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REPORT ON

PHASE II HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE
HAYDEN, ARIZONA

By Haley & Aldrich, Inc.
Phoenix, Arizona

For ASARCO LLC
Hayden, Arizona

File No. 134536-002
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HALEY & ALDRICH, INC.
ONE ARIZONA CENTER
400 E. VAN BUREN ST., SUITE 545
PHOENIX, AZ 85004
602.760.2450

SIGNATURE PAGE FOR

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PREPARED FOR

ASARCO LLC
HAYDEN, ARIZONA

REVIEWED AND APPROVED BY:

Steve Rakowski, P.E.
Senior Associate | Chemical Engineer
Haley & Aldrich, Inc.

26125
STEPHEN M.
RAKOWSKI
ARIZONA, U.S.A.
Expires 3/31/22

Jay Peters
Senior Associate | Risk Assessor
Haley & Aldrich, Inc.

Executive Summary

A Phase II Human Health Risk Assessment for Soil, Water, Sediment, and Air (Phase II HHRA or HHRA) was conducted in accordance with the April 2008 Administrative Settlement Agreement and Order on Consent (AOC) for the Asarco Hayden Plant Site (Site) and the United States Environmental Protection Agency's (USEPA's) March 2012 Final Phase II Remedial Investigation/Feasibility Study (RI/FS) Work Plan Part 1 of 2: Air and Part 2 of 2: Soil, Water, and Sediment (Work Plan) for the Site. The objective of the HHRA under the Work Plan was to characterize health risks to human populations assumed to be exposed to Site-related contamination under the current and foreseeable uses of the Phase II RI Study Area. The Work Plan was prepared by USEPA's contractor, Innovative Technical Solutions, Inc. (ITSI; 2012a, 2012b), and was modified by the HHRA Work Plan Addendum prepared by Haley & Aldrich (2015a).

The HHRA was based on the analytical data for soil, sediment, storm water, and air collected in support of the Phase II RI for the Site. The RI data were collected in accordance with the Work Plan between 2013 and 2015, and are documented in the Final RI Report for Soil, Water, and Sediment (SWS RI Report) (Haley & Aldrich, 2020a) and Final RI Report for Air (Air RI Report) (Haley & Aldrich, 2020b).

EFFECT OF THE 2015 CONSENT DECREE AND CONFORMING TITLE V PERMIT

The findings presented in this HHRA report are based solely on the Phase II field investigation activities conducted from 03 July 2013 through 01 July 2015 in accordance with the Work Plan.

Subsequent to the completion of the Phase II field investigation activities, Asarco entered into a consent decree with USEPA ("2015 Consent Decree" or "Consent Decree") and a conforming Title V permit with the Arizona Department of Environmental Quality that incorporates the substantive requirements of the Consent Decree.

The purpose and effect of the Consent Decree and conforming Title V permit have been to significantly reduce process fugitive emissions and fugitive dust emissions at Hayden Operations, relative to the emissions that occurred during the Phase II field investigation activities. Therefore: (i) the findings of the Phase II remedial investigation presented in the Air RI Report, including the source apportionment study, do not correlate to current conditions at the Asarco Hayden Plant Site; and (ii) to the extent the HHRA relied upon the findings of the Phase II air investigation, the conclusions of the HHRA overestimate potential cancer and non-cancer hazards to all receptors identified herein.

HHRA SUMMARY

The methodology used to complete the HHRA followed USEPA's Work Plan, which was based in material part on the Comprehensive Environmental Response, Compensation, and Liability Act guidance for risk assessment. That guidance specifies how analytical data should be evaluated and chemicals selected for inclusion in a HHRA, the manner in which possible exposures to human populations should be identified and quantified, the information sources of approved toxicity values, and how to calculate and interpret health risk estimates.

As presented in the SWS RI Report and Air RI Report, the environmental media in which Site-related constituents were detected include:

- Surface soil (defined as soil 0 to 2 inches below ground surface [bgs]);
- Subsurface soil (defined as soil 1 to 10 feet bgs);
- Groundwater (at localized areas);
- Storm water; and
- Ambient air.

The HHRA evaluated whether exposure pathways might be potentially complete for these media. An exposure pathway describes the mechanisms by which human receptor populations could potentially be exposed to constituents detected in various receiving media. For exposure pathways to be complete, there must be a source of contaminant (the receiving media listed above), a point of exposure to the source (a.k.a. exposure point), a route of exposure to the exposure point which identifies how exposure could occur, and a human receptor population to which the exposure could occur.

Consistent with the updated Conceptual Site Model (CSM) for the Site, which is presented in the SWS RI Report, the exposure pathways evaluated in the HHRA included:

- Incidental ingestion and dermal contact with surface soil;
- Incidental ingestion and dermal contact with storm water;
- Inhalation of surface soil-derived fugitive dust; and
- Inhalation of ambient air.

The CSM also identifies incomplete pathways that were not evaluated in the HHRA:

- Potential exposure pathways via groundwater are not complete because groundwater within the potable water aquifer does not exhibit concentrations of constituents in excess of drinking water or aquifer protection standards, and there is no complete migration pathway from the Phase II RI Study Area to that aquifer.
- Potential exposure pathways via surface water in the Gila River are not complete because there is no complete migration pathway from the Phase II RI Study Area to the river.
- Potential exposure pathways via subsurface soil are not complete because, as described in Section 3 of this report, receptor populations within the areas evaluated would not excavate into soil and be potentially exposed to subsurface soil.

Within surface soil, storm water, and ambient air, chemicals of potential concern (COPCs) were selected in accordance with USEPA guidance. COPCs represent chemicals that are present in Site media at concentrations that could pose more than a negligible health risk. These COPCs were carried through the HHRA for quantitative evaluation of potential exposures and risks.

- All constituents detected in surface soil were evaluated in the HHRA as COPCs except for beryllium, boron, calcium, and chromium. Beryllium, boron, and chromium were eliminated as COPCs because they were detected at maximum concentrations below USEPA's risk-based screening values. Calcium was eliminated as a COPC because it is an essential nutrient and would pose potential toxicity only at extremely high concentrations.

- All constituents detected in storm water were evaluated in the HHRA as COPCs except for those classified as essential nutrients (i.e., calcium, magnesium, potassium, and sodium).
- For ambient air, aluminum, antimony, arsenic, barium, cadmium, cobalt, lead, manganese, nickel, and vanadium were evaluated in the HHRA as COPCs because their maximum detected concentration in ambient air samples exceeded the residential air Regional Screening Level. Other constituents were eliminated as COPCs because they were detected at concentrations below USEPA's risk-based screening levels or do not have screening levels or are essential nutrient. Hexavalent chromium was eliminated as a COPC in ambient air because it is not associated with Hayden Operations and was detected infrequently at low concentrations consistent with background and below risk-based screening levels.

