated in the biokinetic module. IEUBK v2.0 model defaults were used for all exposure parameters except a site-specific soil lead concentration. An exposure period of 12 to 72 months was assumed as recommended in the USEPA's Office of Land and Emergency Management (OLEM) Directive 9200.2-1, Recommendations for Default Age Range in the IEUBK Model (USEPA 2017c).

The PbB distribution is calculated using the arithmetic average lead concentration in soil. The IEUBK model was also run using an upper-bound estimate (i.e., 95% UCL) of the average lead concentration in soil in an evaluation of uncertainties presented in Section 6.3. Because the IEUBK model assumes exposure over an entire year and the exposure frequency for the child recreator was assumed to be 100 days per year, a time-weighted average soil lead concentration was developed that takes both time spent at the EA and time spent away from the EA (e.g., at home) into account. The USEPA's *Assessing Intermittent or Variable Exposures at Lead Sites* (USEPA 2003b) recommends a time-weighted average approach to evaluate lead at sites, such as day cares or recreational areas, where exposure may be intermittent. This guidance accounts for cumulative exposures when contact with lead-contaminated media at a second defined source in the community is likely (in addition to exposures at residences). Exposure to soil at the secondary location will result in an increase in PbB concentration above the "baseline" PbB concentration attributed to the residential sources of lead if the exposure level or soil ingestion rate at the secondary location is higher than that at the residence.

The time-weighted exposure calculations derive an average value for the two locations where exposure to lead in soil could occur (i.e., the EA and the residence). A weighted value is assigned to a medium (e.g., soil) that reflects the fraction of outdoor exposure to soil at each location. The soil concentrations at each location are weighted based on the fraction of total soil ingestion that occurs at the Site and the residence.

The time-weighted average was calculated using Equation 3-1 below.

Equation 3-1: $$PbS_w = (PbS_{site} \times f_{site}) + (PbS_{other} \times f_{other})$$

Where:

- *PbS_W = Time-weighted average lead concentration in soil (mg/kg)*
- *PbS_{site} = Lead concentration for the Site (mg/kg)*
- *f_{site} = Fraction of time spent at the Site (2 of 7 days a week or 0.286; unitless)*
- *PbS_{other} = Lead concentration in soil at other (offsite) locations (14.7 mg/kg)*

- f_{other} = *Fraction of time spent in other (offsite) locations (5 of 7 days a week or 0.714; unitless)*

The time weighting factor is based on the smallest period in which the exposures repeat (the exposure event period; USEPA 2003b). The fraction of time spent at the Site (f_{site}) was therefore calculated as 2 of 7 days a week (0.286) rather than 100 of 365 days per year (0.274), and the resulting fraction of time spent in other locations (i.e., offsite) was calculated as 5 of 7 days a week (0.714). The lead concentration assumed for off-site or residential soil is the arithmetic mean of seven samples (i.e., S-1A, S-2A, S-3A, S-4A, S-5A, R-3A and R-3B) from unimpacted locations in Area 5 and is considered a Site-specific background concentration (i.e., 14.7 mg/kg).

In Equation 3-1, the lead concentration for the Site (PbS_{site}) is an average soil lead concentration of 1,235 mg/kg for the combined Areas 2, 3, and 4. In addition to this EA-wide average, the lead concentration for the Site (PbS_{site}) was also represented in a separate run of the IEUBK model by an EA-wide, area-weighted average concentration of 885 mg/kg. An area-weighted average was calculated based on review of the data for lead, which indicated differences in soil concentrations among Areas 2, 3, and 4. The area-weighted average lead concentration was calculated using Thiessen polygons, as described in Section 3.3.1.

Using the EA-wide average lead concentration of 1,235 mg/kg as PbS_{site} in the previous equation (i.e., Equation 3-1) results in a time-weighted average lead concentration (PbS_W) of 363 mg/kg that was input to the IEUBK model. Use of the EA-wide, area-weighted average lead concentration of 885 mg/kg as PbS_{site} in Equation 3-1 results in a time-weighted average lead concentration (PbS_W) of 263 mg/kg, which was input to a separate run of the IEUBK model. These inputs were used in the lead evaluation for the EA. The results of the lead evaluation, including the IEUBK model outputs, are discussed in Section 5.4.

The average lead concentration assumes exposure at random across the entire EA (i.e., across all of Areas 2, 3, and 4). The potential for future exposures focused in smaller areas where residual concentrations of lead are higher will be addressed by the application of ADEQ rSRLs and the calculated SSRL (Section 5.5) to guide the remedial action (Arcadis 2022).

4 Toxicity Assessment

The USEPA derives numerical toxicity values for use in risk assessments. Because the impacts associated with exposure to carcinogens are assessed differently than the hazards associated with exposure to non-carcinogens, the toxicity values for carcinogenic health effects and for non-carcinogenic health effects are derived using different assumptions and methods.

For carcinogens, the current approach to carcinogenic risk assessment used by USEPA (2005) assumes, without confirmatory studies, that exposure to any carcinogen poses a finite probability, however small, of producing a carcinogenic response. Oral cancer slope factors (CSFs) are used to estimate potential cancer risk and represent the upper-bound probability of carcinogenic response per unit daily intake of a chemical throughout a lifetime. CSFs are used to assess risks associated with oral and dermal exposures. Inhalation unit risks (IURs) are used to estimate potential cancer risk and represent the upper-bound probability of carcinogenic response per unit (1 microgram per cubic meter [$\mu g/m^3$] in air) of a chemical throughout a lifetime. CSFs and IURs are used in risk assessments to calculate the excess lifetime cancer risks (ELCRs) for evaluated receptors.

Non-carcinogenic toxicity values (reference doses [RfDs] and reference concentrations [RfCs]) are used in risk assessments to estimate the potential non-cancer hazards associated with chemical exposure. In contrast to the default non-threshold assumption used to assess carcinogenic risk, non-carcinogenic effects are assumed by most regulatory agencies, including USEPA, to exhibit a biological or toxicological threshold below which adverse effects are not expected.

As discussed in Section 3.5, exposure to lead is not assessed using toxicity values (e.g., RfD, RfC) but is evaluated in terms of the increase in PbB concentrations following exposure.

The toxicity values for arsenic, cadmium, manganese and zinc were represented in this PRA as point estimates rather than statistical distributions. The toxicity values used for arsenic, cadmium, manganese and zinc are described in the following sections.

4.1 Arsenic

Arsenic is considered carcinogenic via both the oral and inhalation routes of exposure (USEPA 2021c). The toxicity values for arsenic used in this PRA were obtained from the USEPA's Integrated Risk Information System (IRIS) (USEPA 2021c), except for the RfC, which was obtained from the California Environmental Protection Agency (CalEPA 2019). In the absence of dermal toxicity values, route-to-route extrapolation was applied from the oral pathway using a gastrointestinal absorption factor of 1 (USEPA 2022a). Toxicity values for arsenic are provided in Table 3.1.

The most sensitive non-cancer health effects of arsenic via the ingestion exposure route are dermal effects, primarily hyperpigmentation (excess pigmentation of the skin) and hyperkeratosis (skin thickening) (ATSDR 2007a). In terms of the inhalation exposure route, the primary non-cancer effect of arsenic is irritation of the respiratory tract.

4.2 Cadmium

Cadmium occurs in the earth's crust at a concentration of 0.1–0.5 part per million and is commonly associated with zinc, lead, and copper ores (ATSDR 2012). In the environment, cadmium exists in only one oxidation state

(+2) and does not undergo oxidation reduction reactions. IRIS presents an oral "food" RfD for cadmium for use in assessment of risks to soil and biota of 0.0001 mg/kg-day (USEPA 2022a). There is an extensive database on the toxicity of cadmium in exposed populations; however, most of these studies were focused on the presumed sensitive targets of cadmium toxicity (i.e., kidney and bone following oral exposure and kidney and lung following inhalation exposure). Available animal studies support the identification of these sensitive targets. Other non-cancer effects that have been observed in humans and/or animals include reproductive toxicity, hepatic effects, hematological effects, and immunological effects (ATSDR 2012). Toxicity values for cadmium are provided in Table 3.1.

4.3 Lead

A great deal of information on the health effects of lead has been obtained through decades of medical observation and scientific research. By comparison to most other environmental toxicants, the degree of uncertainty about the health effects of lead is quite low. Because age, health, nutritional state, body burden, and exposure duration influence the absorption, release, and excretion of lead, USEPA has not established standard toxicity endpoints for lead. Instead, the concentration of lead in the blood is used as an index of the total exposure level and the potential for adverse health effects.

The IEUBK model was used to predict the risk, as a probability, that a typical recreator child will exhibit a PbB concentration greater than 10 µg/dL. The goal is to limit the estimated portion of the child receptors' PbB distribution exceeding 10 µg/dL to less than 5 percent. This goal was established by USEPA in 1994 and was consistent with the CDC blood lead action level at the time (USEPA 2016).

The current scientific literature on lead toxicology and epidemiology provides evidence that adverse health effects may be associated with PbB concentrations less than 10 µg/dL and that the adverse health effects of lead exposure do not have a threshold. In 2012, the CDC lowered its blood lead reference value (BLRV) for children from 10 to 5 µg/dL. The BLRV corresponds to the 97.5^{th} percentile of blood lead levels among U.S. children ages 1-5 years, and in 2012 was based on the CDC National Health and Nutrition Examination Survey (NHANES) data from 2007-2010. The USEPA acknowledged in 2016 that adverse health effects are associated with BLLs less than 10 µg/dL and possibly as low as 2 to 8 µg/dL (USEPA 2016).

In October 2021, CDC lowered its BLRV to 3.5 µg/dL based on NHANES data from the 2015-2016 and 2017-2018 cycles. Reductions in the CDC's BLRV reflect achievements in environmental policies that have resulted in lower childhood lead exposures in the United States. The BLRV is a screening tool used to identify children with relatively elevated (i.e., the top 2.5 percent) blood lead levels and to prioritize resources towards reducing lead concentrations in the most exposed populations. Similarly, soil screening levels are intended to identify sites or portions of sites that can be removed from further evaluation. In the May 2022 RSL table, the residential soil RSL for lead remains 400 mg/kg. This soil screening level was calculated using the IEUBK model and the goal of no more than a 5 percent probability of the exposed child's blood lead level exceeding 10 µg/dL (USEPA 1994). Sites with lead concentrations exceeding 400 mg/kg require additional evaluation, as was performed for this PRA.

4.4 Manganese

Manganese is a ubiquitous element that is essential for normal physiologic functioning in all animals; however, adverse non-cancer health effects have been associated with both deficiencies and excess intakes of manganese. There are many reports of toxicity to humans exposed to manganese by inhalation, but much less is known about oral intakes resulting in toxicity (USEPA 2021c). Manganese has been demonstrated to be the causative agent in a syndrome of neurologic and psychiatric disorders that has been described in manganese miners (USEPA 2021c). Based on the available data, the USEPA concludes that an appropriate RfD for manganese is 10 mg/day (0.14 mg/kg-day). In applying the RfD for manganese to a risk assessment, it is important to consider the ubiquitous nature of manganese; specifically, that most individuals will consume about 2 to 5 mg of manganese per day in their diet. This is particularly important when using the RfD to determine acceptable concentrations of manganese in soils (USEPA 2021c). Toxicity values for manganese are provided in Table 3.1.

4.5 Zinc

Zinc is another ubiquitous element that is essential for normal physiologic functioning in all animals; however, like manganese, adverse non-cancer health effects have been associated with both deficiencies and excess intakes of zinc. The levels of zinc that produce adverse health effects are much higher than the Recommended Dietary Allowances (RDAs) for zinc of 11 mg/day for men and 8 mg/day for women. If large doses of zinc (10 to 1,000 times higher than the RDA are taken by mouth even for a short time, stomach cramps, nausea, and vomiting may occur. Ingesting high levels of zinc for several months may cause anemia and damage the pancreas and kidneys (ATSDR 2005). Effects on reproductive or developmental end points have been noted in oral-exposure animal studies, but generally only at doses greater than 200 mg/kg/day. ATSDR has derived an intermediate-duration oral minimum risk level (MRL) of 0.3 mg/kg/day for zinc based on decreased erythrocyte superoxide dismutase, a sensitive indicator of body copper status, and changes in serum ferritin in women given supplements containing zinc gluconate for 10 weeks (Yadrick et al. 1989). It should be noted that the MRL represents the level of exposure above and beyond the normal diet that is believed to be without an appreciable risk of toxic response (ATSDR 2005). USEPA also uses 0.3 mg/kg/day as the oral RfD for zinc (USEPA 2021c). Toxicity values for zinc are provided in Table 3.1.

5 Risk Characterization

Risk characterization integrates the exposure assessment and toxicity information. The cancer risk and/or non-cancer hazard was calculated for each soil COC and for each potentially complete exposure route. This section discusses how cancer risk and non-cancer hazard estimates were calculated for arsenic, cadmium, manganese, and zinc and the results of the lead model for recreators. All results were compared to ADEQ allowable cancer risk and non-cancer hazard thresholds, which are described below.

5.1 Cancer Risk Characterization

The ELCRs for ingestion/dermal and inhalation exposures, respectively, were calculated using the following equations:

$$ELCR_{ing/derm} = LADD\left(\frac{mg}{kg-day}\right) \times CSF\left(\frac{mg}{kg-day}\right)^{-1}$$

$$ELCR_{inh} = EC\left(\frac{mg}{m^3}\right) \times URF\left(\frac{mg}{m^3}\right)^{-1}$$

Where:

- *LADD = Lifetime average daily dose of the chemical via the specified exposure route (mg/kg-day)*
- *EC = Exposure concentration for the chemical (mg/m^3)*
- *CSF = Cancer slope factor (mg/kg-day)$^{-1}$*
- *URF = Inhalation unit risk factor (mg/m^3)$^{-1}$*

The daily dose was calculated using age-adjusted factors as contact rates and certain exposure factors for the three age groups evaluated (0 to <6, 6 to <12, and 12+years).

The total ELCR was calculated by summing the risk over all exposure routes. The total ELCR was compared to the allowable target risk range (i.e., 1×10^{-6} to 1×10^{-4}) established by the Arizona Administrative Code (R18-7-206) and USEPA (1990) for excess lifetime cancer risks.

5.2 Noncancer Hazard Characterization

The HQs for ingestion/dermal and inhalation exposures, respectively, were calculated using the following equations:

$$HQ_{ing/derm} = \frac{ADD\left(\frac{mg}{kd-day}\right)}{RfD\left(\frac{mg}{kg-day}\right)}$$

$$HQ_{inh} = \frac{EC\left(\frac{mg}{m^3}\right)}{RfC\left(\frac{mg}{m^3}\right)}$$

Where:

ADD = Average daily dose of the chemical via the specified exposure route (mg/kg-day)

RfD = Reference dose for the chemical (mg/kg-day)

RfC = Reference concentration for the chemical (mg/m^3)

The total HI was calculated by summing the HQs for each non-carcinogen over all exposure routes. If the HI exceeds a value of 1, the possibility exists for a non-carcinogenic hazard. The HI is not a mathematical prediction of the severity or incidence of the effects, but rather indicates that a hazard may exist. ADHS (2003) and USEPA (1989) recommend that the total HI not exceed a value of 1. This HI can be refined further using the segregation of hazard indices approach in accordance with USEPA guidance (USEPA 1989). According to this method, only the HQs of chemicals that have a similar mechanism of toxicity, or that act on the same target organ, should be added to account for cumulative toxicity. The critical non-cancer effects of arsenic (i.e., skin pigmentation and changes in keratin, vascular effects [ATSDR 2007a, USEPA 2021c]), cadmium (i.e., urinary effects [USEPA 2021c]), manganese (i.e., neurological effects [USEPA 2021c]), and zinc (i.e., hematologic and immunologic effects [USEPA 2021c]) do not affect the same target organ or have a similar mode of action. However, as a conservative measure, HQs for arsenic, cadmium, manganese, and zinc were summed as described below.

5.3 Risk Characterization Results

The combination of exposure parameter distributions, point estimates, and arsenic data used to develop the PRA model for the EA resulted in a 95th percentile ELCR estimate of 4×10^{-7} (arsenic ingestion ELCR [3.3×10^{-7}] + arsenic dermal ELCR [3.5×10^{-8}] + arsenic inhalation ELCR [1.7×10^{-10}] + cadmium inhalation ELCR [1.4×10^{-10}]). This ELCR value is below the range of ELCR estimates considered acceptable by the USEPA and ADEQ. As a result, surface soil concentrations of arsenic and cadmium in Areas 2, 3, and 4 at Parcel 30 do not pose a carcinogenic risk to human health that exceeds regulatory levels of concern.

The 95th percentile total HI for combined exposure to COCs (i.e., arsenic, cadmium, manganese, and zinc) in soil is 0.24 (arsenic ingestion HI [0.0091] + cadmium ingestion [0.16] + manganese ingestion HI [0.014] + zinc ingestion [0.014] + arsenic dermal HI [0.00070] + cadmium dermal [0.019] + manganese dermal HI [0.023] + zinc dermal [0.00046] + arsenic inhalation HI [0.0000026] + cadmium inhalation [0.0000080] + manganese inhalation HI [0.000082]). This total HI value is below the acceptable target HI of 1. As a result, surface soil concentrations of COCs in Areas 2, 3, and 4 at Parcel 30 do not pose non-carcinogenic hazards to human health.

The ELCR and HI distributions are provided in Appendix A.

5.4 Lead Evaluation

As described in Section 3.5, the potential for adverse health effects from exposure to lead is evaluated through comparison of predicted PbB concentrations to a health-protective target PbB concentration. The USEPA's IEUBK model (USEPA 2021a) was used to assess recreational child exposures to lead in soil. The IEUBK model output is provided in Appendix B.

The IEUBK model was used to predict PbB concentrations in an exposed child using a time-weighted average soil lead concentration that takes both time spent at the EA and time spent away from the EA (e.g., at home) into account. This time-weighted average approach is used to evaluate lead at sites such as day cares or recreational areas, where exposure may be intermittent (USEPA 2003b). Predicted lead uptakes and PbB concentration for each age interval are shown in the model output in Appendix B. A plausible distribution of PbB concentrations, centered on a geometric mean PbB concentration, was predicted and used to estimate the probability that a child's or a population of children's PbB concentrations will exceed the target PbB concentration of 10 µg/dL. This probability density distribution is shown with the model output.

Using the time-weighted average lead concentration (PbS_W) of 363 mg/kg (based on the EA-wide average lead concentration of 1,235 mg/kg) as the soil lead concentration in the IEUBK model results in an estimated geometric mean PbB concentration of 3.252 µg/dL and a probability of 0.842 percent that the PbB concentration is greater than 10 µg/dL. Using the time-weighted average lead concentration of 263 mg/kg (based on the EA-wide area-weighted average lead concentration of 885 mg/kg) in a separate run of the IEUBK model results in an estimated geometric mean PbB concentration of 2.676 µg/dL and a probability of 0.252 percent that the PbB concentration is greater than 10 µg/dL. Therefore, Site-specific soil lead concentrations do not pose a risk to recreator children. By extension, lead concentrations in soil also do not pose a risk to recreator adults.

5.5 Site-Specific Soil Remediation Levels

As discussed previously and as detailed in the RWP (Arcadis 2022), tailing migration from the current cap will be addressed during the remedial activities planned for Area 1. Activities will include removal of impacted soils in the areas where migration has occurred, and confirmation samples will be collected so residual concentrations of COCs are protective of future recreators. To that end, SSRLs were calculated for arsenic, cadmium, manganese, and zinc to help meet future remedial objectives.

To provide additional context for this assessment, the SSRLs corresponding to an ELCR estimate of 1×10^{-5}, which has been accepted by ADEQ as the target risk for cleanup level development at other VRP sites (BC 2013; Damian 2015; ADEQ 2013 and 2015; Ramboll 2020a and 2020b), and an HI of 1 were identified using the Goal Seek function in @Risk. The Goal Seek function utilizes multiple simulations to adjust the soil concentration, which represents the SSRL, in order to achieve a target 95th percentile HI value of 1 or ELCR value of 1×10^{-5}.

The calculated SSRLs for arsenic, cadmium, manganese, and zinc by exposure route are the following:

$SSRL_C$ based on 95th ELCR = 1×10^{-5}

Arsenic

- Ingestion ($SSRL_o$) = 163 mg/kg
- Dermal ($SSRL_d$) = 1.9×10^3 mg/kg
- Inhalation ($SSRL_i$) = 3.9×10^5 mg/kg

Cadmium

- Ingestion = cadmium is not a carcinogen via this exposure route
- Dermal = cadmium is not a carcinogen via this exposure route
- Inhalation ($SSRL_i$) = 9.47×10^5 mg/kg

$SSRL_{NC}$ based on HQ = 1

Arsenic

- Ingestion ($SSRL_o$) = 576 mg/kg

- Dermal ($SSRL_d$) = 9.8×10^3 mg/kg
- Inhalation ($SSRL_i$) = 2.5×10^6 mg/kg

Cadmium

- Ingestion ($SSRL_o$) = 81.3 mg/kg
- Dermal ($SSRL_d$) = 774 mg/kg
- Inhalation ($SSRL_i$) = 1.7×10^6 mg/kg

Manganese

- Ingestion ($SSRL_o$) = 4.4×10^4 mg/kg
- Dermal ($SSRL_d$) = 3.2×10^4 mg/kg
- Inhalation ($SSRL_i$) = 8.8×10^6 mg/kg

Zinc

- Ingestion ($SSRL_o$) = 2.4×10^5 mg/kg
- Dermal ($SSRL_d$) = 9.28×10^6 mg/kg
- Inhalation = no reference concentration was available; therefore, this exposure route was not evaluated

Total SSRLs for arsenic, cadmium, manganese, and zinc were then calculated by combining all applicable exposure routes[3] as follows:

$$SSRL_C = \frac{1}{[\,1 / (SSRL_o)_C\,] + [\,1 / (SSRL_d)_C\,] + [\,1 / (SSRL_i)_C\,]}$$

$$SSRL_{NC} = \frac{1}{[\,1 / (SSRL_o)_{NC}\,] + [\,1 / (SSRL_d)_{NC}\,] + [\,1 / (SSRL_i)_{NC}]}$$

Where: C= cancer and NC = non-cancer

The $SSRL_C$ for arsenic based on the target risk level of 1×10^{-5} is 150 mg/kg. The calculation of a total SSRL for arsenic based on non-cancer effects ($SSRL_{NC}$) was not necessary because, as seen in the route-specific SSRLs above, the cancer-based SSRLs are lower than the non-cancer-based SSRLs. Therefore, the $SSRL_C$ for arsenic will be protective of potential non-cancer effects. The $SSRL_{NC}$ based on an HI of 1 is 73.6 mg/kg for cadmium, 18,500 mg/kg for manganese, and 236,000 mg/kg for zinc. The calculation of a total SSRL for cadmium based on cancer effects (i.e., $SSRL_C$) was not necessary because, as seen in the route-specific SSRLs above, the non-cancer-based SSRLs for the ingestion and dermal routes of exposure are lower than the inhalation SSRLi based on potential cancer effects. Therefore, the $SSRL_{NC}$ for cadmium will be protective of potential cancer effects.

For lead, an SSRL was developed by first determining, through iterative runs of the IEUBK v2.0 model, the soil lead concentration that would result in no more than 5 percent of the child resident population having a PbB concentration greater than 10 µg/dL. The resultant soil lead concentration is 611 mg/kg, which was rounded down to 600 mg/kg. The SSRL for lead was then calculated by assuming that the time-weighted average lead concentration in soil (PbS_W) is 600 mg/kg and solving Equation 3-1 (in Section 3.5) for the average lead concentration at the Site (PbS_{site}) using Equation 3-3 below.

[3] Zinc non-cancer routes: ingestion + dermal only; cadmium non-cancer routes: ingestion + dermal + inhalation; cadmium cancer routes: inhalation only

Equation 3-3 $$PbS_{site} = \frac{(PbS_W - [PbS_{other} \times f_{other}])}{f_{site}}$$

Where:

- *PbS_{site} = Lead concentration for the Site (mg/kg)*
- *PbS_W = Time-weighted average lead concentration in soil (600 mg/kg)*
- *f_{site} = Fraction of time spent at the Site (2 of 7 days a week or 0.286; unitless)*
- *PbS_{other} = Average lead concentration in soil at other (offsite) locations (14.7 mg/kg)*
- *f_{other} = Fraction of time spent in other (offsite) locations (5 of 7 days a week or 0.714; unitless)*

Based on this approach, the lead SSRL is 2,100 mg/kg.

SSRLs for each COC were calculated to pose no more than either a non-carcinogenic HI of 1 or an ELCR of 1×10^{-5}. If multiple chemicals present at a site affect the same target organ or critical effect system, the potential exists for an unacceptable exposure. To safeguard against this, an analysis of the mode of action for each COC was warranted during the development of SSRLs, and SSRLs were adjusted if it was determined that two or more COCs could affect the same target organ or critical effect system. A review of the USEPA's critical effects systems information indicates that two of the COCs (lead and manganese) can potentially elicit adverse effects to the same critical effect system (USEPA 2021c). However, evaluation of lead exposure and potential risk is based on a biokinetic model and predicted blood lead levels, rather than on an RfD and hazard quotients. Therefore, it is not possible to incorporate lead in any calculations of cumulative hazard as done for other constituents (USEPA 1989), nor is it appropriate to adjust the SSRL based on a shared critical target system with manganese. However, the final SSRL for manganese was adjusted as a conservative measure to 9,250 mg/kg (18,500 mg/kg x 0.5) to account for the potential joint action of lead and manganese on the central nervous system (CNS). The non-cancer SSRLs for the remaining COCs do not require adjustment because the RfDs for those COCs are not based on effects to a common critical effect system.

6 Uncertainties in the Risk Assessment

This section discusses some of the uncertainties associated with the PRA.

6.1 Uncertainties Associated with COC Selection

The selection of COCs was based on the results of the sampling data available for the Site. The factors that contribute to uncertainties associated with the identification of COCs are inherent in the data collection and data evaluation processes, including appropriate sample locations, adequate sample quantities, laboratory analyses, data validation, and treatment of validated sample results. Section 2.1.5 addressed most of these factors as they relate to data usability for the PRA. Non-COCs were evaluated and eliminated from further assessment based on a comparison to USEPA RSLs.

Additionally, in an effort to confirm that no other metals should be further evaluated in the PRA, the Golder (2009) data for samples collected from 0 to 5 ft bgs in Area 1 were screened against USEPA RSLs (Table 6.1). The Golder 2009 data were used because these samples were analyzed for the entire Target Analyte List (TAL) metals list plus molybdenum and tin, whereas the remaining datasets used a focused analyte list with fewer metals. Because the Golder (2009) data are considered representative of metals concentrations in the impounded tailings, they are likely to represent potential ‘source’ conditions for Site-related metals to the other areas in Parcel 30 (i.e., Areas 2, 3, and 4). Based on this presumption, the Area 1 data (Golder 2009) can be considered inclusive and conservative for Areas 2, 3, and 4. Table 6.2 presents a comparison of concentrations detected in Areas 2, 3, and 4 (0 to 1 ft bgs) to detected concentrations from Area 1 (0 to 5 ft bgs) for like metals. As expected, concentrations in Area 1 data (Golder 2009) are similar to or higher than detected soil concentrations in Areas 2, 3, and 4 (except lead, see below). Therefore, it can be presumed that, if a certain metal is not detected at concentrations above the RSL in the tailings from the ore processing (Area 1), then it would likely not be a significant concern in the other areas of Parcel 30 (i.e., Areas 2, 3, and 4).

Table 6.1 presents HQs (i.e., sample concentrations divided by the RSL) and the system-specific HI for each Area 1 sample collected from 0 to 5 ft bgs. According to the “segregation of Hazard Indices” approach (USEPA 1989), only the HQs of chemicals that have a similar mechanism of toxicity, or that act on the same target organ/system, should be added to account for cumulative toxicity. As seen in Table 6.1, system-specific HIs exceed the target of 1 at locations with elevated arsenic, cadmium, lead, manganese, and thallium.

The maximum detected lead concentration occurs outside of Area 1 (18,500 mg/kg at A2-36 in Area 2), and only arsenic, lead, and manganese were analyzed at that location; therefore, concentrations of the remaining non-COC[4] metals were projected for that location using the 95% UCL of the metal/lead ratios calculated for each 0 to 5 ft bgs sample from Area 1 (Appendix E). The projected metal-specific concentrations from this evaluation were used in lieu of actual laboratory-reported concentrations. To demonstrate that the metal/lead ratios result in projected non-COC metal concentrations that are conservative, reported concentrations of arsenic and manganese in sample A2-36 were compared to projected concentrations using the calculated ratios (see Exhibit B). As shown in the exhibit below, the projected concentrations of arsenic and manganese are greater than their reported concentrations. Therefore, based on available information, the projected concentrations of the non-COC

[4] Non-COCs metals: aluminum, antimony, barium, beryllium, boron, chromium, cobalt, copper, fluoride, mercury, molybdenum, nickel, selenium, silver, strontium, thallium, tin, and vanadium

metals are also expected to be similarly conservative (i.e., projected concentrations are anticipated to be greater than measured concentrations).

Exhibit B – Comparison of Arsenic and Manganese Concentrations in Sample A2-36

Metal	Metal/Lead Ratio [a]	Reported Concentration (mg/kg) for A2-36	Projected Concentration (mg/kg) [b]
Arsenic	0.00661	91.1	122
Manganese	1.910	1,740	35,335

[a] The metal/lead ratios are presented in Appendix E.
[b] Projected concentration = lead concentration of 18,500 mg/kg (from A2-36) multiplied by the metal/lead ratio.

Projected concentrations of non-COC metals for sample location A2-36 (maximum detected lead concentration) are presented in Table 6.3 along with HQs and system-specific HIs. Based on the conservative projected concentrations, HIs range from less than 1 to 9 for A2-36. As shown in Table 6.3, the primary contributor to system-specific HIs greater than 1 is thallium (nervous/dermal/respiratory).

The exercise described above provides a conservative evaluation of non-COC data for the Site and was conducted so the PRA does not eliminate any metal that may be contributing appreciably to the potential cumulative risk for future receptors. Based on the evaluation, thallium is discussed in the context of the projected concentrations and HI evaluation.

Thallium data for Areas 2, 3, and 4 are not available; however, concentrations detected in Area 1 range from 1 to 2.8 mg/kg. In the absence of thallium data for the EA, a predicted EA-wide thallium concentration was calculated by multiplying an EA-wide area weighted 95% UCL for lead (890 mg/kg; Appendix B) by the average thallium/lead ratio of 0.000331 (Appendix E). The resulting estimated EA-wide thallium concentration is 0.29 mg/kg, and is below the residential RSL of 0.78 mg/kg and rSRL of 5.2 mg/kg. In addition, even if the highest thallium/lead ratio among all 20 Area 1 samples (i.e., 0.000593) was applied to the lead 95% UCL, the resulting thallium concentration of 0.53 mg/kg is still below the EPA residential RSL of 0.78 mg/kg. U.S. Geological Survey (USGS) background thallium concentrations for Arizona range from 0.1 mg/kg to 1.5 mg/kg (Smith et al 2013). Based on this evaluation, thallium is unlikely to represent an appreciable exposure concern at Areas 2, 3, and 4.

Although this evaluation process does not provide a quantitative risk estimate for all constituents, it confirms the PRA focuses on the constituents accounting for the greatest potential for risk (i.e., arsenic, lead, manganese, cadmium, and zinc). Existing sample data (pre-reclamation) for Area 1 are presented in Figures 3 through 7.

6.2 Uncertainties Associated with PRA Distributions

This PRA evaluated the 0 to < 6, 6 to < 12 and 12 years and older age groups. Data from USEPA (2011, 2017) and other sources are not always available for these exact age groups. Distributions for this PRA used data that were as close as possible to the three age groups evaluated, and in some cases, published data were combined (e.g., weighted average of smaller age categories) to develop distributions. For example, body weight data for children aged 6 to < 11 years were used to characterize exposure for children aged 6 to <12 years. These relatively minor differences are unlikely to have a large effect on outcomes but may result in slight over- or underestimates of exposure and risk. For the age > 12 group, probabilistic model iterations may overestimate those parameters where the distributions are based on the entire range of data for teens to older adults (i.e., body weight, soil ingestion rates, and skin surface areas). If exposure does not extend beyond the teenage/young adult years, cancer risk estimate may be biased low.

For some parameters, point estimates were used in the PRA modeling instead of statistical distributions. Single-point estimates are typically upper percentile values, and as such, likely result in overestimation of risks. For example, toxicity values are developed to be protective of sensitive subpopulations and/or to account for uncertainty in the cancer dose-response model. Due to conservatisms in the derivation of toxicity values (e.g., application of uncertainty factors), their use is expected to be protective and result in an overestimate of ELCRs and/or HIs. Another example is the point estimate used to represent soil manganese bioavailability. The manganese RBA value used in this PRA was based on a single study conducted with urban soils in Scotland, and manganese bioavailability may differ for conditions typical of arid soils present at the Site. Thus, the use of the point estimate RBA may underestimate or overestimate manganese bioavailability in soil at the EA.

Probabilistic risk calculations simulations were run with 10,000 iterations, a level considered sufficient to stabilize the tails of the output distributions. Simulations were also run with 15,000 and 20,000 iterations, to confirm that the upper percentiles of the output distributions were similar to those using 10,000 iterations. A comparison of the 95th and 99th percentiles of the cumulative risk outputs for each level of iterations is shown in Table 1 in Appendix A. At two significant figures, there were very slight differences among the three different iteration levels, reflecting the variability in a probabilistic assessment of risk. However, these small differences are negligible and do not have a material impact on the risk evaluation.

Appendix A provides the @Risk sensitivity figures for each exposure pathway. The sensitivity figures display the rankings of each input parameter assumption according to their effect on the output (risk) 95th percentile. The variability of each parameter is shown, with higher input parameter variability driving variability in the risk estimate. As shown in Appendix A, the ingestion pathway contributes most to the cumulative arsenic cancer and non-cancer risk for recreators. The ingestion pathway also contributes the most variability to the cumulative cadmium, manganese, and zinc non-cancer hazard estimates for recreators. The soil ingestion pathway contributes most to the overall risk and hazard estimates for arsenic; therefore, the discussion of model sensitivity in this section focuses on the ingestion pathway. The sensitivity analysis for the ingestion pathway for arsenic cancer risk shows that the soil ingestion rate for age 0 to <6 has the greatest impact on the risk mean. The relative bioavailability of arsenic, exposure duration, exposure frequency, and arsenic EPC contribute most of the remaining variability in cancer risk estimates. For arsenic ingestion pathway non-cancer HQ estimates, the age 0 to <6 soil ingestion rate distribution contributes most to the risk estimate, followed by the relative bioavailability of arsenic, exposure frequency, and body weight for ages 0 to < 6. This soil ingestion rate distribution is also the main parameter to influence variability for manganese non-cancer HQ estimates for the ingestion exposure pathway.

Soil ingestion rate distributions are likely the greatest contributor to uncertainty to the PRA due to limitations associated with the available methods to estimate ingestion. Soil ingestion rate distributions were derived from modeled rather than measured data: the Ozkaynak et al. (2011) study (Table 5-12; USEPA 2017a) developed soil and dust ingestion rates for children 3 to <6 years of age using USEPA's Stochastic Human Exposure and Dose Simulation (SHEDS) model for multimedia pollutants (SHEDS-Multimedia; USEPA 2010a), and the Wilson et al. (2013) study (Table 5-14; USEPA 2017a) modeled estimates of the ingestion rates of indoor dust and outdoor soil for Canadians using both deterministic and probabilistic methods based on data from multiple studies. The use of data from multiple sources that used different methods to estimate soil ingestion rates may reduce this uncertainty.

Arsenic, cadmium, lead, manganese, and zinc bioavailability measurements can vary substantially between different soil types and between test species. Similar to the study used to develop the arsenic RBA distribution for this PRA, soil present at the Site may have variable levels of arsenic bioavailability. The overall uncertainty in arsenic bioavailability is decreased by including data measured in multiple test species as opposed to a single species. On the other hand, manganese, cadmium, and zinc bioavailabilities were evaluated using a point estimate based on more limited information and, therefore, empirically measured bioavailability from the EA could be lower. Similarly, lead relative bioavailability was modeled based on USEPA default in the IEUBK at 60 percent, but empirical data collected from the EA could show that the actual value is lower.

6.3 Uncertainties Associated with Lead Exposure

A great deal of information on the health effects of lead has been obtained through decades of medical observation and scientific research. By comparison to most other environmental toxicants, the degree of uncertainty about the health effects of lead is quite low. Because age, health, nutritional state, body burden, and exposure duration influence the absorption, release, and excretion of lead, the USEPA has not established standard toxicity endpoints for lead. Instead, the concentration of lead in the blood (expressed as µg/dL), which can be modeled using the IEUBK model (USEPA 2010b), is used as an index of the total exposure level. The IEUBK model was not designed to assess short-term (exposure for less than 90 days), periodic (exposure less frequently than 1 exposure per 1 week), or acute (~14 days) exposures (Stalcup 2016). Instead, the IEUBK model simulates PbB associated with continuous exposure of sufficient duration to result in a quasi-steady state (USEPA 1994, 1996). Based on estimates of the first-order elimination half-time for lead in blood of approximately 30 days for children (USEPA 2003b), a constant lead intake rate over 90 days would be expected to achieve a PbB that is sufficiently close to the quasi-steady state. Infrequent and non-continuous exposures (i.e., less than 1 day per week over a minimum duration of 90 days) would be expected to produce oscillations in PbB associated with the absorption and subsequent clearance of PbB between each exposure event (Stalcup 2016). Thus, the IEUBK model can only provide an approximation of a quasi-steady-state PbB concentration for periodic exposures, and thus is a source of uncertainty in the assessment of lead exposure at the EA.

Another source of uncertainty is the ambient (background) concentration and exposure point concentration for lead used in the IEUBK model. The seven data points from soil sample locations S-1A through S-5A, and samples R-3A and R-3B located in Area 5 provide a basis for an average lead background concentration in soil for Areas 2, 3, and 4 of 14.7 mg/kg. However, due to the small size of the data set and uncertainty in the applicability of Area 5 soil to the residential areas of Sahuarita where most off-Site lead exposures characterized by these background data are expected, ADEQ has expressed relatively low confidence in the estimated average lead background concentration in soil.

In an email from ADEQ to AMAX dated December 28, 2021, ADEQ requested the lead evaluation include a calculation that employs a reasonable upper-bound estimate (i.e., 95% UCL) of average local lead concentrations in soil. The EA-wide area-weighted average lead concentration used in Section 5.4 is 885 mg/kg and is based on data for Areas 2, 3 and 4 (n = 69). When data from 8 samples from Area 5 are added, the area weighted mean is 228 mg/kg due to the relatively low lead concentrations in Area 5 and the larger size (140 acres) of the parcel (Figure 11).

The resulting area weighted 95% UCL for data from Areas 2, 3, 4 and 5 (n = 77) is 229 mg/kg and this concentration is comparable to the time-weighted average lead concentration of 263 mg/kg (based on the EA-wide area-weighted average lead concentration of 885 mg/kg) used in Section 5.4. This exercise confirms that the EPC of 885 mg/kg is representative of lead concentrations over the entire Parcel 30 and demonstrates that recreational exposures are unlikely to result in greater than a five percent probability that child receptors' PbB concentrations will exceed 10 µg/dL.

6.4 Uncertainties Associated with Critical Effects System Adjustments to SSRLs

The USEPA IRIS summary for arsenic reports that the RfD was derived from data by Tseng (1977) and Tseng et al. (1968) that evaluated the relationship between non-cancer effects and human exposure to inorganic arsenic via consumption of affected well water. The RfD for inorganic arsenic was calculated using hyperpigmentation, keratosis, and possible vascular complications as critical effects and USEPA (2022b) reports cardiovascular and dermal as the critical effect systems on their webpage. In contrast, the IRIS RfD for zinc was derived from data by Yadrick et al. (1989), Fischer et al. (1984), Davis et al. (2000), and Milne et al. (2001) that evaluated the relationship between non-cancer effects and human exposure to zinc via consumption in the diet. The RfD for zinc was calculated using decreases in erythrocyte copper, zinc-superoxide dismutase (ESOD) activity as the critical effect and USEPA (2022c) reports hematologic and immune as the critical effect systems on their webpage. Thus, the non-cancer SSRLs for arsenic and zinc do not require adjustment because the RfDs for these two constituents are not based on effects to a common critical effect system.

The CNS has been identified as the critical target effect system for lead and manganese (USEPA 1995, 2022d). While it is unclear if manganese and lead affect the CNS via a common mechanism of action, there is evidence that both have the potential to produce irreversible effects on neurodevelopment in an additive fashion (Neal and Guilarte 2013; Kim et al. 2009). However, while manganese is an element that is essential for normal physiological functioning and for which a reference dose exists (USEPA 1995), an essential role for lead in normal physiological homeostasis is not known to have been reported (EFSA 2010; Flannery et al. 2020; ATSDR 2020). In the absence of additional toxicological information, the SSRL for manganese in this PRA was conservatively reduced by half to account for the potential joint action of lead and manganese on the CNS. The appropriate degree of adjustment for manganese is an uncertainty in the PRA. In terms of lead, it is not appropriate to adjust the SSRL since it is based on a biokinetic model and not amenable to the standard apportionment process used for constituents that have an RfD.

7 Summary and Conclusions

Potential cancer risks and non-cancer hazards to future recreators that could result from exposure to soil containing arsenic, cadmium, manganese, and zinc at the EA were assessed using probabilistic methods. Exposure estimates based on a combination of parameter distributions and point estimates were then combined with toxicity values to provide distributions of risk and hazard estimates that take into account both variability and uncertainty. The resulting 95th percentile ELCR estimate of 4×10^{-7} is below both the ADEQ and the USEPA acceptable risk range of 1×10^{-6} to 1×10^{-4}. The resulting 95th percentile HI estimate of 0.24 is below the target HI of 1.

For comparison, SSRLs resulting in an ELCR of 1×10^{-5}, which has been accepted by ADEQ as the target risk level for cleanup level development at other VRP sites, and an HI of 1 were also identified. An SSRL for arsenic based on the target risk level of 1×10^{-5} is 150 mg/kg. SSRLs based on an HI of 1 are 73.6 mg/kg for cadmium, 9,250 mg/kg for manganese (adjusted for an HI of 0.5 based on critical effect system analysis), and 236,000 mg/kg for zinc. No detected concentrations of arsenic, manganese, and zinc exceed these SSRL values in Areas 2, 3, and 4. The EA-wide area-weighted 95% UCLs[5] for arsenic and manganese are 8.23 mg/kg and 837 mg/kg, respectively (Appendix A). The EA-wide 95% UCL for zinc is 5,245 mg/kg. The maximum cadmium concentration of 75 mg/kg in Area 2 marginally exceeds the SSRL of 73.6 mg/kg, however no action is required since the EA-wide 95% UCL (18.18 mg/kg; Appendix A) is below the SSRL.

The USEPA's IEUBK v2.0 model was used to evaluate the potential for adverse health effects from exposure to lead. Based on the results of the IEUBK model, exposure to lead in soil at the EA is not likely to result in adverse health effects in future child recreators and, by extension, in future adult recreators.

The IEUBK model was also used to derive an SSRL for lead. Based on a goal of no more than 5 percent of the child resident population having a PbB concentration greater than 10 µg/dL, and accounting for time spent at the EA and time away from the EA (e.g., at home) in accordance with USEPA (2003b) guidance, the lead SSRL is 2,100 mg/kg. The average lead concentrations in surface soil (i.e., EA-wide average; EA-wide area-weighted average) do not exceed the lead SSRL.

The results of the PRA indicate that adverse effects to human health from exposure to COCs (arsenic, cadmium, lead, manganese, and zinc) in soil are not expected if Areas 2, 3, and 4 are developed for recreational use. These conclusions are based on a robust dataset and a scientifically defensible process that can support risk management decisions for this Site. That said, remedial action is required to consolidate eroded material and any visible tailings. The published ADEQ rSRLs for arsenic, lead, and manganese were used to design the planned consolidation (Arcadis 2022).

[5] Area-weighted 95% UCLs were calculated from the EPC distributions developed using the bootstrap method.

8 References

Agency for Toxic Substance and Disease Registry (ATSDR). 2005. Toxicological Profile for Zinc. Center for Disease Control. Atlanta.

Arcadis U.S., Inc. (Arcadis). 2022. Remedial Work Plan, Parcel 30, Sahuarita, Arizona.

ATSDR. 2007a. Toxicological Profile for Arsenic. Center for Disease Control. Atlanta.

ATSDR. 2007b. Toxicological Profile for Lead. Center for Disease Control. Atlanta.

ATSDR. 2012. Toxicological Profile for Cadmium. Center for Disease Control. Atlanta.

ATSDR. 2020. Toxicological Profile for Lead. August. Available at: https://www.atsdr.cdc.gov/toxprofiles/tp13.pdf

Arizona Administrative Code (A.A.C.). 2009. Title 18, Chapter 7, Article 2. Supplement 09-1. March 31.

Arizona Department of Environmental Quality (ADEQ). 1991. Evaluation of Background Metals Concentrations in Arizona Soils. June.

ADEQ. 2013. Human Health Risk Assessment Approval. Douglas-Pirtleville Soil Program. Letter from John Patricki, ADEQ to Stuart Brown, FMC dated November 19, 2013.

ADEQ. 2015. Approval of Human Health Risk Assessment. Clarkdale Remediation Study Area – United Verde Soil Program, Clarkdale, Arizona. Letter from John Patricki, ADEQ to Stuart Brown, FMC dated May 1, 2015. Arizona Department of Health Services (ADHS). 2003. Deterministic Risk Assessment Guidance. May 16.

Arizona Department of Health Services (ADHS). 2003. Deterministic Risk Assessment Guidance. May 16.

Bradham, K.D., K.G. Scheckel, C.M. Nelson, P.E. Seales, G.E. Lee, M.F. Hughes, B.W. Miller, A. Yeow, T. Gilmore, S. Harper, and D.J. Thomas. 2011. Relative bioavailability and bioaccessibility and speciation of arsenic in contaminated soils. Environ. Health Perspect. 119:1629-1634.

Bradham, K.D., G.L. Diamond, K.G. Scheckel, M.F. Hughes, S.W.Casteel, B.W. Miller, J.M. Klotzbach, W.C. Thayer, and D.J. Thomas. 2013. Mouse assay for determination of arsenic bioavailability in contaminated soils. J. Toxicol. Environ. Health, Part A. 76:815-826.

Brattin, W. and S.W. Casteel. 2013. Measurement of arsenic relative bioavailability in swine. J. Toxicol. Environ. Health Part A, 76:449-457.

Brown and Caldwell (BC). 2013. Human Health Risk Assessment. Site-Specific Soil Remediation Levels for Arsenic, Copper, and Lead at Douglas Reduction Works. Davis, California.

CalEPA. 2019. Consolidated Table of OEHHA/ARB Approved Risk Assessment Health Values. September 19. Sacramento, CA. https://ww3.arb.ca.gov/toxics/healthval/contable.pdf

Casteel, S.W., L.D. Brown, M.E. Dunsmore, C.P. Weis, G.M. Henningsen, E. Hoffman, W.J. Brattin, and T.L. Hammon. 1997. Relative bioavailability of arsenic in mining wastes. United States Environmental Protection Agency, Region 8, Denver, CO.

CDC. 2012. CDC Response to Advisory Committee on Childhood Lead Poisoning Prevention Recommendations in “Low Level Lead Exposure Harms Children: A Renewed Call for Preliminary Prevention.” (Updated June 2012). Available at http://www.cdc.gov/nceh/lead/acclpp/cdc_response_lead_exposure_recs.pdf.

Clear Creek Associates. 2015. Soil and Groundwater Characterization, Former Eagle Picher Mill Site on Parcel 30, Sahuarita, Arizona.

Damian Applied Technology, LLC (Damian). 2015. Human Health Risk Assessment. Site-Specific Soil Remediation Levels for Arsenic, Copper, and Lead at the United Verde Soil Program. Sacramento, California.

Davis, C.D., Milne, D.B; Nielsen, F.H. 2000. Changes in dietary zinc and copper affect zinc status indicators of postmenopausal women, notably, extracellular superoxide dismutase and amyloid precursor proteins. Am J Clin Nutr 71:781-788.

Davis, S and D. Mirick. 2006. Soil ingestion in children and adults in the same family. J Exp Anal Environ Epidem 16:63−75.

Drexler, J.W. and W.J. Brattin. 2007. An in Vitro Procedure for Estimation of Lead Relative Bioavailability: With Validation. Human and Ecological Risk Assessment, 13: 383–401.

Duval, D, G. Frisvold, A. Bickel. 2020. The Economic Value of Trails in Arizona, A Travel Cost Method Study – TECHNICAL REPORT, March 2020. The Economic Value of Trails in Arizona (d2umhuunwbec1r.cloudfront.net)

EFSA. 2010. Scientific Opinion on Lead in Food.

Fischer, PW; Giroux, A; L'Abbe, MR. (1984) Effect of zinc supplementation on copper status in adult man. Am J Clin Nutr 40:743-746.

Flannery, B.M., Dolan, L.C., Hoffman-Pennesi, D., Gavelek, A., Jones, O.E., Kanwal, R., Wolpert, B., Gensheimer, K., Dennis, S. and Fitzpatrick, S., 2020. US Food and Drug Administration's interim reference levels for dietary lead exposure in children and women of childbearing age. Regulatory Toxicology and Pharmacology, 110, p.104516.

Freeman, G.B., J.D. Johnson, J.M. Killinger, S.C. Liao, A.O. Davis, M.V. Ruby, R.L. Chaney, S.C. Lovre, and P.D. Bergstrom. 1993. Bioavailability of arsenic in soil impacted by smelter activities following oral administration in rabbits. Fundam. Appl. Toxicol. 21:83-88.

Gilbert, R.O. 1987. Statistical Methods for Environmental Pollution Monitoring, U.S. Department of Energy, Control No. DE-AC06-76RLO1830, Van Nostrand Reinhold Company, New York.

Golder Associates, Inc. 2009. Parcel 30 Volumetric Estimate and Geochemical Characterization [Technical Memorandum]. January 20.

Helsel, D.R., and R.M. Hirsch. 1995. Statistical Methods in Water Resources. Studies in Environmental Science 49. New York, NY: Elsevier.

Hydrometrics, Inc. 1999. Soil Sampling Summary Report, Eagle Pitcher Mill Site, Sahuarita, Arizona.

ITRC. 2011. Incorporating Bioavailability Consideration into the Evaluation of Contaminated Sediment http://www.itrcweb.org/contseds-bioavailability/index.htm

Johnson, T. and J. Capel. 1992. A Monte Carlo approach to simulating residential occupancy periods and its application to the general U.S. population [EPA Report]. (EPA-450/3-92-011). Research Triangle Park, NC: U.S. Environmental Protection Agency. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=2000MU7N.txt.

Kim, Y., Kim, B.N., Hong, Y.C., Shin, M.S., Yoo, H.J., Kim, J.W., Bhang, S.Y. and Cho, S.C., 2009. Co-exposure to environmental lead and manganese affects the intelligence of school-aged children. Neurotoxicology, 30(4), pp.564-571.

Lowney, Y; R. Wester, R. Schoof, C. Cushing, M. Edwards, M. Ruby. 2007. Dermal Absorption of Arsenic from Soils as Measured in the Rhesus Monkey. Toxicological Sciences 100(2): 381-392.

Milne, DB; Davis, CD; Nielsen, FH. (2001) Low dietary zinc alters indices of copper function and status in postmenopausal women. Nutrition 17:701-708.

Neal, A.P. and Guilarte, T.R., 2013. Mechanisms of lead and manganese neurotoxicity. Toxicology research, 2(2), pp.99-114.

Neptune and Company (Neptune). 2012. Chino Mines Company Administrative Order on Consent Lampbright Investigation Unit Human Health Risk Assessment Draft. September 27, 2012.

Ontario Ministry of the Environment (MOE). 2011. Rationale for the Development of Soil and Groundwater Standards for Use at Contaminated Sites in Ontario. PIBS 7386e01. Ontario Ministry of the Environment, Standards Development Branch, Toronto, ON.

Oregon Department of Environmental Quality (ODEQ). 1998. Guidance for Use of Probabilistic Analysis in Human Health Risk Assessments. Interim Final. Updated November 1998. Portland.

Özkaynak, H; J. Xue, V.G. Zartarian, G. Glen, L. Smith. 2011. Modeled Estimates of Soil and Dust Ingestion Rates for Children. Risk Anal 31(4): 592−608.

Ramboll US Consulting (Ramboll). 2020a. Probabilistic Risk Assessment for the Clifton Soil Program, Clifton, Arizona.

Ramboll. 2020b. Probabilistic Risk Assessment for The Morenci School Complex Morenci, Arizona.

Roberts, S.M., W.R. Weimar, J.R.T. Vinson, J.W. Munson, R.J. Bergeron. 2002. Measurement of arsenic bioavailability in soil using a primate model. Toxicol. Sci., 67:303-310.

Sahuarita Parks Recreation and Community Services (PRCS). 2021. Park Facility and Trail User Survey December 2020 – January 2021. https://sahuaritaaz.gov/995/Surveys

Sahuarita Square. 2020. Design Concept Report, February 18, 2020. Sahuarita-Square-Design-Concept-Report (sahuaritaaz.gov)

Schoof, R. A. 2003. Final Guide for Incorporating Bioavailability Adjustments into Human Health and Ecological Risk Assessments at U. S. Department of Defense Facilities Part 1: Overview of Metals Bioavailability. June.

Sialelli J, G.J. Urquhart, C.M. Davidson, A.S. Hursthouse. 2010. Use of a physiologically based extraction test to estimate the human bioaccessibility of potentially toxic elements in urban soils from the city of Glasgow, UK. Environ Geochem Health 32:517-527

Smith, D.B., Cannon, W.F., Woodruff, L.G., Solano, Federico, Kilburn, J.E., and Fey, D.L. 2013. Geochemical and mineralogical data for soils of the conterminous United States: U.S. Geological Survey Data Series 801, 19 p., https://pubs.usgs.gov/ds/801/.

Stalcup, D. 2016. Recommendations for Assessing Short-Term Exposure Scenarios Involving Lead al Superfund Sites. [Memorandum]. Office of Superfund Remediation and Technology Innovation. OLEM Directive 9285.6-54. August 2.

Town of Sahuarita. 2019. Aspire 2035 Town of Sahuarita General Plan. December 9, 2019. Available online at: sahuaritaaz.gov

Tseng, W.P. 1977. Effects and dose-response relationships of skin cancer and blackfoot disease with arsenic. Environ. Health Perspect. 19: 109-119.

Tseng, W.P., H.M. Chu, S.W. How, J.M. Fong, C.S. Lin and S. Yeh. 1968. Prevalence of skin cancer in an endemic area of chronic arsenicism in Taiwan. J. Natl. Can0cer. Inst. 40(3): 453-463.

United States Environmental Protection Agency (USEPA). 1989. Risk Assessment Guidance for Superfund, Volume I, Part A – Human Health Evaluation Manual (Part A). Office of Emergency and Remedial Response, Washington, DC. EPA/540/1-89/002.

USEPA. 1990. National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Federal Regulations (CFR), Part 300.400. U.S. Environmental Protection Agency. September.

USEPA. 1992. Guidance for Data Useability in Risk Assessment (Part A). Final. Office of Emergency and Remedial Response, Washington, DC. 9285.7-09A. April.

USEPA. 1994. Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities. OSWER Directive 9355.4-12. Office of Solid Waste and Emergency Response, Washington, DC. 14 July 1994.

USEPA. 1995. IRIS Summary for Manganese (CASRN 7439-96-5). Available at: https://iris.epa.gov/ChemicalLanding/&substance_nmbr=373.

USEPA. 1996. Soil Screening Guidance: Technical Background Document. Office of Emergency and Remedial Response, Washington, DC. EPA/540/R95/128.

USEPA. 2001. Risk Assessment Guidance for Superfund (RAGS), Volume III, Part A – Process for Conducting Probabilistic Risk Assessment. Office of Emergency and Remedial Response. EPA 540-R-02-002. Washington, D.C.

USEPA. 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24. Washington, D.C.

USEPA. 2003a. Guidance for Developing Ecological Soil Screening Levels. OSWER Directive 928.7-55. November 2003, Revised February 2005. https://www.epa.gov/sites/production/files/2015-09/documents/ecossl_guidance_chapters.pdf

USEPA 2003b. Assessing Intermittent or Variable Exposures at Lead Sites. United States Environmental Protection Agency, Office of Solid Waste and Emergency Response, EPA/540-R- 03-008. November 2003.

USEPA. 2004. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Final. EPA/540/R/99/005.

USEPA. 2005. Guidelines for Carcinogenic Risk Assessment. U.S. Environmental Protection Agency, EPA/630/P-03/001B. March 2005.

USEPA. 2007. Short Sheet: Estimating the soil lead concentration term for the integrated exposure uptake biokinetic (IEUBK) model. OSWER 9200.1-78. September.

USEPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance. EPA 530-R-09-007, Office of Resource Conservation and Recovery Program Implementation and Information Division. March.

USEPA. 2010a. The stochastic human exposure and dose simulation (SHEDS) model. National Exposure Research Laboratory, Washington, DC. Available on-line at https://www.epa.gov/chemicalresearch/stochastic-human-exposure-anddose-simulation-sheds-estimate-humanexposure.

USEPA. 2010b. Relative bioavailability of arsenic in soils at 11 hazardous waste sites using an in vivo juvenile swine method. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Bioavailability Subcommittee of the Technical Review Workgroup. OSWER Directive 9200.0-76. June.

USEPA. 2011. Exposure Factors Handbook. EPA/600/R-090/052F. September.

USEPA. 2012a. Compilation and Review of Data on Relative Bioavailability of Arsenic in Soil. U.S. Environmental Protection Agency, OSWER 9200.1-113, Washington, DC.

USEPA. 2012b. Recommendations for Default Value for Relative Bioavailability of Arsenic in Soil. U.S. Environmental Protection Agency, OSWER 9200.1-113, Washington, DC

USEPA. 2014. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. Memorandum from Dana Stalcup, Office of Superfund Remediation and Technology Innovation to Superfund National Policy Managers, Regions 1-10. U.S. Environmental Protection Agency, OSWER 9200.1-120. Washington, DC. February 6.

USEPA. 2015. ProUCL Version 5.1 User Guide. EPA/600/R-07/041. October.

USEPA. 2016. Updated Scientific Considerations for Lead in Soil Cleanups. OLEM Directive 9200.2-167. Office of Land and Emergency Management. 22 Dec 2016.

USEPA. 2017a. Update for Chapter 5 of the Exposure Factors Handbook – Soil and Dust Ingestion. EPA/600/R-17/384F. Washington, D.C

USEPA. 2017b. Release of Standard Operating Procedure for an In Vitro Bioaccessibility Assay for Lead and Arsenic in Soil and Validation Assessment of the In Vitro Arsenic Bioaccessibility Assay for Predicting Relative Bioavailability of Arsenic in Soils and Soil-like Materials at Superfund Sites. Memorandum, Office of Solid Waste and Emergency Response. May 5, 2017.

USEPA. 2017c. Recommendations for Default Age Range in the IEUBK Model. OLEM Directive 9200.2-1. Office of Land and Emergency Management, Washington, DC. November 15.

USEPA. 2021a. Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) Version 2.01. https://www.epa.gov/superfund/lead-superfund-sites-software-and-users-manuals

USEPA. 2021b. Guidance for Sample Collection for *In Vitro* Bioaccessibility Assay for Arsenic and Lead in Soil and Applications of Relative Bioavailability Data in Human Health Risk Assessment. January 4, 2021.

USEPA. 2021c. Integrated Risk Information System. Online database accessed May 2021. https://www.epa.gov/iris

USEPA. 2022a. Regional Screening Levels. May 2022. https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

USEPA. 2022b. IRIS page for Arsenic, Inorganic (CASRN 7440-38-1) | DTXSID4023886. Available at: https://iris.epa.gov/ChemicalLanding/&substance_nmbr=278.

USEPA. 2022c. IRIS page for Zinc and Compounds (CASRN 7440-66-6) | DTCSID7035012. Available at: https://iris.epa.gov/ChemicalLanding/&substance_nmbr=426.

USEPA. 2022d. Learn About Lead. Available at: https://www.epa.gov/lead/learn-about-lead.

Walker, S. and Griffin, S. 1998. Site-specific data confirm arsenic exposure predicted by the U.S. Environmental Protection Agency. Environ. Health Perspect. 106:133-139.

Wester, R.C., Maibach, H.I., Sedik, L. Melendres, J., and Wade, M. 1993. In vivo and in vitro percutaneous absorption and skin decontamination of arsenic from water and soil. Fundam. Appl. Toxicol. 20: 336-340.

Wester, RC, H. Xiaoying, S. Barbadillo, H.I. Maibach, Y.W. Lowney, R.A. Schoof, S.E. Holm and M.V. Ruby. 2004. In vivo percutaneous absorption of arsenic from water and CCA-treated wood residue. Toxicol Sciences 79:287-295.

Wilson, R; Jones-Otazo, H; Petrovic, S; Mitchell, I; Bonvalot, Y; Williams, D; Richardson, GM. 2013. Revisiting Soil and Dust Ingestion Rates Based on Hand-to-Mouth Transfer. Human Ecol Risk Assess 19:158−188.

Yadrick MK, Kenney MA, Winterfelt EA. 1989. Iron, copper, and zinc status: Response to supplementation with zinc or zinc and iron in adult females. Am J Clin Nutr 49:145-150.

Tables

ARCADIS

Table 2.1
Summary of Available Soil Data for Metals
Probabilistic Risk Assessment
Parcel 30, Sahuarita, Arizona

Report Referenc	Sampling Period	Investigation Area	No. Locations	No. / Type Samples [1]	Sample Depths	Sampling Methods	Sieved?	Laboratory	Analysis and Analytical Method	
Hydrometrics (1999)	May 10, 1999	Wash and Property Boundary	5 Locations	10 Surface Soil	0.0-0.5 and 0.5-1.0 ft. bgs	Disposable plastic trowel		Del Mar Analytical Services, Tempe, AZ	As, Cd, Pb, Zn	EPA Method 6010 ICP-AES
		Mill Site/Gate Keepers House	11 Locations	22 Surface Soil	0.0-0.5 and 0.5-1.0 ft. bgs					
		Cap Characterization	5 Locations	10 Surface Soil	0.0-0.5 and 0.5-1.0 or 0.5-1.5 ft. bgs					
		Southern Tract	5 Locations	5 Subsurface Soil	0.5-1.0 ft. bgs					
Golder (2009)	October 28, 2008 - November 3, 2008	Presumed footprint of the historical tailing impoundment (Area 1)	20 boreholes in a rough grid	20 Composite Soil	0-5 ft. bgs	Split Spoon, CME-75HT truck-mounted hollow-stem auger drill rig.	All soil samples were sieved to <250µm prior to sample analysis.	SVL Analytical, Inc., Kellogg, ID	Metals (s.) via	EPA Method 6010 ICP-AES
				2 Composite Soil	5-10 ft. bgs					
				18 Composite Soil	5-15 ft. bgs					
				2 Composite Soil	10-15 ft. bgs					
				15 Composite Soil	15-20 ft. bgs				Fluoride via	EPA Method 300.0
				3 Composite Soil	15-25 ft. bgs					
				4 Composite Soil	20-25 ft. bgs				Mercury (s.) via	EPA Method 7471A CVAA
				2 Composite Soil	25-30 ft. bgs					
Clear Creek (2015)	June 2, 2014 - June 4, 2014	Impoundment Area (Area 1)	1 Borehole	154 Subsurface Soil	1 ft. sample intervals; maximum 8 ft. bgs	Direct Push Acrylic Liner		ALS Environmental Group USA Corp., Kelso, WA	As, Pb, Mn via	EPA Method 6020A ICP-MS
		Mill Site Area (Area 2)	10 Boreholes							
		Pole Area (Area 3)	11 Boreholes							
		North Area (Area 4)	31 Boreholes			Direct Push Acrylic Liner or Hand Auger				
Brown and Caldwell (2018)	May 8, 2018	Rail Berm (Areas 2-3)	9 Boreholes	59 Subsurface Soil	1-4 ft. sample intervals; maximum 10 ft. bgs	Direct Push Acrylic Liner		TestAmerica Laboratories, Inc., Phoenix, AZ	Metals via	EPA Method 6010C ICP-AES
									Mercury via	EPA Method 7471B CVAA

Notes

CVAA = cold-vapor atomic absorption.
EPA = United States Environmental Protection Agency.
ft. bgs = feet below ground surface.
ICP-AES = inductively coupled plasma-atomic emission spectroscopy.
ICP-MS = inductively coupled plasma-mass spectroscopy.

Table 2.2
Statistical Summary and Selection of Constituents of Concern:
Shallow Soil Areas 2, 3 and 4
Probabilistic Risk Assessment
Parcel 30, Sahuarita, Arizona

Constituent [a]	Frequency of Detection No. of Detects	/	No. of Samples	(%)	Reporting Limits Min (mg/kg)	-	Max (mg/kg)	Detected Concentrations Min (mg/kg)	-	Max (mg/kg)	Sample Identification of Maximum Concentration (Sample Date)	Mean Detected Concentration (mg/kg)	Residential Screening Level [b] (mg/kg)	Is Constituent a COC? [c] (YES/no)	Rationale
Arsenic	67	/	83	81	5.00E+00	-	5.00E+00	1.60E+00	-	9.11E+01	A2-36(6/2-4/2014)	7.97E+00	6.8E-01	**YES**	ASL
Barium	8	/	8	100	--	-	--	3.80E+01	-	5.60E+01	BH6-1(5/8/2018)	4.43E+01	1.5E+03	no	BSL*
Cadmium	25	/	31	83	4.90E-01	-	5.00E-01	8.00E-01	-	7.50E+01	M-1B(5/10/1999)	9.87E+00	7.1E-01	**YES**	ASL
Chromium	8	/	8	100	--	-	--	4.30E+00	-	5.90E+00	BH9-1(5/8/2018)	4.83E+00	1.2E+04	no	BSL*
Lead	83	/	83	100	--	-	--	6.90E+00	-	1.85E+04	A2-36(6/2-4/2014)	1.06E+03	4.0E+02	**YES**	ASL
Manganese	61	/	61	100	--	-	--	1.24E+02	-	4.92E+03	A4-07(6/2-4/2014)	6.41E+02	1.8E+02	**YES**	ASL
Mercury	0	/	8	0	5.70E-02	-	6.00E-02	--		--	--	--	2.3E+00	no	BSL*
Selenium	0	/	8	0	4.90E+00	-	5.00E+00	--		--	--	--	3.9E+01	no	BSL*
Silver	1	/	8	13	2.40E+00	-	2.50E+00	7.20E+00	-	7.20E+00	BH9-1(5/8/2018)	7.20E+00	3.9E+01	no	BSL*
Zinc	22	/	22	100	--	-	--	2.90E+01	-	1.40E+04	M-1B(5/10/1999)	1.71E+03	2.3E+03	**YES**	ASL

Notes:

[a] All detected constituents are presented.

[b] United States Environmental Protection Agency (USEPA) Regional Screening Level (RSL) for Resident Soil (November 2021). USEPA RSLs are concentrations associated with a cancer risk level of 1×10^{-6} or a non-cancer hazard quotient of 0.1 to account for cumulative risk from exposure to multiple constituents.

[c] Constituents detected at a maximum concentration above their screening level (ASL) are designated as COCs. Constituents with maximum detected concentrations below their screening level (BSL) are not designated as COCs. Constituents for which data are available for Areas 2 and 3 (but not for Area 4), are denoted with an asterisk (i.e., BSL*) and were evaluated further as non-COC metals as described in Section 6.

–: not available or not applicable.
%: percent.
COC: constituent of concern.
ft bgs: feet below ground surface.
max: maximum.
mg/kg: milligram(s) per kilogram.
min: minimum.
No.: number.
rSRL: residential Soil Remediation Level.
UCL: upper confidence limit of the arithmetic mean.

Table 2.3
Surface Soil (0-1 ft) Data Summary
Areas 2, 3 and 4
Probabilistic Risk Assessment
Parcel 30
Sahuarita, Arizona

Sample ID	USEPA Regional Screening Level		BH1-1	BH2-0-4	BH3-1	BH4-1	BH5-1	BH6-1	BH7-1	BH8-1	BH9-1	A2-31	A2-32	A2-33	A2-34	A2-35	A2-35b	A2-36	A2-45	A2-46	A2-47	A3-38	A3-39
Investigation			Brown Caldwell	Brown Caldwell	Brown Caldwell	Brown Caldwell	Brown Caldwell	Brown Caldwell	Brown Caldwell	Brown Caldwell	Brown Caldwell	Clear Creek	Clear Creek	Clear Creek	Clear Creek	Clear Creek	Clear Creek	Clear Creek	Clear Creek	Clear Creek	Clear Creek	Clear Creek	Clear Creek
Area			Area 2	Area 2	Area 2	Area 2	Area 2	Area 3	Area 3	Area 3	Area 2	Area 2	Area 2	Area 2	Area 2	Area 2	Area 2	Area 2	Area 2	Area 2	Area 2	Area 3	Area 3
Sample Date	Residential (mg/kg)	Industrial (mg/kg)	5/8/2018	5/8/2018	5/8/2018	5/8/2018	5/8/2018	5/8/2018	5/8/2018	5/8/2018	5/8/2018	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014
Sample Interval			0-1	0-4	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1
Arsenic	0.68	3.0	4.3	4.2	4	3.7	4.4	5.9	3.3	4.1	68	5.7	14.6	6.8	8.4	10	15	91.1	2.4	2.2	2.3	7.1	3.9
Barium	1,500	22,000	43	48	38	42	47	56	39	43	46												
Cadmium	0.71	10	<0.49	<0.50	<0.50	12	2.1	<0.50	<0.50	<0.50	43												
Chromium	12000	180000	4.3	5	4.4	4.6	4.9	5.5	4.4	4.6	5.9												
Lead	400	800	34	13	47	46	34	15	12	46	2900	1790	4460	2130	3980	1620	4820	18500	22.5	83.8	72.2	2350	20.9
Manganese	180	2,600	270	300	250	260	300	340	240	280	700	446	811	775	895	1220	1050	1740	186	213	213	2310	316
Mercury	2	35	<0.059	<0.059	<0.059	<0.058	<0.058	<0.059	<0.060	<0.058	<0.057												
Selenium	39	580	<4.9	<5.0	<5.0	<5.0	<4.9	<5.0	<5.0	<5.0	<5.0												
Silver	39	580	<2.5	<2.5	<2.5	<2.5	<2.4	<2.5	<2.5	<2.5	7.2												
Zinc	2,300	35,000																					

Notes:

Grey shading indicates the reported concentration exceeds the USEPA Residential Regional Screening Level.

Duplicate results are presented along with the parent concentration (e.g., [1.8[2.2]) however, only parent sample results are used in the risk assessment.

mg/kg - milligrams per kilogram.

Table 2.3
Surface Soil (0-1 ft) Data Summary
Areas 2, 3 and 4
Probabilistic Risk Assessment
Parcel 30
Sahuarita, Arizona

Sample ID	USEPA Regional Screening Level		A3-40	A3-41	A3-42	A3-43	A3-44	A3-48	A3-49	A3-50	A3-51	A4-01	A4-02	A4-03	A4-04	A4-05	A4-06	A4-07	A4-08	A4-09	A4-10	A4-11	A4-12	A4-13	A4-14	A4-15
Investigation Area			Clear Creek Area 3	Clear Creek Area 3	Clear Creek Area 3	Clear Creek Area 3	Clear Creek Area 3	Clear Creek Area 3	Clear Creek Area 3	Clear Creek Area 3	Clear Creek Area 3	Clear Creek Area 4	Clear Creek Area 4	Clear Creek Area 4	Clear Creek Area 4	Clear Creek Area 4	Clear Creek Area 4	Clear Creek Area 4	Clear Creek Area 4	Clear Creek Area 4	Clear Creek Area 4	Clear Creek Area 4	Clear Creek Area 4	Clear Creek Area 4	Clear Creek Area 4	Clear Creek Area 4
Sample Date	Residential (mg/kg)	Industrial (mg/kg)	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014	6/2-4/2014
Sample Interval			0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-2	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1
Arsenic	0.68	3.0	2.7	7.4	1.8[2.2]	5.8	2.6	8.8	7[6.4]	4.1	2.3[1.9]	1.6	2.1	1.9	2.9	4.8[3.6]	4.1	15	5.6	7.2	4.1	4.1[4.6]	5.3	4.2	2.9	4
Barium	1,500	22,000																								
Cadmium	0.71	10																								
Chromium	12000	180000																								
Lead	400	800	17.5	1740	14.2[15.3]	2590	8.9	189	83.7[80.1]	67.3	23.9[35.6]	27.7	75.6	23.8	15.3	206[169]	664	3940	26.4	610	21.8	59.1[57.1]	235	107	25.7	65
Manganese	180	2,600	238	2640	187[198]	2850	196	997	708[576]	315	255[180]	137	215	159	238	629[594]	967	4920	639	1430	450	381[375]	563	400	298	403
Mercury	2	35																								
Selenium	39	580																								
Silver	39	580																								
Zinc	2,300	35,000																								

Notes:

Grey shading indicates the reported concentration exceeds the USEPA Residential Regional Screening Level.

Duplicate results are presented along with the parent concentration (e.g., [1.8[2.2]) however, only parent sample results are used in the risk assessment.
mg/kg - milligrams per kilogram.

Table 2.3
Surface Soil (0-1 ft) Data Summary
Areas 2, 3 and 4
Probabilistic Risk Assessment
Parcel 30
Sahuarita, Arizona

Sample ID / Investigation / Area / Sample Date / Sample Interval	USEPA Regional Screening Level Residential (mg/kg)	USEPA Regional Screening Level Industrial (mg/kg)	A4-16 Clear Creek Area 4 6/2-4/2014 0-1	A4-17 Clear Creek Area 4 6/2-4/2014 0-1	A4-18 Clear Creek Area 4 6/2-4/2014 0-1	A4-18b Clear Creek Area 4 6/2-4/2014 0-1	A4-19 Clear Creek Area 4 6/2-4/2014 0-1	A4-20 Clear Creek Area 4 6/2-4/2014 0-1	A4-21 Clear Creek Area 4 6/2-4/2014 0-1	A4-22 Clear Creek Area 4 6/2-4/2014 0-1	A4-23 Clear Creek Area 4 6/2-4/2014 0-1	A4-24 Clear Creek Area 4 6/2-4/2014 0-1	A4-25 Clear Creek Area 4 6/2-4/2014 0-1	A4-26 Clear Creek Area 4 6/2-4/2014 0-1	A4-27 Clear Creek Area 4 6/2-4/2014 0-1	A4-28 Clear Creek Area 4 6/2-4/2014 0-1	A4-29 Clear Creek Area 4 6/2-4/2014 0-1	A4-30 Clear Creek Area 4 6/2-4/2014 0-1	M-1A Hydrometrics Area 2 5/10/1999 0-6 inches	M-1B Hydrometrics Area 2 5/10/1999 6-12 inches	M-2A Hydrometrics Area 2 5/10/1999 0-6 inches	M-2B Hydrometrics Area 2 5/10/1999 6-12 inches	M-3A Hydrometrics Area 2 5/10/1999 0-6 inches	M-3B Hydrometrics Area 2 5/10/1999 6-12 inches	M-4A Hydrometrics Area 2 5/10/1999 0-6 inches
Arsenic	0.68	3.0	5	5.2	4	6.8	4.6	5.3	3.4	3.8	3	2	3.7	3.8	5.1	6.2	1.7	2.2	<5.0	27	<5.0[<5.0]	12	<5.0	<5.0	<5.0
Barium	1,500	22,000																							
Cadmium	0.71	10																	1.9	75	1.3[1.8]	23	1.7	1.6	1.3
Chromium	12000	180000																							
Lead	400	800	13.5	13.9	164	399	82.4	70.6	18.6	131	22.2	6.9	10.2	11.4	110	16.2	12.6	18.2	68	14000	28[53]	3300	17	19	17
Manganese	180	2,600	382	477	480	872	367	351	278	326	258	124	350	354	252	559	140	194							
Mercury	2	35																							
Selenium	39	580																							
Silver	39	580																							
Zinc	2,300	35,000																	150	14000	83[160]	5500	66	55	44

Notes:

Grey shading indicates the reported concentration exceeds the USEPA Residential Regional Screening Level.

Duplicate results are presented along with the parent concentration (e.g., [1.8[2.2]) however, only parent sample results are used in the risk assessment.

mg/kg - milligrams per kilogram.

Table 2.3
Surface Soil (0-1 ft) Data Summary
Areas 2, 3 and 4
Probabilistic Risk Assessment
Parcel 30
Sahuarita, Arizona

Sample ID	USEPA Regional Screening Level		M-4B	M-5A	M-5B	B-1A	B-1B	B-2A	B-2B	P-1A	P-1B	P-2A	P-2B	P-3A	P-3B	D-1A	D-1B
Investigation			Hydrometrics	Hydrometrics	Hydrometrics	Hydrometrics	Hydrometrics	Hydrometrics	Hydrometrics	Hydrometrics	Hydrometrics	Hydrometrics	Hydrometrics	Hydrometrics	Hydrometrics	Hydrometrics	Hydrometrics
Area			Area 2	Area 2	Area 2	Area 4	Area 4	Area 4	Area 4	Area 3	Area 3	Area 3	Area 3	Area 3	Area 3	Area 4/wash	Area 4/wash
Sample Date	Residential (mg/kg)	Industrial (mg/kg)	5/10/1999	5/10/1999	5/10/1999	5/10/1999	5/10/1999	5/10/1999	5/10/1999	5/10/1999	5/10/1999	5/10/1999	5/10/1999	5/10/1999	5/10/1999	5/10/1999	5/10/1999
Sample Interval			6-12 inches	0-6 inches	6-12 inches	0-6 inches	6-12 inches	0-6 inches	6-12 inches	0-6 inches	6-12 inches	0-6 inches	6-12 inches	0-6 inches	6-12 inches	0-6 inches	6-12 inches
Arsenic	0.68	3.0	9.9	<5.0	20	<5.0[<5.0]	<5.0	<5.0	<5.0	5.8	10	<5.0	<5.0	<5.0[<5.0]	<5.0	<5.0	<5.0
Barium	1,500	22,000															
Cadmium	0.71	10	34	2.7	11	2.7[2.4]	1.3	3.2	1.5	6.6	7.1	2.9	3.3	2.7[3.3]	2.4	0.8	2
Chromium	12000	180000															
Lead	400	800	5600	220	7200	220[190]	28	240	41	760	470	270	360	290[400]	170	13	120
Manganese	180	2,600															
Mercury	2	35															
Selenium	39	580															
Silver	39	580															
Zinc	2,300	35,000	8200	390	2500	360[310]	63	470	91	1100	2200	560	660	490[690]	350	29	230

Notes:

Grey shading indicates the reported concentration exceeds the USEPA Residential Regional Screening Level.

Duplicate results are presented along with the parent concentration (e.g., [1.8[2.2]) however, only parent sample results are used in the risk assessment.
mg/kg - milligrams per kilogram.

Parameter	Abbreviation	Value or Distribution Type	Description	Reference
Exposure Frequency (d/y)	EF	100	Fixed value	Sahuarita Parks and Recreation (PRCS 2021)
Cancer Exposure Duration (y)	ED_c	Custom	Distribution from Table 16-108	USEPA 2011
Non-Cancer Exposure Duration ages 0 to <6 (y)	ED_{nc}	Custom	Distributions for ages 0 to 11, truncated at 6 years, from Table 3-38	ODEQ 1998
Soil Ingestion Rate ages 0 to <6 (mg/d)	IRs	Custom	Distributions for ages 3 to <6 years, Table 5-12	USEPA 2017 (subreference Ozkaynak et al. 2011)
Soil Ingestion Rate ages 6 to <12 (mg/d)	IRs	Custom	Distributions for ages 5 to 11 from Tables 5-14	USEPA 2017 (subreference Wilson et al. 2013)
Soil Ingestion Rate ages 12+ (mg/d)	IRs	Custom	Distributions for ages 12 to 70 from Tables 5-9 and 5-14	USEPA 2017 (subreference Wilson et al. 2013; Davis & Mirick 2006)
Fraction Ingested soil (unitless)	FI_s	1	Fixed value	All ingestion is assumed to be soil
Bioavailability of arsenic in soil (unitless)	RBA-As	Custom	Distribution from Table 3	USEPA 2012
Bioavailability of manganese in soil (unitless)	RBA-Mn	0.41	Fixed value	Sialelli et al. 2010
Bioavailability of cadmium in soil (unitless)	RBA-Cd	1	Fixed value	Conservative given lack of available data/studies
Bioavailability of zinc in soil (unitless)	RBA-Zn	1	Fixed value	Conservative given lack of available data/studies
Skin Surface Area ages 0 to <6 (cm^2)	SSA	Custom	Distribution for ages 0 to < 6 from Table 7-10, adjusted by fraction of whole body area comrised of the head, legs, feet, lower arms, and hands in Table 7-8	USEPA 2011
Skin Surface Area ages 6 to <12 (cm^2)	SSA	Custom	Distribution for ages 6 to <12 from Table 7-10, adjusted by fraction of whole body area comrised of the head, legs, feet, lower arms, and hands in Table 7-8	USEPA 2011
Skin Surface Area ages 12+ (cm^2)	SSA	Custom	Sum of distributions for head, forearms, hands, and lower legs from Table 7-12	USEPA 2011
Dermal absorption fraction of arsenic (unitless)	ABSd-As	Normal	Mean ± standard (0.5% ± 0.44%) deviation of dataset with highest absorption, lower end of distribution truncated at zero.	Lowney et al. 2007
Dermal absorption fraction of manganese (unitless)	ABSd-Mn	0.01	Fixed value	Ontario Ministry of the Environment (2011) cited by Neptune and Company, Inc (2012)
Dermal absorption fraction of cadmium (unitless)	ABSd-Cd	0.001	Fixed value	USEPA 2004
Dermal absorption fraction of zinc (unitless)	ABSd-Zn	0.01	Fixed value	Ontario Ministry of the Environment (2011) cited by Neptune and Company, Inc (2012)
Dermal Adherence Factor ages 0 to <6 (mg/cm^2)	AF	0.2	Fixed value	USEPA 2004
Dermal Adherence Factor ages 6+ (mg/cm^2)	AF	0.07	Fixed value	USEPA 2004
Body Weight ages 0 to <6 (kg)	BW	Custom	Distribution for ages 0 to < 6 developed using weighted averages of the seven age groups comprising age 0 to <6 years in Table 8-3	USEPA 2011
Body Weight ages 6 to <12 (kg)	BW	Custom	Distribution for ages 6 to < 11 from Table 8-3	USEPA 2011
Body Weight ages 12+ (kg)	BW	Custom	Distribution for ages 11 to < 70 developed using weighted averages of the seven age groups comprising age > 12 years in Table 8-3	USEPA 2011
Exposure Time (particulate), all ages	ET	Normal	Mean ± standard deviation (1.5 ± 0.5 hours) exposure time derived from 2021 survey of time spent at Sahuarita, AZ parks.	Sahuarita Department of Parks, Recreation, and Community Services. 2021. Park facility and use survey, March 2021 (https://sahuaritaaz.gov/995/Surveys)
Conversion Factor (kg/mg)	CF1	0.000001	Fixed value	--
Cancer Averaging Time (d)	AT_c	25,550	Fixed value	ADHS 2003; USEPA 2014
Non-Cancer Averaging Time (d)	ATnc	$ED_{nc} \times 365$	Fixed value	ADHS 2003; USEPA 2014
Particulate Emission Factor (m^3/kg)	PEF	1.396E+09	Fixed value	ADHS 2003
Event per day (event/d)	EV	1	Fixed value	USEPA 2004
Exposure Point Concentration, Arsenic	EPC, As	Normal	Distribution of EPC means (bootstrap sampling)	This report, Appendix A
Exposure Point Concentration, Manganese	EPC, Mn	Normal	Distribution of EPC means (bootstrap sampling)	This report, Appendix A
Exposure Point Concentration, Cadmium	EPC, Cd	Normal	Distribution of EPC means (bootstrap sampling)	This report, Appendix A
Exposure Point Concentration, Zinc	EPC, Zn	Normal	Distribution of EPC means (bootstrap sampling)	This report, Appendix A
Arsenic oral slope factor ($(mg/kg\text{-}d)^{-1}$)	SF_o	1.5E+00	Fixed value	USEPA 2021 (November 2021 RSL Table)
Arsenic gastrointestinal absorption (unitless)	ABSGI	1	Fixed value	USEPA 2004; USEPA 2021 (November 2021 RSL Table)
Arsenic dermal slope factor ($(mg/kg\text{-}d)^{-1}$)	SFderm	1.5E+00	Fixed value	USEPA 2004 (SF_o / ABS_{GI})
Arsenic inhalation unit risk factor ($(mg/m^3)^{-1}$)	IUR	4.3E+00	Fixed value	USEPA 2021 (November 2021 RSL Table)
Arsenic oral reference dose (mg/kg-d)	RfD_o	3.0E-04	Fixed value	USEPA 2021 (November 2021 RSL Table)
Arsenic dermal reference dose (mg/kg-d)	RfDderm	3.0E-04	Fixed value	USEPA 2004 ($RfD_o \times ABS_{GI}$)
Arsenic reference concentration (mg/m^3)	RfC	1.5E-05	Fixed value	USEPA 2021 (November 2021 RSL Table)

Parameter	Abbreviation	Value or Distribution Type	Description	Reference
Manganese oral slope factor $((mg/kg\text{-}d)^{-1})$	SF_o	N/A	Not a carcinogen	--
Manganese gastrointestinal absorption (unitless)	ABSGI	0.04	Fixed value	USEPA 2004; USEPA 2021 (November 2021 RSL Table)
Manganese dermal slope factor $((mg/kg\text{-}d)^{-1})$	SFderm	N/A	Not a carcinogen	--
Manganese inhalation unit risk factor $((mg/m^3)^{-1})$	IUR	N/A	Not a carcinogen	--
Manganese oral reference dose (mg/kg-d)	RfD_o	2.4E-02	Fixed value	USEPA 2021 (November 2021 RSL Table)
Manganese dermal reference dose (mg/kg-d)	RfDderm	9.6E-04	Fixed value	USEPA 2004 ($RfD_o \times ABS_{GI}$)
Manganese reference concentration (mg/m^3)	RfC	5.0E-05	Fixed value	USEPA 2021 (November 2021 RSL Table)
Cadmium oral slope factor $((mg/kg\text{-}d)^{-1})$	SF_o	N/A	No value available	--
Cadmium gastrointestinal absorption (unitless)	ABSGI	2.5E-02	Fixed value	USEPA 2004; USEPA 2021 (November 2021 RSL Table)
Cadmium dermal slope factor $((mg/kg\text{-}d)^{-1})$	SFderm	N/A	No value available	--
Cadmium inhalation unit risk factor $((mg/m^3)^{-1})$	IUR	1.8E+00	Fixed value	USEPA 2021 (November 2021 RSL Table)
Cadmium oral reference dose (mg/kg-d)	RfD_o	1.0E-04	Fixed value	USEPA 2021 (November 2021 RSL Table)
Cadmium dermal reference dose (mg/kg-d)	RfDderm	2.5E-06	Fixed value	USEPA 2004 (RfDo × ABSGI)
Cadmium reference concentration (mg/m^3)	RfC	1.0E-05	Fixed value	USEPA 2021 (November 2021 RSL Table)
Zinc oral slope factor $((mg/kg\text{-}d)^{-1})$	SF_o	N/A	Not a carcinogen	--
Zinc gastrointestinal absorption (unitless)	ABSGI	1.0E+00	Fixed value	USEPA 2004; USEPA 2021 (November 2021 RSL Table)
Zinc dermal slope factor $((mg/kg\text{-}d)^{-1})$	SFderm	N/A	Not a carcinogen	--
Zinc inhalation unit risk factor $((mg/m^3)^{-1})$	IUR	N/A	Not a carcinogen	--
Zinc oral reference dose (mg/kg-d)	RfD_o	3.0E-01	Fixed value	USEPA 2021 (November 2021 RSL Table)
Zinc dermal reference dose (mg/kg-d)	RfDderm	3.0E-01	Fixed value	USEPA 2004 (RfDo × ABSGI)
Zinc reference concentration (mg/m^3)	RfC	N/A	No value available	USEPA 2021 (November 2021 RSL Table)
95th Percentile Cumulative ELCR Estimate - Arsenic	**3.6E-07**			
Ingestion Pathway	3.3E-07			
Dermal Pathway	3.5E-08			
Inhalation Pathway	1.7E-10			
95th Percentile Cumulative HI Estimate - Manganese	**3.7E-02**			
Ingestion Pathway	1.4E-02			
Dermal Pathway	2.3E-02			
Inhalation Pathway	8.2E-05			
95th Percentile Cumulative HI Estimate - Arsenic	**9.8E-03**			
Ingestion Pathway	9.1E-03			
Dermal Pathway	7.0E-04			
Inhalation Pathway	2.6E-06			
95th Percentile ELCR Estimate - Cadmium	**1.4E-10**			
Inhalation Pathway	1.4E-10			
95th Percentile Cumulative HI Estimate - Cadmium	**1.8E-01**			
Ingestion Pathway	1.6E-01			
Dermal Pathway	1.9E-02			
Inhalation Pathway	8.0E-06			
95th Percentile Cumulative HI Estimate - Zinc	**1.5E-02**			
Ingestion Pathway	1.4E-02			
Dermal Pathway	4.6E-04			
95th Percentile Cumulative ELCR Estimate - Arsenic and Cadmium Combined	**3.6E-07**			
95th Percentile Cumulative HI Estimate - Manganese, Arsenic, Cadmium, and Zinc Combined	**2.4E-01**			

Notes:
ADEQ = Arizona Department of Environmental Quality.
ELCR = Excess lifetime cancer risk
HI = hazard index
ODEQ = Oregon Department of Environmental Quality.
USEPA = United States Environmental Protection Agency.
N/A or -- = not applicable.