Exposure Assessment

The HHRA evaluated health risks to receptor populations that could potentially be exposed to COPCs under current and reasonably foreseeable future land use conditions. The HHRA process subdivided the Site into exposure study areas (ESAs) for assessing and characterizing risk. ESAs represent the geographic areas of the Site where exposures could potentially occur. The ESAs collectively included all 19 RI Areas established in USEPA's Work Plan.

The current land uses of the Site include open space areas within Hayden and adjacent to Winkelman, facility operational areas that are secured, facility operational areas that are unsecured, and remote open space areas. All of the property in these areas is owned by Asarco, except for some portions of the remote areas. Persons other than Asarco employees or authorized visitors are not permitted on Asarco-owned property. Aside from the secured facility operational areas, the Asarco-owned property is not fenced. Also, open space areas within Hayden border residential neighborhoods.

Based on this land use information, receptor populations that may access the Phase II RI Study Area were deemed to be trespassers, and four types of ESAs were defined to identify where possible trespasser exposures to COPCs could occur. These are listed below and shown in Figure 1:

1. <u>In-Town Area</u>: Portions of the Phase II Study Area that are located near or adjacent to residential areas. The San Pedro, Kennecott Avenue, and Power House washes are located within the In-Town ESA D; the open spaces surrounding the washes bisect residential neighborhoods in Hayden. Four air monitoring stations (ST-01, ST-16, ST-23, and ST-26) are located in ESA D. One station (ST-09) is located in In-Town ESA H. In addition, one station (ST-02) is located at Hayden High School, adjacent to ESA H.
2. <u>Restricted Facility Area</u>: Portions of the Phase II Study Area that are located within portions of the Asarco property where active industrial operations are conducted on a daily basis. These areas are secured by fencing or landform barriers, are regularly patrolled by facility security personnel, and are occupied by a significant number of other facility workers. One air monitoring station (ST-14) is located in the Restricted Facility Area.
3. <u>Isolated Facility Areas</u>: Portions of the Phase II Study Area that are located within portions of the Asarco property where active industrial operations are conducted on a daily basis, but which are generally located farther from residential areas. These areas are not constantly occupied by a significant number of facility workers and access is not generally prohibited by fencing or landform barriers. No air monitoring stations are located in the Isolated Facility Areas.

4. Remote Facility Areas: Portions of the Phase II Study Area that are located away from any developed residential and industrial areas. Two air monitoring stations (ST-05 and ST-18) are located in or adjacent to Remote Facility Areas.

The Phase II RI Study Area does not include residential or public-use properties, which were evaluated in USEPA's Phase I HHRA. Therefore, the Phase II HHRA did not evaluate residential, recreational, or commercial receptor population exposures to soil on residential or public-use properties.

Because Hayden and Winkelman are the only population centers near the facility where people reside, the trespassing populations for purposes of the HHRA were assumed to be children, adolescents, and adults who live and work in non-facility related occupations near the facility.

The HHRA evaluated exposures to trespassing populations who could potentially be exposed to surface soil by incidental ingestion, dermal contact, and inhalation of fugitive dusts from soil (e.g., fugitive dusts generated during receptor activities such walking, use of all-terrain vehicles, or wind blowing within the ESAs), as well as trespassing populations who could potentially be exposed to storm water in the washes located within the In-Town Areas by incidental ingestion and dermal contact.

The HHRA also evaluated exposures to residents living in Hayden who may be exposed to ambient air; trespassing populations who may be exposed to ambient air within the In-Town, Remote, and Restricted Area ESAs; and high school student and faculty populations who may be exposed to ambient air within the In-Town ESAs.

Separate trespassing scenarios were developed to accommodate each of the four types of ESAs; this approach accommodates the differences in land use activities and associated exposure that may be associated with each type of ESA. In addition, residential and high school student and faculty scenarios were developed to accommodate potential exposures to ambient air by those populations.

The trespasser exposure scenarios were based on consideration of three age groups: children ages 6 - <11 (5-year exposure), adolescents ages 11 - <16 (5-year exposure), and adults (16-year exposure), which culminate in a cumulative exposure duration of 26 years. The residential exposure scenario was based on these age groups as well as young children ages 0 - <6. These age groups were selected because they coincide with the age ranges for many of the default exposure parameter recommendations in the 2011 edition of the Exposure Factors Handbook (USEPA, 2011), and are commensurate with the age ranges defined in USEPA's Supplemental Cancer Guidance (USEPA, 2008). The high school student scenario considered adolescents ages 14 to 18 and high school faculty considered adults who were assumed to be employed at the high school for a 25-year duration.

Consistent with the Work Plans, the exposure scenarios did not include very young children (under age 6) for trespassing scenarios. It is not realistic to consider young children accessing the ESAs, either alone or under adult supervision.

Health risks for each of the exposure scenarios were quantified using exposure point concentrations derived as the 95th upper confidence limit on the arithmetic mean and algorithms specified in USEPA guidance. The majority of quantitative parameter values used in the exposure scenarios were USEPA reasonable maximum exposure (RME) default values published in USEPA guidance.

Risk Characterization

Results of the risk assessment were expressed as incremental lifetime cancer risk (ILCR) and hazard index (HI) values, as estimates of cancer risk and non-cancer hazard, respectively, for the various scenarios. ILCR and HI values were quantified by combining the COPC intakes calculated for the exposure scenarios with toxicity values (cancer slope factor and unit risk values, and reference dose and reference concentration values) published in USEPA-approved sources.

The relative significance of the calculated risks was evaluated in terms of a comparison with acceptable risk levels established in the National Contingency Plan (NCP).

For all trespassing exposure scenarios, the HHRA concluded that potential exposures to soil and storm water under RME conditions would not pose risks in excess of USEPA risk thresholds. Specifically, ILCR values were within the NCP cancer risk range of 10^{-6} to 10^{-4}, and the non-cancer HI values did not exceed 1. In addition, the HHRA concluded that potential exposures to lead in soil and storm water would not result in calculated blood lead levels in excess of USEPA threshold blood lead limits.

For each of the trespassing, high school, and residential exposure scenarios for all ESAs in the Study Area, the HHRA concluded that potential exposures to ambient air would not pose risks in excess of USEPA risk thresholds. Specifically, ILCR values were within the NCP cancer risk range of 10^{-6} to 10^{-4} and the non-cancer HI values did not exceed 1. In addition, the HHRA concluded that potential exposures to lead in ambient air would not result in calculated blood lead levels in excess of USEPA threshold blood lead limits.

The HHRA concluded that cumulative risks from multi-media exposures to ambient air, soil, and storm water were within the NCP cancer risk range of 10^{-6} to 10^{-4}, did not pose a non-cancer HI greater than 1, and would not result in calculated blood lead levels in excess of USEPA threshold blood lead limits.