Table 6.1
Summary of Tailings Data (Area 1) from 0 to 5 ft and Calculated Hazard Indices
Probabilistic Risk Assessment
Parcel 30
Sahuarita, Arizona

Sample ID Sample Date Sample Interval	Chronic Target System	USEPA Residential Regional Screening Level	P30-BH-001 1/1/2009 0-5	P30-BH-002 1/1/2009 0-5	P30-BH-003 1/1/2009 0-5	P30-BH-004 1/1/2009 0-5	P30-BH-005 1/1/2009 0-5	P30-BH-006 1/1/2009 0-5	P30-BH-007 1/1/2009 0-5	P30-BH-008 1/1/2009 0-5	P30-BH-009 1/1/2009 0-5	P30-BH-010 1/1/2009 0-5	P30-BH-011 1/1/2009 0-5	P30-BH-012 1/1/2009 0-5	P30-BH-013 1/1/2009 0-5	P30-BH-014 1/1/2009 0-5	P30-BH-015 1/1/2009 0-5	P30-BH-016 1/1/2009 0-5	P30-BH-017 1/1/2009 0-5	P30-BH-018 1/1/2009 0-5	P30-BH-019 1/1/2009 0-5	P30-BH-020 1/1/2009 0-5
Aluminum	Nervous	77,000	4170	4160	4970	3820	5660	3970	5090	3500	3250	3720	4250	3250	7330	4180	4320	5810	3670	3260	3270	3700
Antimony	Hematologic, Whole Body	31	<0.36	<0.36	0.94	<0.36	<0.36	0.38	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	<0.36	0.47	0.59	<0.36	<0.36	<0.36	<0.36
Arsenic	Cardiovascular, Dermal	0.68	17	20.3	19.7	61.2	34.5	17.2	21	20	16.3	15	22.2	17.3	78.8	18	17.2	16	18	16.4	42.4	14.6
Barium	Urinary	15,000	28.5	33.7	22	12.5	23.6	29.9	28.8	45.5	20.8	15.8	35.9	8.6	25.3	58.1	27.6	44.5	26.5	21.8	11.9	20.5
Beryllium	Gastrointestinal, Immune, Respiratory	160	0.63	0.7	0.66	0.59	0.81	0.64	0.65	0.6	0.6	0.6	0.72	0.79	6.3	0.65	0.67	0.79	0.61	0.62	0.79	0.65
Boron	Developmental	16,000	8.7	27	7.1	3.8	5.9	8.4	41.4	22.8	9.9	10.5	29	6.3	9.7	12.8	20.7	13.2	10.8	9.1	7.8	14.9
Cadmium	Urinary	7.1	15.3	26.5	13.9	66.9	19.5	34.2	35.6	33.5	39.9	10.6	34.6	11.7	35.7	18.6	20.1	23.4	25.8	25.8	19.4	18.5
Chromium	Respiratory	120,000	16.2	13.5	17.8	9.6	14.1	12.8	15.3	9.9	8.2	8.8	13.4	10.3	19.8	14.4	13.6	13.4	9.5	8.5	7.9	9
Cobalt	Endocrine	23	13.2	18.4	13.7	23.5	16.3	13.6	14.2	19.2	18.8	9.8	19.3	14.1	14.8	13	12.5	14.1	15.1	14.7	11.7	11.7
Copper	Gastrointestinal	3,100	1060	991	808	2130	921	1360	1330	1460	1760	654	1300	1050	1130	643	709	1050	1040	964	852	756
Fluoride	Dental	3,100	2.88	2.27	2.73	23	3.76	2.68	2.25	3.43	3.11	1.65	1	4.07	4.32	1.74	2.81	4.82	2.31	3.35	4.37	2.68
Lead	Nervous, Whole Body	400	4860	5260	4890	7080	4610	6110	5330	5380	8130	3530	6260	4630	3940	4400	3370	5270	4740	5050	5450	4150
Manganese	Nervous	1,800	8050	6420	9040	10700	13000	8560	6890	7320	9030	9390	8050	11400	7420	7400	6860	7860	6980	7690	10000	8180
Mercury	Nervous	23	0.028	0.055	0.035	0.17	0.073	0.07	0.06	0.1	0.087	0.047	0.072	0.037	0.052	0.063	0.06	0.055	0.12	0.065	0.053	0.047
Molybdenum	Urinary	390	31.4	37.4	34.8	31.7	26.5	43.3	38.9	31	27.1	24.5	43.3	48	39.6	40.1	30	30.3	30.2	34.3	23.7	27.4
Nickel	Respiratory/Whole Body	1,500	8.5	9	11.1	7.8	7.3	7.5	10.7	5.5	3	2.1	9.3	4.7	6.9	7.6	5.6	7.7	2.4	2.8	1.6	2.4
Selenium	Dermal, Hematologic, Nervous	390	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Silver	Dermal	390	10.2	11.1	9.2	18.6	10.1	15.9	11.8	12.4	12.6	7.6	13.1	7.5	10.6	8.3	7.5	10.1	10.5	10.6	7.5	7.8
Strontium	Musculoskeletal	47,000	70.5	61.3	63.7	34.1	51.8	65.3	62.5	49.2	46	66.5	62.3	72.2	63.2	63.8	56.3	56.3	49.2	50.8	46.9	53
Thallium	Nervous/Dermal/Respiratory	0.78	1.5	1.3	1.7	2.8	2.1	1.3	1	1.5	2.4	1.3	2	1.5	1.1	1.3	2	1.2	1.7	1.8	1.8	1.8
Tin	Gastrointestinal/ Urinary	47,000	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	1.3	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9
Vanadium	Dermal	390	12.8	13.6	16.4	17.9	23	12.9	14.9	10.5	9.5	10	14.5	11.5	17.4	17.9	12.1	17	10.7	9.6	9.6	9.9
Zinc	Hematologic	23,000	5540	8500	5250	17700	6620	13200	13500	8880	14400	3750	13400	4520	9540	6620	5360	9010	6580	6670	7020	6200

Table 6.1
Summary of Tailings Data (Area 1) from 0 to 5 ft and Calculated Hazard Indices
Probabilistic Risk Assessment
Parcel 30
Sahuarita, Arizona

ARCADIS

Sample ID	Chronic Target System	USEPA Residential Regional Screening Level	P30-BH-001	P30-BH-002	P30-BH-003	P30-BH-004	P30-BH-005	P30-BH-006	P30-BH-007	P30-BH-008	P30-BH-009	P30-BH-010	P30-BH-011	P30-BH-012	P30-BH-013	P30-BH-014	P30-BH-015	P30-BH-016	P30-BH-017	P30-BH-018	P30-BH-019	P30-BH-020
Sample Date			1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009	1/1/2009
Sample Interval			0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-5	0-5
												Residential HQ										
Aluminum	Nervous		0.054	0.054	0.065	0.050	0.074	0.052	0.066	0.045	0.042	0.048	0.055	0.042	0.095	0.054	0.056	0.075	0.048	0.042	0.042	0.048
Antimony	Hematologic, Whole Body		--	--	0.030	--	--	0.012	--	--	--	--	--	--	--	--	0.015	0.019	--	--	--	--
Arsenic	Cardiovascular, Dermal		25.000	29.853	28.971	90.000	50.735	25.294	30.882	29.412	23.971	22.059	32.647	25.441	115.882	26.471	25.294	23.529	26.471	24.118	62.353	21.471
Barium	Urinary		0.002	0.002	0.001	0.001	0.002	0.002	0.002	0.003	0.001	0.001	0.002	0.001	0.002	0.004	0.002	0.003	0.002	0.001	0.001	0.001
Beryllium	Gastrointestinal, Immune, Respiratory		0.004	0.004	0.004	0.004	0.005	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.039	0.004	0.004	0.005	0.004	0.004	0.005	0.004
Boron	Developmental		0.001	0.002	0.000	0.000	0.000	0.001	0.003	0.001	0.001	0.001	0.002	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.001
Cadmium	Urinary		2.155	3.732	1.958	9.423	2.746	4.817	5.014	4.718	5.620	1.493	4.873	1.648	5.028	2.620	2.831	3.296	3.634	3.634	2.732	2.606
Chromium	Respiratory		0.00014	0.00011	0.00015	0.00008	0.00012	0.00011	0.00013	0.00008	0.00007	0.00007	0.00011	0.00009	0.00017	0.00012	0.00011	0.00011	0.00008	0.00007	0.00007	0.00008
Cobalt	Endocrine		0.574	0.800	0.596	1.022	0.709	0.591	0.617	0.835	0.817	0.426	0.839	0.613	0.643	0.565	0.543	0.613	0.657	0.639	0.509	0.509
Copper	Gastrointestinal		0.342	0.320	0.261	0.687	0.297	0.439	0.429	0.471	0.568	0.211	0.419	0.339	0.365	0.207	0.229	0.339	0.335	0.311	0.275	0.244
Fluoride	Dental		0.001	0.001	0.001	0.007	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001
Lead	Nervous, Whole Body		12.150	13.150	12.225	17.700	11.525	15.275	13.325	13.450	20.325	8.825	15.650	11.575	9.850	11.000	8.425	13.175	11.850	12.625	13.625	10.375
Manganese	Nervous		4.472	3.567	5.022	5.944	7.222	4.756	3.828	4.067	5.017	5.217	4.472	6.333	4.122	4.111	3.811	4.367	3.878	4.272	5.556	4.544
Mercury	Nervous		0.001	0.002	0.002	0.007	0.003	0.003	0.003	0.004	0.004	0.002	0.003	0.002	0.002	0.003	0.003	0.002	0.005	0.003	0.002	0.002
Molybdenum	Urinary		0.081	0.096	0.089	0.081	0.068	0.111	0.100	0.079	0.069	0.063	0.111	0.123	0.102	0.103	0.077	0.078	0.077	0.088	0.061	0.070
Nickel	Respiratory/Whole Body		0.006	0.006	0.007	0.005	0.005	0.005	0.007	0.004	0.002	0.001	0.006	0.003	0.005	0.005	0.004	0.005	0.002	0.002	0.001	0.002
Selenium	Dermal, Hematologic, Nervous		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Silver	Dermal		0.026	0.028	0.024	0.048	0.026	0.041	0.030	0.032	0.032	0.019	0.034	0.019	0.027	0.021	0.019	0.026	0.027	0.027	0.019	0.020
Strontium	Musculoskeletal		0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Thallium	Nervous/Dermal/Respiratory		1.923	1.667	2.179	3.590	2.692	1.667	1.282	1.923	3.077	1.667	2.564	1.923	1.410	1.667	2.564	1.538	2.179	2.308	2.308	2.308
Tin	Gastrointestinal/ Urinary		--	--	--	--	--	--	--	--	--	--	--	0.000	--	--	--	--	--	--	--	--
Vanadium	Dermal		0.033	0.035	0.042	0.046	0.059	0.033	0.038	0.027	0.024	0.026	0.037	0.029	0.045	0.046	0.031	0.044	0.027	0.025	0.025	0.025
Zinc	Hematologic		0.241	0.370	0.228	0.770	0.288	0.574	0.587	0.386	0.626	0.163	0.583	0.197	0.415	0.288	0.233	0.392	0.286	0.290	0.305	0.270
												System HI										
		Nervous	**19**	**18**	**19**	**27**	**22**	**22**	**19**	**19**	**28**	**16**	**23**	**20**	**15**	**17**	**15**	**19**	**18**	**19**	**22**	**17**
		Hematologic	0.2	0.4	0.3	0.8	0.3	0.6	0.6	0.4	0.6	0.2	0.6	0.2	0.4	0.3	0.2	0.4	0.3	0.3	0.3	0.3
		Whole Body	**12**	**13**	**12**	**18**	**12**	**15**	**13**	**13**	**20**	**9**	**16**	**12**	**10**	**11**	**8**	**13**	**12**	**13**	**14**	**10**
		Gastrointestinal	0.3	0.3	0.3	0.7	0.3	0.4	0.4	0.5	0.6	0.2	0.4	0.3	0.4	0.2	0.2	0.3	0.3	0.3	0.3	0.2
		Immune	0.004	0.004	0.004	0.004	0.005	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.04	0.004	0.004	0.005	0.004	0.004	0.005	0.004
		Respiratory	**2**	**2**	**2**	**4**	**3**	**2**	1	**2**	**3**	**2**	**3**	**2**	1	**2**	**3**	**2**	**2**	**2**	**2**	**2**
		Urinary	**2**	**4**	**2**	**10**	**3**	**5**	**5**	**5**	**6**	**2**	**5**	**2**	**5**	**3**	**3**	**3**	**4**	**4**	**3**	**3**
		Dermal	**27**	**32**	**31**	**94**	**54**	**27**	**32**	**31**	**27**	**24**	**35**	**27**	**117**	**28**	**28**	**25**	**29**	**26**	**65**	**24**
		Musculoskeletal	0.002	0.001	0.001	0.0007	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		Dental	0.0009	0.0007	0.0009	0.007	0.001	0.0009	0.0007	0.0011	0.0010	0.0005	0.0003	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001
		Endocrine	0.6	0.8	0.6	1	0.7	0.6	0.6	0.8	0.8	0.4	0.8	0.6	0.6	0.6	0.5	0.6	0.7	0.6	0.5	0.5
		Cardiovascular	**25**	**30**	**29**	**90**	**51**	**25**	**31**	**29**	**24**	**22**	**33**	**25**	**116**	**26**	**25**	**24**	**26**	**24**	**62**	**21**
		Developmental	0.001	0.002	0.0004	0.0002	0.0004	0.001	0.003	0.001	0.0006	0.0007	0.002	0.0004	0.0006	0.0008	0.001	0.0008	0.0007	0.0006	0.0005	0.0009

Notes:

Grey shading indicates the reported concentration exceeds the USEPA Residential Regional Screening Level (RSL) or an HI exceeds 1.

[a] HIs were calculated using Golder (2009) 0-5 ft data collected from Area 1. This was the only data set that included a full list of TAL metals plus molybdenum and tin. Area 1 is the tailings impoundment and concentrations are considered conservative for Areas 2, 3 and 4.

mg/kg - milligrams per kilogram.

HQ - Hazard Quotient (HQ = Reported concentration / Residential RSL)

HI - Hazard Index (HI = Σ HQs with common target system/organ).

Table 6.2
Comparison of Detected Concentrations in Areas 2, 3, and 4 and Area 1
Probabilistic Risk Assessment
Parcel 30, Sahuarita, Arizona

Constituent	Areas 2, 3,and 4 (Shallow Soil)				Area 1 (Tailings 0-5 ft bgs)			
	Minimum (mg/kg)	-	Maximum (mg/kg)	Mean (mg/kg)	Minimum (mg/kg)	-	Maximum (mg/kg)	Mean (mg/kg)
Aluminum	--		--		3,250	-	7,330	4,268
Antimony	--		--		0.38	-	0.94	0.60
Arsenic	1.6	-	91	7.97	14.6	-	78.8	25.16
Barium	38.0	-	56	44.3	8.60	-	58.1	27.09
Beryllium	--		--	–	0.59	-	6.3	0.95
Boron	--		--	–	3.8	-	41.4	13.99
Cadmium	0.80	-	75	9.87	10.6	-	66.9	26.48
Chromium	4.30	-	5.9	4.83	7.9	-	19.8	12.30
Cobalt	--		--	–	9.8	-	23.5	15.09
Copper	--		--		643	-	2,130	1,098
Fluoride	--		--		1	-	23	3.96
Lead	6.9	-	18,500	1,060	3,370	-	8,130	5,122
Manganese	124	-	4920	641	6,420	-	13,000	8,512
Mercury	ND	-	ND		0.03	-	0.17	0.07
Molybdenum	--		--		23.7	-	48.0	33.7
Nickel	--		--		1.60	-	11.10	6.18
Selenium	ND	-	ND		ND	-	ND	ND
Silver	7.2	-	7.2	7.2	7.5	-	18.6	10.7
Strontium	--		--		34.1	-	72.2	57.2
Thallium	--		--		1.0	-	2.8	1.7
Tin	--		--		1.3	-	1.3	1.3
Vanadium	--		--		9.5	-	23	13.6
Zinc	29	-	14,000	1,710	3,750	-	17,700	8,613

Notes:

– not available or not applicable.
ft bg - feet below ground surface.
mg/kg - milligram(s) per kilogram.
ND - constituent was not detected.

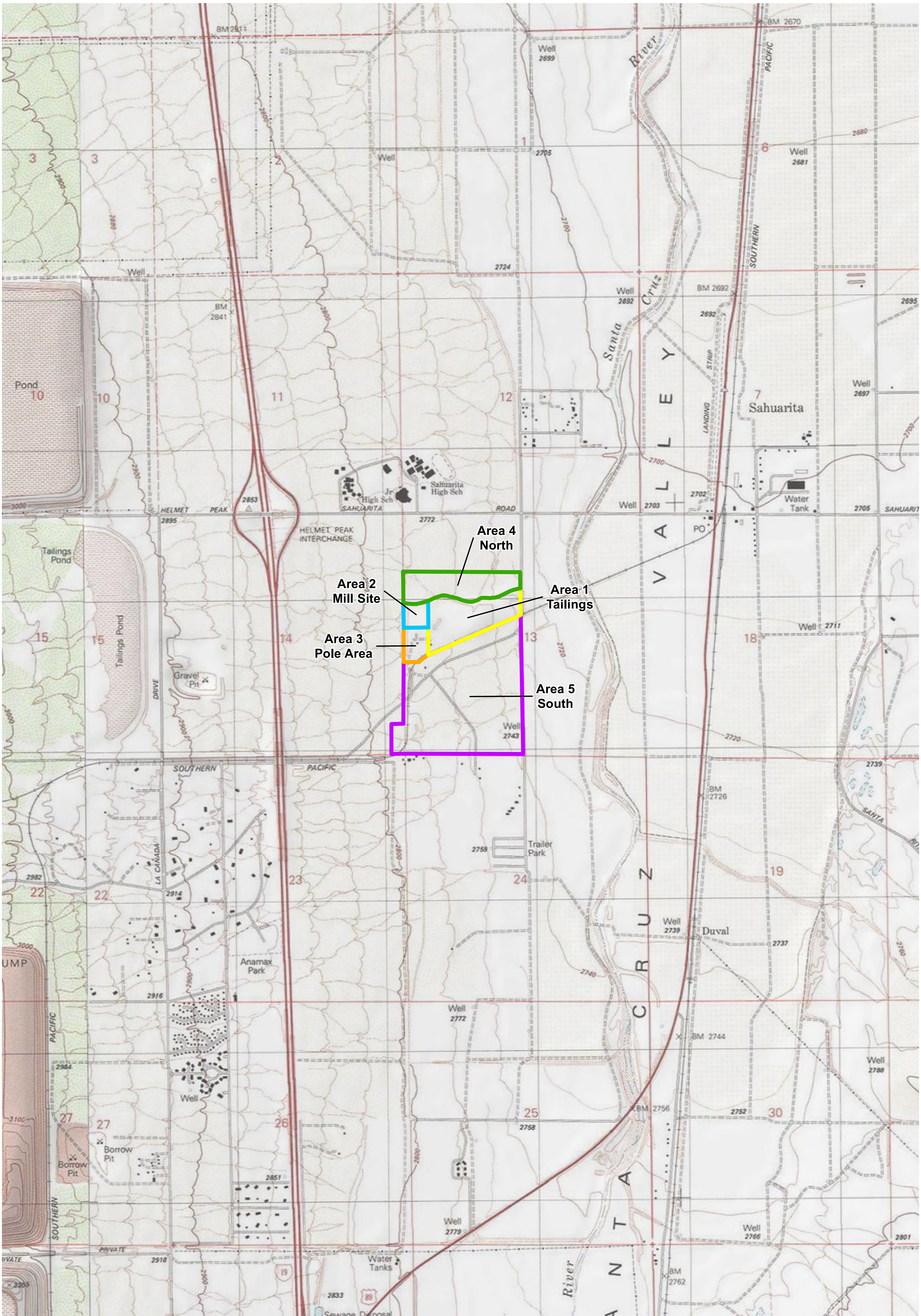
Table 6.3
Projected Concentrations and Hazard Indices for A2-36
Probabilistic Risk Assessment
Parcel 30, Sahuarita, Arizona

Sample ID Sample Date Sample Interval	Projection Ratios (Metal/Lead) [a]	Chronic Target System	USEPA Residential Regional Screening Level (RSL)	Projected Concentration for A2-36 (0-1 ft bgs)	Projected HQ for A2-36 (0-1 ft bgs)
Aluminum	1.0080	Nervous	77,000	18648	0.242
Antimony	0.00019	Hematologic, Whole Body	31	3.52	0.113
Barium	0.00655	Urinary	15,000	121.2	0.008
Beryllium	0.000529	Gastrointestinal, Immune, Respiratory	160	9.79	0.061
Boron	0.00357	Developmental	16,000	66.05	0.004
Chromium	0.00292	Respiratory	120,000	54.0	0.0005
Cobalt	0.00317	Endocrine	23	58.65	2.550
Copper	0.228	Gastrointestinal	3,100	4218	1.361
Fluoride	0.000978	Dental	3,100	18.09	0.006
Lead	--	--	--	**18500**	**--**
Mercury	0.0000151	Nervous	23	0.280	0.012
Molybdenum	0.00752	Urinary	390	139.1	0.357
Nickel	0.00146	Respiratory/Whole Body	1,500	27.01	0.018
Selenium	NA	Dermal, Hematologic, Nervous	390	ND	--
Silver	0.00222	Dermal	390	41.07	0.105
Strontium	0.0132	Musculoskeletal	47,000	244.2	0.005
Thallium	0.000366	Nervous/Dermal/Respiratory	0.78	6.77	8.681
Tin	0.000281	Gastrointestinal/ Urinary	47,000	5.19	0.0001
Vanadium	0.0031	Dermal	390	57.9	0.148
					System HI
				Nervous	**9**
				Hematologic	0.1
				Whole Body	0.1
				Gastrointestinal	1
				Immune	0.06
				Respiratory	**9**
				Urinary	0.4
				Dermal	**9**
				Musculoskeletal	0.005
				Dental	0.006
				Endocrine	**3**
				Developmental	0.004

Notes:
mg/kg - milligrams per kilogram.
ND - projected as non-detected based on all historical data.
HQ - Hazard Quotient
HI - Hazard Index

[a] Ratios were calculated using Golder (2009) 0-5 ft data collected from Area 1. This was the only data set that included a full list of TAL metals plus molybdenum and tin. The 95% Upper Confidence Limit of the ratios calculated for each detected metal concentration to lead concentration was used to project concentrations for sample A2-36 where the maximum lead concentration for the site was reported but the sample was only analyzed for a focused analyte list. Orange cells are projected data based on ratios using Golder 2009 data from Area 1 and sample specific lead concentration (e.g., projected aluminum concentration = 1.008 x 18,500 mg/kg) or projected HQs (projected concentration ÷ residential RSL).

Figures



LEGEND:

- Area 1 Tailings
- Area 2 Mill Site
- Area 3 Pole Area
- Area 4 North
- Area 5 South

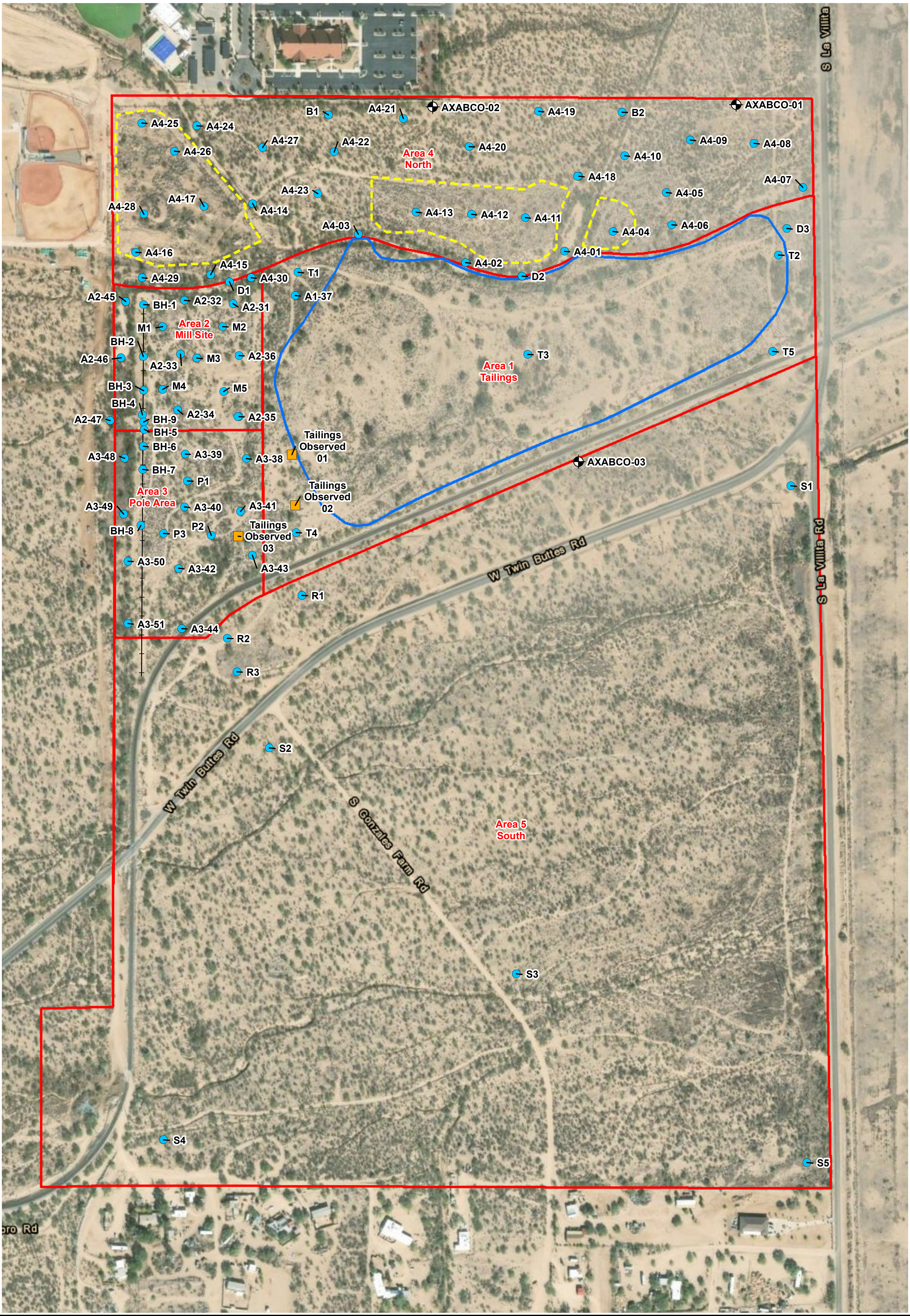
0 2,000 4,000
SCALE IN FEET

PARCEL 30
SUAHARITA, AZ 85629

SITE LOCATION MAP

ARCADIS

FIGURE
1



LEGEND:

- Soil Sample Location
- Monitoring Well
- Observation
- Abandoned Railroad Spur
- Historic Cover Soil Borrow Locations
- Tailing Extent
- Parcel 30 Project Area Boundary

0 330 660

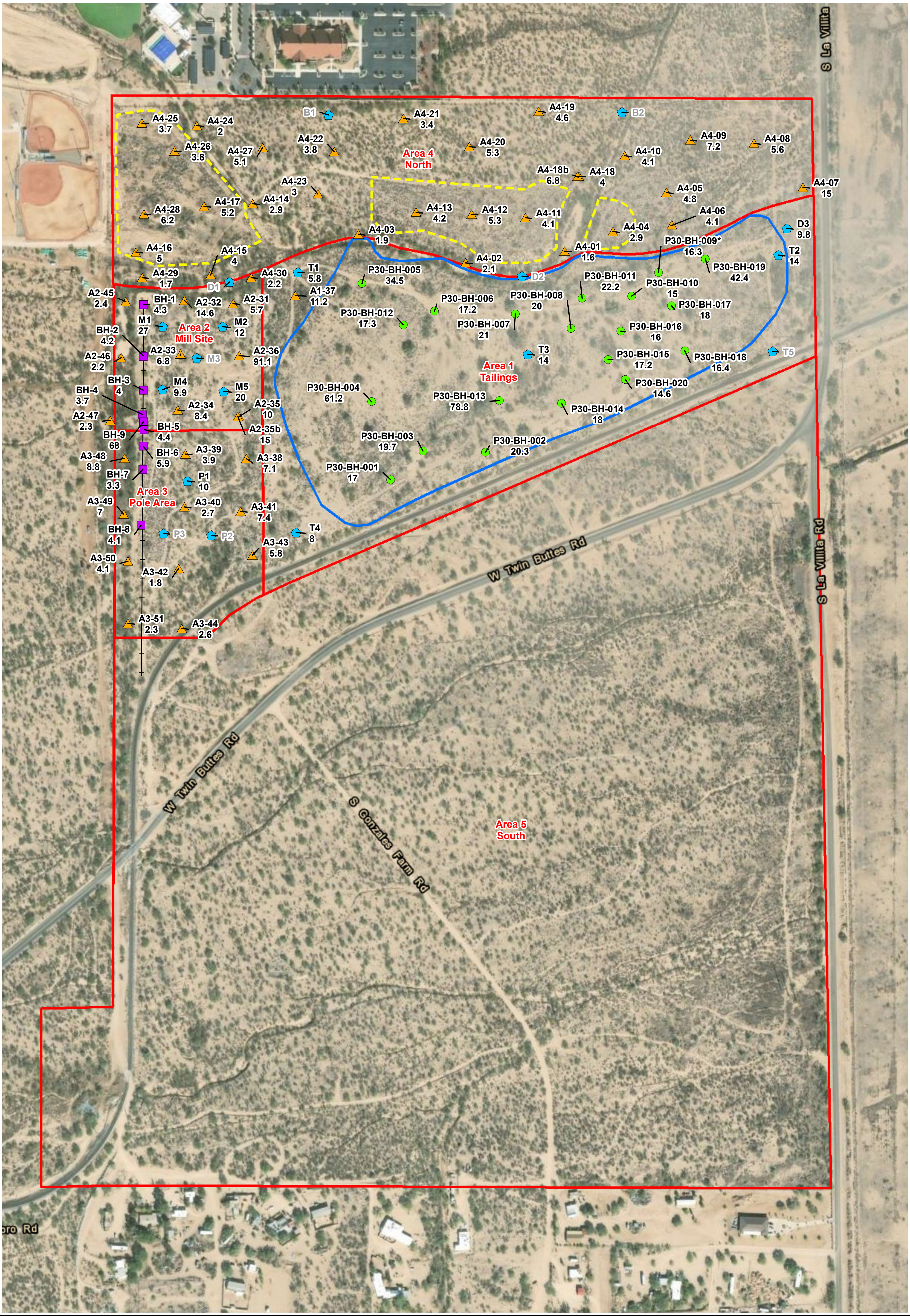
SCALE IN FEET

PARCEL 30
SUAHARITA, AZ 85629

HISTORICAL SAMPLE LOCATIONS

ARCADIS

FIGURE
2



LEGEND:

- Golder Associates, Inc. (2009)
- Brown and Caldwell (2018)
- Clear Creek Associates (2015)
- Hydrometrics, Inc. (1999)
- Abandoned Railroad Spur
- Historic Cover Soil Borrow Locations
- Tailing Extent
- Parcel 30 Project Area Boundary

Note:
1. Concentrations are in milligrams per kilogram

0 330 660
SCALE IN FEET

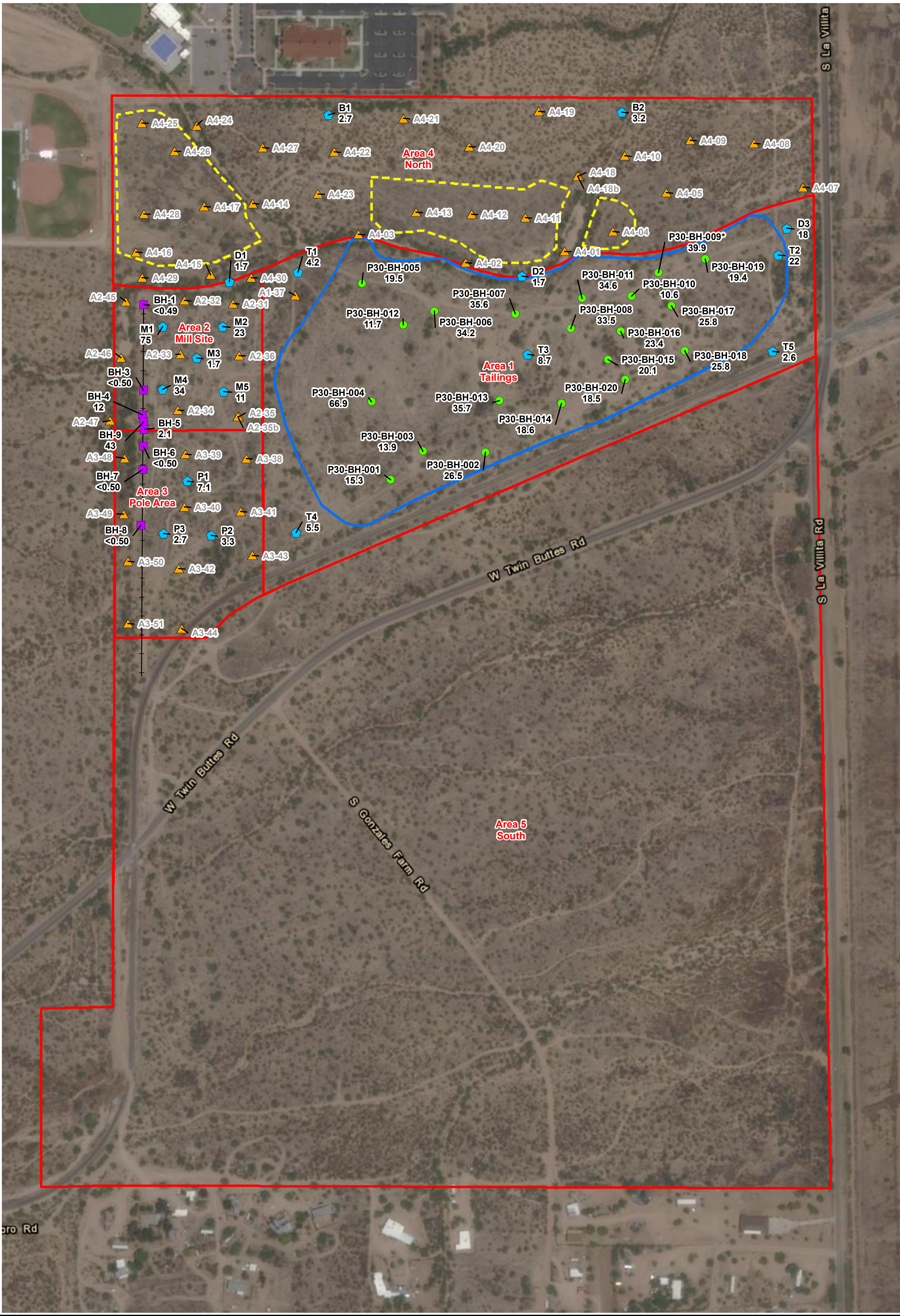
PARCEL 30
SUAHARITA, AZ 85629

ARSENIC CONCENTRATIONS IN SOIL

ARCADIS

FIGURE
3

T:_ENV\PHASE_I_ESAS\PROJECT_ANACONDA\PARCEL_30_AREA_5\GIS\ARCMAP_MXD\PHASE_I_ESA_REPORT\FIG_2_CADMIUM_CONCENTRATIONS.MXD DATE: 1/5/2022 12:14:52 PM



LEGEND:

- Golder Associates, Inc. (2009)
- Brown and Caldwell (2018)
- Clear Creek Associates (2015)
- Hydrometrics, Inc. (1999)
- Abandoned Railroad Spur
- Historic Cover Soil Borrow Locations
- Tailing Extent
- Parcel 30 Project Area Boundary

Note:
1. Concentrations are in milligrams per kilogram

0 330 660
SCALE IN FEET

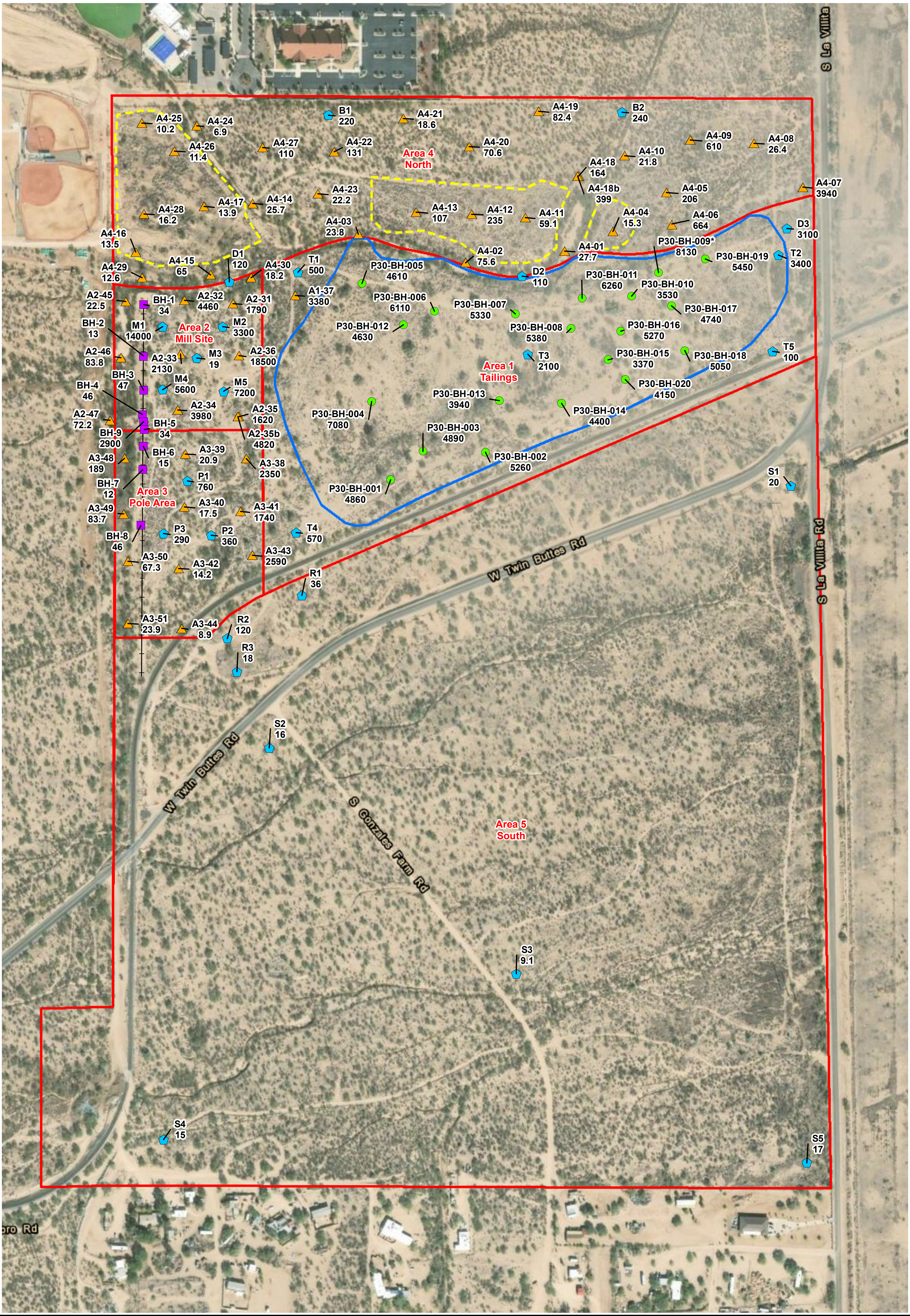
PARCEL 30
SUAHARITA, AZ 85629

CADMIUM CONCENTRATIONS IN SOIL

ARCADIS

FIGURE 4

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



LEGEND:

- Golder Associates, Inc. (2009)
- Brown and Caldwell (2018)
- Clear Creek Associates (2015)
- Hydrometrics, Inc. (1999)
- Abandoned Railroad Spur
- Historic Cover Soil Borrow Locations
- Tailing Extent
- Parcel 30 Project Area Boundary

Note:
1. Concentrations are in milligrams per kilogram

0 330 660
SCALE IN FEET

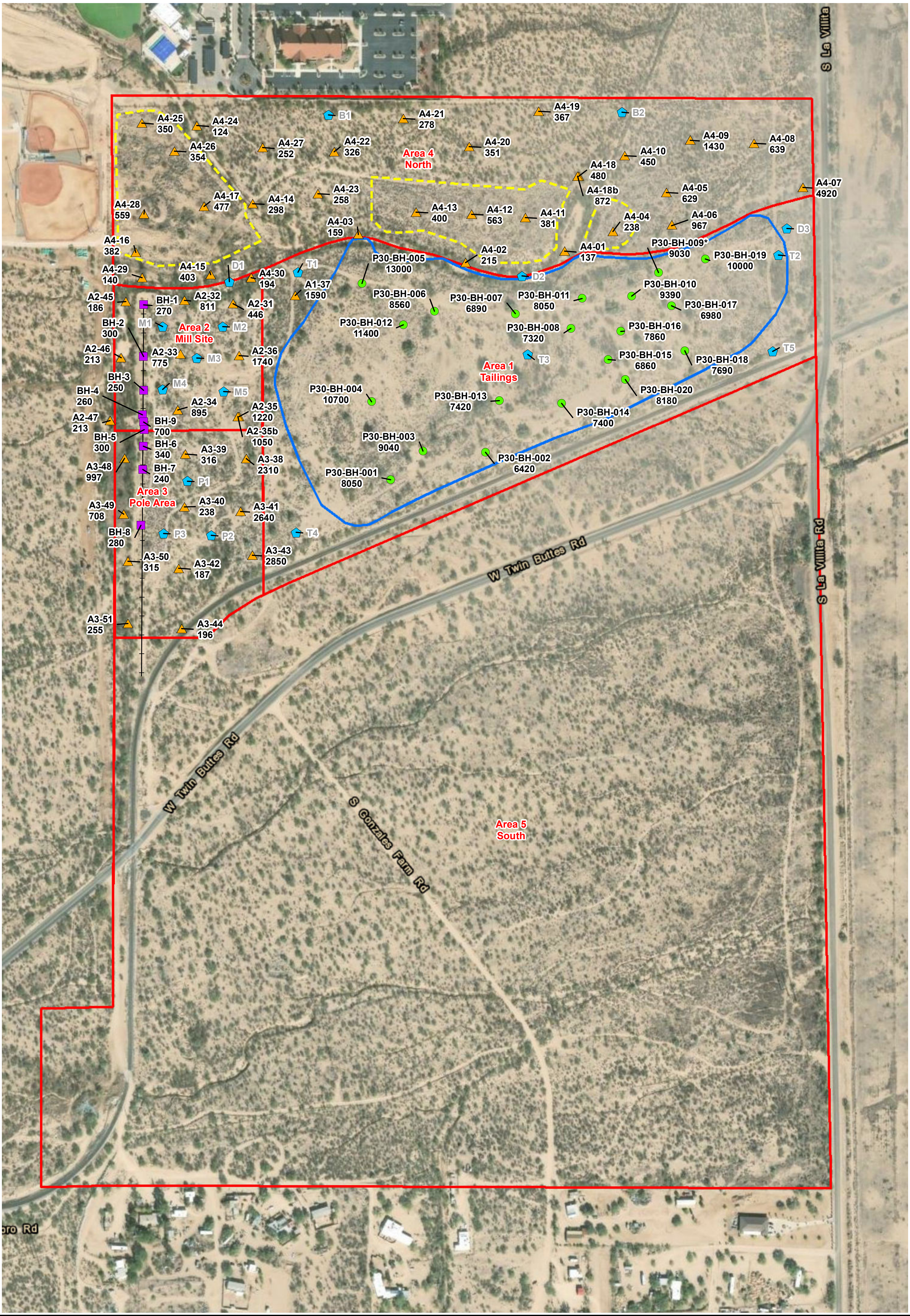
PARCEL 30
SUAHARITA, AZ 85629

LEAD CONCENTRATIONS IN SOIL

ARCADIS

FIGURE
5

Service Layer Credits: Esri, HERE, Garmin, (c) OpenStreetMap contributors



LEGEND:

- Golder Associates, Inc.
- Brown and Caldwell (2018)
- Clear Creek Associates
- Hydrometrics, Inc. (1999)
- Abandoned Railroad Spur
- Historic Cover Soil Borrow
- Tailing Extent
- Parcel 30 Project Area

Note:
1. Concentrations are in milligrams per kilogram

0 330 660
SCALE IN FEET

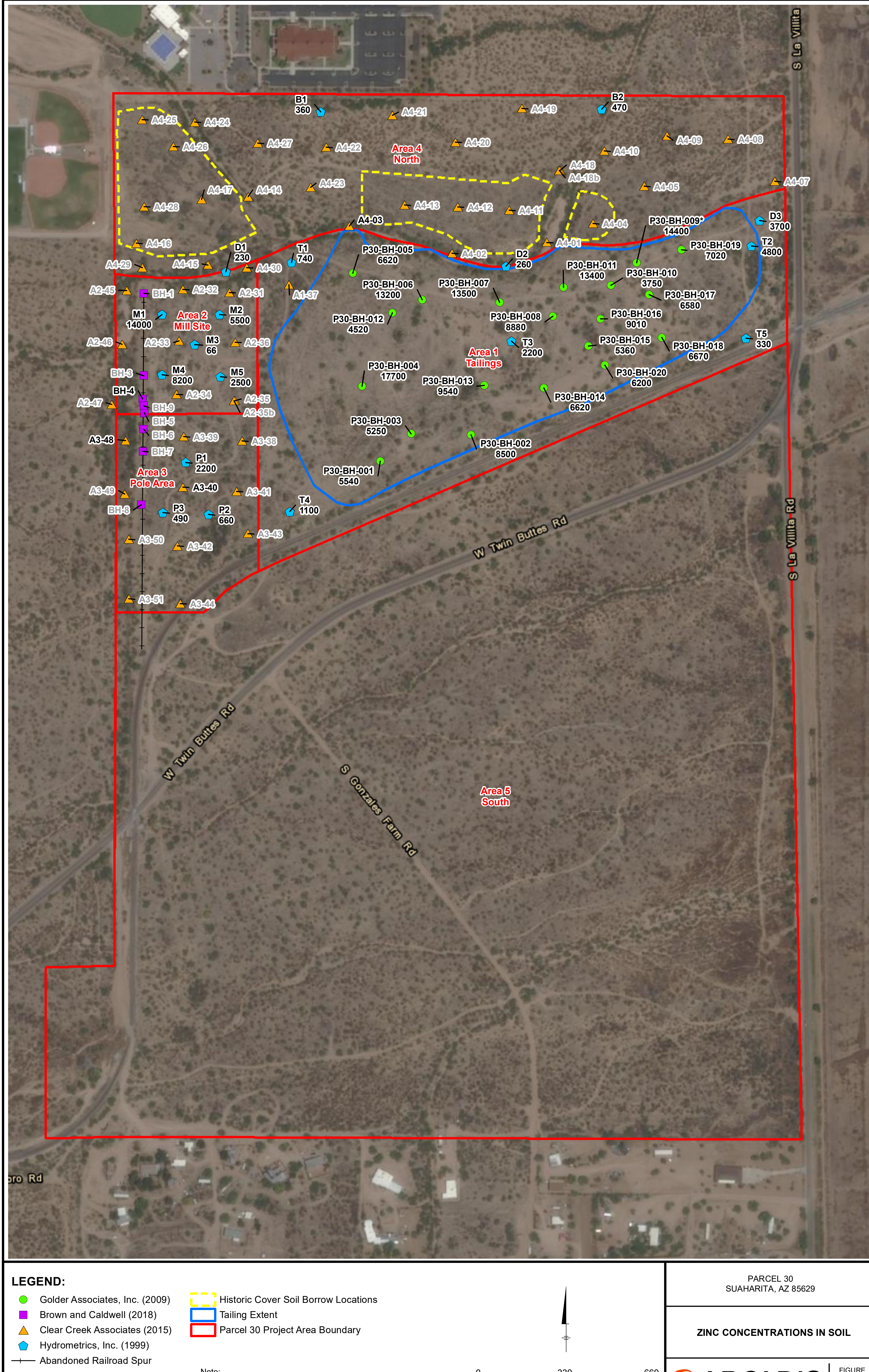
PARCEL 30
SUAHARITA, AZ 85629

MANGANESE CONCENTRATIONS IN SOIL

ARCADIS

FIGURE 6

T:_ENV\PHASE_I_ESAS\PROJECT_ANACONDA\PARCEL_30_AREA_5\GIS\ARCMAP_MXD\PHASE_I_ESA_REPORT\FIG_5_ZINC_CONCENTRATIONS.MXD DATE: 1/5/2022 1:04:45 PM



LEGEND:

- Golder Associates, Inc. (2009)
- Brown and Caldwell (2018)
- Clear Creek Associates (2015)
- Hydrometrics, Inc. (1999)
- Abandoned Railroad Spur
- Historic Cover Soil Borrow Locations
- Tailing Extent
- Parcel 30 Project Area Boundary

Note:
1. Concentrations are in milligrams per kilogram

0 330 660
SCALE IN FEET

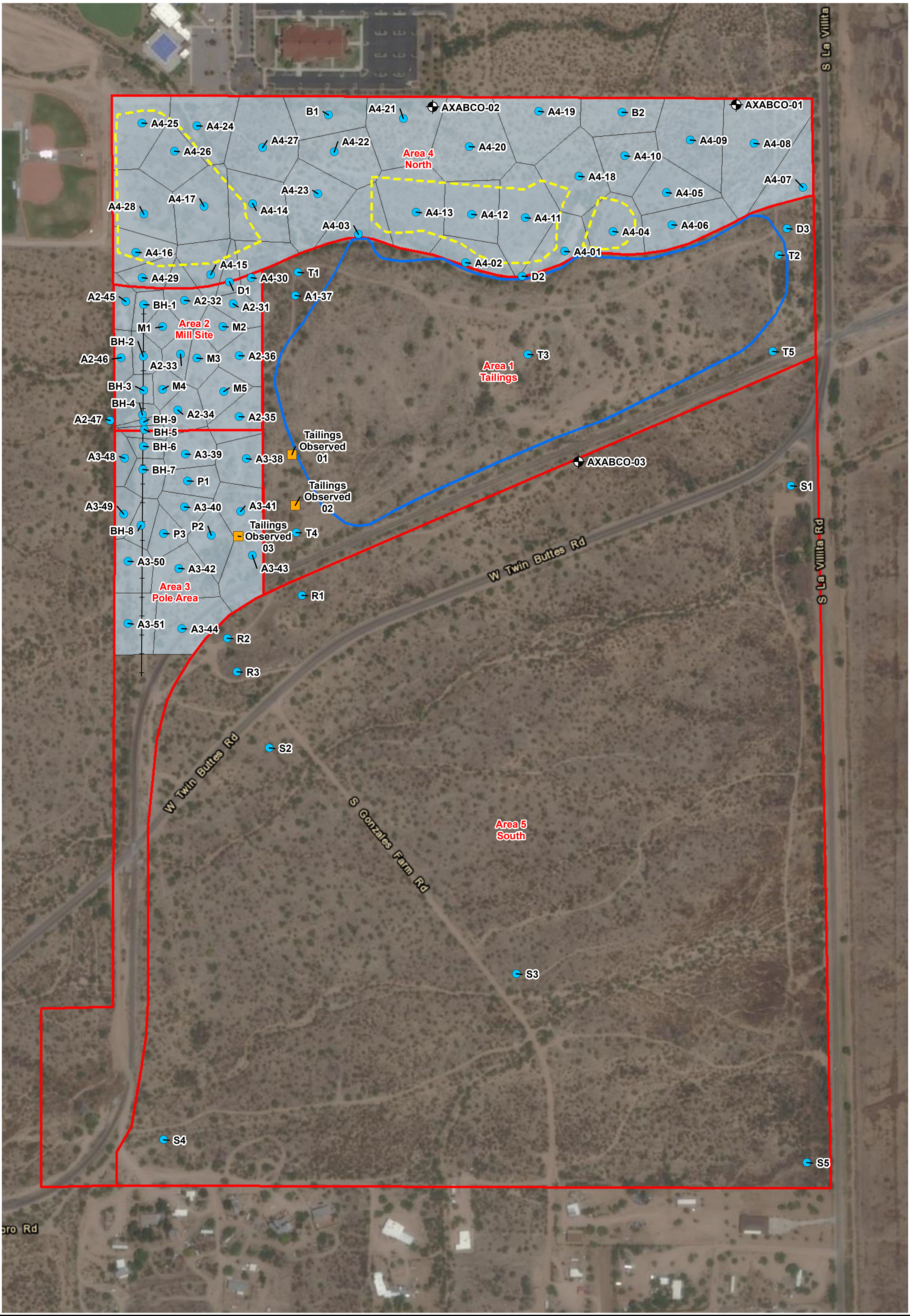
PARCEL 30
SUAHARITA, AZ 85629

ZINC CONCENTRATIONS IN SOIL

ARCADIS

FIGURE
7

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



LEGEND:

- Soil Sample Location
- Monitoring Well
- Observation
- Abandoned Railroad Spur
- Historic Cover Soil Borrow Locations
- Tailing Extent
- Parcel 30 Project Area Boundary
- Thiessen Polygons

0 330 660

SCALE IN FEET

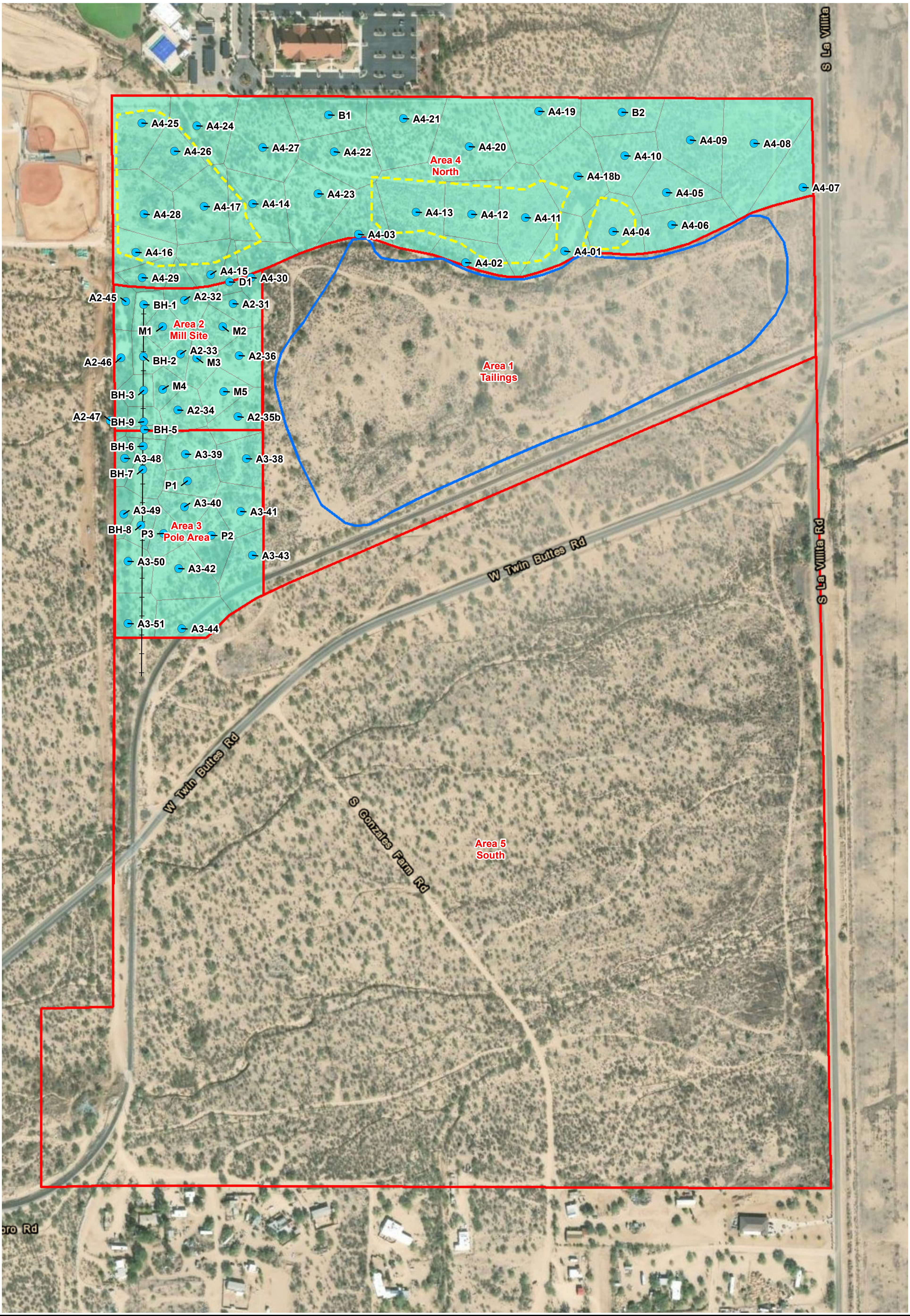
PARCEL 30
SUAHARITA, AZ 85629

ARSENIC THIESSEN POLYGONS

ARCADIS

FIGURE 8

T:_ENV\PHASE_I_ESAS\PROJECT_ANACONDA\PARCEL_30_AREA_5\GIS\ARCMAP_MXD\PHASE_I_ESA_REPORT\FIG_X_THIESSEN_PB.MXD DATE: 5/10/2022 12:21:11 PM



LEGEND:

- Soil Sample Location
- Abandoned Railroad Spur
- Historic Cover Soil Borrow Locations
- Tailing Extent
- Parcel 30 Project Area Boundary
- Thiessen Polygons

0 330 660
SCALE IN FEET

PARCEL 30
SUAHARITA, AZ 85629

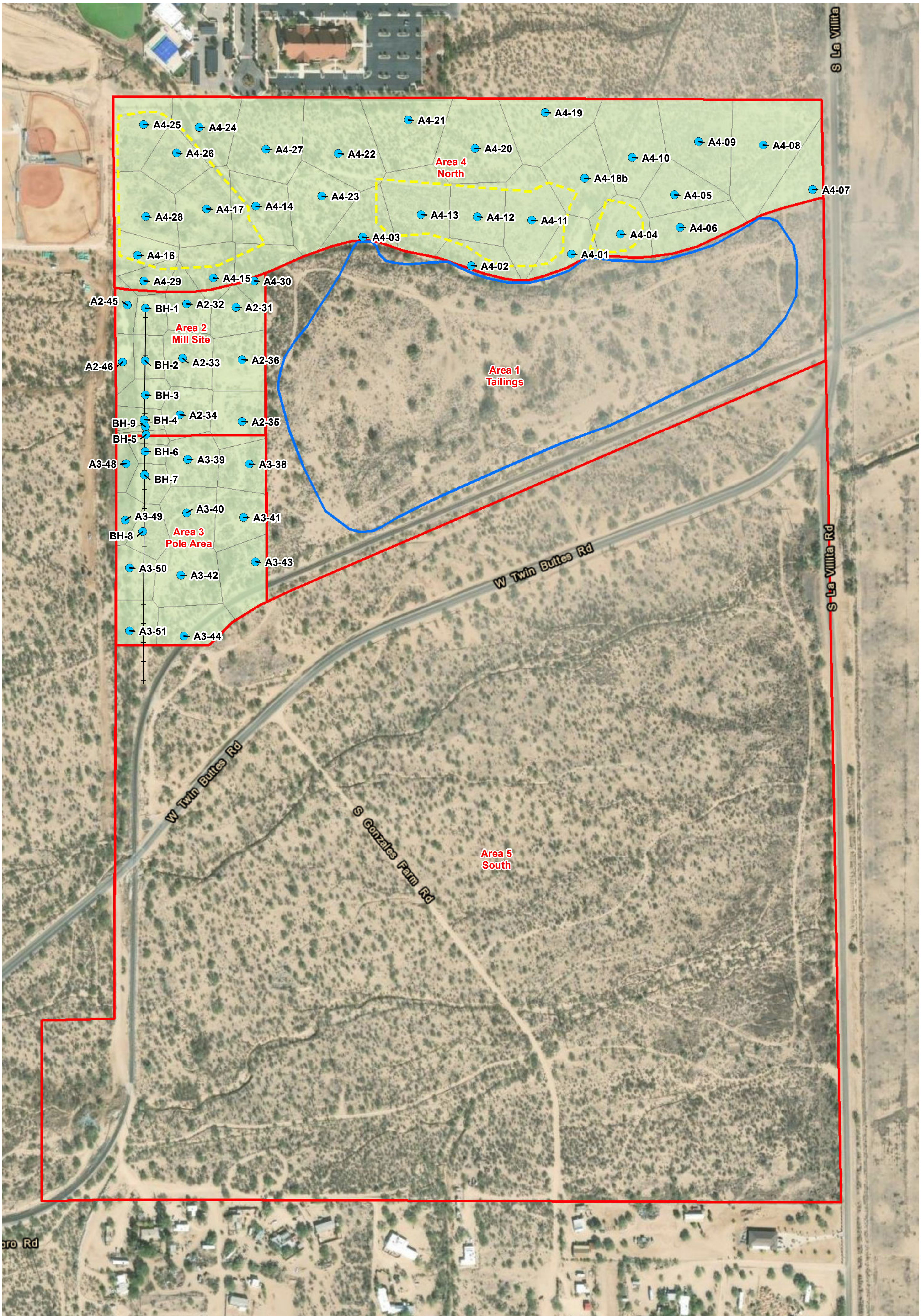
LEAD THIESSEN POLYGONS

ARCADIS

FIGURE
9

Service Layer Credits: Esri, HERE, Garmin, (c) OpenStreetMap contributors

T:_ENV\PHASE_I_ESAS\PROJECT_ANACONDA\PARCEL_30_AREA_5\GIS\ARCMAP_MXD\PHASE_I_ESA_REPORT\FIG_X_THIESSEN_MN.MXD DATE: 5/3/2022 1:43:36 PM



LEGEND:

- Soil Sample Location
- Abandoned Railroad Spur
- Historic Cover Soil Borrow Locations
- Tailing Extent
- Parcel 30 Project Area Boundary
- Thiessen Polygons

0 330 660

SCALE IN FEET

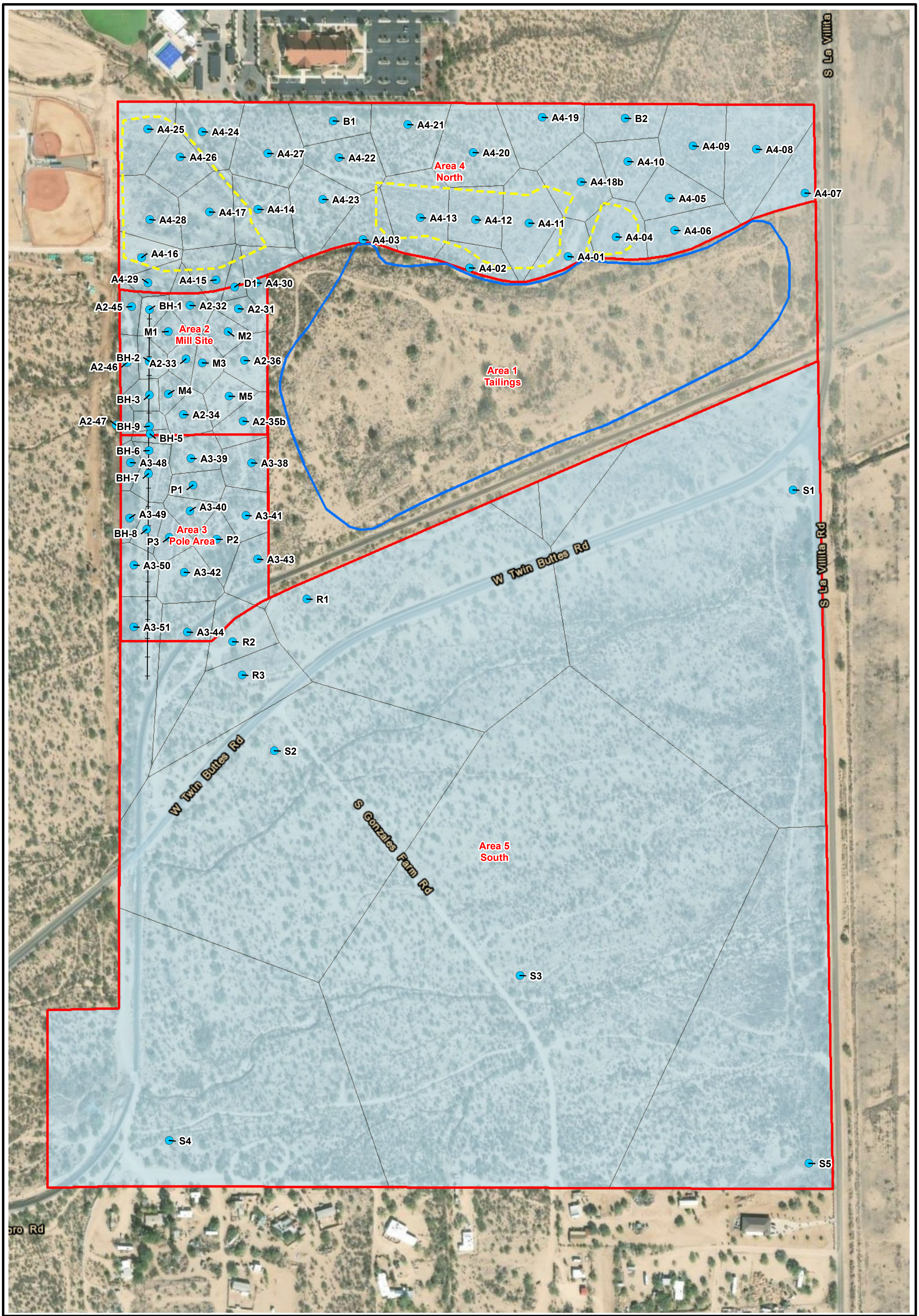
PARCEL 30
SUAHARITA, AZ 85629

MANGANESE THIESSEN POLYGONS

ARCADIS

FIGURE
10

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



LEGEND:

- Soil Sample Location
- Abandoned Railroad Spur
- Historic Cover Soil Borrow Locations
- Tailing Extent
- Parcel 30 Project Area
- Thiessen Polygons

0 330 660

SCALE IN FEET

PARCEL 30
SUAHARITA, AZ 85629

UNCERTAINTY ANALYSIS FOR LEAD

ARCADIS

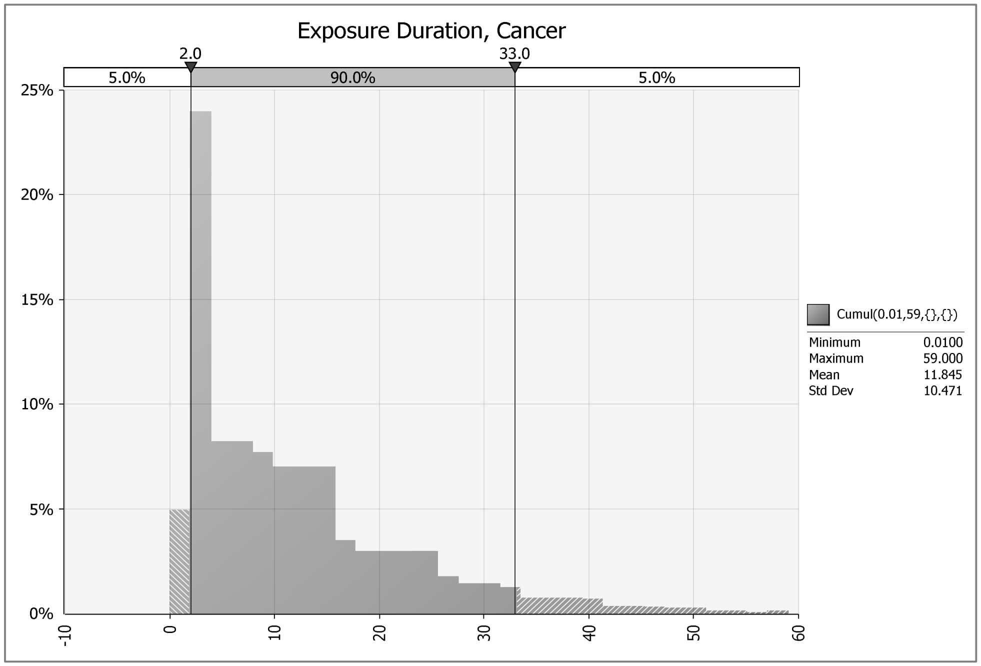
FIGURE 11

Appendix A

@Risk Report

Table 1. Comparison of 95th and 99th percentile risk outputs among simulations run with 10,000, 15,000, and 20,000 iterations.

Percentile	Arsenic Cumulative ELCR			Arsenic Cumulative Non-cancer HI			Cadmium, Cumulative ELCR			Cadmium, Cumulative Non-cancer HI			Manganese, Cumulative Non-cancer HI			Zinc, Cumulative Non-cancer HI		
	10,000	15,000	20,000	10,000	15,000	20,000	10,000	15,000	20,000	10,000	15,000	20,000	10,000	15,000	20,000	10,000	15,000	20,000
95th	3.6E-07	3.5E-07	3.5E-07	9.8E-03	9.5E-03	9.6E-03	1.4E-10	1.4E-10	1.4E-10	1.8E-01	1.7E-01	1.7E-01	3.7E-02	3.7E-02	3.8E-02	1.5E-02	1.5E-02	1.5E-02
99th	1.3E-06	1.2E-06	1.3E-06	4.1E-02	4.3E-02	3.9E-02	1.8E-10	1.8E-10	1.9E-10	7.5E-01	7.1E-01	6.8E-01	7.5E-02	7.6E-02	7.8E-02	6.1E-02	6.6E-02	6.5E-02



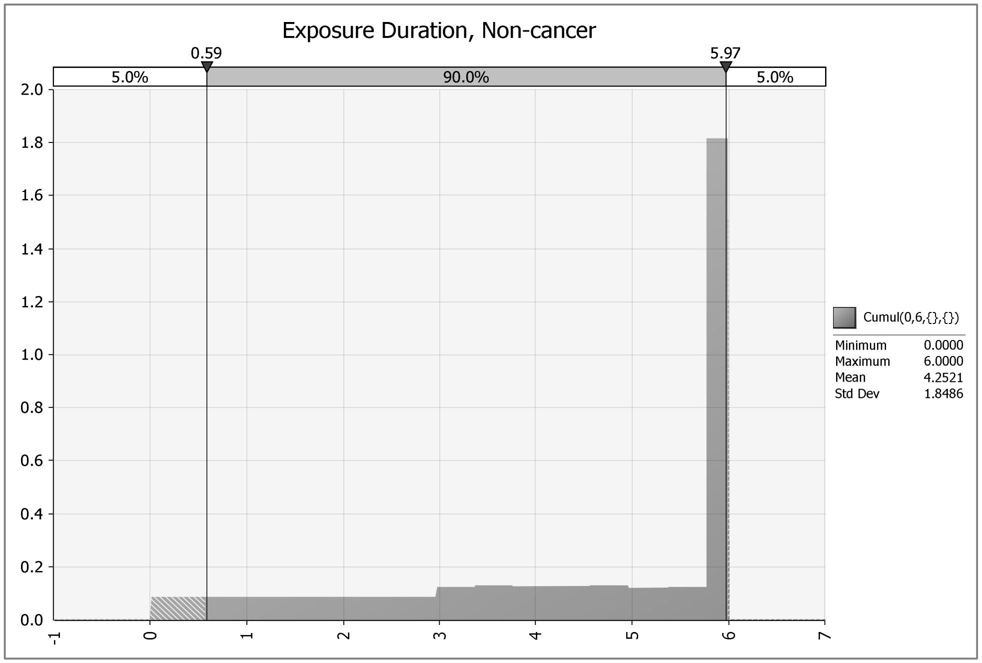
Distribution Input	
Percentile	**Exposure Duration, Cancer (Years)**
5%	2
10%	2
25%	3
50%	9
75%	16
90%	26
95%	33
98%	41
99%	47
99.5%	51
99.8%	55
99.9%	59

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Distribution for Exposure Duration, Cancer (Years)

ARCADIS



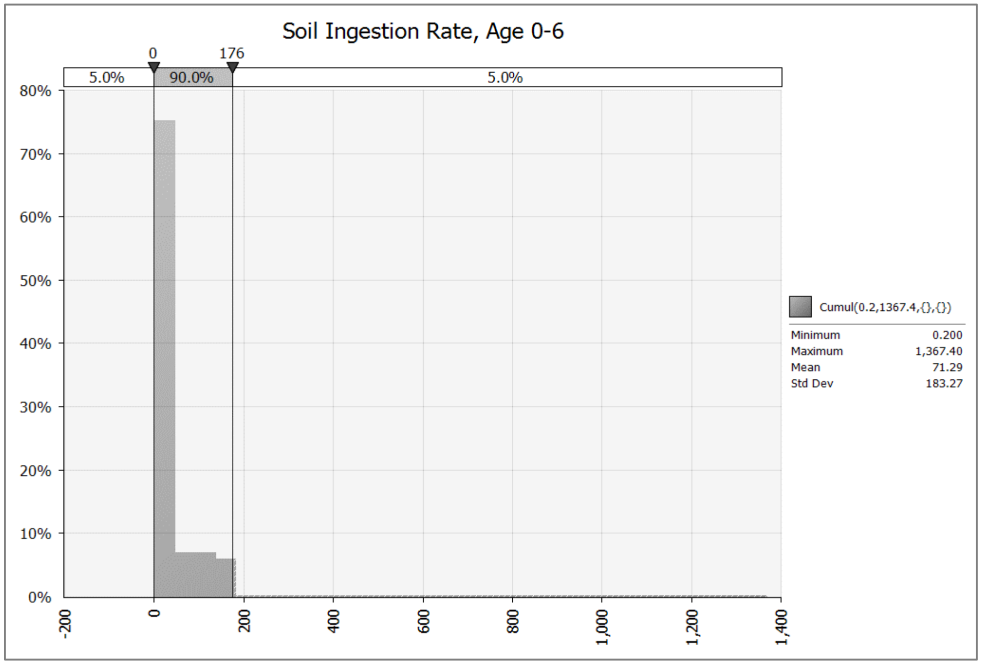
Distribution Input	
Percentile	**Exposure Duration, Non-cancer (Years)**
5%	0.6
10%	1.2
15%	1.8
20%	2.4
25%	3.0
30%	3.4
35%	3.8
40%	4.2
45%	4.6
50%	5.0
55%	5.4
60%	5.8
100%	6.0

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Distribution for Exposure Duration, Non-cancer (Years)

ARCADIS



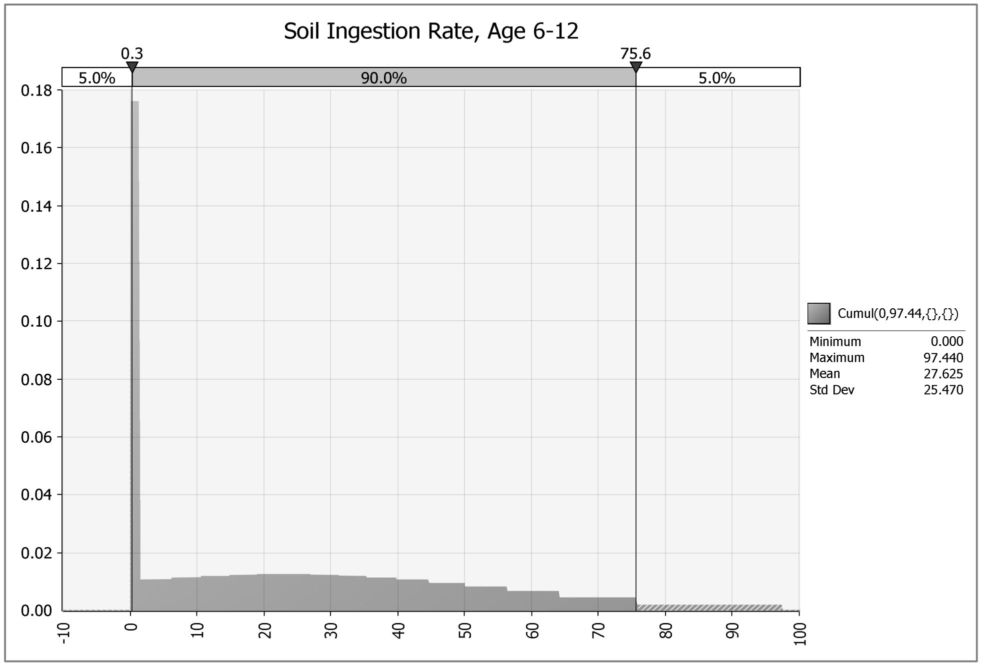
Distribution Input	
Percentile	Soil Ingestion Rate, Age 0 to <6 (mg/day)
5%	0.2
25%	5.3
50%	15.3
75%	44.9
95%	175.6
100%	1,367.4

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Distribution for Soil Ingestion Rate, Age 0 to <6 (mg/day)

ARCADIS



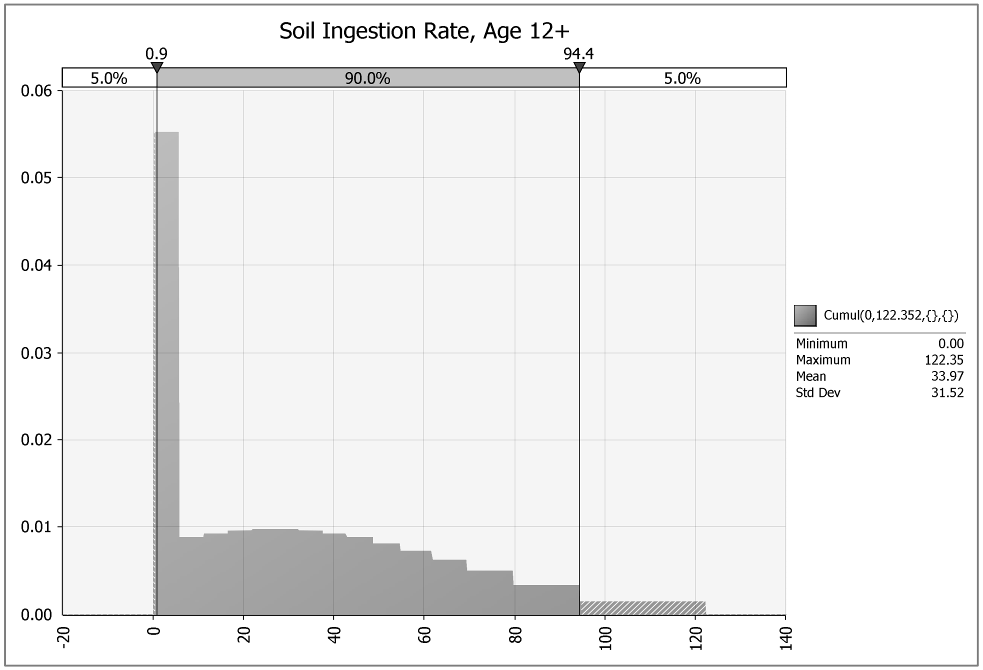
Distribution Input	
Normal Distribution	**Soil Ingestion Rate, Age 6 to <12 (mg/day)**
Mean	23
Standard Deviation	32
95%	75

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Distribution for Soil Ingestion Rate, Age 6 to <12 (mg/day)

ARCADIS



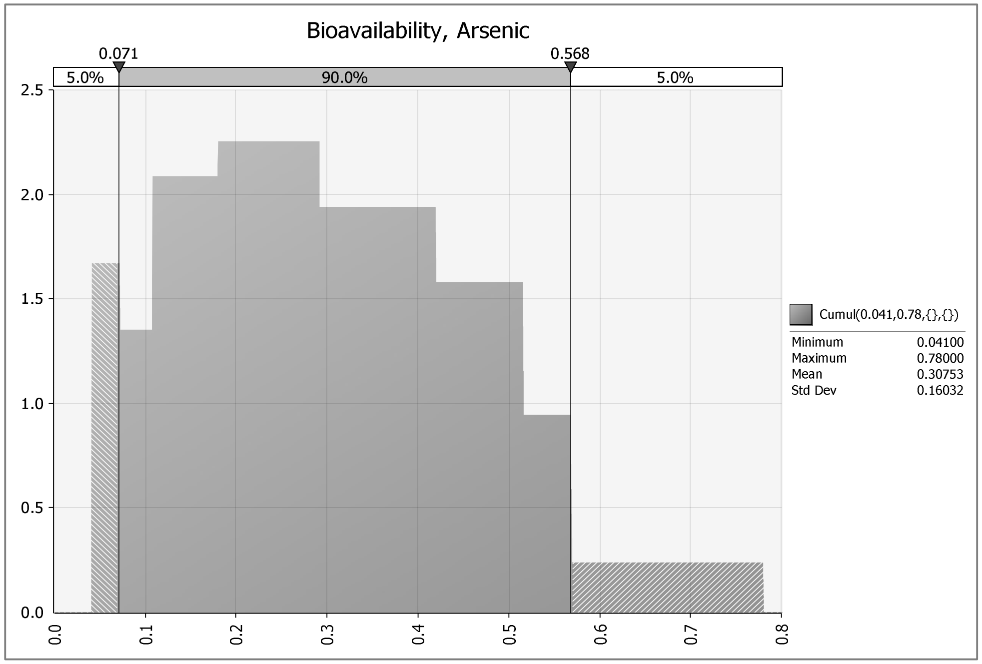
Distribution Input	
Percentiles	**Soil Ingestion Rate, Age 12+ (mg/day)**
1%	0.0
5%	0.0
10%	0.0
15%	0.0
20%	0.0
25%	0.0
30%	5.4
35%	11.1
40%	16.5
45%	21.8
50%	26.9
55%	32.1
60%	37.3
65%	42.7
70%	48.4
75%	54.6
80%	61.5
85%	69.4
90%	79.5
95%	94.4
99%	122.4

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Distribution for Soil Ingestion Rate, Age 12+ (mg/day)

ARCADIS



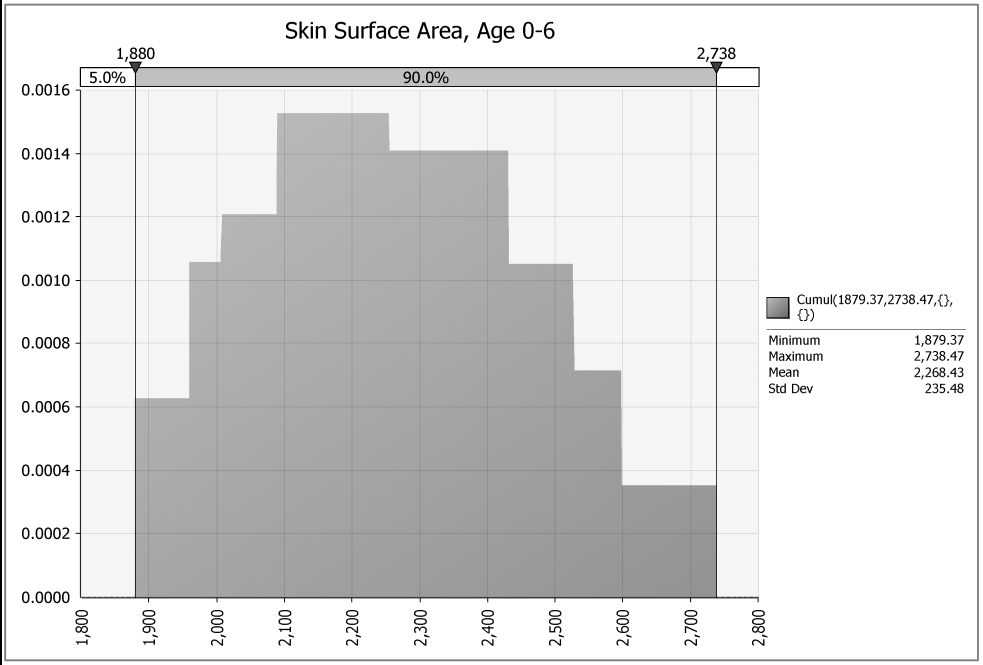
Distribution Input	
Percentile	**Bioavailability of Arsenic (Fraction)**
5%	0.071
10%	0.108
25%	0.180
50%	0.291
75%	0.420
90%	0.515
95%	0.568

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Distribution for Bioavailability of Arsenic (Fraction)

ARCADIS



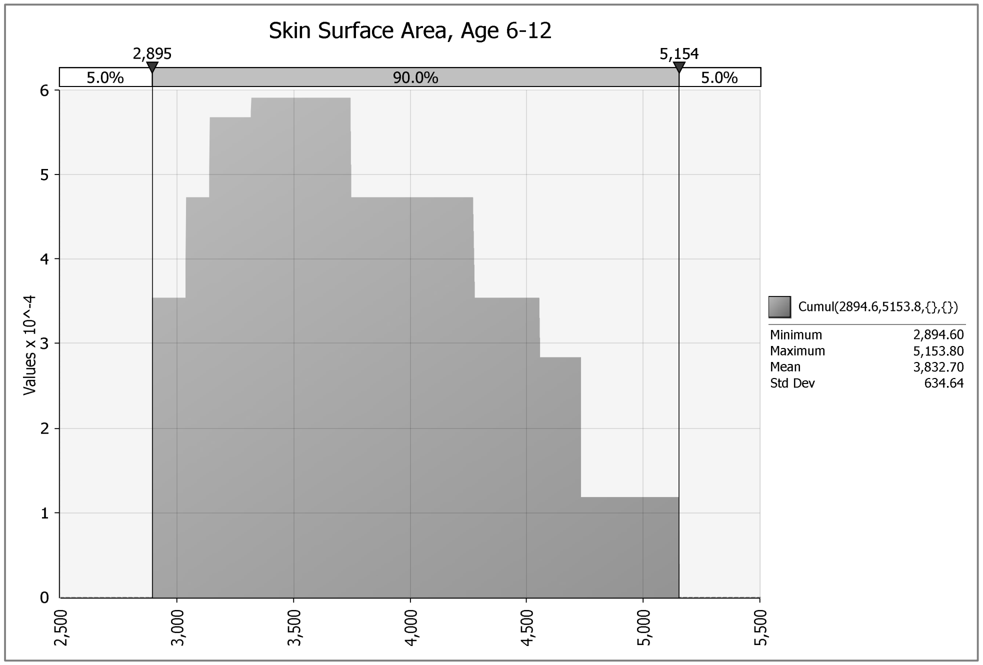
Distribution Input	
Percentile	Skin Surface Area, Age 0 to <6 (cm^2)
5%	1,880
10%	1,959
15%	2,007
25%	2,090
50%	2,253
75%	2,431
85%	2,526
90%	2,596
95%	2,738

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Distribution for Skin Surface Area, Age 0 to <6 (cm^2)

ARCADIS



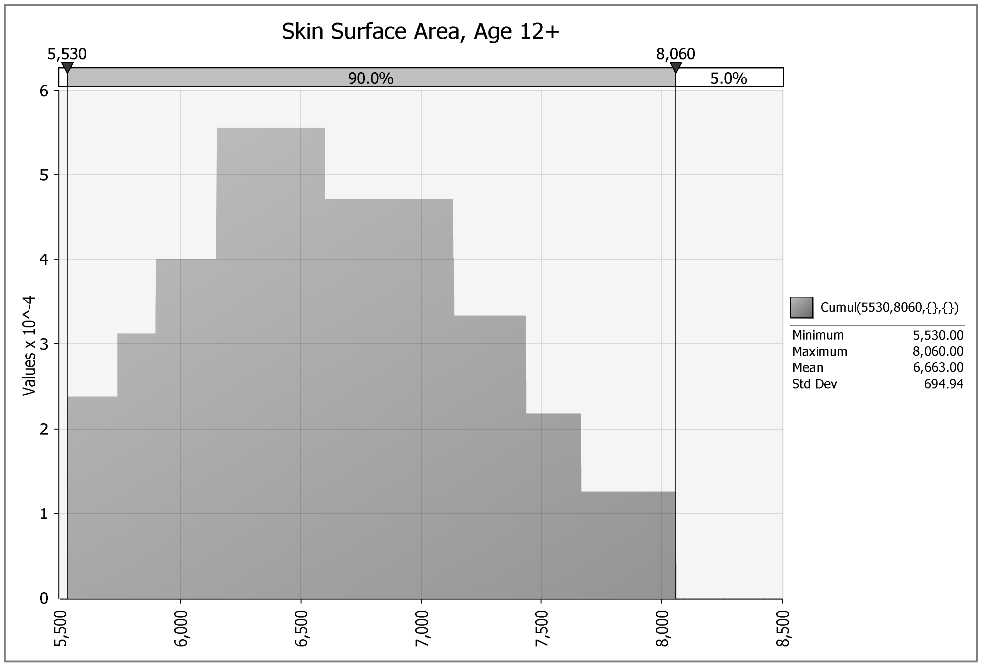
Distribution Input	
Percentile	Skin Surface Area, Age 6 to <12 (cm^2)
5%	2,895
10%	3,036
15%	3,142
25%	3,318
50%	3,742
75%	4,271
85%	4,554
90%	4,730
95%	5,154

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Distribution for Skin Surface Area, Age 6 to <12 (cm^2)

ARCADIS



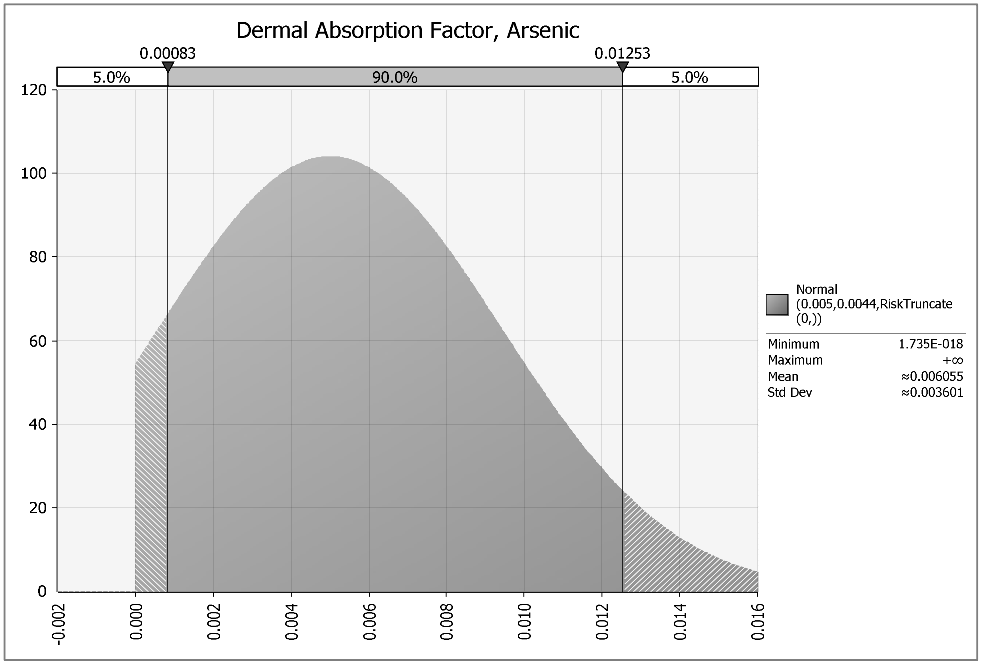
Distribution Input	
Percentile	Skin Surface Area, Age 12+ (cm^2)
5%	5,530
10%	5,740
15%	5,900
25%	6,150
50%	6,600
75%	7,130
85%	7,430
90%	7,660
95%	8,060

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Distribution for Skin Surface Area, Age 12+ (cm^2)