To provide perspective on the risk characterization results, a one-directional upper bound sensitivity analysis was completed by sequentially adjusting key exposure assumptions to be increasingly conservative. The results of the analysis help to resolve the question "*If exposure variables were even more conservative than the RME values, would the conclusions of the risk assessment be different?*"

The conclusions of the soil and storm water sensitivity analysis were as follows:

1. Even under exposure assumptions which are considerably more conservative than the RME, cancer risks do not exceed the upper end of the NCP cancer risk range of $1x10^{-4}$ and, for all but two ESAs and storm water, do not exceed a HI of 1.
2. For In-Town ESAs D and H, the HI for gastrointestinal (GI) system effects of ingesting soil marginally exceeded 1 under the assumption that children (ages 6 - <11) spend all of their average daily outdoor time at In-Town Areas, each week day all year, and ingest soil at a rate that is applicable to children of a younger age group (which are recognized as ingesting higher volumes of soil).
3. The HI for GI system effects of ingesting storm water marginally exceeded 1 under the assumption that children (ages 6 - <11) play in storm water on one-half of the rain events per year and ingest two teaspoons of water during each event. Storm water flow data for the washes indicates it is improbable that storm water even collects on one-half of the storm events.

4. The soil and storm water HI values are due primarily to copper. 'Serious' health effects related to copper (Agency for Toxic Substances and Disease Registry, 2004) potentially occur at exposures nearly 2,000 times greater than those estimated in the HHRA.
5. The bioavailability of arsenic in the types of soil within the Phase II RI Study Area are likely to be lower than the bioavailability assumed in the HHRA, which was based on USEPA's default arsenic bioavailability factor. Consequently, RME values and bounding risks and hazards for arsenic, which did not exceed the NCP risk range or a HI of 1, are likely to be lower than those calculated in the HHRA, indicating that arsenic does not pose risks within the Phase II RI Study Area at levels that exceed USEPA risk thresholds.

The conclusions of the air sensitivity analysis were as follows:

1. Increasing exposure time to the point where it is assumed that a resident never leaves their place of residence from birth to age 26, and spends up to 7 hours outdoors each day at their place of residence, is associated with excess lifetime cancer risk (ELCR) values that are within the range of $1x10^{-6}$ to $1x10^{-4}$ and HI values that do not exceed 1.
2. Even if it is assumed that a resident is exposed to ambient air represented by an upper-bound estimate of PM_{10} concentrations measured throughout ESA D, under the assumptions that the resident never leaves their place of residence from birth to age 26 and spends up to 7 hours outdoors each day at their place of residence, ELCR values remain within the range of $1x10^{-6}$ to $1x10^{-4}$ and HI values do not exceed 1.

Overall, the results of the HHRA indicated that cancer risks and non-cancer hazards associated with the Phase II RI Study Area, prior to the implementation of the 2015 Consent Decree, did not exceed the acceptable risk thresholds established in the NCP.

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Registered Professional Engineer (Chemical) CERTIFICATE NO. 28126 STEPHEN M. RAKOWSKI Date Signed 12/23/20 ARIZONA, U.S.A. Expires 3/31/22

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List of Acronyms

10^{-6}	one in a million
10^{-4}	one in ten thousand
µg/dL	micrograms per deciliter
µg/L	micrograms per liter
ABS	absorption efficiency
ADAF	age-dependent adjustment factor
ADEQ	Arizona Department of Environmental Quality
ALM	Adult Lead Model
AOC	Administrative Order by Consent
APP	Aquifer Protection Permit
ATSDR	Agency for Toxic Substances and Disease Registry
ATV	all-terrain vehicle
AWQS	Aquifer Water Quality Standard (Arizona)
BERA	Baseline Ecological Risk Assessment
bgs	below ground surface
BTV	background threshold value
CALEPA	California Environmental Protection Agency
CDC	Centers for Disease Control
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COPC	chemical of potential concern
CR	contact rate
CSF	cancer slope factors
CSM	USEPA's Conceptual Site Model, updated in this submittal
CT	central tendency
ED	exposure duration
EF	exposure frequency
EFH	Exposure Factors Handbook
ELCR	excess lifetime cancer risk
EPC	exposure point concentration
EPPs	emergency pump-back ponds
ESA	exposure study area or exposure area
FS	Feasibility Study
g/kg/day	grams/kilogram/day
GI	gastrointestinal
HHRA	Human Health Risk Assessment
HI	hazard index
HQ	hazard quotient
IEUBK	integrated exposure uptake biokinetic model
ILCR	incremental lifetime cancer risk
IRIS	Integrated Risk Information System
ITSI	Innovative Technical Solutions, Inc.
kg	kilogram
kg/yr	kilogram per year
KM-mean	Kaplan-Meier mean
LOAEL	lowest observed adverse effect level
mg/day	milligrams per day

List of Acronyms (continued)

mg/kg	milligrams per kilogram
mg/m^3	milligrams per cubic meter
MCL	maximum contaminant level
MDL	method detection limit
MOA	mode of action
MRL	minimum risk level
MSGP	Multi-Sector General Permit
NCP	National Contingency Plan
NM	National Monument
OSWER	Office of Solid Waste and Emergency Response
PDL	project decision limits
PEF	particulate emission factor
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
REL	reference exposure level
RfC	reference concentration
RfD	reference dose
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
RSL	Regional Screening Level
SLERA	Screening Level Ecological Risk Assessment
STSC	Superfund Technical Support Center
SWPPP	Storm Water Pollution Prevention Plan
SWS RI	Final RI Report for Soil, Water, and Sediment
TSP	total suspended particulates
UCL	upper confidence limit
UR	unit risk
USEPA	United States Environmental Protection Agency
UTL	upper tolerance limit
XRF	x-ray fluorescence

1. Introduction

ASARCO LLC (Asarco) retained Haley & Aldrich, Inc. (Haley & Aldrich) to conduct a Phase II Human Health Risk Assessment (Phase II HHRA or HHRA) and prepare this Phase II HHRA Report for Soil, Water, Sediment, and Air (HHRA Report) for the Phase II Remedial Investigation (RI) Study Area in the area of Hayden, Arizona (Figure 1.1). The Phase II HHRA followed the Phase I RI and baseline human health risk assessment (Phase I HHRA) completed by the United States Environmental Protection Agency (USEPA) in 2008 (CH2M Hill, 2008b).

The Phase I RI completed by USEPA (CH2M Hill, 2008a) included an evaluation of residential soil and indoor dust, non-residential soil within public areas in Hayden and Winkelman (Winkelman is the town located next to Hayden), soil and sediment in washes, groundwater quality, tap water quality, surface water quality, in-stream and riparian sediments, and air quality. That report also included a Phase I HHRA (CH2M Hill, 2008b) and a Draft Screening Level Ecological Risk Assessment (SLERA; CH2M Hill, 2008c). Section 1 of the Final RI Report for Soil, Water, and Sediment (SWS RI Report) (Haley & Aldrich, 2020a) provides a detailed summary of the Phase I RI. Key conclusions of the Phase I HHRA were:

- Surface soil in some residential properties contained arsenic, copper, and lead at concentrations that posed potential risks to residential populations. Remediation was subsequently performed by Asarco under USEPA oversight at 235 private properties.
- Surface water and sediment associated with the Gila River and San Pedro River did not pose unacceptable risks to human populations.
- Metals concentrations in surface soil in certain public (non-residential) areas did not pose health risks in excess of acceptable risk levels established in the National Contingency Plan (NCP; USEPA, 1990). In other public areas and Asarco-owned property, the analytical data were not sufficient in quantity or quality to inform conclusions regarding potential health risks.
- Cancer risk associated with exposure to ambient air in Hayden for arsenic, cadmium, and chromium is 1×10^{-4}. Concentrations of metals in ambient air in Hayden are significantly higher than in Winkelman.