ARCADIS



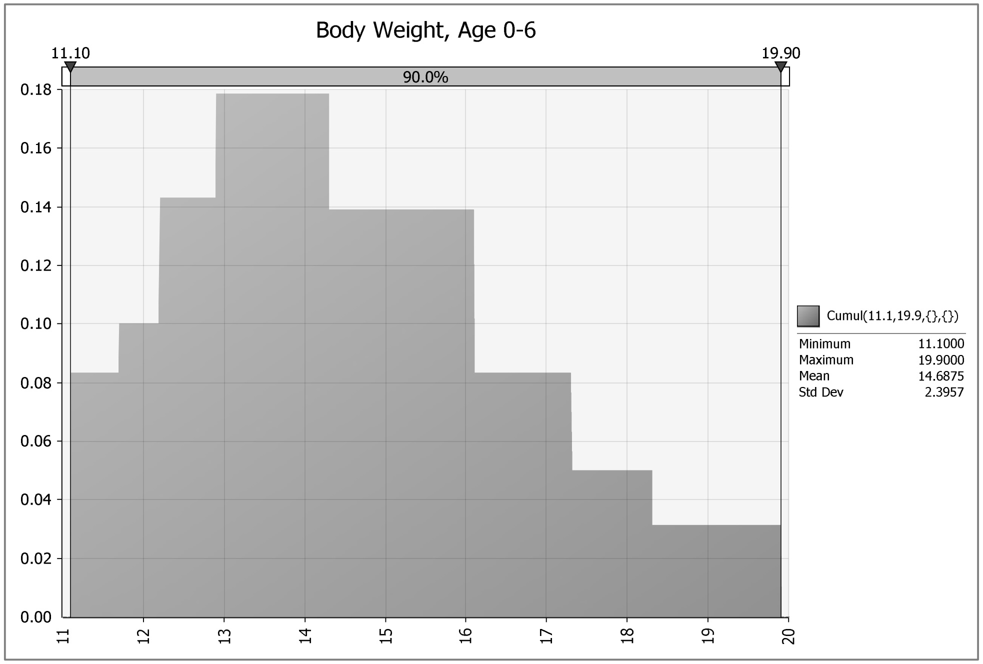
Distribution Input	
Normal Distribution	**Dermal Absorption Factor, Arsenic (Fraction)**
Mean	0.0050
Standard Deviation	0.0044

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Distribution for Dermal Absorption Factor, Arsenic (Fraction)

ARCADIS



Distribution Input	
Percentile	**Body Weight, Age 0 to <6 (kg)**
5%	11.1
10%	11.7
15%	12.2
25%	12.9
50%	14.3
75%	16.1
85%	17.3
90%	18.3
95%	19.9

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Distribution for Body Weight, Age 0 to <6 (kg)

ARCADIS

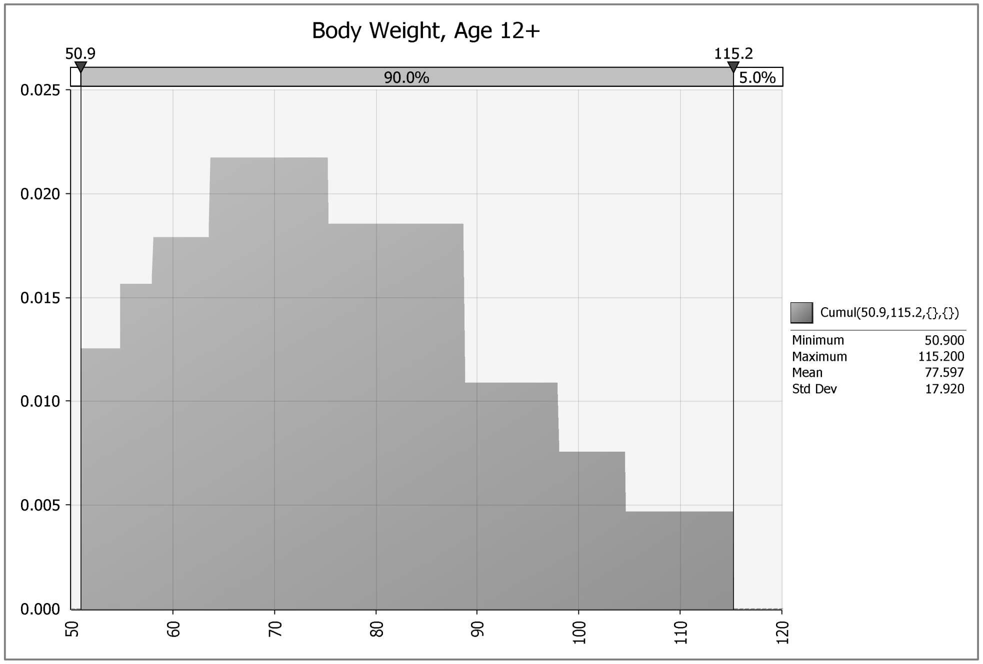
Distribution Input	
Percentile	Body Weight, Age 6 to <12 (kg)
5%	19.7
10%	21.3
15%	22.3
25%	24.4
50%	29.3
75%	36.8
85%	42.1
90%	45.6
95%	52.5

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Distribution for Body Weight, Age 6 to <12 (kg)

ARCADIS



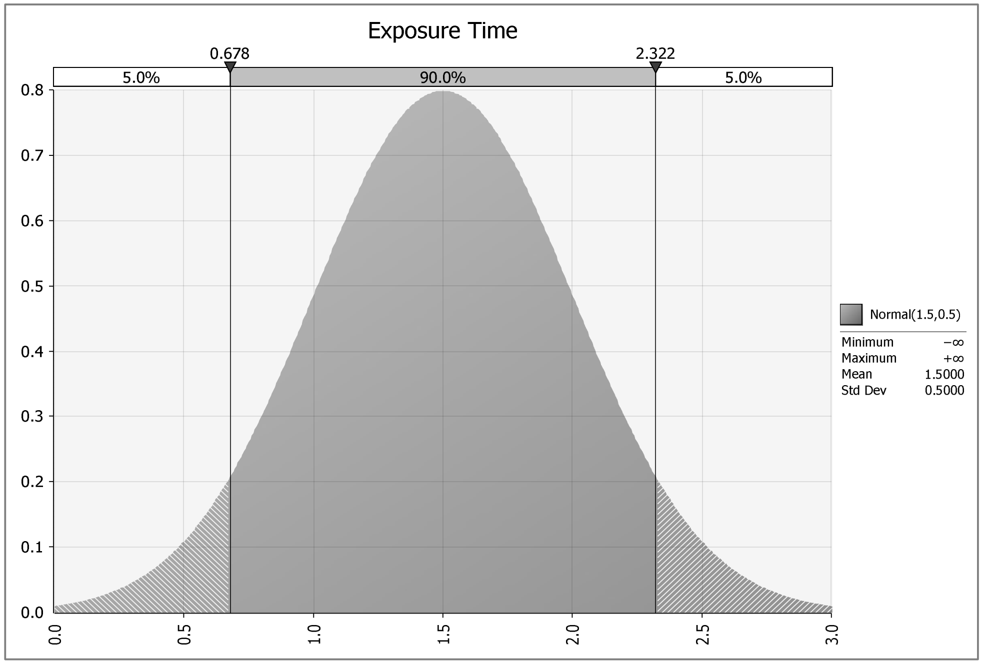
Distribution Input	
Percentile	**Body Weight, Age 12+ (kg)**
5%	50.9
10%	54.9
15%	58.1
25%	63.7
50%	75.2
75%	88.7
85%	97.9
90%	104.5
95%	115.2

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Distribution for Body Weight, Age 12+ (kg)

ARCADIS



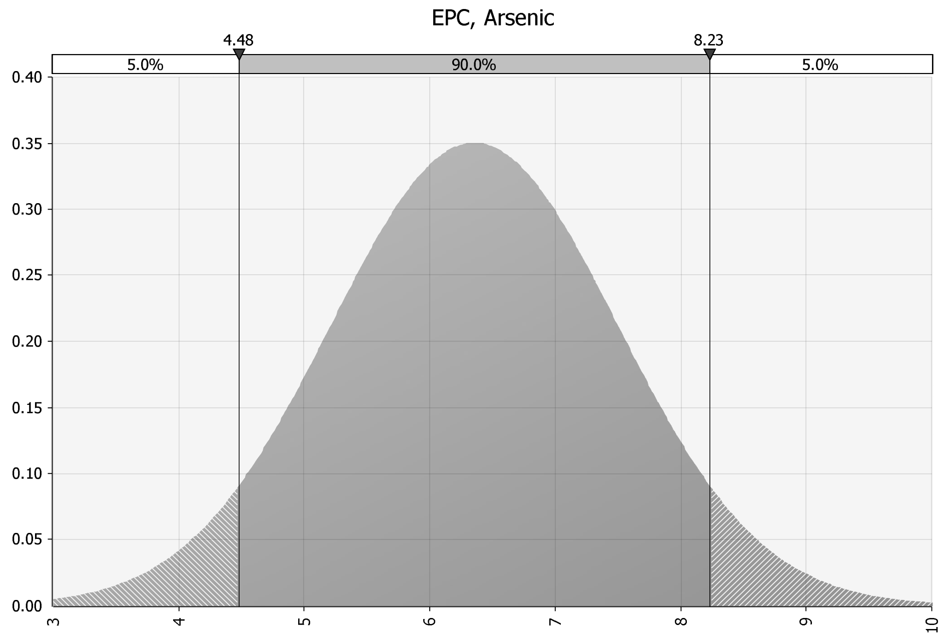
Distribution Input	
Normal Distribution	Exposure Time (hours)
Mean	1.5
Standard Deviation	0.5

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Distribution for Exposure Time (hours)

ARCADIS



See Appendix C for arsenic soil concentrations used to develop this distribution

Distribution Input	
Normal Distribution	**EPC (mg/kg)**
Mean	6.35
Standard Deviation	1.14
95% UCL	8.23

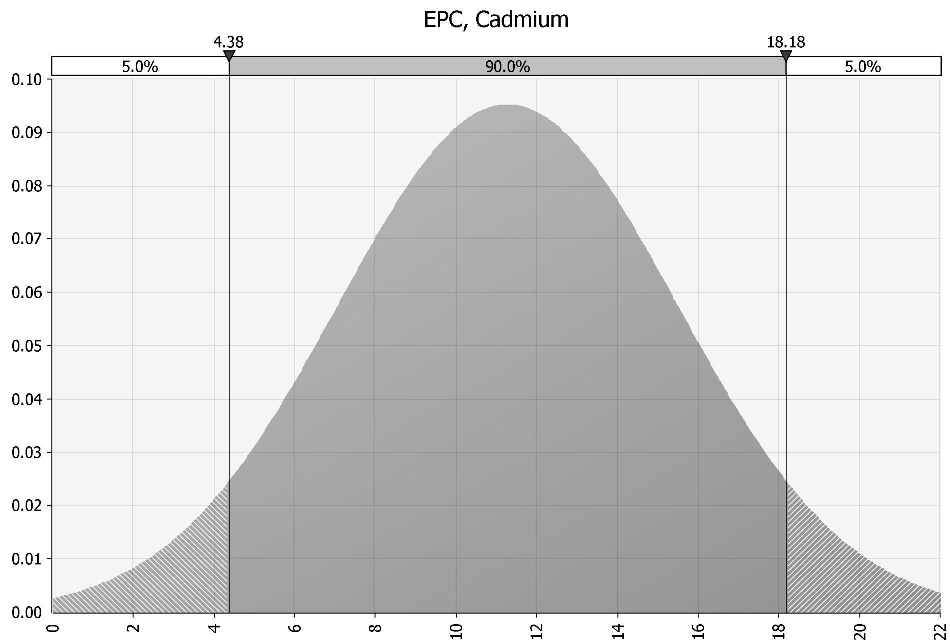
Note:
The standard deviation is an estimate of the standard error of the mean.

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Distribution for Area-weighted Exposure Point Concentration, Arsenic in Soil (0-1 ft bgs) (mg/kg)

ARCADIS



See Appendix C for cadmium soil concentrations used to develop this distribution

Distribution Input	
Normal Distribution	EPC (mg/kg)
Mean	11.28
Standard Deviation	4.19
95% UCL	18.18

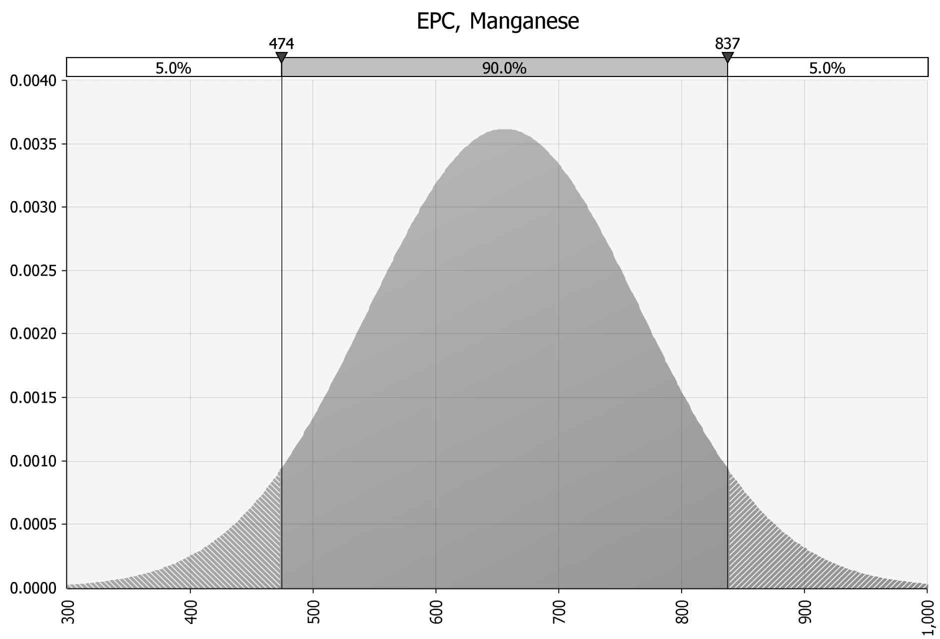
Note:
The standard deviation is an estimate of the standard error of the mean.

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Distribution for Exposure Point Concentration, Cadmium in Soil (0-1 ft bgs) (mg/kg)

ARCADIS



See Appendix C for manganese soil concentrations used to develop this distribution

Distribution Input	
Normal Distribution	EPC (mg/kg)
Mean	655.8
Standard Deviation	110.4
95% UCL	837.0

Note:

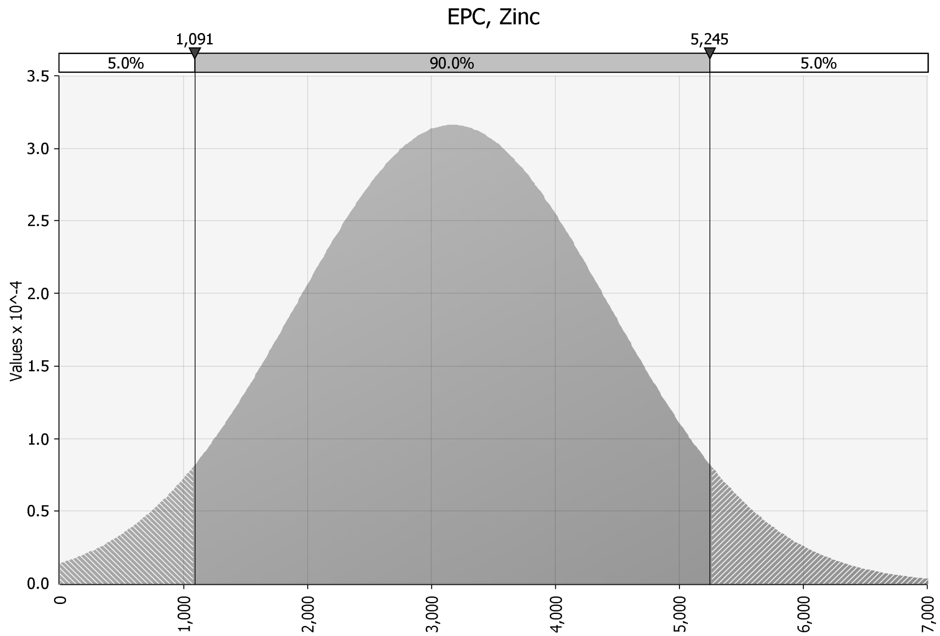
The standard deviation is an estimate of the standard error of the mean.

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Distribution for Area-weighted Exposure Point Concentration, Manganese in Soil (0-1 ft bgs) (mg/kg)

ARCADIS



See Appendix C for zinc soil concentrations used to develop this distribution

Distribution Input	
Normal Distribution	**EPC (mg/kg)**
Mean	3,168
Standard Deviation	1,263
95% UCL	5,245

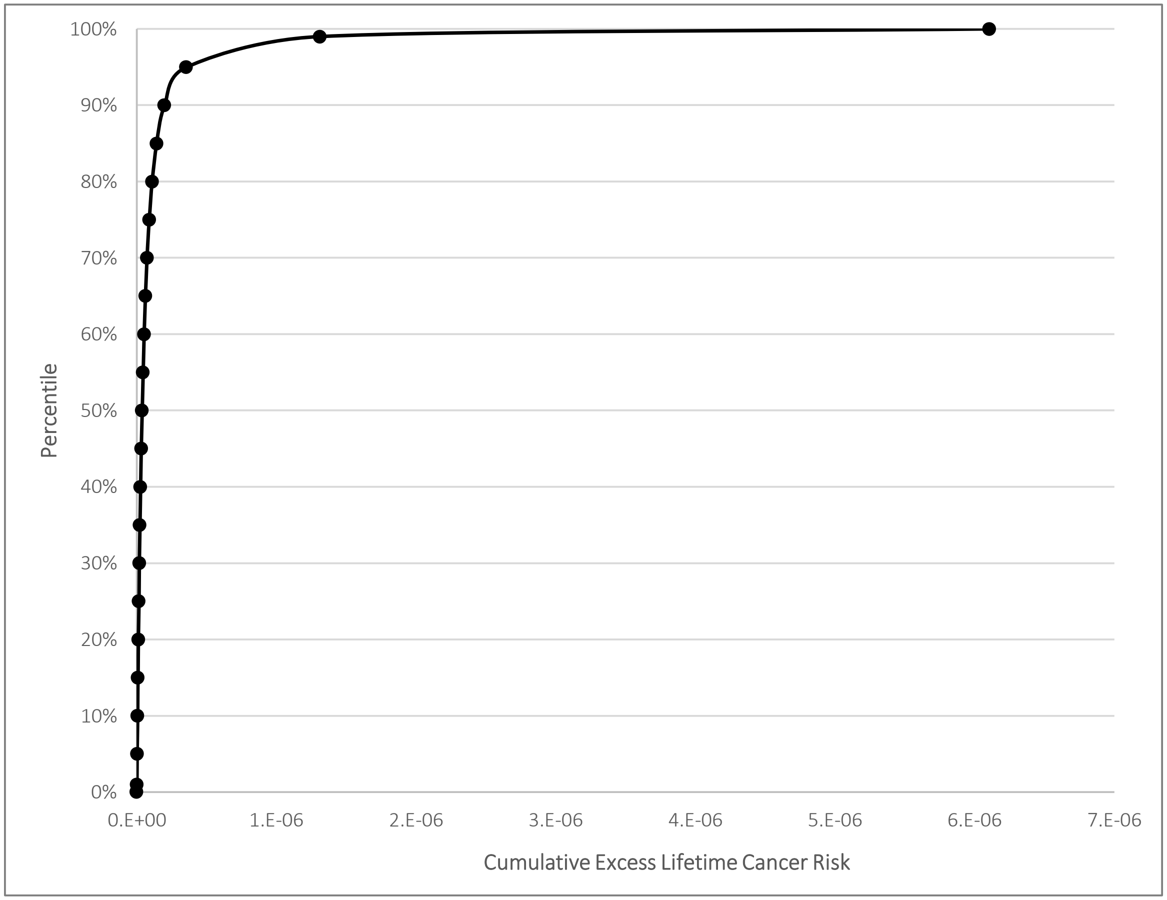
Note:
The standard deviation is an estimate of the standard error of the mean.

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Distribution for Exposure Point Concentration, Zinc in Soil (0-1 ft bgs) (mg/kg)

ARCADIS



Percentile	Cumulative Excess Lifetime Cancer Risk
0%	5.76E-11
1%	1.06E-09
5%	3.65E-09
10%	6.26E-09
15%	9.03E-09
20%	1.20E-08
25%	1.54E-08
30%	1.90E-08
35%	2.30E-08
40%	2.74E-08
45%	3.28E-08
50%	3.85E-08
55%	4.52E-08
60%	5.30E-08
65%	6.28E-08
70%	7.44E-08
75%	8.97E-08
80%	1.10E-07
85%	1.42E-07
90%	1.99E-07
95%	3.55E-07
99%	1.31E-06
100%	6.11E-06
Mean	1.02E-07
Mode	5.49E-09
Std Dev	2.58E-07

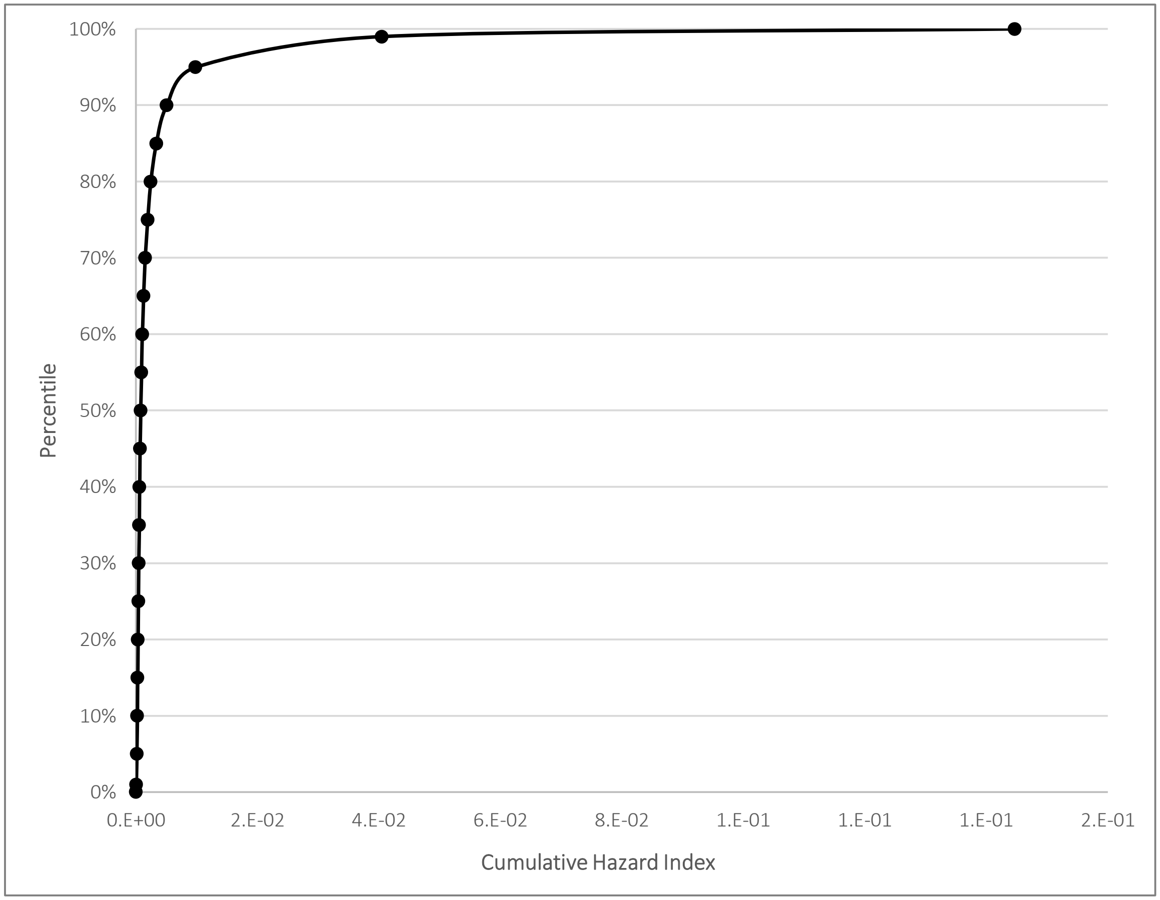
Notes:
Run with 10,000 iterations

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Cumulative Excess Lifetime Cancer Risk from Arsenic in Soil (0-1 ft bgs)

ARCADIS



Percentile	Cumulative Hazard Index
0%	8.45E-06
1%	6.28E-05
5%	1.57E-04
10%	2.30E-04
15%	2.94E-04
20%	3.53E-04
25%	4.13E-04
30%	4.81E-04
35%	5.45E-04
40%	6.16E-04
45%	6.97E-04
50%	7.92E-04
55%	9.12E-04
60%	1.06E-03
65%	1.26E-03
70%	1.54E-03
75%	1.94E-03
80%	2.44E-03
85%	3.37E-03
90%	5.09E-03
95%	9.84E-03
99%	4.05E-02
100%	1.45E-01
Mean	2.72E-03
Mode	3.47E-04
Std Dev	7.63E-03

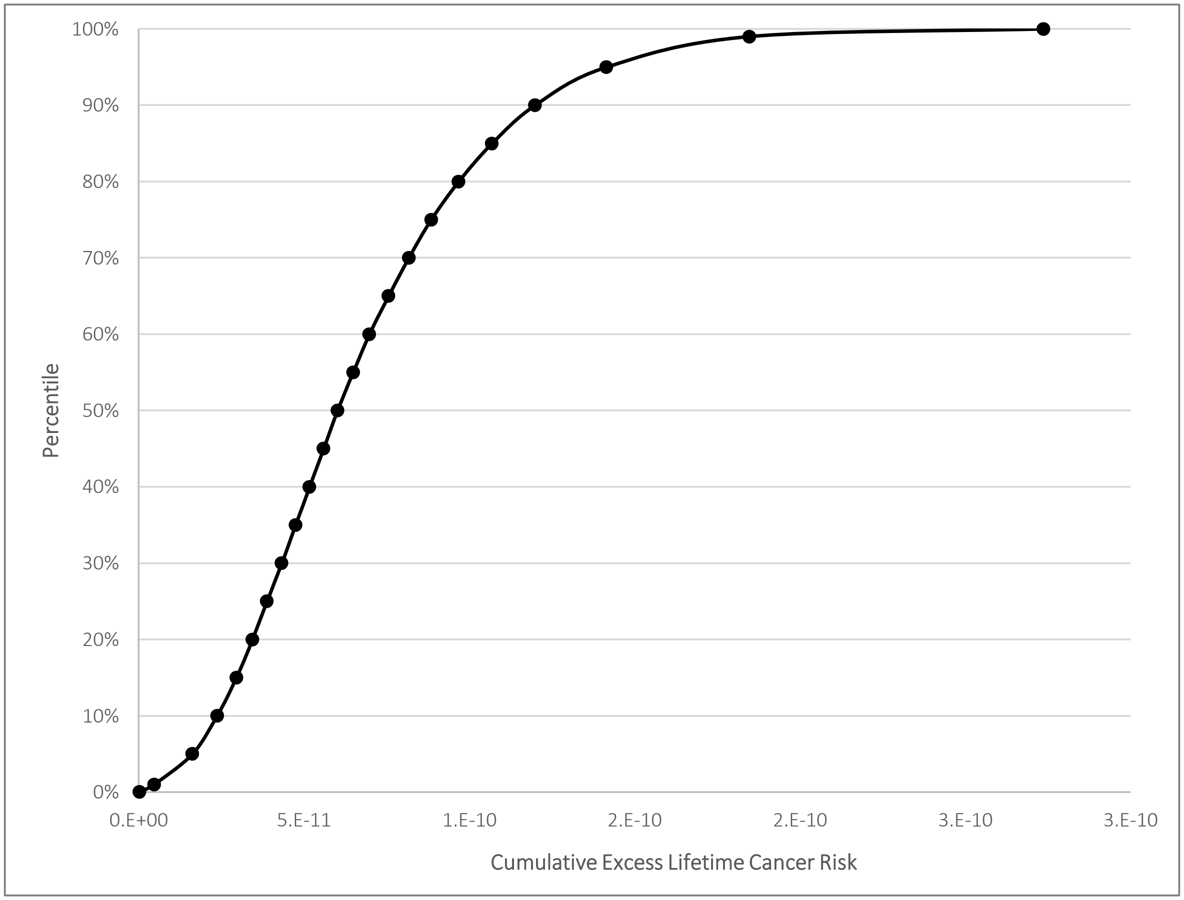
Notes:
Run with 10,000 iterations

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Cumulative Non-cancer Hazard Index from Arsenic in Soil (0-1 ft bgs)

ARCADIS



Percentile	Cumulative Excess Lifetime Cancer Risk
0%	3.10E-13
1%	4.74E-12
5%	1.63E-11
10%	2.38E-11
15%	2.97E-11
20%	3.45E-11
25%	3.89E-11
30%	4.33E-11
35%	4.75E-11
40%	5.17E-11
45%	5.60E-11
50%	6.02E-11
55%	6.49E-11
60%	6.98E-11
65%	7.56E-11
70%	8.18E-11
75%	8.85E-11
80%	9.68E-11
85%	1.07E-10
90%	1.20E-10
95%	1.42E-10
99%	1.85E-10
100%	2.74E-10
Mean	6.72E-11
Mode	4.96E-11
Std Dev	3.89E-11

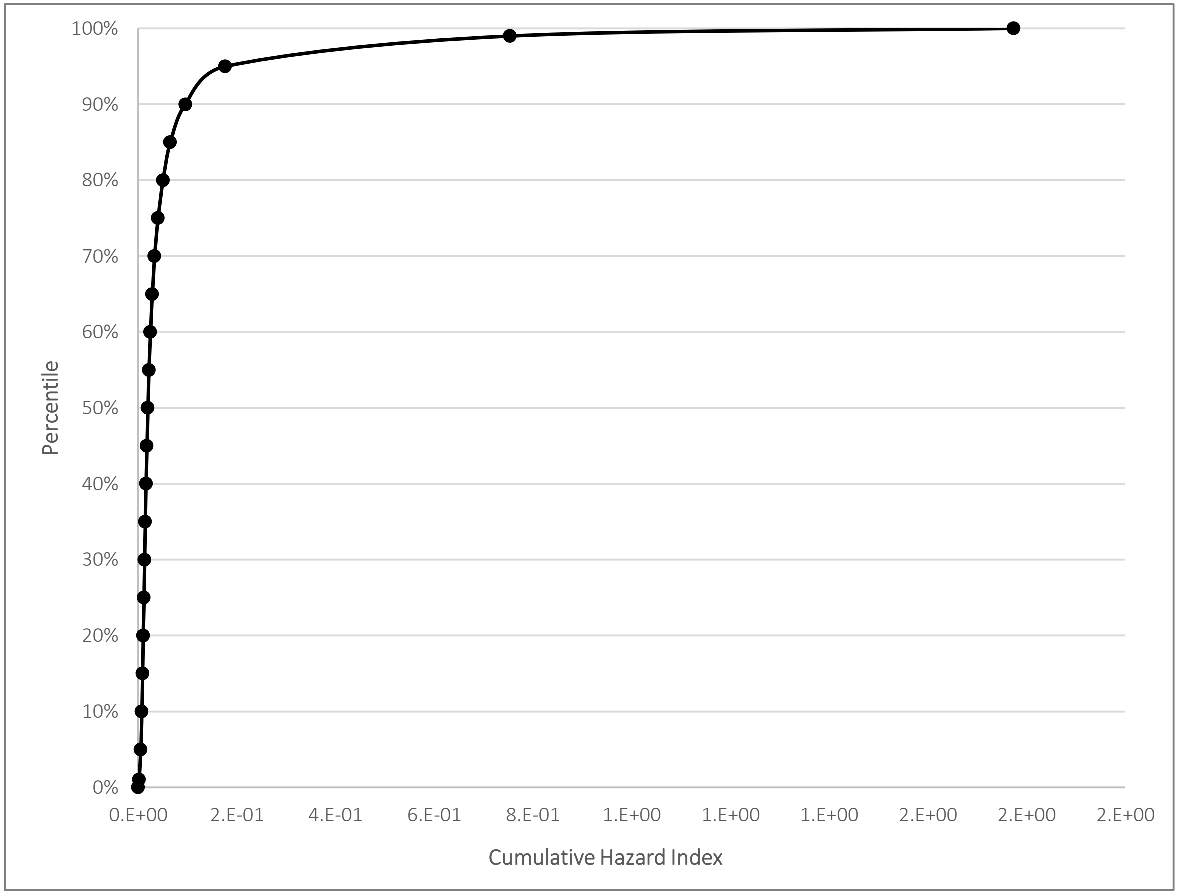
Notes:
Run with 10,000 iterations
Only the inhalation exposure pathway was included in the cadmium ELCR risk calculation

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Cumulative Excess Lifetime Cancer Risk from Cadmium in Soil (0-1 ft bgs)

ARCADIS



Percentile	Cumulative Hazard Index
0%	1.73E-04
1%	2.17E-03
5%	5.68E-03
10%	7.75E-03
15%	9.30E-03
20%	1.07E-02
25%	1.21E-02
30%	1.34E-02
35%	1.48E-02
40%	1.63E-02
45%	1.79E-02
50%	2.00E-02
55%	2.23E-02
60%	2.52E-02
65%	2.89E-02
70%	3.35E-02
75%	4.07E-02
80%	5.07E-02
85%	6.54E-02
90%	9.62E-02
95%	1.76E-01
99%	7.54E-01
100%	1.77E+00
Mean	5.32E-02
Mode	1.30E-02
Std Dev	1.27E-01

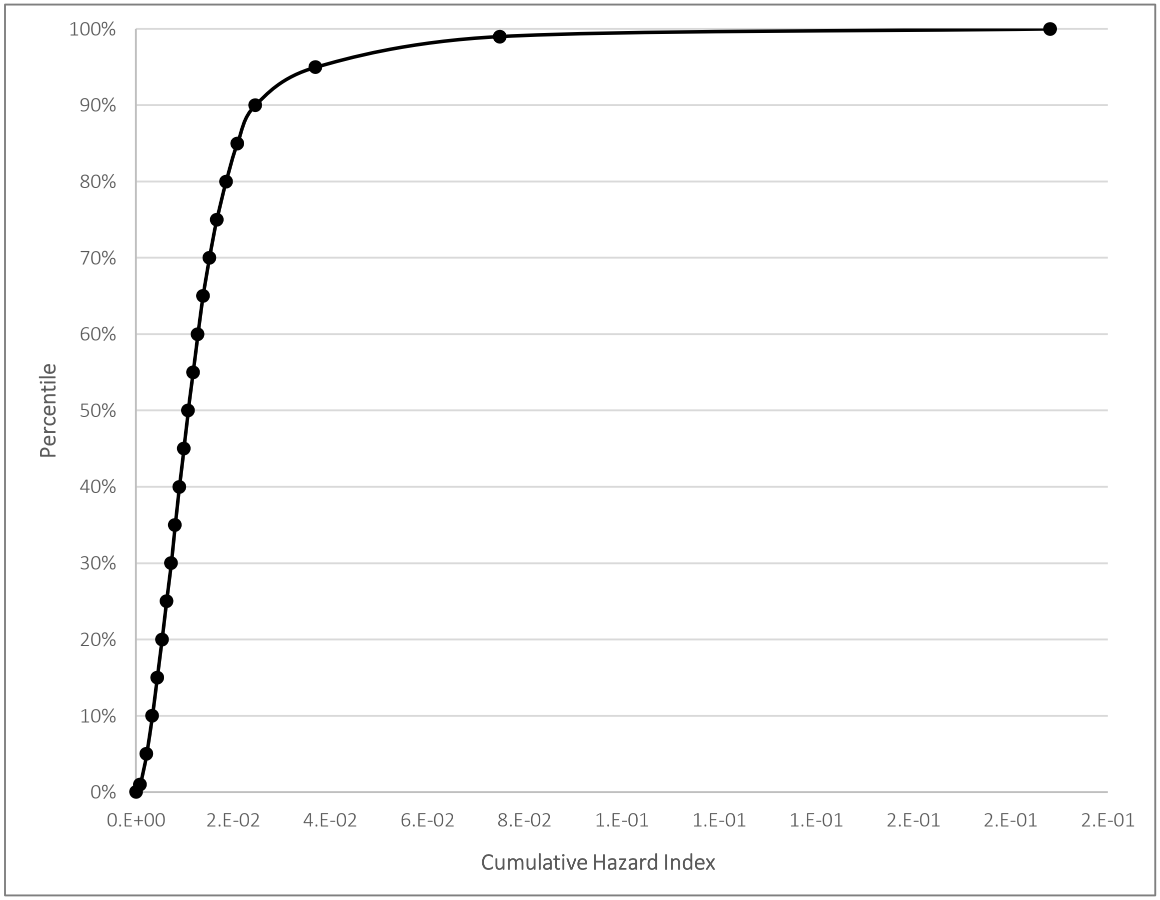
Notes:
Run with 10,000 iterations

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Cumulative Non-cancer Hazard Index from Cadmium in Soil (0-1 ft bgs)

ARCADIS



Percentile	Cumulative Hazard Index
0%	8.14E-05
1%	8.90E-04
5%	2.21E-03
10%	3.40E-03
15%	4.41E-03
20%	5.40E-03
25%	6.31E-03
30%	7.28E-03
35%	8.08E-03
40%	8.96E-03
45%	9.89E-03
50%	1.08E-02
55%	1.18E-02
60%	1.28E-02
65%	1.38E-02
70%	1.52E-02
75%	1.67E-02
80%	1.86E-02
85%	2.09E-02
90%	2.46E-02
95%	3.70E-02
99%	7.49E-02
100%	1.88E-01
Mean	1.37E-02
Mode	9.98E-03
Std Dev	1.35E-02

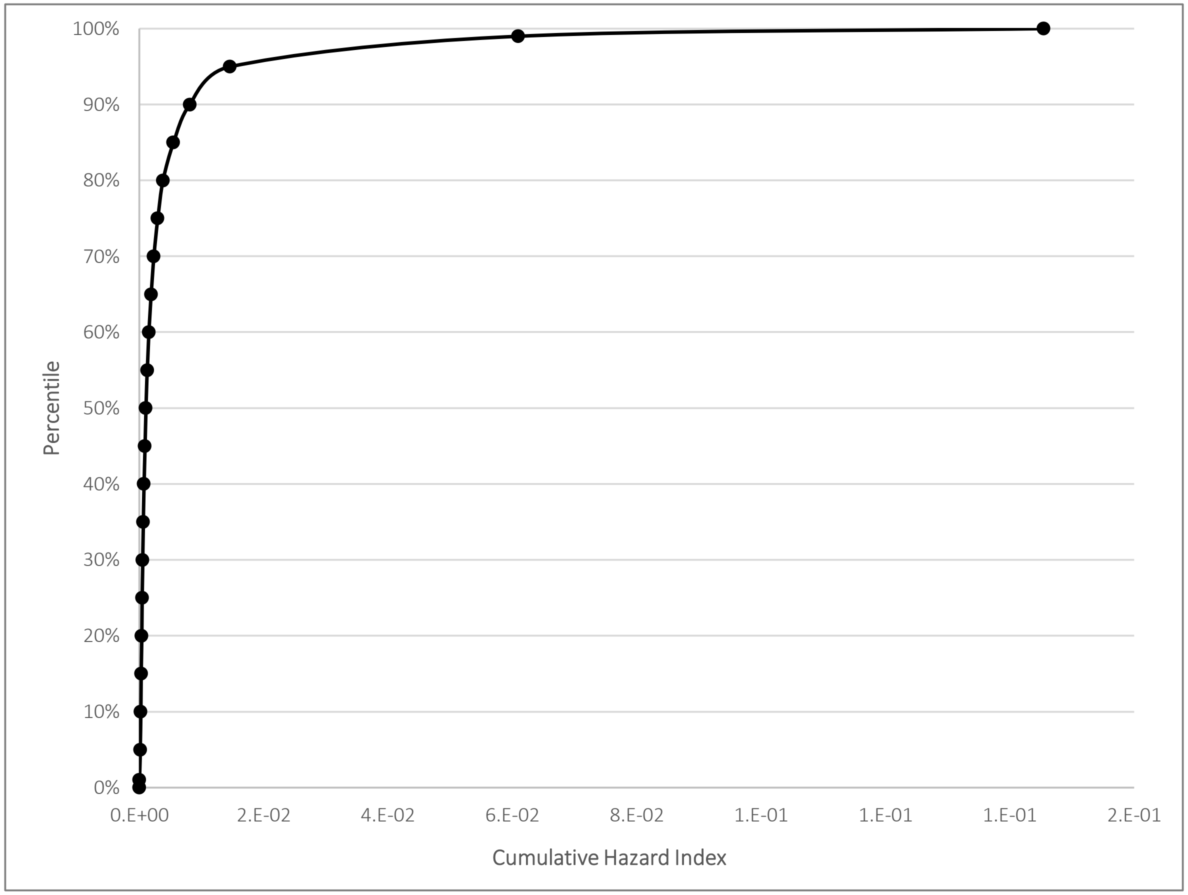
Notes:
Run with 10,000 iterations

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Cumulative Non-cancer Hazard Index from Manganese in Soil (0-1 ft bgs)

ARCADIS



Percentile	Cumulative Hazard Index
0%	1.02E-06
1%	3.96E-05
5%	1.70E-04
10%	2.47E-04
15%	3.15E-04
20%	3.86E-04
25%	4.58E-04
30%	5.45E-04
35%	6.46E-04
40%	7.57E-04
45%	8.93E-04
50%	1.07E-03
55%	1.28E-03
60%	1.55E-03
65%	1.90E-03
70%	2.35E-03
75%	2.97E-03
80%	3.82E-03
85%	5.49E-03
90%	8.13E-03
95%	1.46E-02
99%	6.09E-02
100%	1.45E-01
Mean	4.06E-03
Mode	3.48E-04
Std Dev	1.08E-02

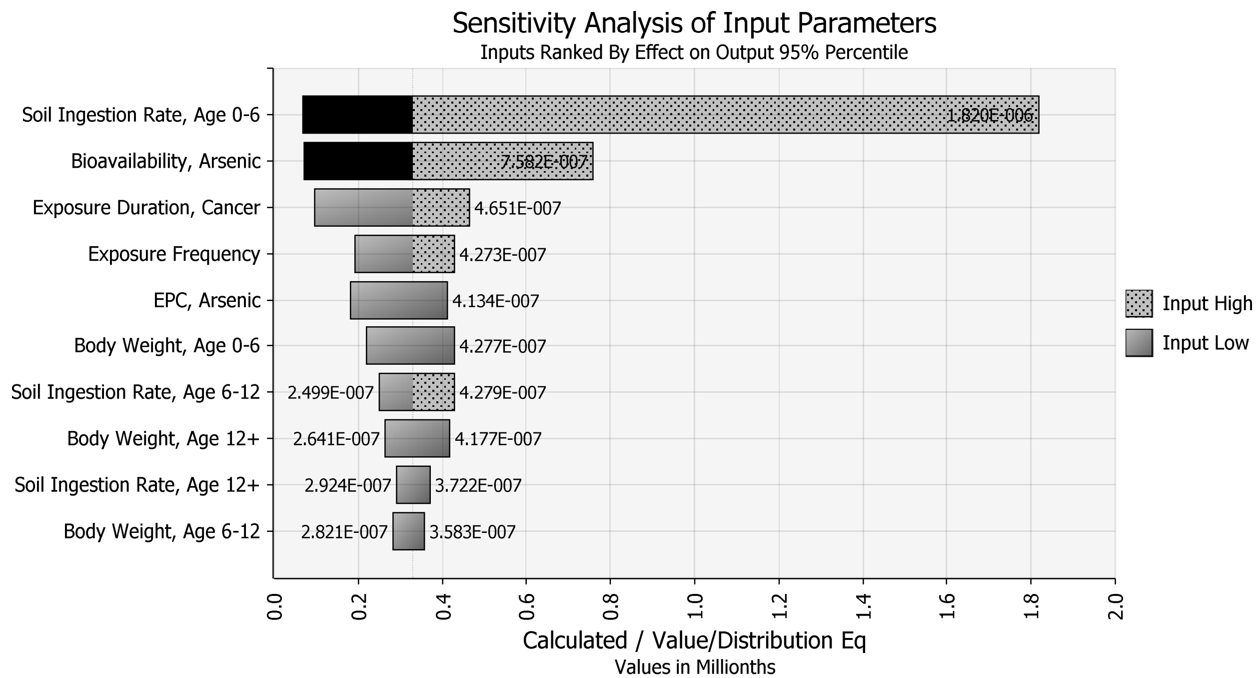
Notes:
Run with 10,000 iterations
Only the dermal and ingestion exposure pathways were included in the zinc cumulative hazard index calculation.

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Cumulative Non-cancer Hazard Index from Zinc in Soil (0-1 ft bgs)

ARCADIS



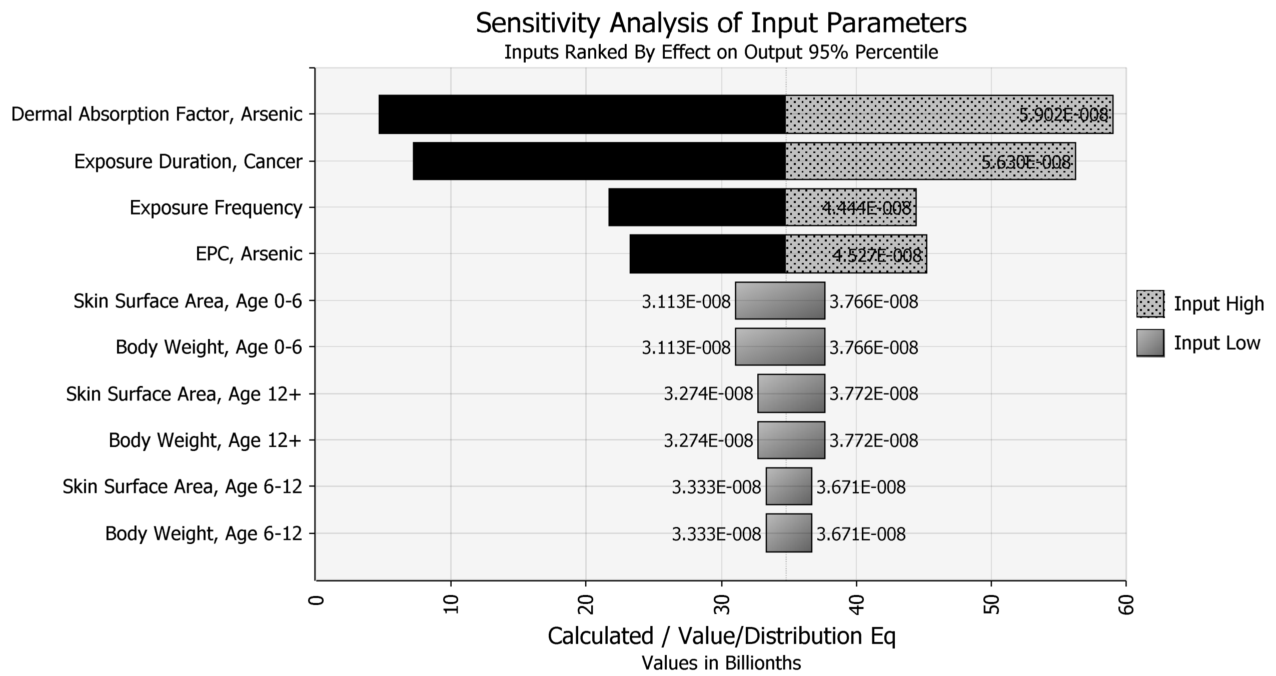
Notes:
Run with 10,000 iterations.
Effect of risk input parameters on cancer risk 95th percentile. Parameters with the longest bars have the largest impact on the output distribution. The length of the bar shown for each parameter is based on the range of the highest input value to the lowest input value. Parameters that have a positive impact on the 95th percentile output have the high inputs on the right and parameters that have a negative impact on 95th percentile output have the high inputs on the left.