Data gaps identified in the Phase I RI Report, including the Phase I HHRA, in connection with soil, sediment, storm water, and ambient air were addressed during the Phase II RI and incorporated into the Phase II HHRA. The Phase II RI is documented in two separate reports: the Phase II SWS RI Report (Haley & Aldrich, 2020a) and the Phase II Air RI Report (Haley & Aldrich, 2020b). This HHRA Report generally provides summary level information regarding procedures and findings of the RI reports. The reader should refer to the RI reports for additional detail.

1.1 REGULATORY CONTEXT OF HHRA

The Phase II HHRA was conducted in accordance with the April 2008 Administrative Settlement Agreement and Order on Consent (AOC) for the Asarco Hayden Plant Site (Site) and the USEPA's March 2012 Final Phase II Remedial Investigation/Feasibility Study (RI/FS) Work Plan Part 1 of 2: Air and Part 2 of 2: Soil, Water, and Sediment (Work Plan) for the Site. The objective of the HHRA under the Work Plan was to characterize health risks to human populations assumed to be exposed to Site-related contamination under the current and foreseeable uses of the Phase II RI Study Area. The Work Plan was prepared by USEPA's contractor, ITSI (2012a, 2012b), and was modified by the HHRA Work Plan Addendum prepared by Haley & Aldrich (2015a).

The methodology used to complete the HHRA followed USEPA's Work Plan and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) guidance and directives listed below:

- Risk Assessment Guidance for Superfund. Volume 1: Human Health Evaluation Manual (Parts A, E and F) (RAGS) (USEPA, 1989; 2004; 2009).
- Guidance for Data Usability in Risk Assessments (USEPA, 1992).
- Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA, 2002b).
- Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites (USEPA, 2002c).
- Human Health Toxicity Values in Superfund Risk Assessments (USEPA, 2003b).
- Guidelines for Carcinogen Risk Assessment, Final (USEPA, 2005a).
- Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005b).
- Exposure Factors Handbook (EFH) (USEPA, 2011).
- Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors (USEPA, 2014).

A complete list of references that were used to guide the Phase II HHRA is included in the References section at the end of this HHRA Report.

1.2 CONTENT OF THE HHRA

The HHRA was completed using a four-step process, consistent with the framework for risk assessment described in *Risk Assessment Guidance for Superfund* (USEPA, 1989). The four steps included Data Evaluation, Exposure Assessment, Toxicity Assessment, and Risk Characterization. Supporting documentation of the risk assessment methods, inputs, and results are provided in tables, figures, and appendices to this HHRA Report.

This Section 1 provides the regulatory context of the HHRA, discusses the Phase II RI Study Area background, and describes the updated conceptual site model (CSM).

Section 2 of this report, Data Evaluation, discusses the data used in the HHRA, including:

- Media and Phase II RI Study Area locations sampled;
- Data quality, emphasizing data quality limitations that could introduce uncertainty into the risk assessment;
- Phase II RI Study Area data used in the HHRA;
- Data not used in the HHRA;
- Methods used to group and summarize data for use in the HHRA;

- Methods used to select Chemicals of Potential Concern (COPCs) evaluated in the HHRA; and
- Results of the COPC selection process.

Figures 3.A.1 through 3.K.1 show the locations of surface soil and sediment samples collected to provide the data evaluated in the HHRA. Appendix A provides documentation of the data sets evaluated in the HHRA, including lists of samples and the analytical data used for each data set.

Section 3 of this report, Exposure Assessment, identifies the human populations that could potentially access or use the Phase II RI Study Area under current and reasonably foreseeable future land use conditions, explains how those populations could potentially be exposed to the COPCs in Phase II RI Study Area media, and quantifies how much exposure could occur. Specific components of the Exposure Assessment describe current and future land uses, exposure study areas (ESAs), exposure pathways, exposure scenarios, and exposure point concentration (EPC) and exposure intake calculations. Figure 3.1 shows the ESAs. Appendices B and C document the EPC calculations. Tables 3.1 through 3.26 summarize the information used in the exposure assessment.

Section 4, Toxicity Assessment, describes the toxicological attributes of COPCs and the dose-response relationships of the COPCs that were used to quantify health risks. Appendix D describes the potential health effects associated with exposures to COPCs Tables 4.1 through 4.4 document the toxicity values used in the HHRA.

Section 5, Risk Characterization, describes the methodology used to calculate and summarize risks and derive cumulative risk estimates. An uncertainty analysis is included of the variables and assumptions in the HHRA that could have a substantial bearing on the results of the risk assessment. Appendices E, F, and G document the risk calculations. Tables 5.1 through 5.13 summarize the estimated health risks.

Section 6 summarizes the HHRA and states its conclusions. This is followed by a list of referenced information used to complete the HHRA.

Appendices A through G provided data, calculations, and other technical supporting information for the HHRA. Appendix H provides complete copies of the Phase II SWS RI Report and the Phase II Air RI Report on disc. Appendix I includes Asarco's responses to USEPA and ADEQ comments on the Draft RI and HHRA reports.

1.3 PHASE II RI STUDY AREA DESCRIPTION

Hayden Operations consists of Asarco's active operations, which are comprised of the concentrator, smelter, and various support facilities including materials conveyance systems, process materials storage areas, tailings impoundments, and process and storm water management systems (Figure 1.2). The function of Hayden Operations is to produce 99 percent pure copper anodes. The concentrating and smelting process is described in the Phase II RI Reports.

The majority of operations that are required to process copper ore and concentrate into refined copper metal occur in portions of Hayden Operations that have an intense level of industrial use; these areas are therefore secured by fencing and are patrolled by facility security personnel to maintain a safe work environment. A secondary function of the security in these areas is to prevent thievery of copper and copper-bearing materials.

The land bordering the active concentrator and smelter operations (secured area) includes property owned or leased by Asarco to the north and east that includes various active facilities that provide ancillary support to Hayden Operations, as well as portions of the former Kennecott operation. Open space, rail lines, and the high school are located to the south. Residential neighborhoods are located within the Town of Hayden to the west. Tailings impoundments are located on Asarco-owned land south of Highway 177. The Gila River is located between the two tailings impoundments. Land surrounding the areas listed above is undeveloped open space generally consisting of sandy soil, steep grades, and desert vegetation typical of the Phase II RI Study Area.

Hayden had an estimated population of 662 residents in 2014, according to the U.S. Census Bureau (http://factfinder.census.gov). Hayden Operations border the residential areas of Hayden on the north, south, and east. Residential areas are bounded on the west by the San Pedro Wash and are bisected by the Kennecott Wash. The town of Winkelman, located just to the southeast of the Hayden Operations, had an estimated population of 346 residents in 2014, according to the U.S. Census Bureau.

The climate in Hayden is dry, with an annual average precipitation of 13.9 inches. Temperatures range from a low of 30 degrees Fahrenheit in winter, to daily highs of 100 degrees Fahrenheit or greater June through August[1].

Drinking water within the Phase II RI Study Area is supplied by the Hayden wellfield (operated by Asarco) and the Winkelman wellfield (operated by the Arizona Water Company). Groundwater quality within the Phase II RI Study Area is routinely monitored by Asarco under an Arizona Aquifer Protection Permit (APP) issued by the Arizona Department of Environmental Quality (ADEQ).

The foreseeable future use of the Phase II RI Study Area is not expected to change. With the exception of some areas that are distant from Hayden Operations and certain groundwater monitoring well locations, the property evaluated in the HHRA is entirely owned by Asarco, and Asarco has no plans of transferring property to other owners. Minor portions of the Hayden Operations area are leased by Asarco, but use of these areas is also not expected to change due to the ongoing operations.

1.4 REMEDIAL INVESTIGATION SUMMARY FOR SOIL, WATER AND SEDIMENT

The Phase II soil and sediment investigation included collection and laboratory analysis of 1,641 soil and sediment samples throughout the Hayden Operations and upland areas[2]. An enhanced level of characterization within selected portions of the Phase II RI Study Area was acquired at an additional 360 locations subjected solely to field x-ray fluorescence (XRF) analysis. Sample collection was conducted primarily in two stages. The first stage of sample collection occurred from February 2013 to October 2013, and addressed pre-determined locations identified in the Work Plans. A second stage of sample collection, conducted to resolve remaining data gaps pertaining to lateral and vertical characterization, began in November 2013 and was performed periodically through June 2015.

The objective of the RI was to characterize the nature and delineate the extent of COPC concentrations that are above risk-based screening levels and background values. Project decision limits (PDLs) were established (Haley & Aldrich, 2013) to provide a basis for delineating a target for concluding when the

[1] https://customweather.com/

[2] Use of the terms "soil" or "sediment" in context of the Phase II RI/FS often includes materials other than native soils and sediments, including but not limited to concentrate tailings, slag, and various in-process materials.

lateral and vertical extent of COPCs was defined within the 19 RI Areas identified in USEPA's Work Plan. The PDLs were based on conservative criteria provided in USEPA's Work Plan that considered Phase I and Phase II background soil samples collected from unaffected portions of the Phase II RI Study Area, human health residential and ecological risk-based screening values published by USEPA, and laboratory reporting and detection limits. Separate sets of PDLs were developed for Remedial Investigation Areas subject to evaluation under the Baseline Ecological Risk Assessment (BERA) (i.e., RI Areas 2, 5, 10, and 19) versus RI Areas not subject to the BERA.

Samples of surface soil and sediment (0 to 2 inches below ground surface [bgs]) were collected throughout the 19 RI Areas. Sample locations are shown on Figures 3.A.1 through 3.K.1 of the SWS RI Report. Vertical delineation sampling was conducted at numerous locations at depths ranging from 1 foot to 15 feet to determine the vertical extent of COPCs and assess the potential for adverse impacts to groundwater quality. The sample collection methodology and associated results of the Phase II soil and sediment investigation are detailed in Section 3 of the SWS RI Report.

The Phase II storm water investigation included collection and laboratory analysis of 54 storm water samples from 14 wash locations, including 5 background locations, and 1 area of ponded storm water (Figure 5.3 of the SWS RI Report). Storm water samples were collected during the time period of April 2013 to April 2015. The sample collection methodology and associated results of the Phase II storm water investigation are detailed in Sections 5.1.3 and 5.4 of the SWS RI Report.

The Phase II RI also included comprehensive investigations of groundwater, surface water in the Gila River and San Pedro River, and process water produced by Hayden Operations. The sample collection methodology and associated results are detailed in Sections 4 and 5 of the SWS RI Report.

The RI identified metals at concentrations greater than PDLs in soil and sediment in these areas. As documented in the SWS RI Report, the RI successfully characterized the nature, extent, and fate and transport of the detected constituents in the various media in the Phase II RI Study Area.

1.5 REMEDIAL INVESTIGATION SUMMARY FOR AIR

The Phase II ambient air investigation included collection and laboratory analysis of 5,294 samples from 11 ambient air monitoring stations throughout the Study Area[3] (Figure 1.3). The ambient air monitoring stations were located within residential and commercial areas within the town of Hayden (ST-01, ST-08, ST-16, ST-23, and ST-26), at the high school located in Winkelman (ST-02), along a public highway (ST-05), and within or near active portions of Hayden Operations (ST-09, ST-14, ST-18, and meteorology station ST-10). All ambient air samples were collected from 03 July 2013 to 29 June 2015, prior to the advent of the 2015 Consent Decree. The Phase II RI also included evaluation of PM_{10} data collected by ADEQ at ST-06 during this time period.

Each ambient air monitoring station operated by Haley & Aldrich was equipped with a minimum of seven ambient air monitors plus an anemometer, with the exception of ST-01, ST-08, and ST-10 (Table 2.1 of the Air RI Report). Most of the monitors were Partisols, MiniVols, and Pb-TSP Hi-Vol samplers designed to collect physical samples of particulate matter on various types of filter media (i.e., Teflon, quartz, polycarbonate, and glass fiber). Stations were also equipped with DustTraks and E-BAMs,

[3] The referenced 11 ambient air monitoring stations were operated by Haley & Aldrich during the Phase II RI. ST-06 constitutes a 12th ambient air monitoring station for the Phase II RI that was operated by ADEQ.

which provided continuous (24 hours per day, 365 days per year), real-time concentration data for various sizes of particulate matter in ambient air. Up to 17,500 hours of continuous particulate matter and wind data were obtained at each ambient air monitoring station equipped with the indicated equipment.

A full set of meteorological data types were collected at ST-10, situated on Camera Hill (Figure 1.3). Data types included wind speed and direction, ambient temperature (2 meters and 10 meters above ground surface), atmospheric pressure, precipitation, relative humidity, and solar radiation. Wind data from meteorological station ST-10 were supplemented by wind data from each of the ambient air quality monitoring stations.