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Sensitivity Analysis for Arsenic Cancer Risk, Ingestion Pathway

ARCADIS



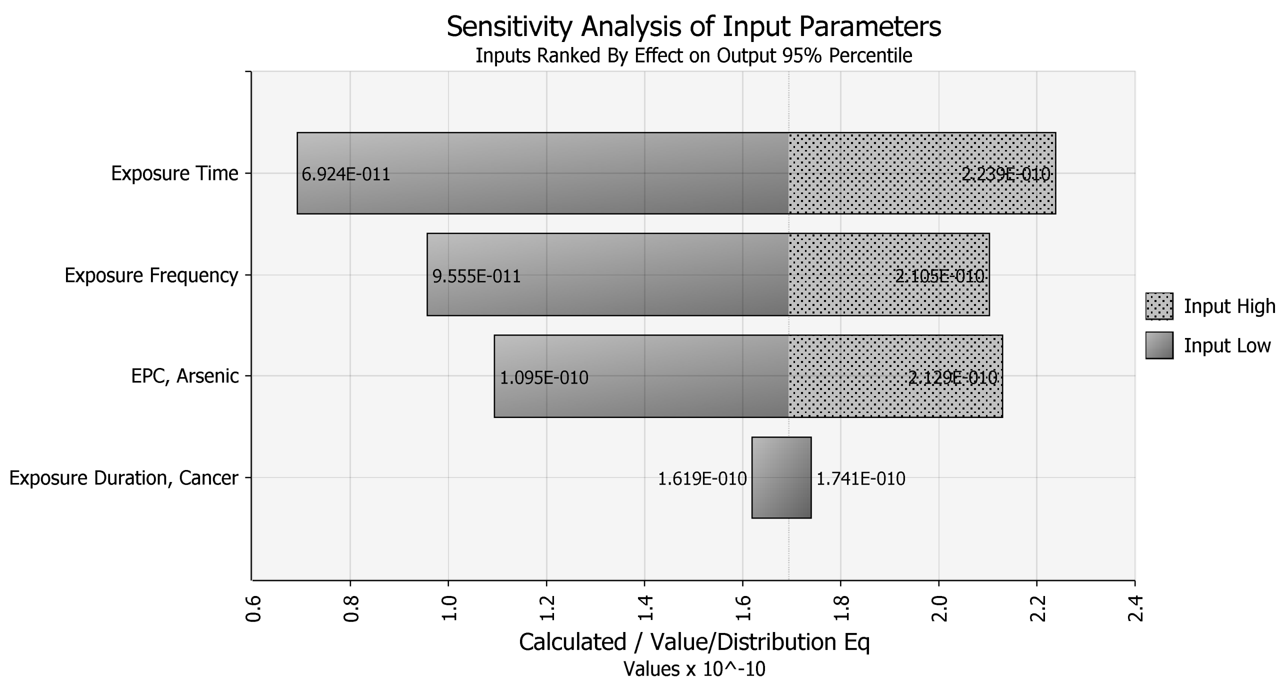
Notes:
Run with 10,000 iterations.
Effect of risk input parameters on cancer risk 95th percentile. Parameters with the longest bars have the largest impact on the output distribution. The length of the bar shown for each parameter is based on the range of the highest input value to the lowest input value. Parameters that have a positive impact on the 95th percentile output have the high inputs on the right and parameters that have a negative impact on 95th percentile output have the high inputs on the left.

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Sensitivity Analysis for Arsenic Cancer Risk, Dermal Pathway

ARCADIS



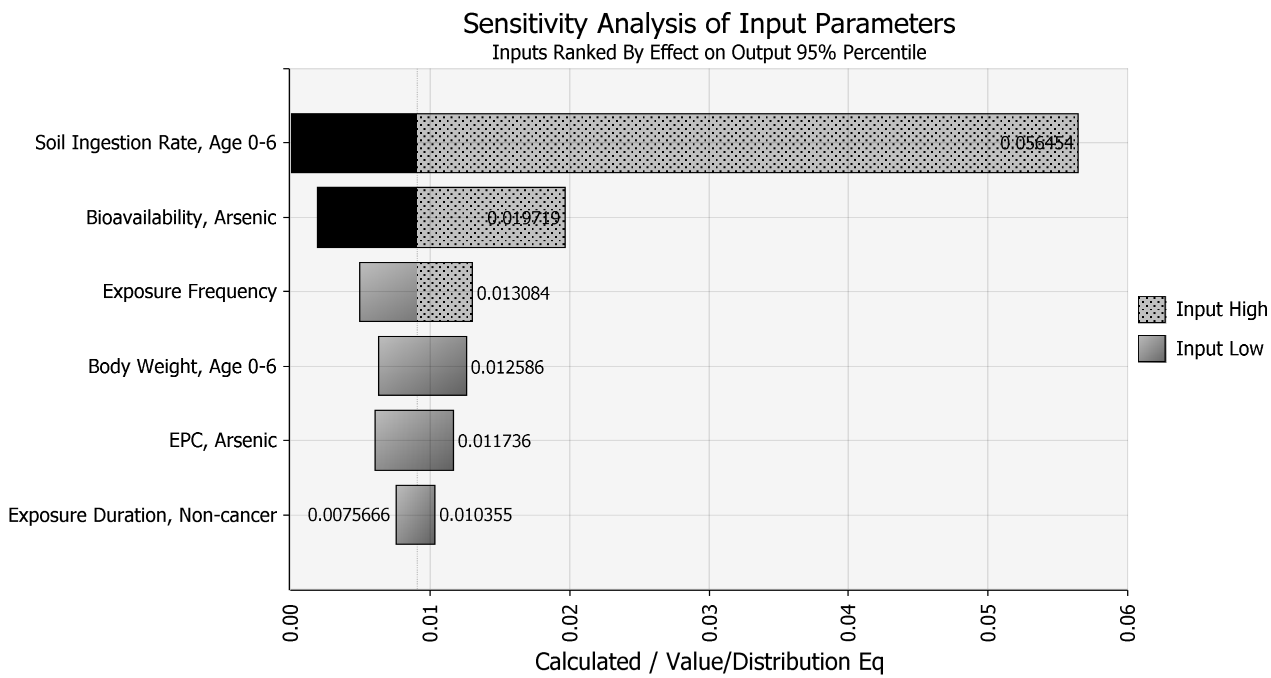
Notes:
Run with 10,000 iterations.
Effect of risk input parameters on cancer risk 95th percentile. Parameters with the longest bars have the largest impact on the output distribution. The length of the bar shown for each parameter is based on the range of the highest input value to the lowest input value. Parameters that have a positive impact on the 95th percentile output have the high inputs on the right and parameters that have a negative impact on 95th percentile output have the high inputs on the left.

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Sensitivity Analysis for Arsenic Cancer Risk, Inhalation Pathway

ARCADIS



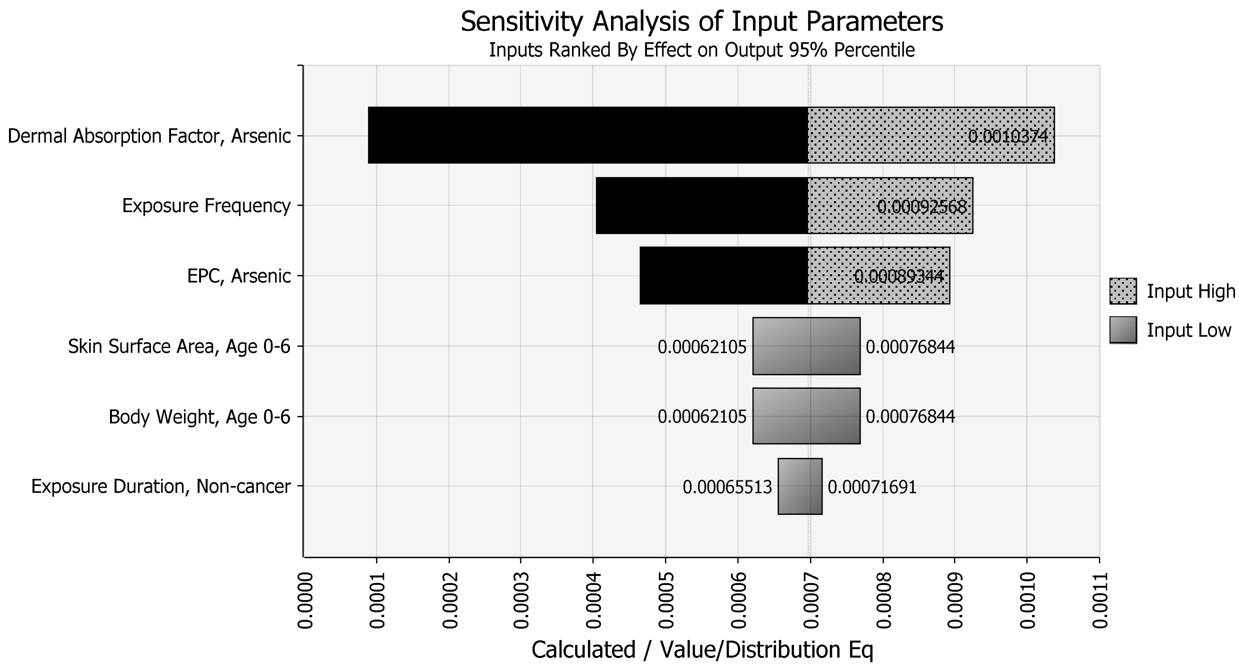
Notes:
Run with 10,000 iterations.
Effect of risk input parameters on non-cancer hazard index 95th percentile.
Parameters with the longest bars have the largest impact on the output distribution. The length of the bar shown for each parameter is based on the range of the highest input value to the lowest input value. Parameters that have a positive impact on the 95th percentile output have the high inputs on the right and parameters that have a negative impact on 95th percentile output have the high inputs on the left.

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Sensitivity Analysis for Arsenic Non-cancer Risk, Ingestion Pathway

ARCADIS



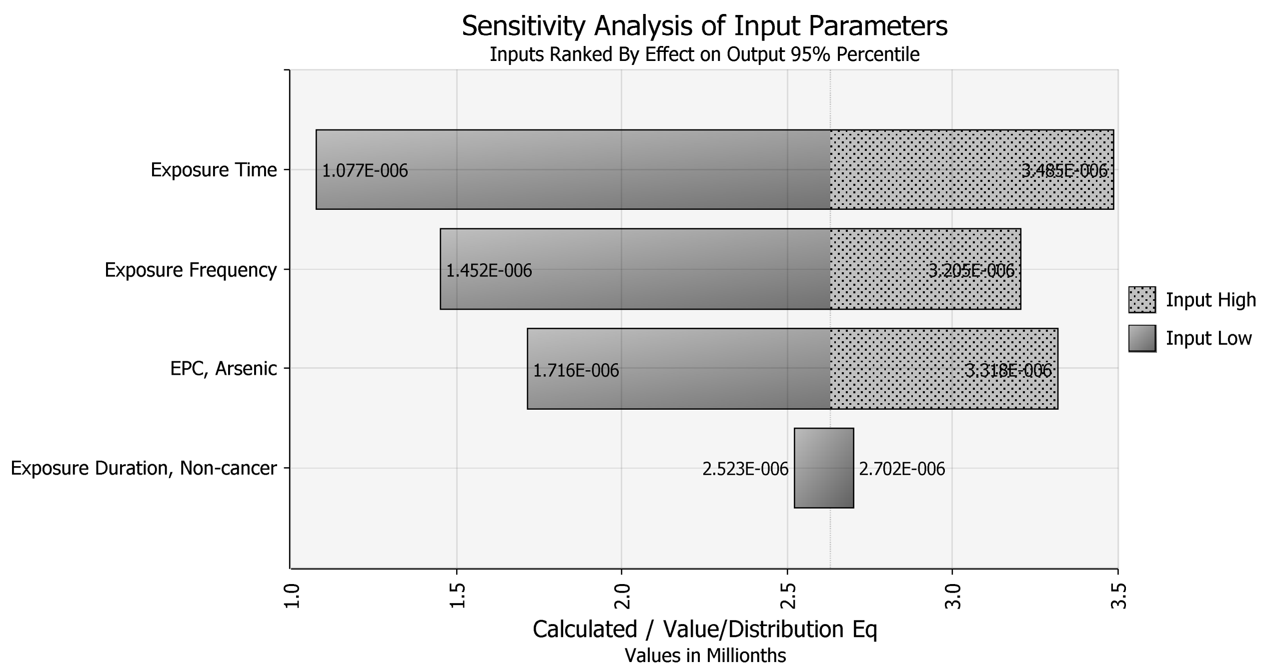
Notes:
Run with 10,000 iterations.
Effect of risk input parameters on non-cancer hazard index 95th percentile. Parameters with the longest bars have the largest impact on the output distribution. The length of the bar shown for each parameter is based on the range of the highest input value to the lowest input value. Parameters that have a positive impact on the 95th percentile output have the high inputs on the right and parameters that have a negative impact on 95th percentile output have the high inputs on the left.

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Sensitivity Analysis for Arsenic Non-cancer Risk, Dermal Pathway

ARCADIS



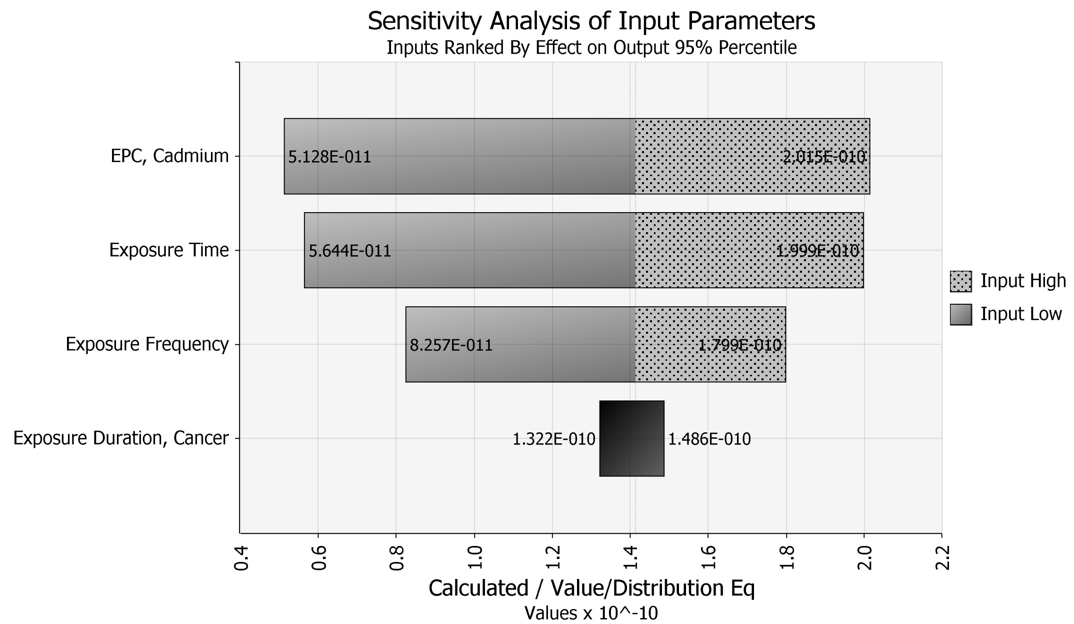
Notes:
Run with 10,000 iterations.
Effect of risk input parameters on non-cancer hazard index 95th percentile. Parameters with the longest bars have the largest impact on the output distribution. The length of the bar shown for each parameter is based on the range of the highest input value to the lowest input value. Parameters that have a positive impact on the 95th percentile output have the high inputs on the right and parameters that have a negative impact on 95th percentile output have the high inputs on the left.

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Sensitivity Analysis for Arsenic Non-cancer Risk, Inhalation Pathway

ARCADIS



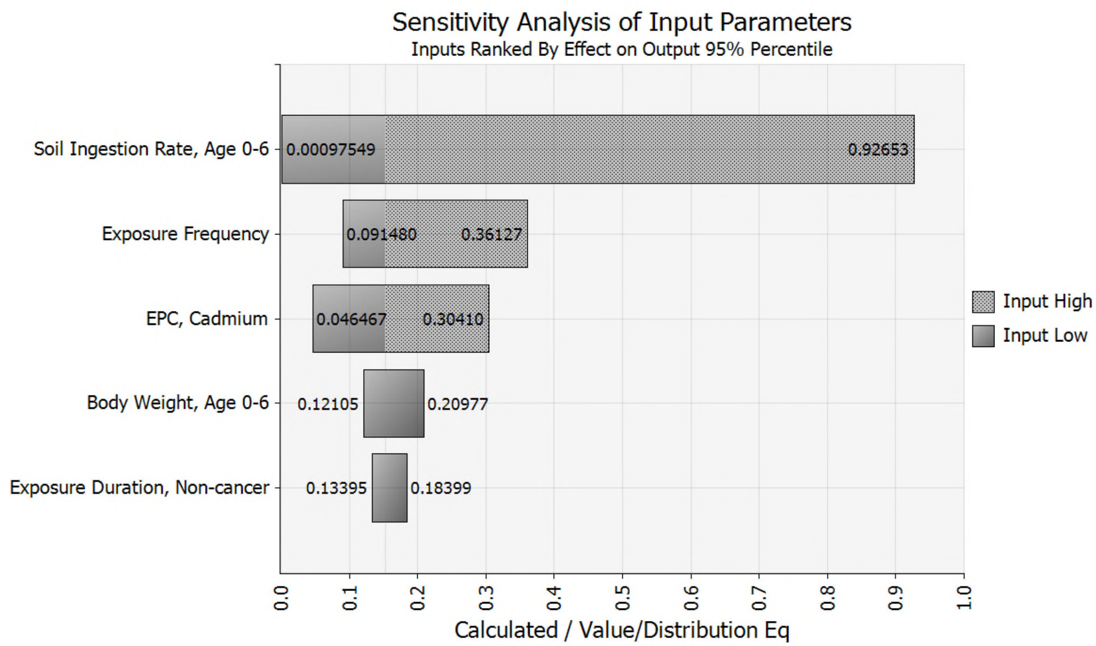
Notes:
Run with 10,000 iterations.
Effect of risk input parameters on non-cancer hazard index 95th percentile. Parameters with the longest bars have the largest impact on the output distribution. The length of the bar shown for each parameter is based on the range of the highest input value to the lowest input value. Parameters that have a positive impact on the 95th percentile output have the high inputs on the right and parameters that have a negative impact on 95th percentile output have the high inputs on the left.

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Sensitivity Analysis for Cadmium Cancer Risk, Inhalation Pathway

ARCADIS



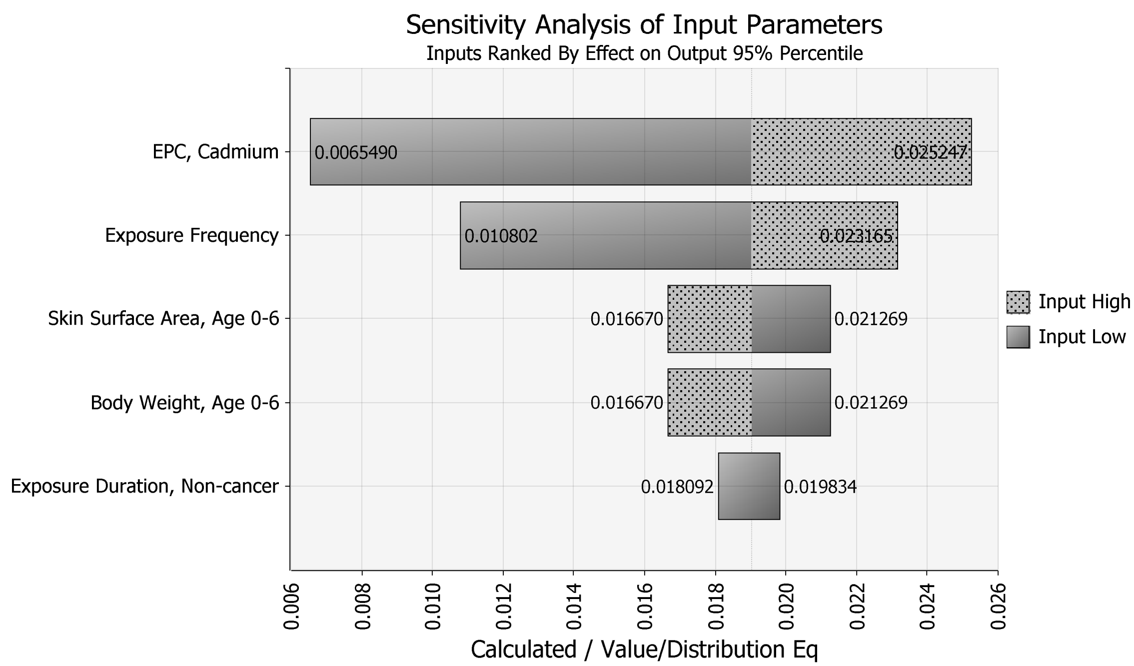
Notes:
Run with 10,000 iterations.
Effect of risk input parameters on non-cancer hazard index 95th percentile. Parameters with the longest bars have the largest impact on the output distribution. The length of the bar shown for each parameter is based on the range of the highest input value to the lowest input value. Parameters that have a positive impact on the 95th percentile output have the high inputs on the right and parameters that have a negative impact on 95th percentile output have the high inputs on the left.

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Sensitivity Analysis for Cadmium Non-cancer Risk, Ingestion Pathway

ARCADIS



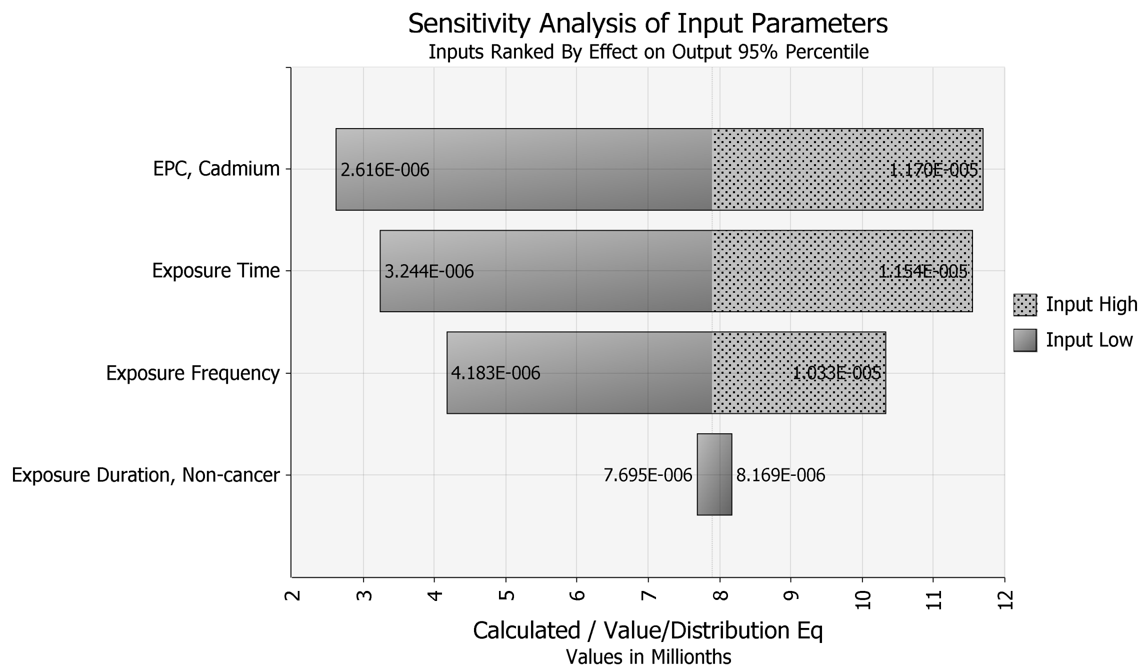
Notes:
Run with 10,000 iterations.
Effect of risk input parameters on non-cancer hazard index 95th percentile. Parameters with the longest bars have the largest impact on the output distribution. The length of the bar shown for each parameter is based on the range of the highest input value to the lowest input value. Parameters that have a positive impact on the 95th percentile output have the high inputs on the right and parameters that have a negative impact on 95th percentile output have the high inputs on the left.

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Sensitivity Analysis for Cadmium Non-cancer Risk, Dermal Pathway

ARCADIS



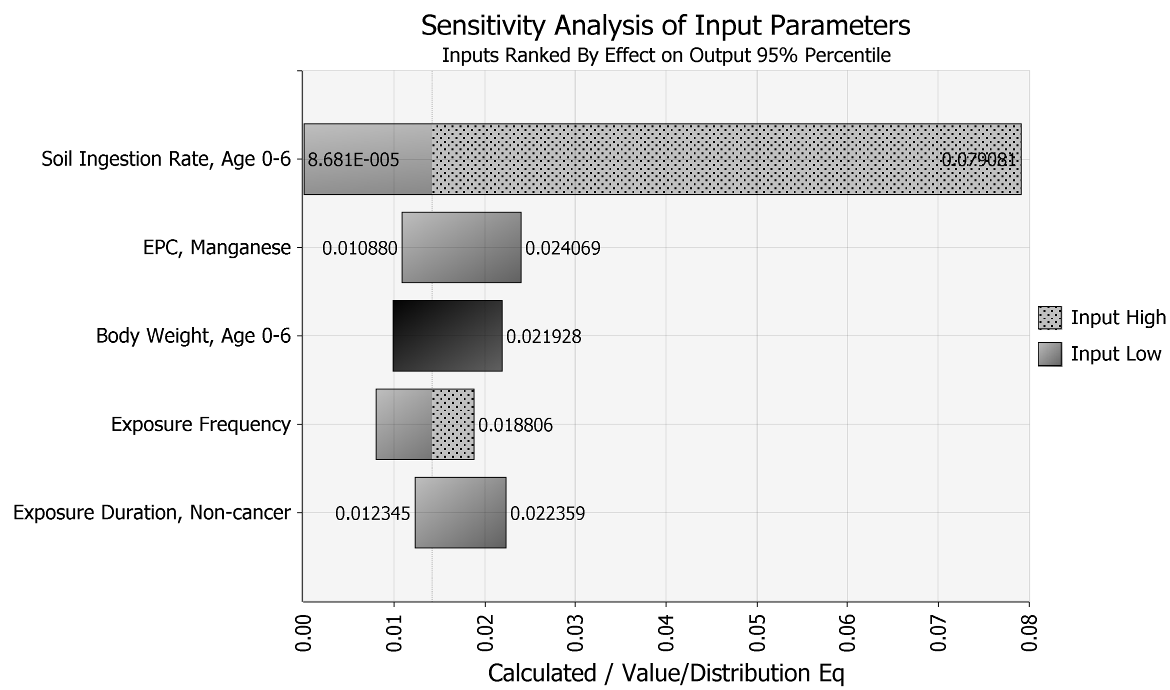
Notes:
Run with 10,000 iterations.
Effect of risk input parameters on non-cancer hazard index 95th percentile.
Parameters with the longest bars have the largest impact on the output distribution. The length of the bar shown for each parameter is based on the range of the highest input value to the lowest input value. Parameters that have a positive impact on the 95th percentile output have the high inputs on the right and parameters that have a negative impact on 95th percentile output have the high inputs on the left.

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Sensitivity Analysis for Cadmium Non-cancer Risk, Inhalation Pathway

ARCADIS



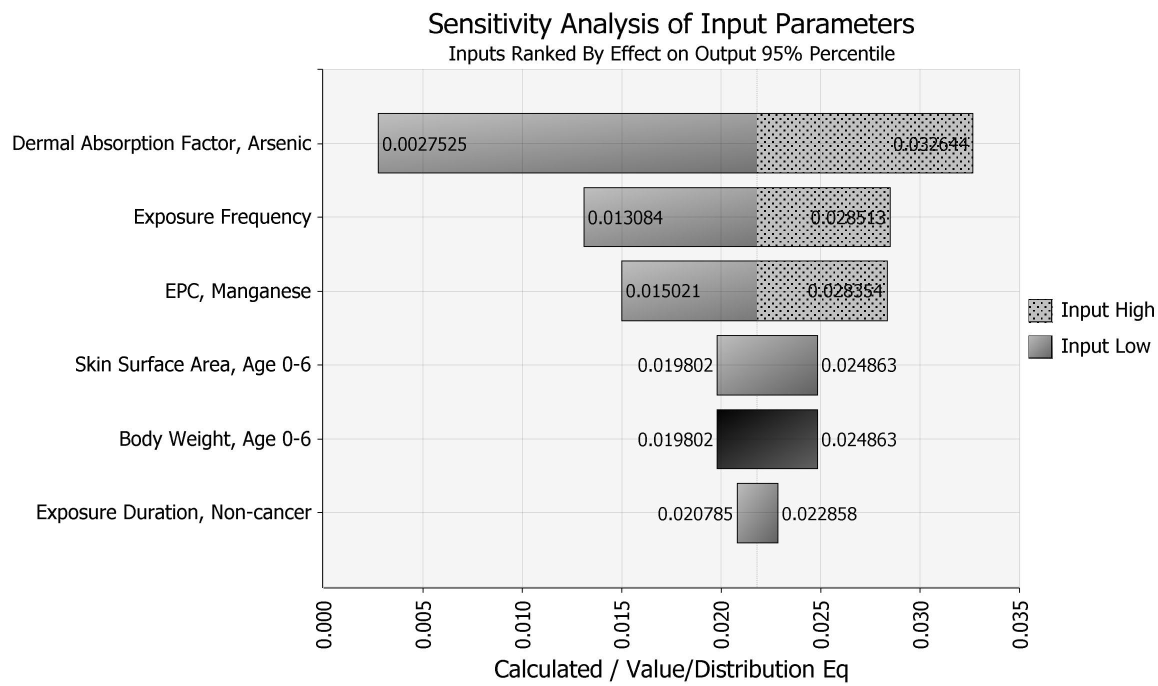
Notes:
Run with 10,000 iterations.
Effect of risk input parameters on non-cancer hazard index 95th percentile. Parameters with the longest bars have the largest impact on the output distribution. The length of the bar shown for each parameter is based on the range of the highest input value to the lowest input value. Parameters that have a positive impact on the 95th percentile output have the high inputs on the right and parameters that have a negative impact on 95th percentile output have the high inputs on the left.

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Sensitivity Analysis for Manganese Non-cancer Risk, Ingestion Pathway

ARCADIS



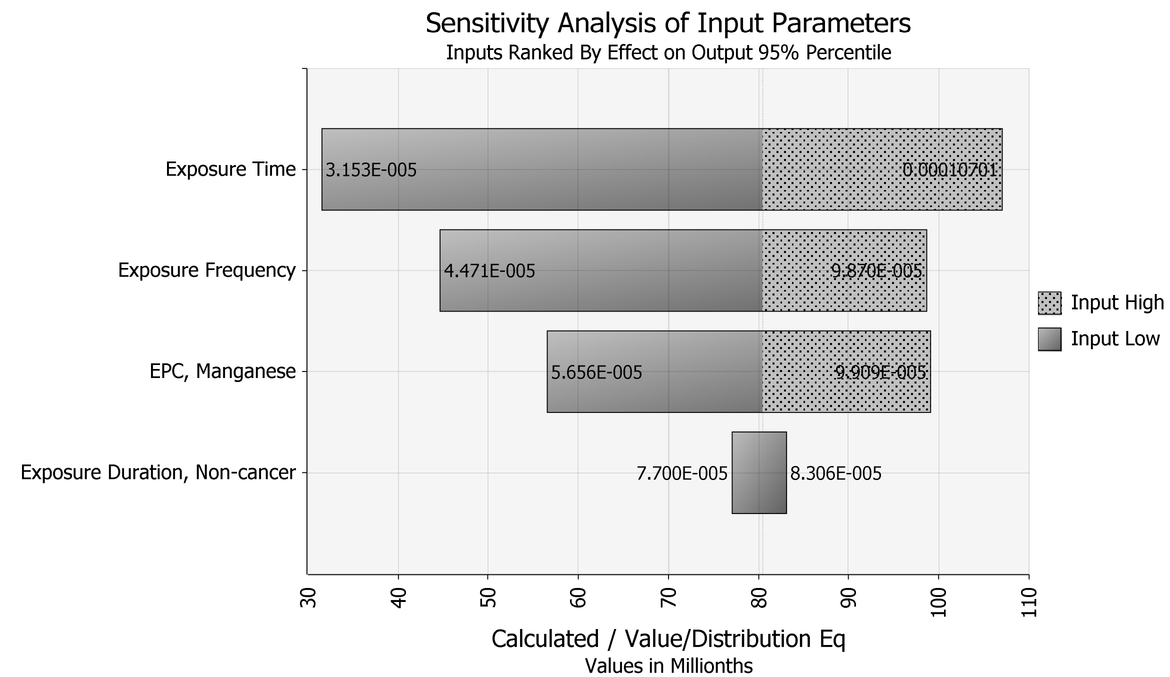
Notes:
Run with 10,000 iterations.
Effect of risk input parameters on non-cancer hazard index 95th percentile. Parameters with the longest bars have the largest impact on the output distribution. The length of the bar shown for each parameter is based on the range of the highest input value to the lowest input value. Parameters that have a positive impact on the 95th percentile output have the high inputs on the right and parameters that have a negative impact on 95th percentile output have the high inputs on the left.

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Sensitivity Analysis for Manganese Non-cancer Risk, Dermal Pathway

ARCADIS



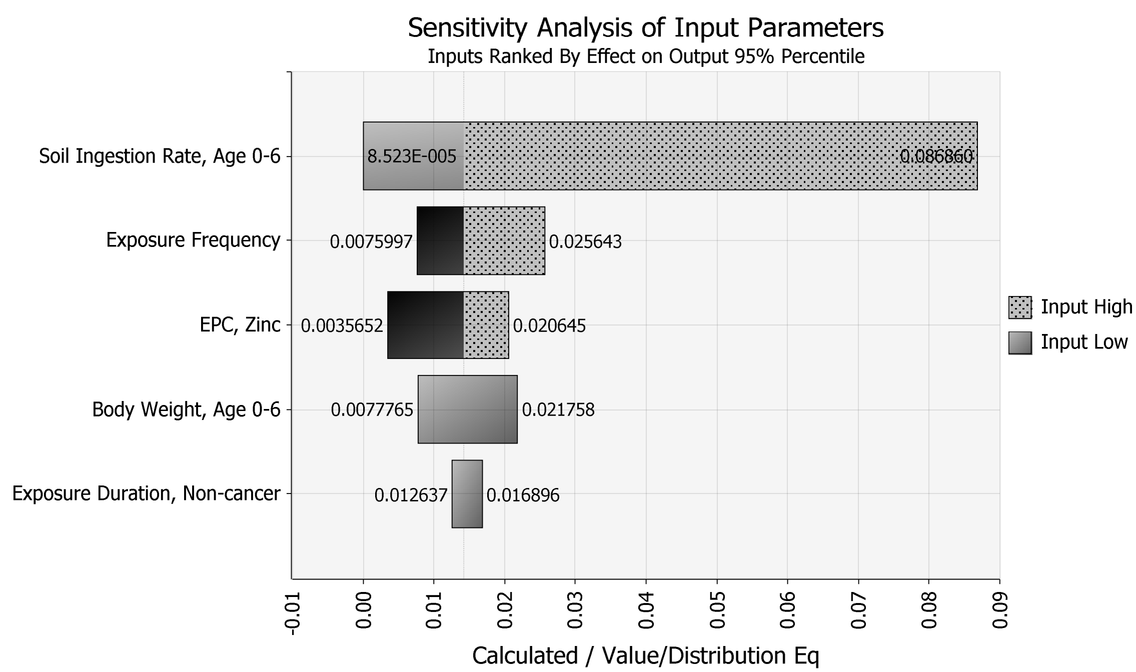
Notes:
Run with 10,000 iterations.
Effect of risk input parameters on non-cancer hazard index 95th percentile. Parameters with the longest bars have the largest impact on the output distribution. The length of the bar shown for each parameter is based on the range of the highest input value to the lowest input value. Parameters that have a positive impact on the 95th percentile output have the high inputs on the right and parameters that have a negative impact on 95th percentile output have the high inputs on the left.

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Sensitivity Analysis for Manganese Non-cancer Risk, Inhalation Pathway

ARCADIS



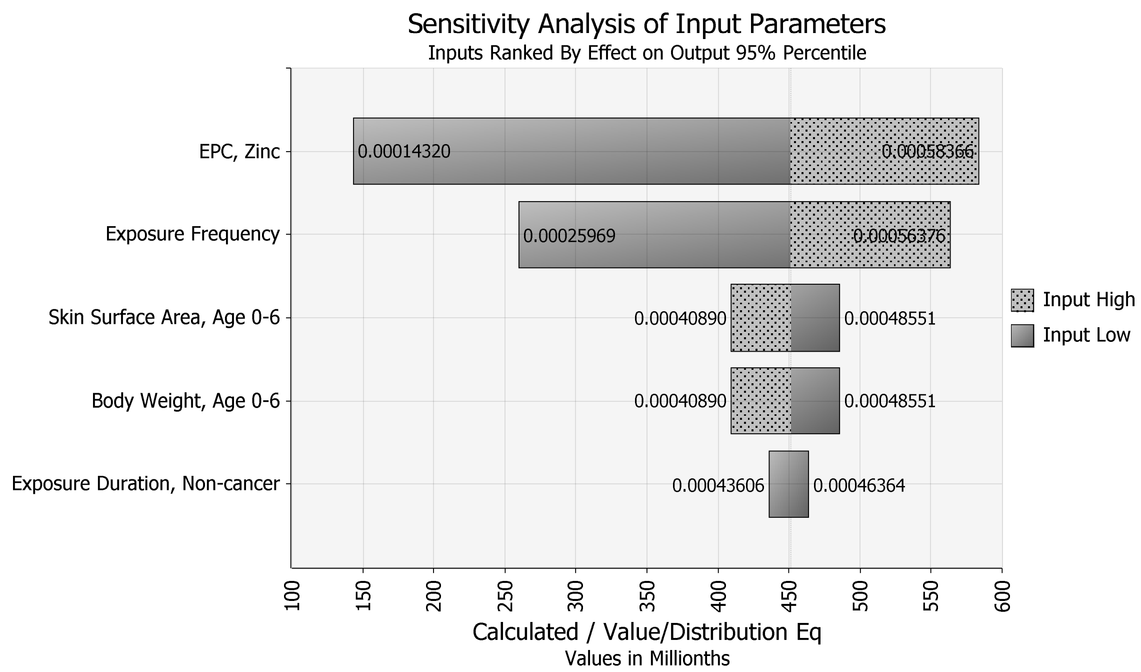
Notes:
Run with 10,000 iterations.
Effect of risk input parameters on non-cancer hazard index 95th percentile. Parameters with the longest bars have the largest impact on the output distribution. The length of the bar shown for each parameter is based on the range of the highest input value to the lowest input value. Parameters that have a positive impact on the 95th percentile output have the high inputs on the right and parameters that have a negative impact on 95th percentile output have the high inputs on the left.

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Sensitivity Analysis for Zinc Non-cancer Risk, Ingestion Pathway

ARCADIS



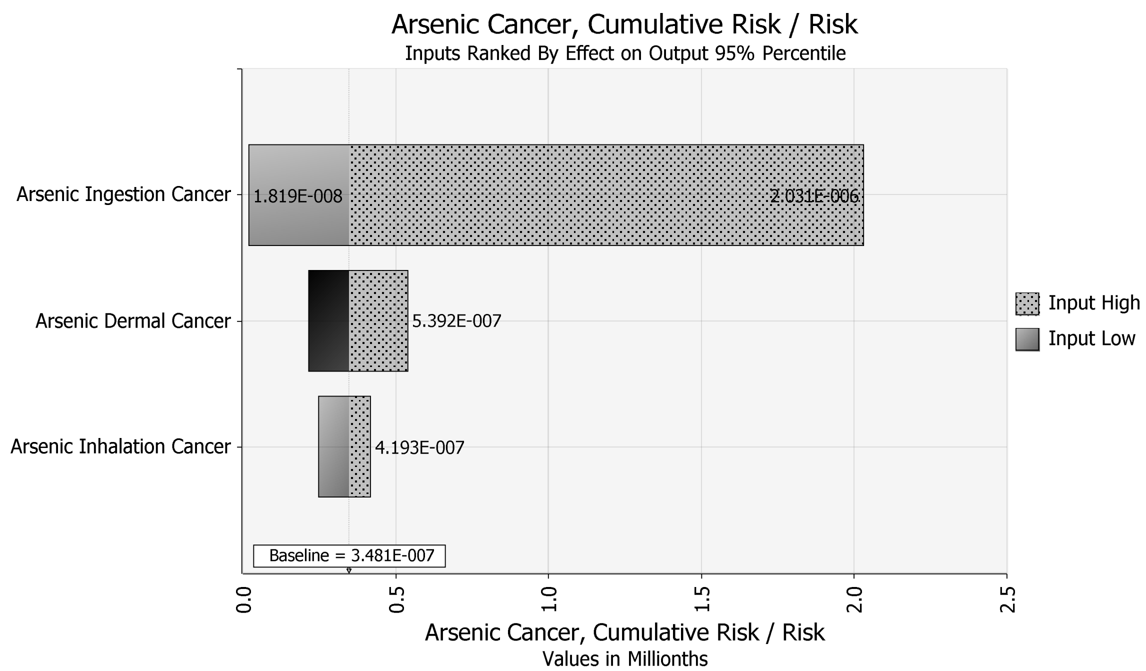
Notes:
Run with 10,000 iterations.
Effect of risk input parameters on non-cancer hazard index 95th percentile.
Parameters with the longest bars have the largest impact on the output distribution. The length of the bar shown for each parameter is based on the range of the highest input value to the lowest input value. Parameters that have a positive impact on the 95th percentile output have the high inputs on the right and parameters that have a negative impact on 95th percentile output have the high inputs on the left.

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Sensitivity Analysis for Zinc Non-cancer Risk, Dermal Pathway

ARCADIS



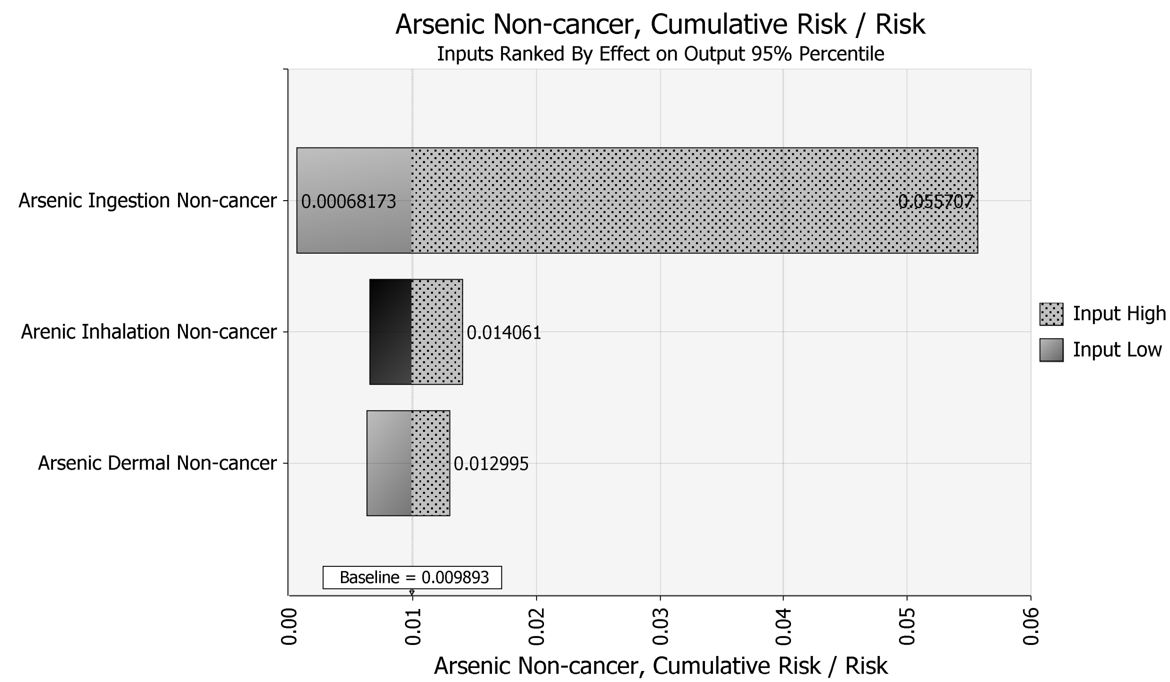
Notes:
Run with 10,000 iterations.
Effect of each exposure pathway on cumulative cancer risk 95th percentile. Parameters with the longest bars have the largest impact on the output distribution. The length of the bar shown for each parameter is based on the range of the highest input value to the lowest input value. Parameters that have a positive impact on the 95th percentile output have the high inputs on the right and parameters that have a negative impact on 95th percentile output have the high inputs on the left.