Sample collection methodology and the results of the Phase II Air RI are detailed in Section 2 of the Air RI Report. Station-specific data distributions for the two-year Phase II monitoring period are presented in the Air RI Report, along with information pertaining to particle size distribution (PM_{10} versus $PM_{2.5}$) and correlations with various aspects of Hayden Operations production levels prior to the implementation of the Consent Decree. Specific ambient air data used for the HHRA versus that collected for the source apportionment evaluation are identified in Sections 2.3 and 2.4 of this HHRA Report.

1.6 REGULATORY OVERSIGHT OF HAYDEN OPERATIONS

Process fugitive emissions and fugitive dust emissions at Hayden Operations are governed by the 2015 Consent Decree, 2018 Title V Permit, federal Clean Air Act, and implementing USEPA and ADEQ regulations. The major regulatory requirements that govern the emissions are summarized in Sections 1.3.3 and 1.3.4 of the Air RI Report. The complete set of requirements is presented in Appendices M and N of the Air RI Report (Haley & Aldrich, 2020b).

Discharges to groundwater at Hayden Operations are governed by the facility's 2020 Areawide APP and Arizona's aquifer protection statute and regulations (Arizona Revised Statutes §§ 49-241 through 49-252 and Arizona Administrative Code R18-9-101 through R18-9-E323). The major regulatory requirements that govern the discharges are summarized in Section 1.4.3 of the SWS RI Report (Haley & Aldrich, 2020a). These include corrective action requirements applicable to impoundments and other surface features if they correlate to exceedances of groundwater quality alert levels specified in the APPs. The complete set of requirements is presented in Appendix Q of the SWS RI Report.

The potential for discharges to surface water at Hayden Operations is governed by the 2019 Arizona Pollutant Discharge Elimination System General Permit for Stormwater Discharges Associated with Industrial Activity (MSGP) and Hayden Operations' implementing Stormwater Pollution Prevention Plan (SWPPP). The major regulatory requirements that govern potential discharges to surface water are summarized in Section 1.3.6 of the SWS RI Report. These include requirements that contain and route to the APP-regulated impoundments storm water that comes into contact with facility operations. The complete set of requirements is presented in Appendix R of the SWS RI Report.

1.7 CONCEPTUAL SITE MODEL

A CSM is used to describe the potential exposure pathways through which Phase II RI Study Area-related COPCs have the potential to be transported and/or trans-located from source or release areas within the Phase II RI Study Area to other environmental media where possible human and environmental exposure may occur. An update of the portion of the CSM in USEPA's Work Plan that applies to the Phase II RI Study Area is detailed in Section 6 of the SWS RI Report and illustrated as Figure 6.1. This section provides a summary of the major aspects of the updated CSM.

1.7.1 Sources

The principal sources of COPCs detected within the Phase II RI Study Area are the concentrating and smelting operations which are subject to the 2015 Consent Decree, 2018 Title V Permit, federal Clean Air Act, and implementing regulations. Other sources of COPCs include background conditions.

1.7.2 Release Mechanisms

Within active areas of Hayden Operations, various beneficiation and process materials are located within specified areas for temporary staging while they await transfer to the next step in the manufacturing process. Washes and other off-facility locations within the Phase II RI Study Area exhibit evidence of releases of tailings and other process materials that are attributable to historic operations (Figure 1.2).

Storm water runoff from any of the above-referenced areas potentially entrains soil or sediment containing elevated COPCs. All storm water runoff from the Hayden smelter area and most of the storm water runoff from the Hayden concentrator area is retained within the respective smelter and concentrator areas in accordance with the MSGP and SWPPP. The small portion of storm water runoff not retained within the concentrator area flows toward an unnamed tributary of Kennecott Avenue Wash or Power House Wash. No storm water from Hayden Operations flows through the lower reach of San Pedro Wash. Storm water from San Pedro Wash and Kennecott Wash, and storm water and process water from Power House Wash, flow into a drainage channel that directs the water into Emergency Pump-back Ponds (EPPs) adjacent to Tailings Impoundments AB/BC, from which water is pumped to the Water Reclamation Ponds for reuse within Hayden Operations. Any water that potentially overflows the EPPs is retained in a drainage channel along Tailings Impoundment AB/BC that ultimately reports to Last Chance Basin. These ponds and impoundments are regulated under the facility's APPs.

Portions of the Phase II RI Study Area that are not actively used or subject to periodic surface disturbances (e.g., storm water flow) may have been affected by aerial deposition of particulate matter from historic smelting operations.

Copper, arsenic, and lead showed the greatest extent of concentrations in excess of PDLs within the Phase II RI Study Area, particularly within the secured portions of Hayden Operations.

The Phase I HHRA (CH2M Hill, 2008b) already concluded that potential human health risks associated with the Gila River are not significant (regardless of the source of constituents detected in the river); therefore, potential exposure to surface water is not evaluated in the HHRA.

Phase II data for groundwater samples collected from all monitoring and water supply wells in the Gila River alluvium aquifer indicates that all metals are below Maximum Contaminant Levels (MCLs) and Arizona Aquifer Water Quality Standards (AWQSs). In contrast, Phase II results for groundwater samples collected from some monitoring wells in bedrock and wash alluvium aquifers indicate the presence of some metals (antimony, arsenic, cadmium, chromium, lead, and selenium) at concentrations greater than MCLs and AWQSs. However, these occurrences were limited to isolated wells bounded by adjacent and downgradient wells where COPC levels were found to be less than all MCLs and AWQSs. Therefore, migration of groundwater with metals at concentrations greater than MCLs and AWQSs is not occurring, and elevated COPCs in bedrock and wash alluvium wells does not represent a potential threat to downgradient water supply wells in the Gila River alluvium aquifer, indicating this potential exposure pathway is incomplete or insignificant. In summary, there is no associated complete exposure pathway to COPCs in groundwater for any human receptors, as no COPCs have been detected in any wells within the Gila River alluvium aquifer at concentrations exceeding MCLs or AWQSs, including the Hayden and Winkelman wellfields that supply drinking water within the Phase II RI Study Area.

1.7.3 Receiving Media

Based on the assessment of source media and complete exposure pathways, COPCs are evaluated in the following media within the Phase II RI Study Area:

- Surface soil (defined as soil 0 to 2 inches bgs);[4]
- Subsurface soil (defined as soil 1 to 15 feet bgs); and
- Storm water.

1.7.4 Exposure Pathways

Exposure pathways describe the mechanisms by which human receptor populations could be exposed to constituents detected in the various receiving media identified above. For exposure pathways to be complete, there must be a source containing COPCs (which are the receiving media identified above), a point of exposure to the source (termed an exposure point), a route of exposure to the exposure point (which identifies how exposure could occur), and a human receptor population to which the exposure could occur.

Section 3 provides detailed discussion of the human receptor populations and exposure pathways that were evaluated in the HHRA:

- Incidental ingestion and dermal contact with surface soil;
- Incidental ingestion and dermal contact with storm water;
- Inhalation of surface soil-derived fugitive dust; and
- Inhalation of ambient air.

Potential exposure pathways via groundwater are not complete because groundwater within the potable water aquifer does not exhibit concentrations of constituents in excess of drinking water or aquifer protection standards, and there is no complete migration pathway from the Phase II RI Study Area to that aquifer.

[4] Surface samples collected within the Study Area consisted of both soil and sediment samples, as defined by the Work Plan. Surface "sediment" refers to areas of soil that may at times be wet due to physical features (e.g., depressions). Both soil and "sediment" in upland areas would have the same exposure routes and exposure potential and are therefore collectively evaluated as surface soil. Use of the term "sediment" is minimized in the remainder of this report to enhance report clarity. All references herein to soil, as investigated within the Study Area, refer to soil and sediment.

Potential exposure pathways via surface water in the Gila River are not complete because there is no complete migration pathway from the Phase II RI Study Area to the river.[5]

Potential exposure pathways via subsurface soil are not complete because, as described in Section 3, receptor populations within the areas evaluated would not excavate into soil and be potentially exposed to subsurface soil.

[5] The Phase I HHRA conducted by USEPA concluded that human health risks associated with potential exposures to Gila River surface water were within acceptable levels.

2. Data Evaluation

This section documents the data evaluated for relevance to the HHRA, explains why certain data were included in or excluded from the HHRA, provides the rationale for the way the data were grouped for evaluation, and describes the methods used to summarize the data using statistical descriptors. The data evaluation section also provides the methods used to select COPCs and documents the COPC selection results.

2.1 DATA SOURCES AND DATA QUALITY

The HHRA is based on the data collected in support of the Phase II Air RI from March 2013 to September 2015, prior to the advent of the 2015 Consent Decree. In addition, ten rounds of groundwater sample collection and analysis and six rounds of surface water sample collection (in the San Pedro and Gila River) and analysis were performed during the RI. However, the groundwater data were not evaluated in the HHRA because there are no complete exposure pathways for Phase II RI Study Area related constituents in groundwater and the surface water data are not evaluated in the HHRA because the Phase I HHRA concluded that there are no unacceptable risks associated with potential exposures to the river.

Data collected for the RI were selected for use in the HHRA using the criteria established by USEPA in "Guidance for Data Usability in Risk Assessment" (USEPA, 1992). These data were a product of sample collection and handling, laboratory analyses, and data quality assurance/quality control (QA/QC) procedures performed in accordance with USEPA's Quality Assurance Project Plan (QAPP) for the Phase II RI Study Area**.** The SWS RI Report (Sections 3.1, 4.1, and 5.1) and the Air RI Report (Section 2.1) provide detailed descriptions of the sampling and analytical methods that were used to generate the data. Complete versions of the two RI reports are provided on disc in Appendix H.

The following bullets provide a brief summary of the types of samples that were collected for the Phase II RI:

- Surface soil samples were collected by hand (e.g., using clean, disposable plastic scoops) as soil from the ground surface to 2 inches below the ground surface (0 to 2 inches bgs). Organic debris was removed from the ground surface prior to collecting the soil samples. Surface soil samples were collected from locations throughout the Study Area.
- Storm water samples were typically collected using automatic, passive Nalgene storm water sampling devices installed within specified wash channels. On a few occasions, samples of standing or flowing storm water were manually collected using a laboratory-supplied disposable 1-liter cup. Filtered storm water samples were collected by filtering the sample at the time of sample collection.
- Ambient air samples were collected from Partisols, Pb-TSP Hi-Vol, and MiniVol samplers. Air samples were collected as 6-day samples continuously between 03 July 2013 to 29 June 2015 from 12 air monitoring stations.

2.1.1 Analytical Methods

Soil and sediment samples were analyzed for boron, molybdenum, and target analyte list metals (excluding magnesium, potassium, and sodium) using USEPA Test Methods SW6010B and SW7471A (mercury)[6]. Based on the results of field XRF analysis and initial laboratory results for total chromium, selected samples were also analyzed for hexavalent chromium using USEPA Test Method SW7199.

Depending on the available sample volume, storm water samples were analyzed by the laboratory for some or all of the following analytes:

- Total metals (aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc) using USEPA Test Method SW-846 3050B/6010C;
- Total and dissolved metals (aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, molybdenum, nickel, potassium, selenium, silver, sodium, vanadium, and zinc) using USEPA Test Method E200.7;
- Total and dissolved metals (antimony, arsenic, cobalt, selenium, and thallium) using USEPA Test Method E200.8;
- Total and dissolved mercury using USEPA Test Method SW7470;
- Nitrite/nitrate (as nitrogen) using USEPA Test Method E353.2;
- Sulfate using USEPA Test Method D516-90;
- Chloride using USEPA Test Method SM4500-CL-E;
- Fluoride using USEPA Test Method SM4500F-C;
- Cyanide using USEPA Test Method SM4500-CN-E;
- Alkalinity using USEPA Test Method SM2320B;
- Total dissolved solids using USEPA Test Method SM2540C;
- Total suspended solids using USEPA Test Method SM2540D; and
- Total organic carbon using USEPA Test Method SM5310B.

The types of analyses that were collected for ambient air samples include:

- Samples from Partisols and Pb-TSP Hi-Vol samplers were analyzed in accordance with Federal Reference Methods (USEPA, 1987; 2006; 2013b), thereby providing gravimetric results (i.e., particulate matter in the PM_{10}, $PM_{2.5}$, and total suspended particulate [TSP] size ranges) and lead concentrations in the TSP size range.
- Laboratory XRF was used to quantify concentrations of 36 metals and other elements in two different size ranges (PM_{10} and $PM_{2.5}$) for both Partisol and MiniVol Teflon filters.
- Confirmatory analysis of a portion of XRF results for Partisol samples was conducted using Inductively Coupled Plasma – Mass Spectrometry.

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[6] The complete analyte list for soil and sediment samples is aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc. Selected samples were analyzed for hexavalent chromium.

- Chloride, nitrate (as nitrogen), orthophosphate, and sulfate were determined for MiniVol quartz filters using ion chromatography (IC); elemental carbon and organic carbon were analyzed by the Interagency Monitoring of Protected Visual Environments (IMPROVE) Thermal Optical Reflectance method.
- A subset of MiniVol polycarbonate samples were analyzed by scanning electron microscopy and energy dispersive x-ray spectrometry.

2.1.2 Data Quality

As part of the QA program for the Phase II RI, quality control samples were collected and analyzed. These included field quality control blanks (trip blanks and temperature blanks for water samples), field duplicates (at a frequency of 10 percent for soil and 5 percent for storm water), matrix spike/matrix spike duplicate, and laboratory QC samples.