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Sensitivity Analysis for Cumulative Arsenic Cancer Risk

ARCADIS



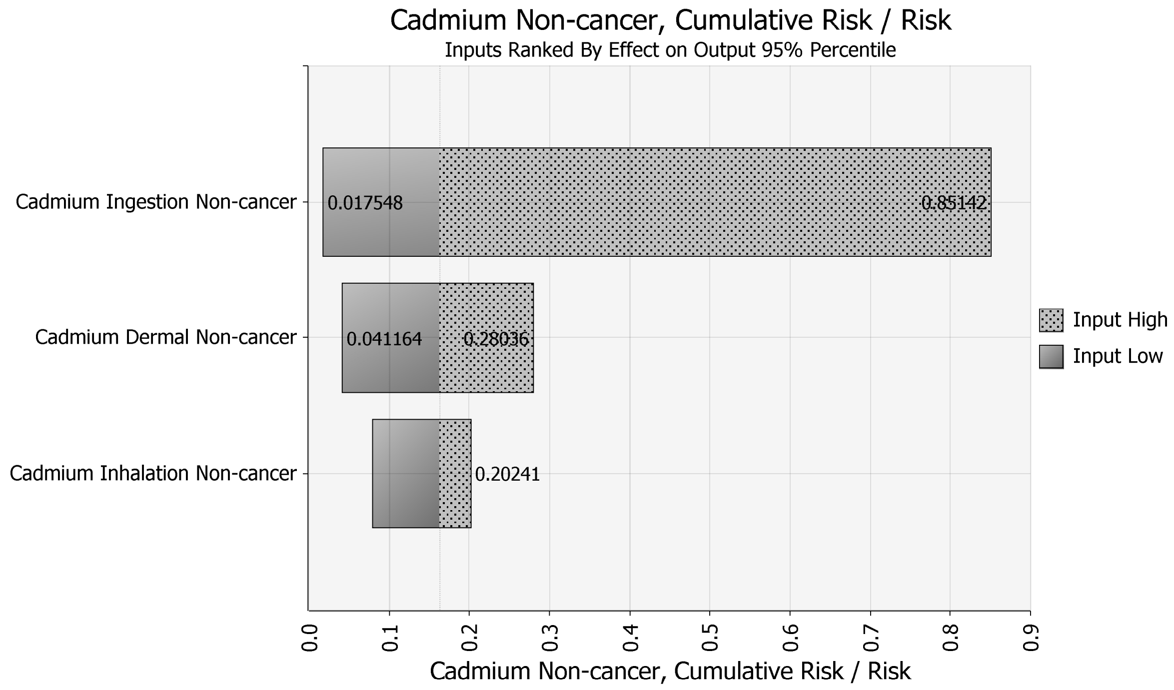
Notes:
Run with 10,000 iterations.
Effect of each exposure pathway on cumulative non-cancer hazard index 95th percentile. Parameters with the longest bars have the largest impact on the output distribution. The length of the bar shown for each parameter is based on the range of the highest input value to the lowest input value. Parameters that have a positive impact on the 95th percentile output have the high inputs on the right and parameters that have a negative impact on 95th percentile output have the high inputs on the left.

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Sensitivity Analysis for Cumulative Arsenic Non-cancer Risk

ARCADIS



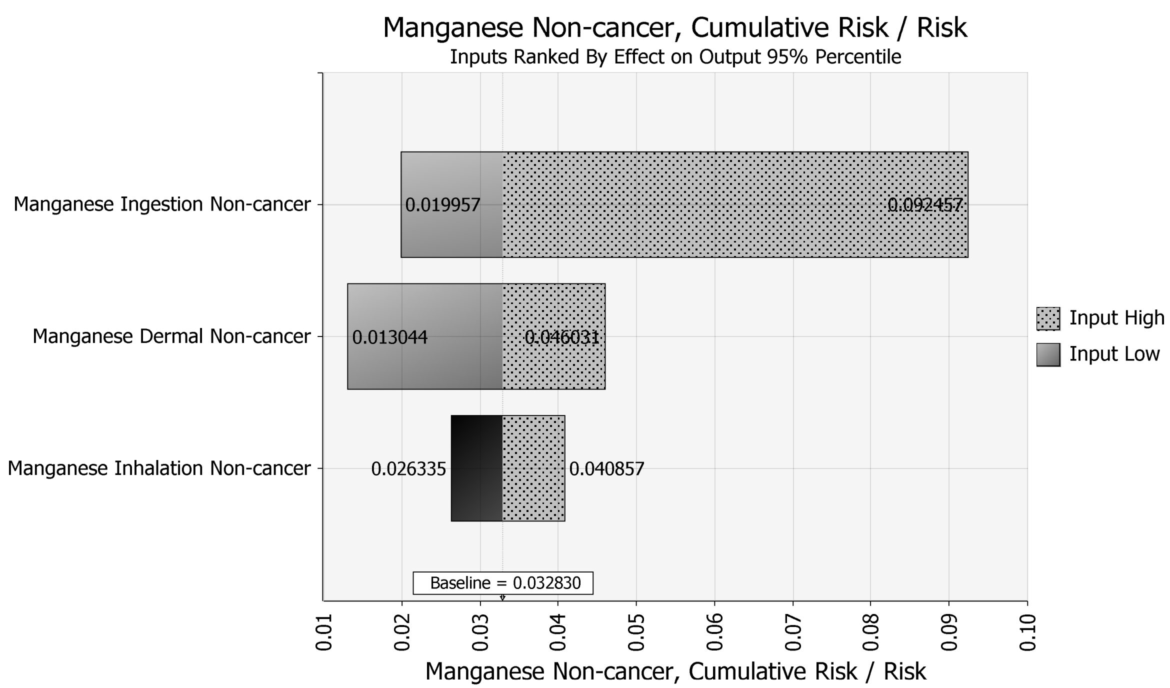
Notes:
Run with 10,000 iterations.
Effect of each exposure pathway on cumulative cancer risk 95th percentile.
Parameters with the longest bars have the largest impact on the output distribution. The length of the bar shown for each parameter is based on the range of the highest input value to the lowest input value. Parameters that have a positive impact on the 95th percentile output have the high inputs on the right and parameters that have a negative impact on 95th percentile output have the high inputs on the left.

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Sensitivity Analysis for Cumulative Cadmium Non-cancer Risk

ARCADIS



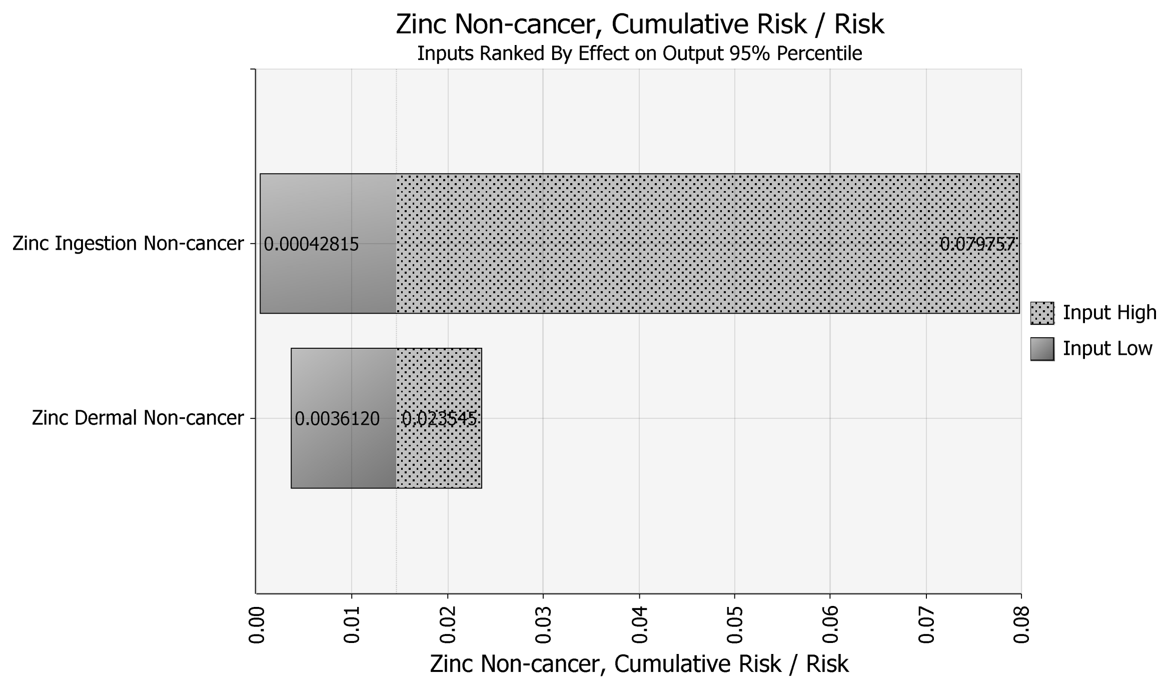
Notes:
Run with 10,000 iterations.
Effect of each exposure pathway on cumulative non-cancer hazard index 95th percentile. Parameters with the longest bars have the largest impact on the output distribution. The length of the bar shown for each parameter is based on the range of the highest input value to the lowest input value. Parameters that have a positive impact on the 95th percentile output have the high inputs on the right and parameters that have a negative impact on 95th percentile output have the high inputs on the left.

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Sensitivity Analysis for Cumulative Manganese Non-cancer Risk

ARCADIS



Notes:
Run with 10,000 iterations.
Effect of each exposure pathway on cumulative cancer risk 95th percentile. Parameters with the longest bars have the largest impact on the output distribution. The length of the bar shown for each parameter is based on the range of the highest input value to the lowest input value. Parameters that have a positive impact on the 95th percentile output have the high inputs on the right and parameters that have a negative impact on 95th percentile output have the high inputs on the left.

AMAX Arizona, Inc. / Anaconda Arizona, Inc

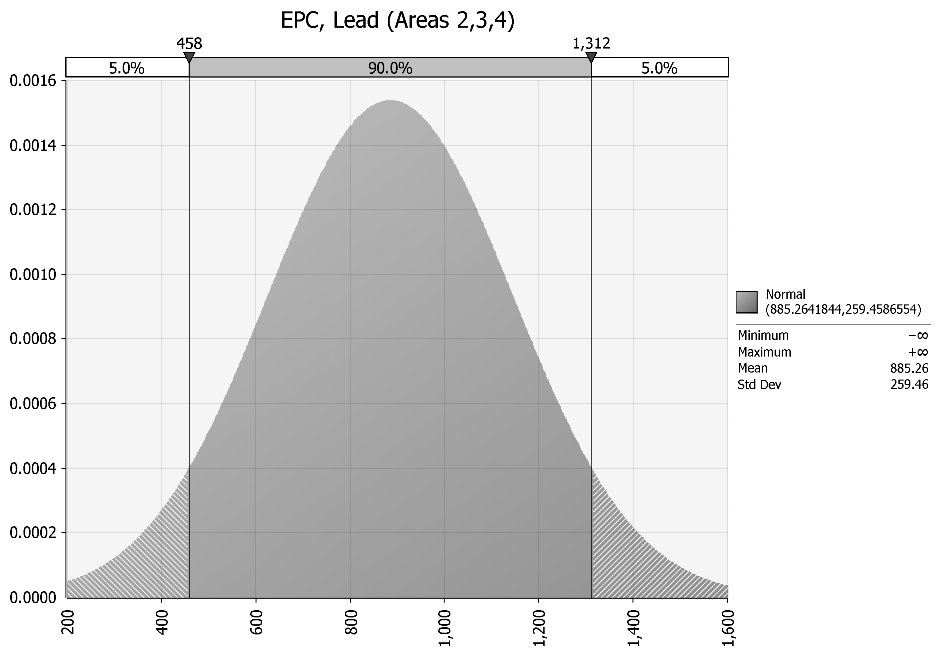
Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Sensitivity Analysis for Cumulative Zinc Non-cancer Risk

ARCADIS

Appendix B

IEUBK Model Output and Lead Distribution



See Appendix C for lead soil concentrations used to develop this distribution

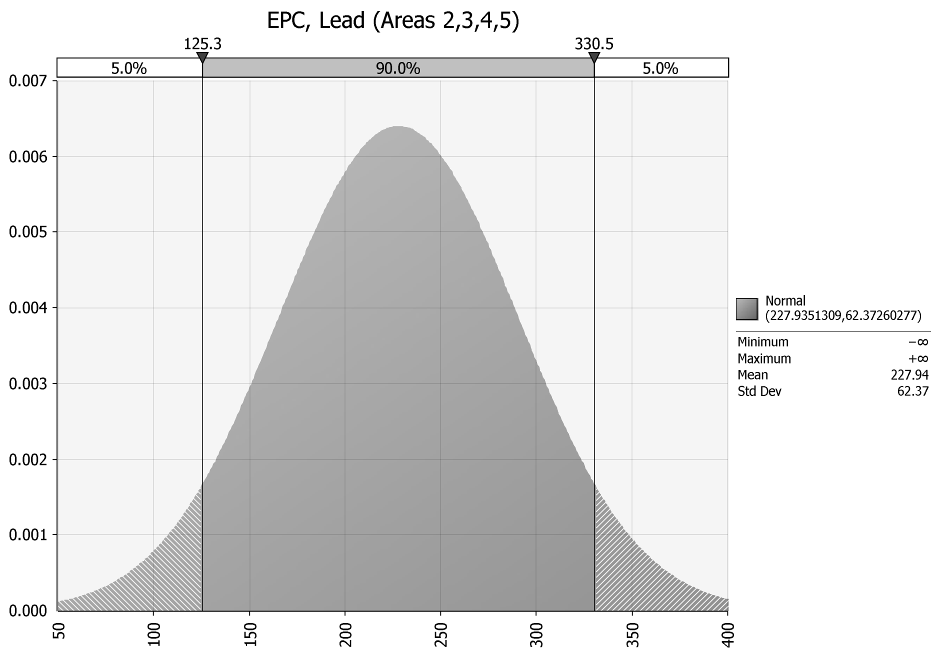
Distribution Input	
Normal Distribution	EPC (mg/kg)
Mean	885.26
Standard Deviation	259.46
95% UCL	890.35

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Distribution for Area-weighted Exposure Point Concentration, Lead in Soil (0-1 ft bgs) (mg/kg)
Areas 2, 3, 4

ARCADIS



See Appendix C for lead soil concentrations used to develop this distribution

Distribution Input	
Normal Distribution	**EPC (mg/kg)**
Mean	227.94
Standard Deviation	62.37
95% UCL	229.16

AMAX Arizona, Inc. / Anaconda Arizona, Inc

Former Eagle Picher Mill Site on Parcel 30
Sahuarita, Arizona

Distribution for Area-weighted Exposure Point Concentration, Lead in Soil (0-1 ft bgs) (mg/kg)
Areas 2, 3, 4, 5

ARCADIS

LEAD MODEL FOR WINDOWS Version 2.0

These IEUBK Model results are valid as long as they were produced with an official, unmodified version of the IEUBK Model with a software certificate.

While IEUBK Model output is generally written with three digits to the right of the decimal point, the true precision of the output is strongly influenced by least precise input values.

==
Model Version: 2.0 Build1
User Name: Arcadis
Date: May 2022
Site Name: Parcel 30
Exposure Scenario: Time-weighted Soil Lead Concentration of 363 mg/kg.
Run Mode: Research
==

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

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

Month	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (µg Pb/m^3)
6-12	1.000	3.216	32.000	0.100
12-24	2.000	4.970	32.000	0.100
24-36	3.000	6.086	32.000	0.100
36-48	4.000	6.954	32.000	0.100
48-60	4.000	7.682	32.000	0.100
60-72	4.000	8.318	32.000	0.100
72-84	4.000	8.887	32.000	0.100

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

Month	Diet Intake(µg/day)
6-12	2.660
12-24	5.030
24-36	5.210
36-48	5.380
48-60	5.640
60-72	6.040
72-84	5.950

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

Water Consumption:

Month	Water (L/day)
6-12	0.400
12-24	0.430
24-36	0.510
36-48	0.540
48-60	0.570
60-72	0.600
72-84	0.630

Drinking Water Concentration: 0.900 µg Pb/L

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

Multiple Source Analysis Used
Average multiple source concentration: 264.100 µg/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

Month	Soil (µg Pb/g)	House Dust (µg Pb/g)
6-12	363.000	264.100
12-24	363.000	264.100
24-36	363.000	264.100
36-48	363.000	264.100
48-60	363.000	264.100
60-72	363.000	264.100
72-84	363.000	264.100

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

Month	Alternate (µg Pb/day)
6-12	0.000
12-24	0.000
24-36	0.000
36-48	0.000
48-60	0.000
60-72	0.000
72-84	0.000

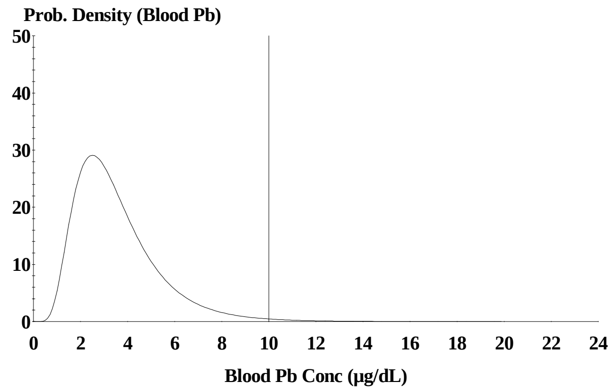
******** Maternal Contribution: Infant Model ********

Maternal Blood Concentration: 0.600 µg Pb/dL

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

Month	Air (µg/day)	Diet (µg/day)	Alternate (µg/day)	Water (µg/day)
6-12	0.034	1.205	0.000	0.163
12-24	0.057	2.294	0.000	0.177
24-36	0.075	2.445	0.000	0.215
36-48	0.093	2.552	0.000	0.230
48-60	0.102	2.687	0.000	0.244
60-72	0.111	2.908	0.000	0.260
72-84	0.118	2.870	0.000	0.274

Month	Soil+Dust (µg/day)	Total (µg/day)	Blood (µg/dL)
6-12	7.215	8.617	4.6
12-24	7.939	10.467	4.4
24-36	5.823	8.559	3.4
36-48	5.533	8.407	3.0
48-60	5.910	8.943	2.9
60-72	4.635	7.914	2.6
72-84	4.913	8.175	2.3



Cutoff = 10.000 µg/dl
Geo Mean = 3.252
GSD = 1.600
% Above = 0.842
% Below = 99.158

Age Range = 12 to 72 months

Run Mode = Research

These IEUBK Model results are valid as long as they were produced with an official, unmodified version of the IEUBK Model with a software certificate.
While IEUBK Model output is generally written with three digits to the right of the decimal point, the true precision of the output is strongly influenced by least precise input values.

LEAD MODEL FOR WINDOWS Version 2.0

These IEUBK Model results are valid as long as they were produced with an official, unmodified version of the IEUBK Model with a software certificate.

While IEUBK Model output is generally written with three digits to the right of the decimal point, the true precision of the output is strongly influenced by least precise input values.

==
Model Version: 2.0 Build1
User Name: Arcadis
Date: May 2022
Site Name: Parcel 30
Exposure Scenario: Time-weighted Soil Lead Concentration of 263 mg/kg.
Run Mode: Research
==

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

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

Month	Time Outdoors (hours)	Ventilation Rate (m³/day)	Lung Absorption (%)	Outdoor Air Pb Conc (µg Pb/m³)
6-12	1.000	3.216	32.000	0.100
12-24	2.000	4.970	32.000	0.100
24-36	3.000	6.086	32.000	0.100
36-48	4.000	6.954	32.000	0.100
48-60	4.000	7.682	32.000	0.100
60-72	4.000	8.318	32.000	0.100
72-84	4.000	8.887	32.000	0.100

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

Month	Diet Intake(µg/day)
6-12	2.660
12-24	5.030
24-36	5.210
36-48	5.380
48-60	5.640
60-72	6.040
72-84	5.950

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

Water Consumption:

Month	Water (L/day)
6-12	0.400
12-24	0.430
24-36	0.510
36-48	0.540
48-60	0.570
60-72	0.600
72-84	0.630

Drinking Water Concentration: 0.900 µg Pb/L

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

Multiple Source Analysis Used
Average multiple source concentration: 194.100 µg/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

Month	Soil (µg Pb/g)	House Dust (µg Pb/g)
6-12	263.000	194.100
12-24	263.000	194.100
24-36	263.000	194.100
36-48	263.000	194.100
48-60	263.000	194.100
60-72	263.000	194.100
72-84	263.000	194.100

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

Month	Alternate (µg Pb/day)
6-12	0.000
12-24	0.000
24-36	0.000
36-48	0.000
48-60	0.000
60-72	0.000
72-84	0.000

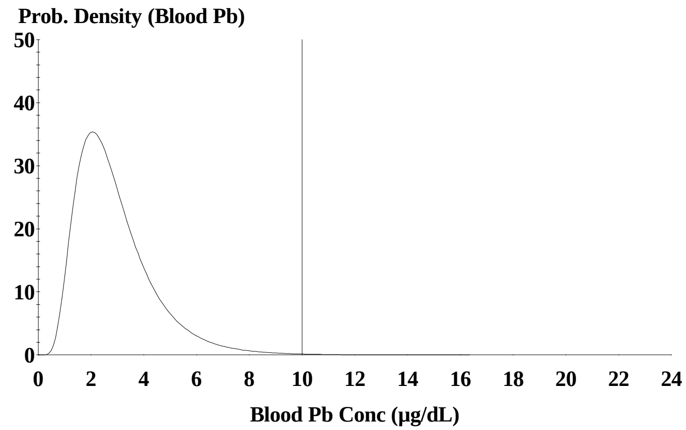
******** Maternal Contribution: Infant Model ********

Maternal Blood Concentration: 0.600 µg Pb/dL

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

Month	Air (µg/day)	Diet (µg/day)	Alternate (µg/day)	Water (µg/day)
6-12	0.034	1.231	0.000	0.167
12-24	0.057	2.336	0.000	0.180
24-36	0.075	2.473	0.000	0.218
36-48	0.093	2.575	0.000	0.233
48-60	0.102	2.710	0.000	0.246
60-72	0.111	2.925	0.000	0.262
72-84	0.118	2.887	0.000	0.275

Month	Soil+Dust (µg/day)	Total (µg/day)	Blood (µg/dL)
6-12	5.375	6.807	3.6
12-24	5.896	8.468	3.6
24-36	4.296	7.062	2.8
36-48	4.073	6.973	2.5
48-60	4.347	7.406	2.4
60-72	3.401	6.699	2.2
72-84	3.604	6.885	2.0



Cutoff = 10.000 µg/dl
Geo Mean = 2.676
GSD = 1.600
% Above = 0.252
% Below = 99.748

Age Range = 12 to 72 months

Run Mode = Research

These IEUBK Model results are valid as long as they were produced with an official, unmodified version of the IEUBK Model with a software certificate.
While IEUBK Model output is generally written with three digits to the right of the decimal point, the true precision of the output is strongly influenced by least precise input values.

Appendix C

EPC Data Sets

Appendix C: Parcel 30 Soil Data (0-1 ft bgs) for Arsenic, Cadmium, Lead, Manganese and Zinc

Investigation	Sample ID	Note	Area	Sample Date	Sample Interval	Arsenic	Cadmium	Lead	Manganese	Zinc
Brown Caldwell	BH1-1		Area 2	5/8/2018	0-1	4.3	<0.49	34	270	
Brown Caldwell	BH2-0-4	(1)	Area 4	5/8/2018	0-4	4.2	<0.50	13	300	
Brown Caldwell	BH3-1		Area 2	5/8/2018	0-1	4	<0.50	47	250	
Brown Caldwell	BH4-1	(2)	Area 2	5/8/2018	0-1	3.7	12	~~46~~	260	
Brown Caldwell	BH5-1		Area 2	5/8/2018	0-1	4.4	2.1	34	300	
Brown Caldwell	BH6-1		Area 3	5/8/2018	0-1	5.9	<0.50	15	340	
Brown Caldwell	BH7-1		Area 3	5/8/2018	0-1	3.3	<0.50	12	240	
Brown Caldwell	BH8-1		Area 3	5/8/2018	0-1	4.1	<0.50	46	280	
Brown Caldwell	BH9-1		Area 2	5/8/2018	0-1	68	43	2900	700	
Clear Creek	A2-31		Area 2	6/2-4/2014	0-1	5.7		1790	446	
Clear Creek	A2-32		Area 2	6/2-4/2014	0-1	14.6		4460	811	
Clear Creek	A2-33		Area 2	6/2-4/2014	0-1	6.8		2130	775	
Clear Creek	A2-34		Area 2	6/2-4/2014	0-1	8.4		3980	895	
Clear Creek	A2-35	(3)	Area 2	6/2-4/2014	0-1	~~10~~		~~1620~~	1220	
Clear Creek	A2-35b	(3)	Area 2	6/2-4/2014	0-1	15		4820	~~1050~~	
Clear Creek	A2-36		Area 2	6/2-4/2014	0-1	91.1		18500	1740	
Clear Creek	A2-45		Area 2	6/2-4/2014	0-1	2.4		22.5	186	
Clear Creek	A2-46		Area 2	6/2-4/2014	0-1	2.2		83.8	213	
Clear Creek	A2-47	(2)	Area 2	6/2-4/2014	0-1	~~2.3~~		72.2	~~213~~	
Clear Creek	A3-38		Area 3	6/2-4/2014	0-1	7.1		2350	2310	
Clear Creek	A3-39		Area 3	6/2-4/2014	0-1	3.9		20.9	316	
Clear Creek	A3-40		Area 3	6/2-4/2014	0-1	2.7		17.5	238	
Clear Creek	A3-41		Area 3	6/2-4/2014	0-1	7.4		1740	2640	
Clear Creek	A3-42		Area 3	6/2-4/2014	0-1	1.8		14.2	187	
Clear Creek	A3-43		Area 3	6/2-4/2014	0-1	5.8		2590	2850	
Clear Creek	A3-44		Area 3	6/2-4/2014	0-1	2.6		8.9	196	
Clear Creek	A3-48		Area 3	6/2-4/2014	0-1	8.8		189	997	
Clear Creek	A3-49		Area 3	6/2-4/2014	0-1	7		83.7	708	
Clear Creek	A3-50		Area 3	6/2-4/2014	0-1	4.1		67.3	315	
Clear Creek	A3-51		Area 3	6/2-4/2014	0-1	2.3		23.9	255	
Clear Creek	A4-01		Area 4	6/2-4/2014	0-1	1.6		27.7	137	
Clear Creek	A4-02		Area 4	6/2-4/2014	0-1	2.1		75.6	215	
Clear Creek	A4-03		Area 4	6/2-4/2014	0-1	1.9		23.8	159	
Clear Creek	A4-04		Area 4	6/2-4/2014	0-1	2.9		15.3	238	
Clear Creek	A4-05		Area 4	6/2-4/2014	0-1	4.8		206	629	
Clear Creek	A4-06		Area 4	6/2-4/2014	0-2	4.1		664	967	
Clear Creek	A4-07		Area 4	6/2-4/2014	0-1	15		3940	4920	
Clear Creek	A4-08		Area 4	6/2-4/2014	0-1	5.6		26.4	639	
Clear Creek	A4-09		Area 4	6/2-4/2014	0-1	7.2		610	1430	
Clear Creek	A4-10		Area 4	6/2-4/2014	0-1	4.1		21.8	450	
Clear Creek	A4-11		Area 4	6/2-4/2014	0-1	4.1		59.1	381	
Clear Creek	A4-12		Area 4	6/2-4/2014	0-1	5.3		235	563	
Clear Creek	A4-13		Area 4	6/2-4/2014	0-1	4.2		107	400	
Clear Creek	A4-14		Area 4	6/2-4/2014	0-1	2.9		25.7	298	
Clear Creek	A4-15		Area 4	6/2-4/2014	0-1	4		65	403	
Clear Creek	A4-16		Area 4	6/2-4/2014	0-1	5		13.5	382	
Clear Creek	A4-17		Area 4	6/2-4/2014	0-1	5.2		13.9	477	
Clear Creek	A4-18	(4)	Area 4	6/2-4/2014	0-1	~~4~~		~~164~~	~~480~~	
Clear Creek	A4-18b	(4)	Area 4	6/2-4/2014	0-1	6.8		399	872	
Clear Creek	A4-19		Area 4	6/2-4/2014	0-1	4.6		82.4	367	
Clear Creek	A4-20		Area 4	6/2-4/2014	0-1	5.3		70.6	351	
Clear Creek	A4-21		Area 4	6/2-4/2014	0-1	3.4		18.6	278	
Clear Creek	A4-22		Area 4	6/2-4/2014	0-1	3.8		131	326	
Clear Creek	A4-23		Area 4	6/2-4/2014	0-1	3		22.2	258	
Clear Creek	A4-24		Area 4	6/2-4/2014	0-1	2		6.9	124	
Clear Creek	A4-25		Area 4	6/2-4/2014	0-1	3.7		10.2	350	
Clear Creek	A4-26		Area 4	6/2-4/2014	0-1	3.8		11.4	354	
Clear Creek	A4-27		Area 4	6/2-4/2014	0-1	5.1		110	252	
Clear Creek	A4-28		Area 4	6/2-4/2014	0-1	6.2		16.2	559	
Clear Creek	A4-29		Area 4	6/2-4/2014	0-1	1.7		12.6	140	
Clear Creek	A4-30		Area 4	6/2-4/2014	0-1	2.2		18.2	194	
Hydrometrics	M-1A	(5)	Area 2	5/10/1999	0-6 inches	~~<5.0~~	~~1.9~~	~~68~~		150
Hydrometrics	M-1B		Area 2	5/10/1999	6-12 inches	27	75	14000		14000
Hydrometrics	M-2A		Area 2	5/10/1999	0-6 inches	~~<5.0~~	~~1.3~~	~~28~~		83
Hydrometrics	M-2B		Area 2	5/10/1999	6-12 inches	12	23	3300		5500
Hydrometrics	M-3A		Area 2	5/10/1999	0-6 inches	~~<5.0~~	1.7	~~17~~		66
Hydrometrics	M-3B		Area 2	5/10/1999	6-12 inches	<5.0	~~1.6~~	19		55
Hydrometrics	M-4A		Area 2	5/10/1999	0-6 inches	~~<5.0~~	~~1.3~~	~~17~~		44
Hydrometrics	M-4B		Area 2	5/10/1999	6-12 inches	9.9	34	5600		8200
Hydrometrics	M-5A		Area 2	5/10/1999	0-6 inches	~~<5.0~~	~~2.7~~	~~220~~		390
Hydrometrics	M-5B		Area 2	5/10/1999	6-12 inches	20	11	7200		2500
Hydrometrics	B-1A		Area 4	5/10/1999	0-6 inches	~~<5.0~~	2.7	220		360
Hydrometrics	B-1B		Area 4	5/10/1999	6-12 inches	<5.0	~~1.3~~	~~28~~		63
Hydrometrics	B-2A		Area 4	5/10/1999	0-6 inches	~~<5.0~~	3.2	240		470
Hydrometrics	B-2B		Area 4	5/10/1999	6-12 inches	<5.0	~~1.5~~	~~41~~		91
Hydrometrics	P-1A		Area 3	5/10/1999	0-6 inches	~~5.8~~	~~6.6~~	760		1100
Hydrometrics	P-1B		Area 3	5/10/1999	6-12 inches	10	7.1	~~470~~		2200
Hydrometrics	P-2A		Area 3	5/10/1999	0-6 inches	~~<5.0~~	~~2.9~~	~~270~~		560
Hydrometrics	P-2B		Area 3	5/10/1999	6-12 inches	<5.0	3.3	360		660
Hydrometrics	P-3A		Area 3	5/10/1999	0-6 inches	~~<5.0~~	2.7	290		490
Hydrometrics	P-3B		Area 3	5/10/1999	6-12 inches	<5.0	~~2.4~~	~~170~~		350
Hydrometrics	D-1A		Area 4/wash	5/10/1999	0-6 inches	~~<5.0~~	~~0.8~~	~~13~~		29
Hydrometrics	D-1B		Area 4/wash	5/10/1999	6-12 inches	<5.0	1.7	120		230

Appendix C: Parcel 30 Soil Data (0-1 ft bgs) for Arsenic, Cadmium, Lead, Manganese and Zinc

Investigation	Sample ID	Note	Area	Sample Date	Sample Interval	Arsenic	Cadmium	Lead	Manganese	Zinc
Hydrometrics	R-1A	(6)	Area 5	5/10/1999	0-6 inches			36		
Hydrometrics	R-1B		Area 5	5/10/1999	6-12 inches			~~13~~		
Hydrometrics	R-2A		Area 5	5/10/1999	0-6 inches			120		
Hydrometrics	R-2B		Area 5	5/10/1999	6-12 inches			~~26~~		
Hydrometrics	R-3A		Area 5	5/10/1999	0-6 inches			18		
Hydrometrics	R-3B		Area 5	5/10/1999	6-12 inches			~~7.8~~		
Hydrometrics	S-1A		Area 5	5/10/1999	0-6 inches			20		
Hydrometrics	S-2A		Area 5	5/10/1999	0-6 inches			16		
Hydrometrics	S-3A		Area 5	5/10/1999	0-6 inches			9.1		
Hydrometrics	S-4A		Area 5	5/10/1999	0-6 inches			15		
Hydrometrics	S-5A		Area 5	5/10/1999	0-6 inches			17		

Notes:

Sample results that were not included in the human health risk assessment are in "strikethrough" font.

1. Data from sample BH2-0-4 were selectively added to this data set, because there are no 0-1 foot sample data from BH2.
2. Used maximum of BH4-1 and A2-47 because latter appears to be outside Parcel 30 boundary and BH-4 location is closest to A2-47.
3. Used maximum of A2-35 and A2-35b because samples are co-located.
4. Used maximum of A4-18 and A4-18b because samples are co-located.
5. For Hydrometrics data:
   For arsenic, cadmium, and lead, used maximum of two samples collected at each location.
   For zinc, used all results (two samples were collected at each location); no zinc data are available from other locations.
6. For Area 5, data from 8 lead samples were used to calculate an upper-bound estimate (i.e., 95% UCL) of average local lead concentrations in soil (see Section 6.3). Used maximums of R-1A/B, R-2A/B, and R-3A/B because samples are co-located. Data from seven samples (i.e., S-1A, S-2A, S-3A, S-4A, S-5A, R-3A and R-3B) from unimpacted locations in Area 5 were used to calculate an arithmetic mean background lead concentration (see Section 3.5).

Appendix D

Box Plots and Statistics

Constituent of Potential Concern	Frequency of Detection	Kruskal-Wallis Test [1]						
		Count Per Group			Kruskal-Wallis Test Statistic	Percentile of Chi-Square Distribution (USEPA 2009)	p-value	Variability? [2]
		0 - 1 foot	0 - 6 inches	6 - 12 inches				
Cadmium	25 / 30 [83%]	8	11	11	4.493	5.991	0.106	No
Lead	82 / 82 [100%]	60	11	11	5.067	5.991	0.079	No
Zinc	22 / 22 [100%]	--	11	11	2.183	3.841	0.140	No

Notes:

[1] The Kruskal-Wallis test was performed when the sample size was greater than or equal to 12 and the FOD for each dataset was greater than 25%.

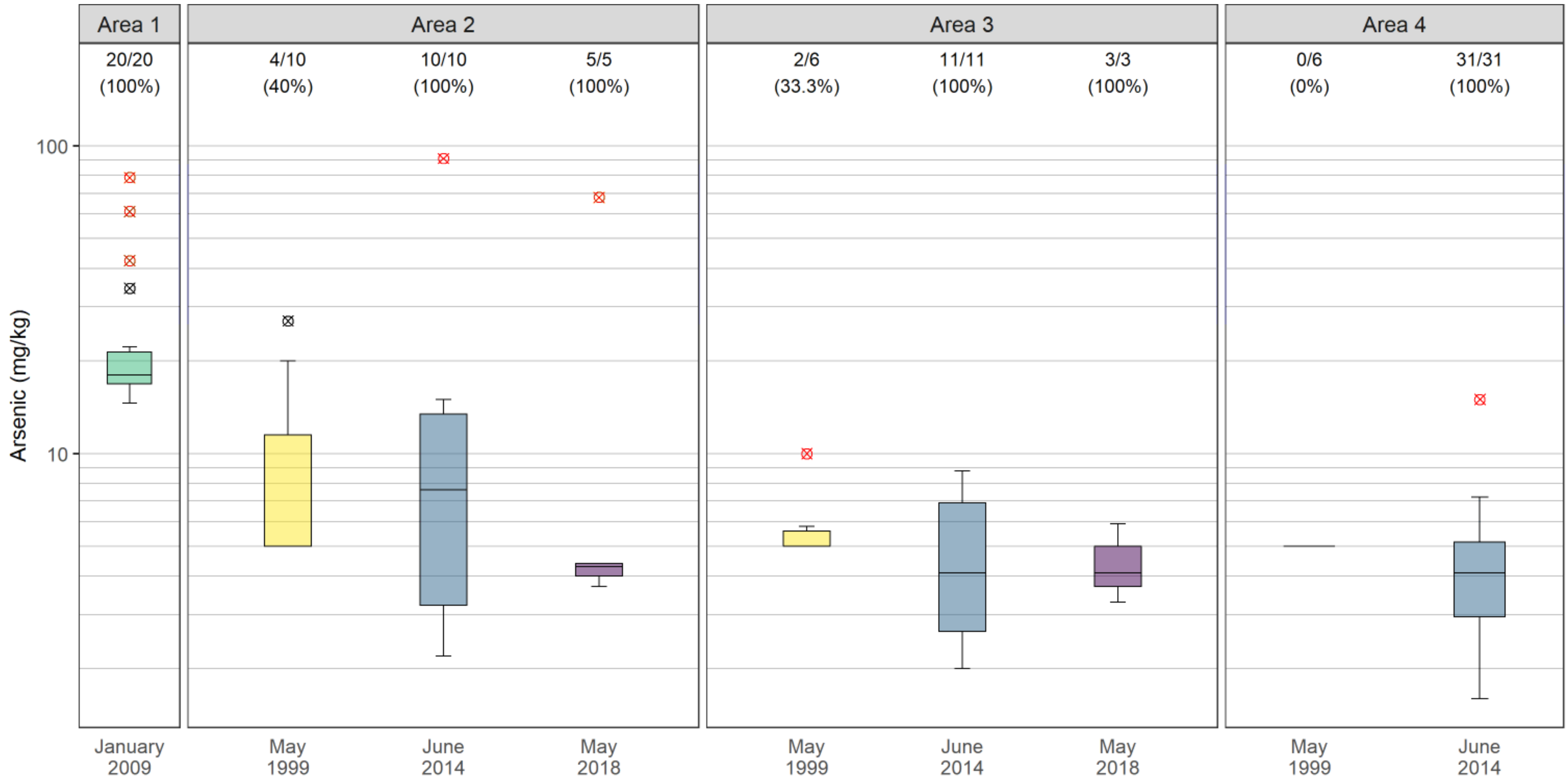
[2] Evidence the mean concentration for at least one group differed from the others was found if the p-value was less than or equal to 0.05.

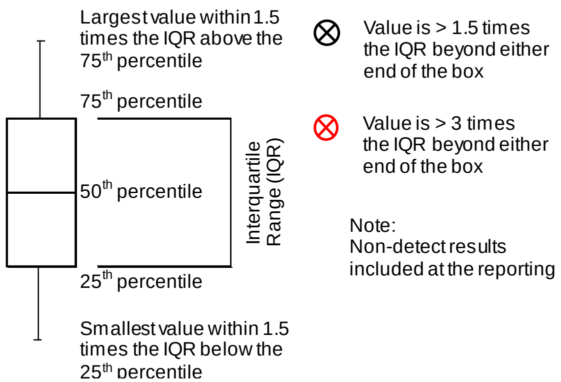
Acronyms and Abbreviations:

FOD : frequency of detection (# detects / # samples)
p-value : probability value
USEPA : United States Environmental Protection Agency
-- : insufficient data for calculating statistics or not available
% : percent

References:

USEPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities. Unified Guidance. EPA/530/R-09/007, 2009.



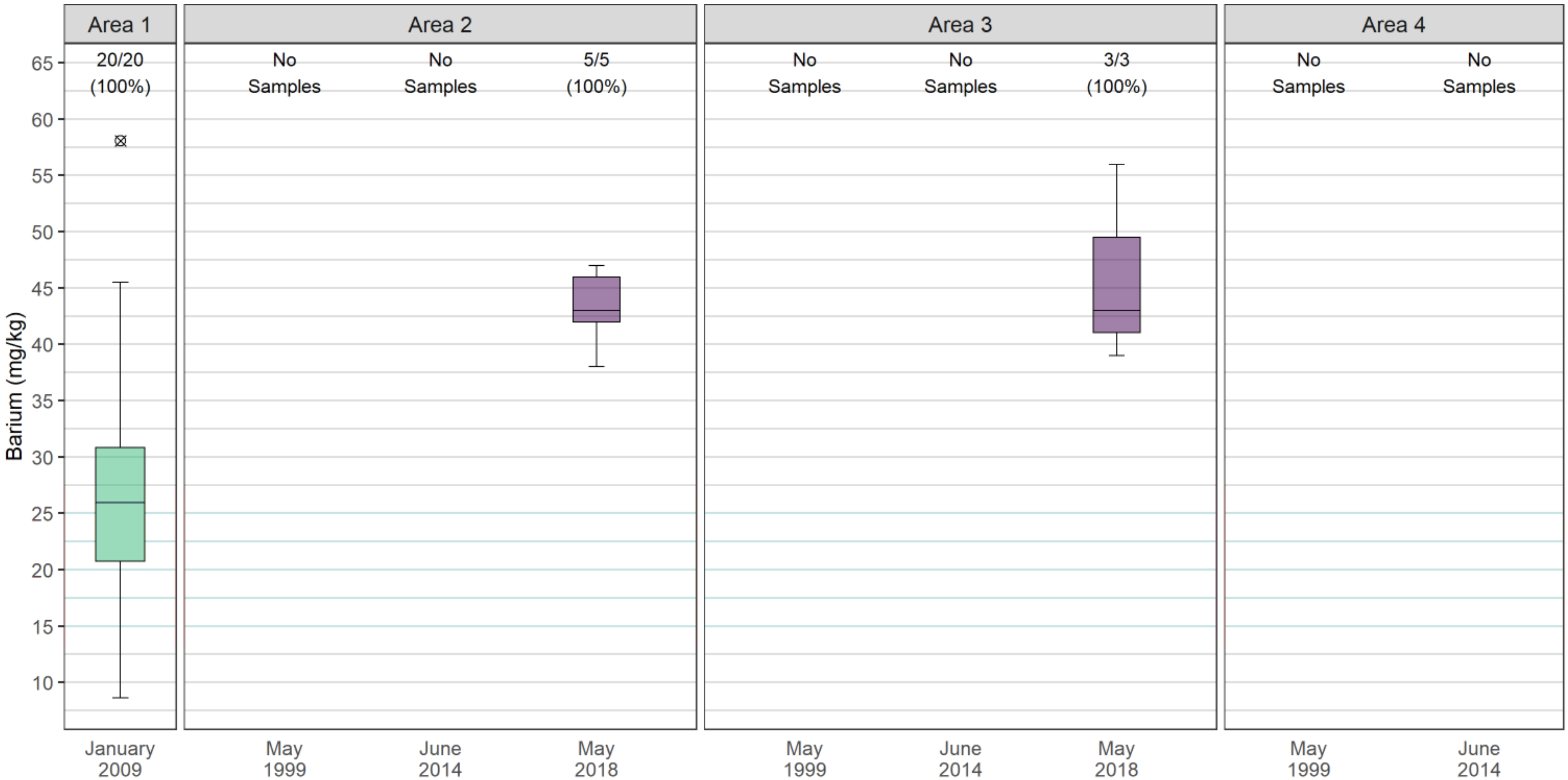


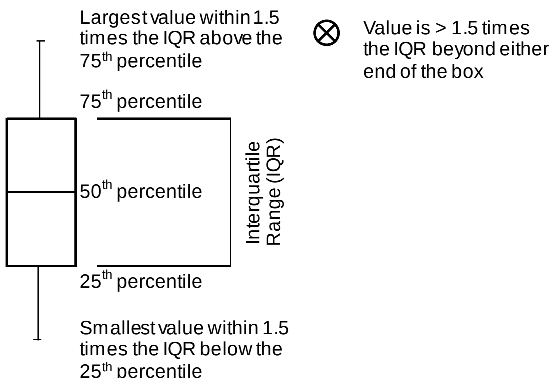
PARCEL 30
SUAHARITA, AZ

ARSENIC CONCENTRATION BY AREA

ARCADIS

FIGURE
D-1



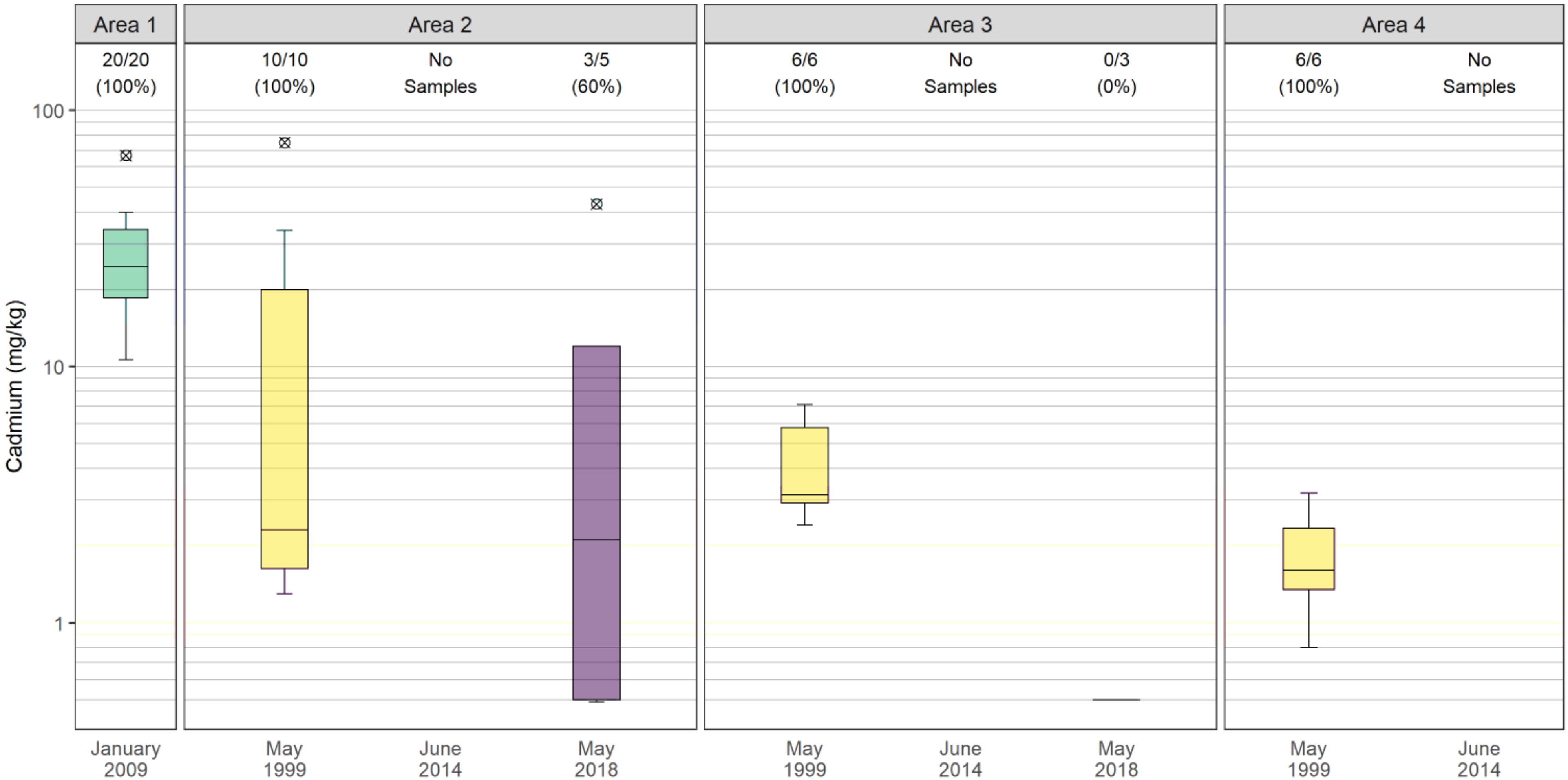


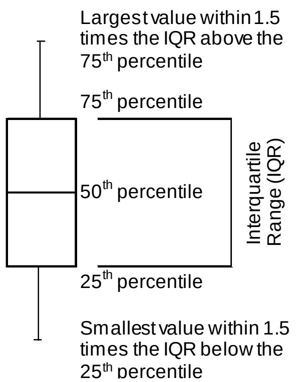
PARCEL 30
SUAHARITA, AZ

BARIUM CONCENTRATION BY AREA

ARCADIS

FIGURE
D-2





⊗ Value is > 1.5 times the IQR beyond either end of the box

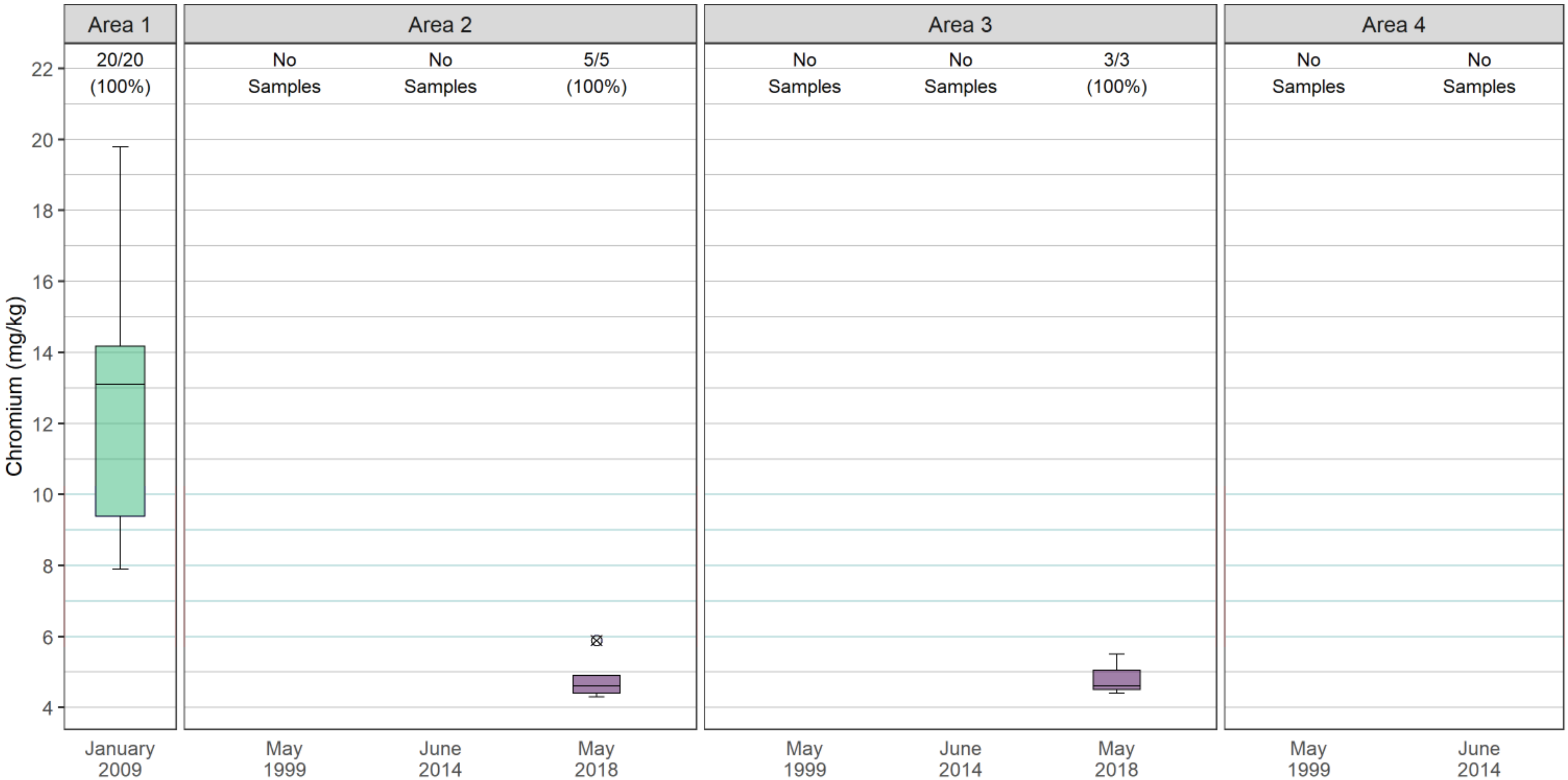
Note:
Non-detect results included at the reporting

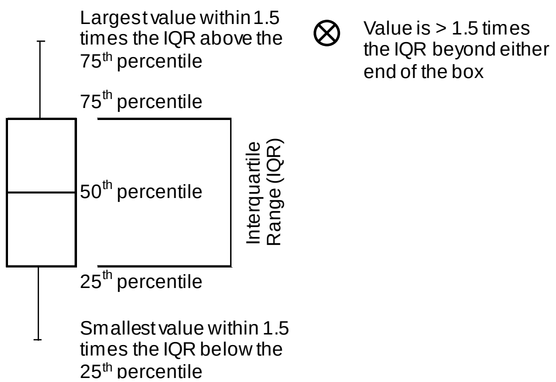
PARCEL 30
SUAHARITA, AZ

CADMIUM CONCENTRATION BY AREA

ARCADIS

FIGURE
D-3



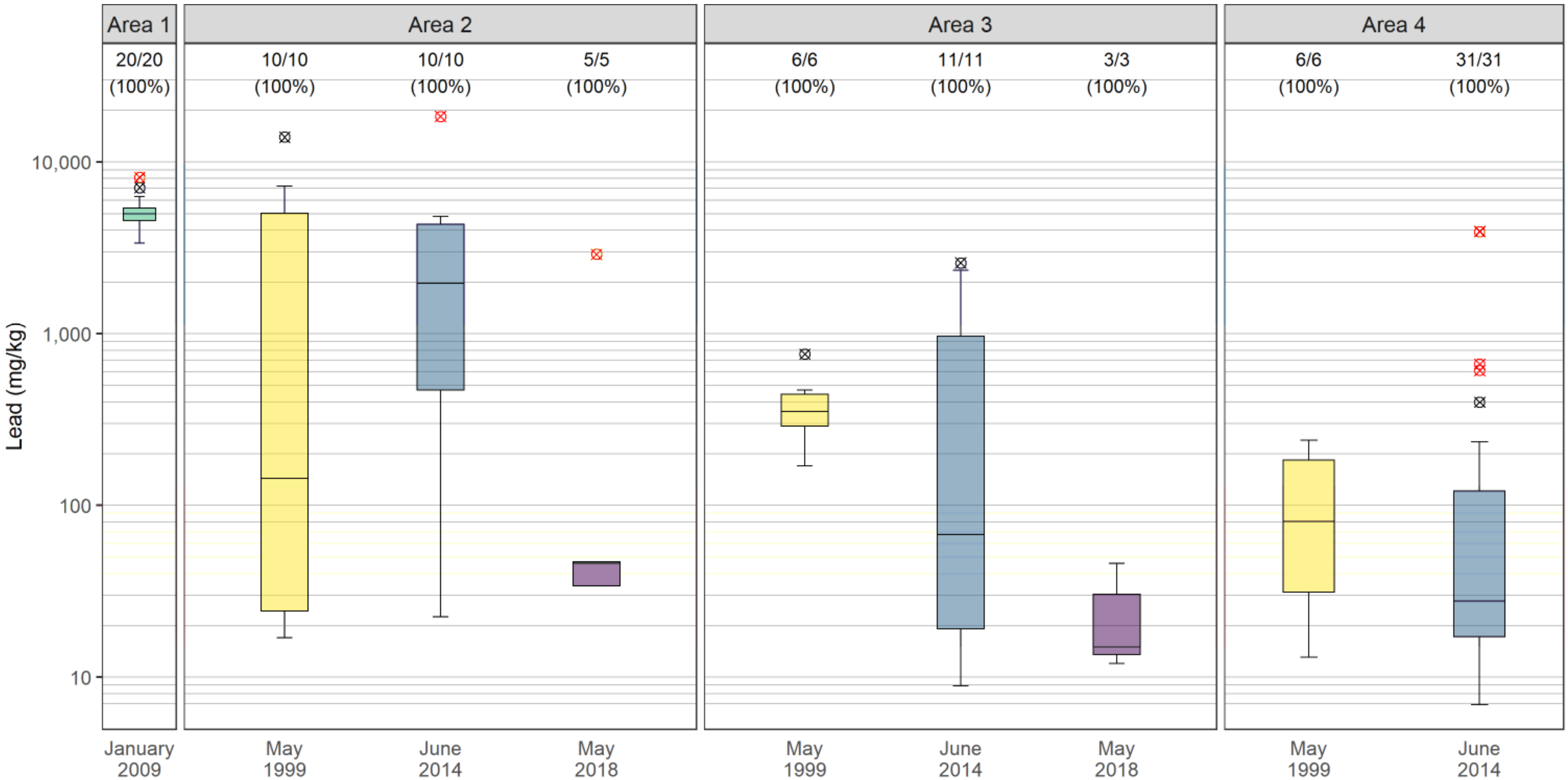


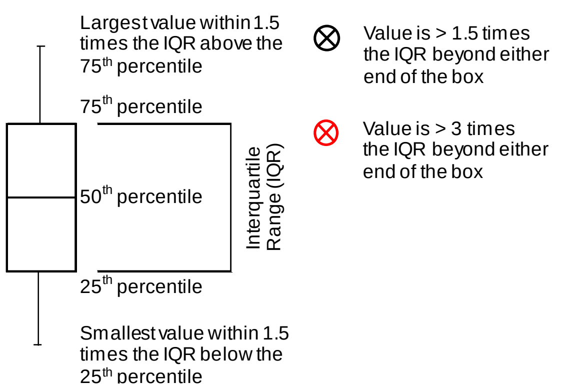
PARCEL 30
SUAHARITA, AZ

CHROMIUM CONCENTRATION BY AREA

ARCADIS

FIGURE
D-4



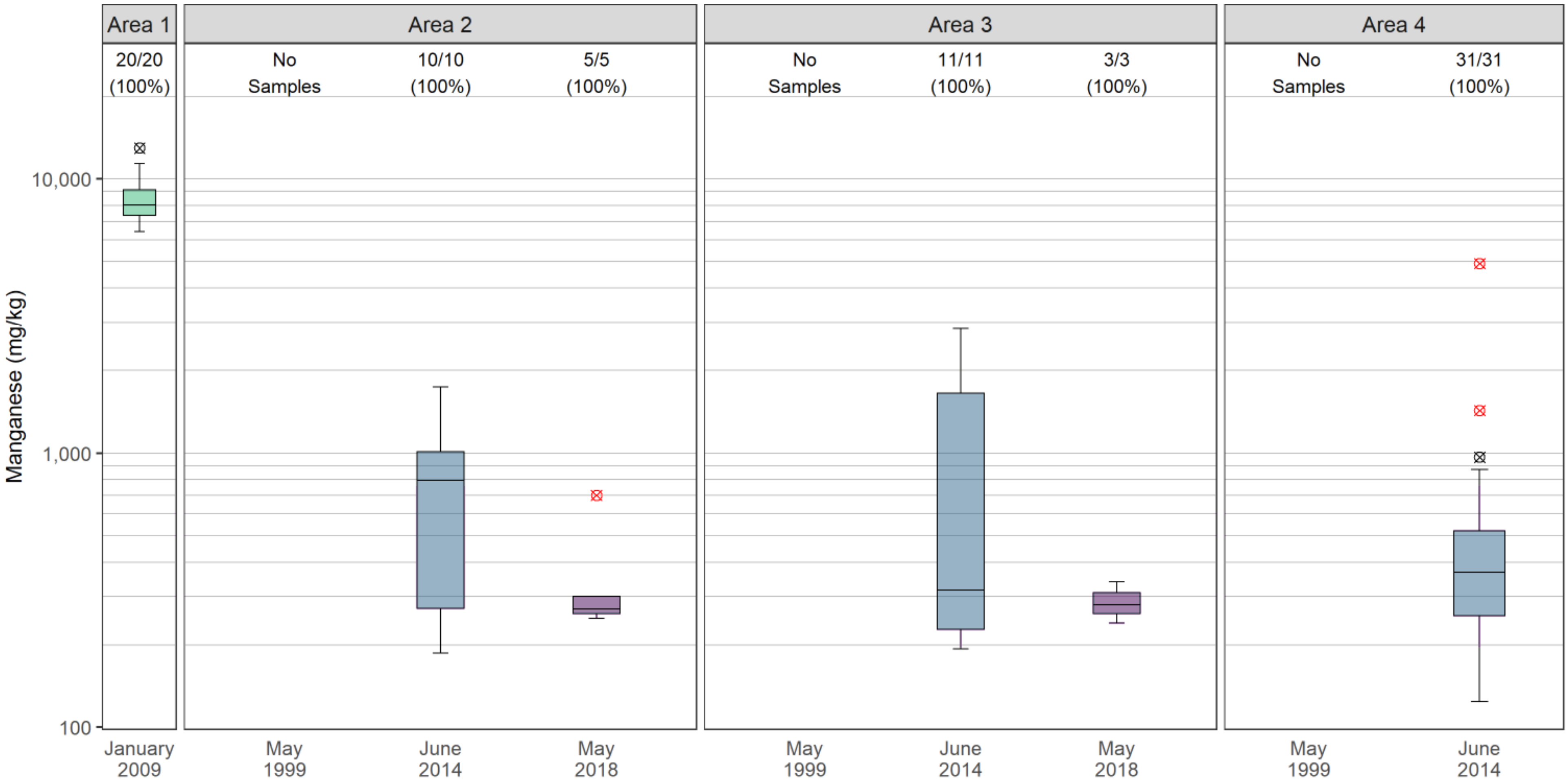


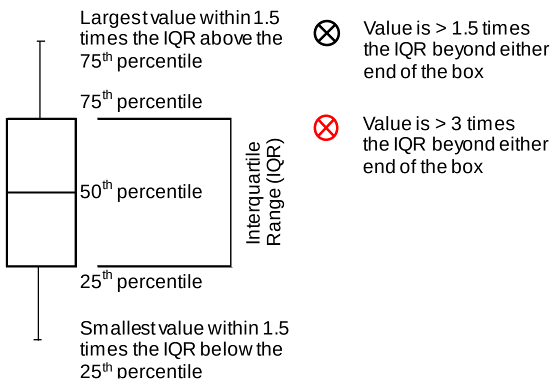
PARCEL 30
SUAHARITA, AZ

LEAD CONCENTRATION BY AREA

ARCADIS

FIGURE
D-5



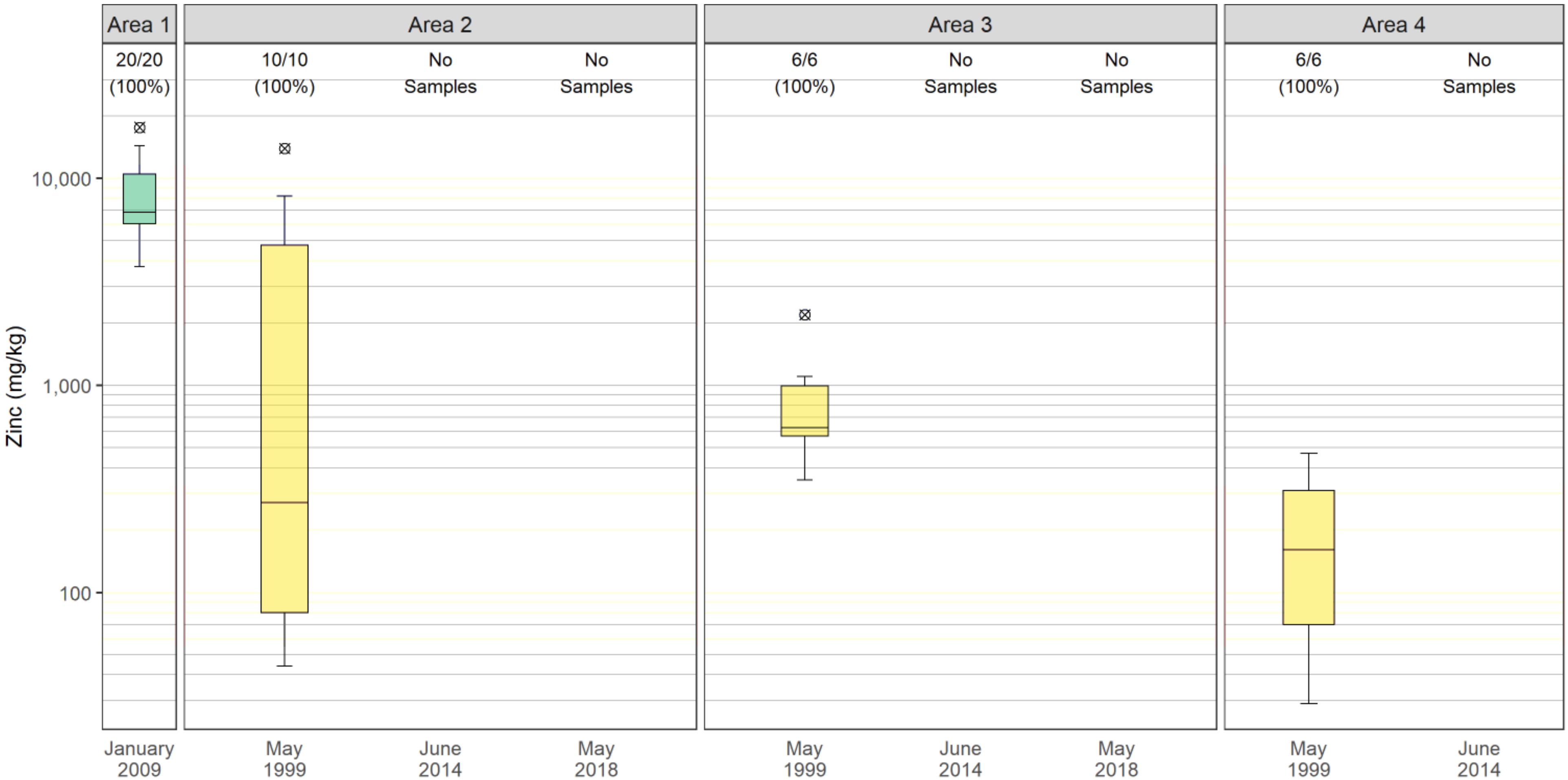


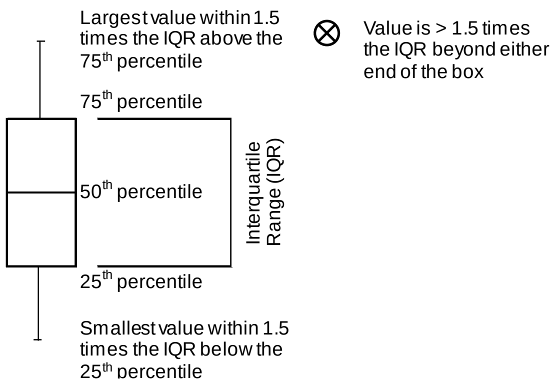
PARCEL 30
SUAHARITA, AZ

MANGANESE CONCENTRATION BY AREA

ARCADIS

FIGURE
D-6





SITE
SITE
REPORT

ZINC CONCENTRATION BY AREA

ARCADIS

FIGURE
D-7

Appendix E

Area 1 Metal/Lead Ratio Calculation

Appendix E
Area 1 Metal/Lead Ratio Calculation
Probabilistic Risk Assessment
Parcel 30, Sahuarita, Arizona

ARCADIS

Golder Analytical Data (2009)

Sample ID	Sample Date	Sample Interval	Aluminum (mg/kg)	Antimony (mg/kg)	Arsenic (mg/kg)	Barium (mg/kg)	Beryllium (mg/kg)	Boron (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Cobalt (mg/kg)	Copper (mg/kg)	Fluoride (mg/kg)	Lead (mg/kg)	Manganese (mg/kg)	Mercury (mg/kg)	Molybdenum (mg/kg)	Nickel (mg/kg)	Selenium (mg/kg)	Silver (mg/kg)	Strontium (mg/kg)	Thallium (mg/kg)	Tin (mg/kg)	Vanadium (mg/kg)
P30-BH-001	Jan-09	0-5	4,170	<0.36	17.0	28.5	0.630	8.70	15.3	16.2	13.2	1,060	2.88	4,860	8,050	0.028	31.4	8.50	<1.1	10.2	70.5	1.50	<0.9	12.8
P30-BH-002	Jan-09	0-5	4,160	<0.36	20.3	33.7	0.700	27.0	26.5	13.5	18.4	991	2.27	5,260	6,420	0.055	37.4	9.00	<1.1	11.1	61.3	1.30	<0.9	13.6
P30-BH-003	Jan-09	0-5	4,970	0.940	19.7	22.0	0.660	7.10	13.9	17.8	13.7	808	2.73	4,890	9,040	0.035	34.8	11.1	<1.1	9.20	63.7	1.70	<0.9	16.4
P30-BH-004	Jan-09	0-5	3,820	<0.36	61.2	12.5	0.590	3.80	66.9	9.60	23.5	2,130	23.0	7,080	10,700	0.170	31.7	7.80	<1.1	18.6	34.1	2.80	<0.9	17.9
P30-BH-005	Jan-09	0-5	5,660	<0.36	34.5	23.6	0.810	5.90	19.5	14.1	16.3	921	3.76	4,610	13,000	0.073	26.5	7.30	<1.1	10.1	51.8	2.10	<0.9	23.0
P30-BH-006	Jan-09	0-5	3,970	0.380	17.2	29.9	0.640	8.40	34.2	12.8	13.6	1,360	2.68	6,110	8,560	0.070	43.3	7.50	<1.1	15.9	65.3	1.30	<0.9	12.9
P30-BH-007	Jan-09	0-5	5,090	<0.36	21.0	28.8	0.650	41.4	35.6	15.3	14.2	1,330	2.25	5,330	6,890	0.060	38.9	10.7	<1.1	11.8	62.5	1	<0.9	14.9
P30-BH-008	Jan-09	0-5	3,500	<0.36	20.0	45.5	0.600	22.8	33.5	9.90	19.2	1,460	3.43	5,380	7,320	0.100	31.0	5.50	<1.1	12.4	49.2	1.50	<0.9	10.5
P30-BH-009	Jan-09	0-5	3,250	<0.36	16.3	20.8	0.600	9.90	39.9	8.20	18.8	1,760	3.11	8,130	9,030	0.087	27.1	3.00	<1.1	12.6	46.0	2.40	<0.9	9.50
P30-BH-010	Jan-09	0-5	3,720	<0.36	15.0	15.8	0.600	10.5	10.6	8.80	9.80	654	1.65	3,530	9,390	0.047	24.5	2.10	<1.1	7.60	66.5	1.30	<0.9	10.0
P30-BH-011	Jan-09	0-5	4,250	<0.36	22.2	35.9	0.720	29.0	34.6	13.4	19.3	1,300	1.00	6,260	8,050	0.072	43.3	9.30	<1.1	13.1	62.3	2.00	<0.9	14.5
P30-BH-012	Jan-09	0-5	3,250	<0.36	17.3	8.60	0.790	6.30	11.7	10.3	14.1	1,050	4.07	4,630	11,400	0.037	48.0	4.70	<1.1	7.50	72.2	1.50	1.300	11.5
P30-BH-013	Jan-09	0-5	7,330	<0.36	78.8	25.3	6.300	9.70	35.7	19.8	14.8	1,130	4.32	3,940	7,420	0.052	39.6	6.90	<1.1	10.6	63.2	1.10	<0.9	17.4
P30-BH-014	Jan-09	0-5	4,180	<0.36	18.0	58.1	0.650	12.8	18.6	14.4	13.0	643	1.74	4,400	7,400	0.063	40.1	7.60	<1.1	8.30	63.8	1.30	<0.9	17.9
P30-BH-015	Jan-09	0-5	4,320	0.470	17.2	27.6	0.670	20.7	20.1	13.6	12.5	709	2.81	3,370	6,860	0.060	30.0	5.60	<1.1	7.50	56.3	2.00	<0.9	12.1
P30-BH-016	Jan-09	0-5	5,810	0.590	16.0	44.5	0.790	13.2	23.4	13.4	14.1	1,050	4.82	5,270	7,860	0.055	30.3	7.70	<1.1	10.1	56.3	1.20	<0.9	17.0
P30-BH-017	Jan-09	0-5	3,670	<0.36	18.0	26.5	0.610	10.8	25.8	9.50	15.1	1,040	2.31	4,740	6,980	0.120	30.2	2.40	<1.1	10.5	49.2	1.70	<0.9	10.7
P30-BH-018	Jan-09	0-5	3,260	<0.36	16.4	21.8	0.620	9.10	25.8	8.50	14.7	964	3.35	5,050	7,690	0.065	34.3	2.80	<1.1	10.6	50.8	1.80	<0.9	9.60
P30-BH-019	Jan-09	0-5	3,270	<0.36	42.4	11.9	0.790	7.80	19.4	7.90	11.7	852	4.37	5,450	10,000	0.053	23.7	1.60	<1.1	7.50	46.9	1.80	<0.9	9.60
P30-BH-020	Jan-09	0-5	3,700	<0.36	14.6	20.5	0.650	14.9	18.5	9.00	11.7	756	2.68	4,150	8,180	0.047	27.4	2.40	<1.1	7.80	53.0	1.80	<0.9	9.90

RATIOS = Metal Concentration / Lead Concentration

Sample ID			Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Cobalt	Copper	Fluoride	Lead	Manganese	Mercury	Molybdenum	Nickel	Selenium	Silver	Strontium	Thallium	Tin	Vanadium
P30-BH-001			0.8580		0.003498	0.005864	0.000130	0.001790	0.003148	0.003333	0.002716	0.218107	0.000593		1.656379	0.000006	0.006461	0.001749	NA	0.002099	0.014506	0.000309		0.002634
P30-BH-002			0.7909		0.003859	0.006407	0.000133	0.005133	0.005038	0.002567	0.003498	0.188403	0.000432		1.220532	0.000010	0.007110	0.001711	NA	0.002110	0.011654	0.000247		0.002586
P30-BH-003			1.0164	0.000192	0.004029	0.004499	0.000135	0.001452	0.002843	0.003640	0.002802	0.165235	0.000558		1.848671	0.000007	0.007117	0.002270	NA	0.001881	0.013027	0.000348		0.003354
P30-BH-004			0.5395		0.008644	0.001766	0.000083	0.000537	0.009449	0.001356	0.003319	0.300847	0.003249		1.511299	0.000024	0.004477	0.001102	NA	0.002627	0.004816	0.000395		0.002528
P30-BH-005			1.2278		0.007484	0.005119	0.000176	0.001280	0.004230	0.003059	0.003536	0.199783	0.000816		2.819957	0.000016	0.005748	0.001584	NA	0.002191	0.011236	0.000456		0.004989
P30-BH-006			0.6498	0.000062	0.002815	0.004894	0.000105	0.001375	0.005597	0.002095	0.002226	0.222586	0.000439		1.400982	0.000011	0.007087	0.001227	NA	0.002602	0.010687	0.000213		0.002111
P30-BH-007			0.9550		0.003940	0.005403	0.000122	0.007767	0.006679	0.002871	0.002664	0.249531	0.000422		1.292683	0.000011	0.007298	0.002008	NA	0.002214	0.011726	0.000188		0.002795
P30-BH-008			0.6506		0.003717	0.008457	0.000112	0.004238	0.006227	0.001840	0.003569	0.271375	0.000638		1.360595	0.000019	0.005762	0.001022	NA	0.002305	0.009145	0.000279		0.001952
P30-BH-009			0.3998		0.002005	0.002558	0.000074	0.001218	0.004908	0.001009	0.002312	0.216482	0.000383		1.110701	0.000011	0.003333	0.000369	NA	0.001550	0.005658	0.000295		0.001169
P30-BH-010			1.0538		0.004249	0.004476	0.000170	0.002975	0.003003	0.002493	0.002776	0.185269	0.000467		2.660057	0.000013	0.006941	0.000595	NA	0.002153	0.018839	0.000368		0.002833
P30-BH-011			0.6789		0.003546	0.005735	0.000115	0.004633	0.005527	0.002141	0.003083	0.207668	0.000160		1.285942	0.000012	0.006917	0.001486	NA	0.002093	0.009952	0.000319		0.002316
P30-BH-012			0.7019		0.003737	0.001857	0.000171	0.001361	0.002527	0.002225	0.003045	0.226782	0.000879		2.462203	0.000008	0.010367	0.001015	NA	0.001620	0.015594	0.000324	0.000281	0.002484
P30-BH-013			1.8604		0.020000	0.006421	0.001599	0.002462	0.009061	0.005025	0.003756	0.286802	0.001096		1.883249	0.000013	0.010051	0.001751	NA	0.002690	0.016041	0.000279		0.004416
P30-BH-014			0.9500		0.004091	0.013205	0.000148	0.002909	0.004227	0.003273	0.002955	0.146136	0.000395		1.681818	0.000014	0.009114	0.001727	NA	0.001886	0.014500	0.000295		0.004068
P30-BH-015			1.2819	0.000139	0.005104	0.008190	0.000199	0.006142	0.005964	0.004036	0.003709	0.210386	0.000834		2.035608	0.000018	0.008902	0.001662	NA	0.002226	0.016706	0.000593		0.003591
P30-BH-016			1.1025	0.000112	0.003036	0.008444	0.000150	0.002505	0.004440	0.002543	0.002676	0.199241	0.000915		1.491461	0.000010	0.005750	0.001461	NA	0.001917	0.010683	0.000228		0.003226
P30-BH-017			0.7743		0.003797	0.005591	0.000129	0.002278	0.005443	0.002004	0.003186	0.219409	0.000487		1.472574	0.000025	0.006371	0.000506	NA	0.002215	0.010380	0.000359		0.002257
P30-BH-018			0.6455		0.003248	0.004317	0.000123	0.001802	0.005109	0.001683	0.002911	0.190891	0.000663		1.522772	0.000013	0.006792	0.000554	NA	0.002099	0.010059	0.000356		0.001901
P30-BH-019			0.6000		0.007780	0.002183	0.000145	0.001431	0.003560	0.001450	0.002147	0.156330	0.000802		1.834862	0.000010	0.004349	0.000294	NA	0.001376	0.008606	0.000330		0.001761
P30-BH-020			0.8916		0.003518	0.004940	0.000157	0.003590	0.004458	0.002169	0.002819	0.182169	0.000646		1.971084	0.000011	0.006602	0.000578	NA	0.001880	0.012771	0.000434		0.002386
		Average Ratio	**0.8814**	**0.00013**	**0.0051**	**0.00552**	**0.000209**	**0.00284**	**0.00507**	**0.00254**	**0.00299**	**0.212**	**0.000744**		**1.726171**	**0.0000132**	**0.00683**	**0.00123**		**0.00209**	**0.0118**	**0.000331**	**0.000281**	**0.00277**
		Minimum Ratio	**0.3998**	**0.00006**	**0.0020**	**0.00177**	**0.000074**	**0.00054**	**0.00253**	**0.00101**	**0.00215**	**0.146**	**0.000160**		**1.110701**	**0.0000058**	**0.00333**	**0.00029**		**0.00138**	**0.0048**	**0.000188**	**0.000281**	**0.00117**
		Maximum Ratio	**1.860**	**0.00019**	**0.0200**	**0.01320**	**0.001599**	**0.00777**	**0.00945**	**0.00503**	**0.00376**	**0.301**	**0.003249**		**2.819957**	**0.0000253**	**0.01037**	**0.00227**		**0.00269**	**0.0188**	**0.000593**	**0.000281**	**0.00499**
		95% UCL Ratio	**1.008**	**0.00019**	**0.00661**	**0.00655**	**0.000529**	**0.00357**	**0.00578**	**0.00292**	**0.00317**	**0.228**	**0.000978**		**1.910**	**0.0000151**	**0.00752**	**0.00146**		**0.00222**	**0.0132**	**0.000367**		**0.00313**

Notes:
mg/kg - milligrams per kilogram.
UCL - 95% Upper confidence limit on the mean calculated using ProUCL.

Appendix F

ADEQ Correspondence

From:	Nichole Osuch
To:	Steward, Michael
Cc:	david gosen; Thatcher, Anne; Sorensen, Oscar; Kurt Fehling
Subject:	Re: Background Analysis - PRA Eagle Picher Mill Parcel 30
Date:	Tuesday, December 28, 2021 5:30:18 PM

Hello Mike. The VRP, in conjunction with its contractor, The Fehling Group LLC, has reviewed Amax's December 10, 2021 background analysis email submitted in response to the VRP's November 1, 2021 comment letter and December 1, 2021 meeting between Amax and the VRP. The VRP has the following observations and comments pertinent to establishing local background for lead in soil to support calculation of a time-weighted average lead concentration:

1. Upper tolerance limits calculated from a set of 10 or 11 values are not meaningful, and tests for normality have very low power and therefore little utility with such a small data set.

   How to Respond: Since these calculations do not provide value, the VRP requests they not be included in a revised Probabilistic Risk Assessment (PRA).

2. The lead and zinc analytical data from soil sample locations R1 and R2 appear to reflect migration of Site contamination in that area beyond the Site boundary. Use of these data to calculate a best-estimate value for a lead background concentration in soil, even with the removal of the R-2A value, will likely introduce a slight protective bias to the background estimate. Of greater importance is recognition that Site-related contamination appears to have migrated beyond Areas 1 through 4, and how that information will be used going forward.

   How to Respond: No response required.

3. The seven data points from soil sample locations S1-A through S-5A, and samples R-3A and R-3B, provide a basis for a best-estimate value of average lead background concentration in soil.

   How to Respond: The VRP recommends these seven results be used to estimate average lead background concentration in soil for Areas 2, 3, and 4 in the IEUBK model of a revised PRA.

4. Due to the small size of the data set and uncertainty in the applicability of Area 5 soil to the residential areas of Sahuarita where most off-Site lead exposures characterized by these background data are expected, the VRP has relatively low confidence in the estimated average lead background concentration in soil.

   How to Respond: The VRP requests the IEUBK blood lead evaluation be supplemented using either the seven or ten soil sample results in Area 5 to represent background with a calculation that employs a reasonable upper-bound estimate of average local lead concentrations in soil, either as part of the lead evaluation presented in Section 5.4, or as a component of the uncertainty analysis in Section 6. Further, the VRP recommends that the lead soil data from Area 5 be supplemented with data from Areas 2, 3 and 4 to identify such an upper-bound estimate. The VRP provides this recommendation with the objective of avoiding delays introduced by the design and implementation of a background study if the revised PRA defensibly demonstrates that recreational exposures are unlikely to result in greater than a five percent probability that child blood lead concentrations will exceed ten micrograms per deciliter.

Please contact me if you have any questions.

Nichole Osuch, PMP
Project Manager - VRP & WQARF
Ph: 602-771-4847

azdeq.gov

Your feedback matters to ADEQ. Visit azdeq.gov/feedback

On Fri, Dec 10, 2021 at 8:55 AM Steward, Michael <msteward@fmi.com> wrote:

> Nichole,
>
> Please see the below and attached background analysis for the Parcel 30 site using historical data collected in Area 5 and as discussed on our December 1, 2021 teleconference with ADEQ and the Fehling Group. In addition to this analysis, we have one additional question regarding ADEQ's November 1, 2021 comments, which is provided below and in advance of the background analysis:

Additional Question

Comment # 24: AMAX plans to adjust the exposure frequency (EF) to 100 days/year (based on twice a week for 50 weeks/year). Is this acceptable to ADEQ?

Background Analysis

Introduction

In response to ADEQ's November 1, 2021 comments on the Draft Probabilistic Risk Assessment (PRA) for the Eagle Picher Mill Parcel 30 site in Sahuarita, Arizona, AMAX has prepared the following background soil evaluation using data from Area 5 as recommended in Comments 13 and 31, and as agreed to during the December 1, 2021 conference call between AMAX, Arcadis, ADEQ and Fehling Group.

In 1999, Hydrometrics collected 11 soil grab samples from two shallow depth intervals (i.e., 0 to 6 inches and 6 to 12 inches) from the southern portion of Parcel 30 (i.e., Area 5). These samples were analyzed for arsenic, cadmium, lead, and zinc. As described in the PRA, Area 5 has not been impacted by historical mineral processing operations and is representative of background conditions. Therefore, as requested, AMAX developed site-specific background concentrations based on data for soil samples collected from Area 5 (**Table 1**). That evaluation is described below.

Outlier Test

The inclusion of outliers in a dataset can lead to Type I (false positive) or Type II (false negative) errors (USEPA 2002). Type I errors may also occur with the exclusion of data points from a dataset. When extreme values are inappropriately eliminated from the dataset, it tends to bias the mean and variance low. Thus, an outlier analysis was completed on the Area 5 datasets to identify potential outliers that may not be representative of the true dataset population.

The outlier analysis was conducted according to the steps outlined in the *Data Quality Assessment: Statistical Methods for Practitioners* (USEPA 2006) as follows:

1. Box and whisker and probability plots were developed and inspected to identify potential outliers and isolated results that were separate from the majority of the data. Box and whisker plots present an overall picture of the distribution of a dataset by displaying several percentiles (10th, 25th, 50th, 75th, and 90th). They provide insight into the location, shape, and spread of the data. Potential elevated or extreme values (i.e., outliers) are identified on box and whisker plots as either 1.5 or 3 times Tukey's interquartile range (IQR; defined as the third quartile [75th percentile] minus the first quartile [25th percentile]; USEPA 2006, 2015; Tukey 1977) from either end of the box, respectively. Probability plots allow for a visual inspection of the data distribution, which complements formal statistical tests for distribution testing. Inflection points or changes in slope can indicate that the data represent a mixture of multiple populations. Probability plots can also be used to identify extreme values in the upper tail of

the distribution, which may be indicative of potential outliers. **Figure 1** presents box and whisker plots and probability plots for arsenic, cadmium, lead and zinc.

2. Distribution testing was performed using USEPA software ProUCL (2015) on datasets with visually identified potential outliers removed. Statistical tests require datasets be normally distributed (either with the raw dataset or through ladder of powers transformations).

3. Datasets which were determined to be normally distributed were then subjected to a statistical outlier test. ProUCL uses Dixon's test (Barnett and Lewis 1994) since the sample size was less than 25. Observations identified as statistical outliers at 5 percent significance were documented and the analysis was performed with and without the outliers.

Two potential outliers were visually identified using the box-and-whisker and probability plots (**Figure 1**):

- Lead reported for the sample collected from R2-A: 120 milligram per kilogram (mg/kg)

- Zinc reported for the sample collected from R2-A: 210 mg/kg

The datasets were normally distributed with these potential outliers removed and the potential outliers were considered statistical outliers using Dixon's test at 5 percent significance. The ProUCL outlier test output is provided in **Table 2**.

Upper Tolerance Limits

Background upper tolerance limits (UTLs) for Area 5 were determined using ProUCL. UTLs represent an upper limit to be used for individual site observation comparisons. A site observation less than a background UTL indicates that the constituent is present at the site at levels consistent with background concentrations. The 95% upper tolerance limit with 90% coverage (95-90 UTL) was used to represent background. The 95-90 UTL represents the statistic, such that 95% of observations (current and future) from the target population will be less than or equal to the 95-90 UTL with a confidence coefficient (CC) of 0.90. A 95-90 UTL is designed to simultaneously provide coverage for 95% of the potential observations (current and future) from the background population (or comparable to background) with a CC of 0.90. The calculated 95-90 UTLs are provided in **Table 3**. The ProUCL output is provided in **Table 4a** (with lead and zinc outliers) and **Table 4b** (without lead and zinc outliers).

Based on the information provided herein, the proposed site-specific background concentrations for Parcel 30 are equal to the UTLs and are as follows:

Arsenic: 5.1 mg/kg

Cadmium: 2.1 mg/kg
Lead: 37.24 mg/kg
Zinc: 84 mg/kg

As seen on **Table 3**, these concentrations lie within state-wide USGS background ranges (Smith et al 2013) and are considered reasonable for the Parcel 30 site. For the metals where data is not available for Area 5 (e.g., chromium), state-wide background concentrations will be used for comparison purposes in the PRA.

If you find the above information acceptable, the following will be provided in response to Comment No. 13 and Comment No. 31:

Response to Comment 13: Site-specific background UTL concentrations for arsenic, cadmium, lead, and zinc were developed using sample data from Area 5 of Parcel 30. These concentrations will be used in the PRA to support evaluation of metals in soil. For metals that were not evaluated in Area 5 (e.g., barium, chromium, and manganese), state-specific background concentrations (ADEQ 1991; Smith et al 2013) will be used to determine if Site concentrations are representative of background.

Response to Comment 31: As discussed and agreed to during the December 1, 2021 call, the soil data collected from Area 5 are representative of ambient background conditions and therefore a work plan for characterizing background metal levels in soil is not necessary. The calculated lead UTL of 37.24 mg/kg, along with the UTLs calculated for arsenic, cadmium, and zinc, will be used to characterize background soil levels for the Site.

References

Barnett, V. and T. Lewis. 1994. Outliers in Statistical Data, 3rd edition. New York: John Wiley & Sons.

Hydrometrics, Inc. 2013. Project Report Background Concentrations of Inorganic Constituents in Montana Surface Soils. Prepared for Montana Department of Environmental Quality.

Tukey, J. 1977. Exploratory Data Analysis. Reading, MA: Addison-Wesley.

USEPA. 2002. Guidance on Choosing a Sampling Design for Environmental Data Collection for Use in Developing a Quality Assurance Project Plan. Office of Environmental Information. EPA QA/G-5S. EPA/240/R-02/005. December.

USEPA. 2006. Data Quality Assessment: Statistical Methods for Practitioners. Office of

Environmental Information. EPA/240/B-06/003. February.

USEPA. 2015. ProUCL Version 5.1 Technical Guide. Office of Research and Development. EPA/6--/R-07/041. October.

Smith, D.B., Cannon, W.F., Woodruff, L.G., Solano, Federico, Kilburn, J.E., and Fey, D.L. 2013. Geochemical and Mineralogical Data for Soils of the Conterminous United States: U.S. Geological Survey Data Series 801, 19 p., https://pubs.usgs.gov/ds/801/.

We look forward to continuing to advance these efforts and getting to the construction phase.

Thank you,

Mike

Michael Steward

Freeport Minerals Corporation

Mobile: 520-437-3005

msteward@fmi.com

Arcadis U.S., Inc.
410 N. 44th Street, Suite 1000
Phoenix, Arizona 85008
Phone: 602 438 0883
Fax: 602 438 0102
www.arcadis.com