All of the data collected in support of the Phase II RI, and all of the data selected for use in the HHRA, have undergone validation. Data validation is a systematic process of reviewing a body of data to provide assurance that the data are adequate for their intended uses. The data validation process uses the QA samples. As described in the QAPP, two types of validation were used for the data collected in support of the Phase II RI:

- Verification and Level III validation was performed on all data. This level of validation includes verification of the data package and a detailed review of the case narrative, holding times, field duplicates, QC summary forms, sample dilutions, sample reanalysis, initial calibration, and continuing calibration.
- Full or Level IV validation was required for 10 percent of the data. This level of validation includes a Level III validation plus a full review of all raw data. The percentage of Level IV validation performed was 10 percent for soil and sediment and 17 percent for storm water. The 10-percent requirement was met and exceeded.

The laboratory analytical data are assigned data validation qualifier codes during the validation process. The validation codes used are:

- J : Indicates the result is an estimated concentration that was reported as positively detected at a concentration greater than the instrument detection limit, but less than the method detection limit.
- J+ : Indicates an estimated value that may be biased high.
- J- : Indicates an estimated value that may be biased low.
- U : Indicates that analyte was not positively detected at a concentration greater than the method detection limit (MDL).
- UJ : Indicates an estimated detection limit.
- R : Rejected. Indicates result is unreliable and un-useable.

In accordance with USEPA data validation guidelines, values reported as positively detected were evaluated to determine if the detections could be associated with contamination of blanks. Any detects were assessed to determine if the concentration warranted qualification. Twenty-seven percent of detects in field and laboratory blanks were detected at concentrations greater than one-half the reporting limit. The percentage of analyte results that were qualified as non-detect based on blank contamination was 3 percent for soil and sediment and 4 percent for storm water.

Appendix F of the SWS RI Report includes a complete data quality assessment, including data validation reports. A review of the Phase II RI data indicates that:

- The number of rejected data records was small: 2.03 percent for soil and sediment and 0.00 percent for storm water. Resampling of original soil and sediment locations was conducted to mitigate associated data that was rejected due to exceedance of hold times.
- Most MDLs for soil and sediment were less than PDLs, with the primary exception of approximately 50 samples that were reported as non-detect for arsenic at an elevated MDL of 54 or 55 milligrams per kilogram (mg/kg). No such values were established for storm water. All non-detect values for all analytes in soil, sediment, and storm water were evaluated in the HHRA as being present at their reported MDLs. Moreover, detected concentrations for arsenic are higher than the highest non-detect concentrations, indicating that risk estimates will be influenced by the detected concentrations, not the MDLs. This is also the case for the negligible number of other analytes in soil and sediment for which some MDLs exceeded PDLs.
- Metrics for evaluating data precision, accuracy, completeness, and comparability met or exceeded the project goals established in the QAPP.

Overall, the RI data set provides sufficient quality of data for use in the risk assessment.

2.2 DATA USED IN HHRA

The HHRA evaluated potential exposures and health risks by ESA. ESAs represent the geographic areas of the Phase II RI Study Area where exposures may occur. One or more RI Study Areas or air monitoring stations may be associated with a given ESA. The risk assessment evaluated potential human receptor exposures to the media at each of the ESAs under current and reasonably foreseeable land use conditions.

The following data sets were compiled for use in the HHRA. Samples included in each of the data sets, as well as the analytical data for the samples, are identified in Appendix A.

2.2.1 Soil and Sediment

Soil data were used in the HHRA to evaluate potential direct contact (incidental ingestion and dermal contact), and inhalation (particulate) risks that could occur if people were to contact soil. The soil data for the Phase II RI Study Area were evaluated as surface soil (samples collected 0 to 2 inches bgs). The soil sample locations are shown in Figures 3.A.1 through 3.K.1 of the SWS RI Report.

Although the HHRA evaluated potential exposures and risks for soil by ESA, data for all ESAs were combined for the purpose of selecting the COPCs for soil. Consequently, a single data set was developed for use in selecting COPCs, as presented in Table 2.1. This approach resulted in a single set of COPCs selected for surface soil. Selecting COPCs using data sets for all Phase II RI Study Area soil has the advantage of ensuring that the same COPCs were carried through the assessment for each of the ESAs, which helped to standardize the HHRA as well as facilitate a comparison of risk contributors across the various ESAs. For the analytes selected as COPCs, separate data sets were developed for each of the ESAs, and from those data sets, EPCs were calculated as described in Section 3.

A list of soil samples and analytical data used in the HHRA is presented in Appendix A.

2.2.2 Storm Water

Storm water data were used in the HHRA to evaluate potential direct contact (incidental ingestion and dermal contact) risks that could occur if people were to wade in washes while storm events occur. The storm water sample locations are shown in Figure 5.3 of the SWS RI Report. Between 2 and 7 samples were collected from each station. A list of storm water samples and storm water data used in the HHRA is presented in Appendix A. The data are summarized in Table 2.2.

2.2.3 Ambient Air

Ambient air data in the PM_{10} fraction, based on samples collected from Partisols prior to the advent of the 2015 Consent Decree, were used in the HHRA to evaluate potential inhalation (particulate) risks that could occur if people inhale ambient air having the COPC profile of the samples collected from the ambient air monitoring stations. The ambient air monitoring locations are shown in Figure 1.3.

Although the HHRA evaluated potential exposures and risks for soil by ESA, data for all ESAs were combined for the purpose of selecting COPCs for ambient air. Consequently, a single data set was developed for use in selecting COPCs, as presented in Table 2.3. This approach resulted in a single set of COPCs selected for ambient air. Selecting COPCs using data sets for all Phase II Study Area air data has the advantage of ensuring that the same COPCs were carried through the assessment for each of the ESAs, which helped to standardize the HHRA as well as facilitate a comparison of risk contributors across the various ESAs. For the analytes selected as COPCs, separate data sets were developed for each of the ESAs, and from those data sets, EPCs were calculated as described in Section 3.

2.2.4 Background Data

2.2.4.1 Soil and Storm Water

Samples were collected from background reference areas for soil and storm water. The following background data sets were collected:

Phase II RI Study Area	Background Data Set
Soil (Phase II RI Study Area-wide)	Remedial Investigation Area 19, Region 1, subsurface soil (12 to 14 inches bgs) and Phase I RI background data
Storm water	Sampling stations STW02, STW03, STW13, STW14, and STW14U

One of the key objectives of the background evaluation for soil was to establish values for each parameter in the background reference area that are representative of background conditions (i.e., background values), for the purposes of setting PDLs and delineating the nature and extent of contamination. Storm water background, or 'up stream', data were also used in the HHRA to evaluate whether potential sources within the Phase II RI Study Area could influence the EPCs for metals in storm water. Background values for soil and storm water were based on the 95 percent upper tolerance limit (UTL) with 95 percent coverage (Haley & Aldrich, 2013). Background threshold values (BTVs) for soil are presented in Table 2.4, and BTVs for storm water are presented in Table 2.5.

Soil and storm water background data were also used to evaluate risks associated with background conditions and estimate incremental risks above background. The evaluations of risks associated with soil and storm water background conditions are discussed further in Section 5.

2.2.4.2 Ambient Air

Background ambient air samples were not collected as part of the Phase II RI. However, Haley & Aldrich (2014) conducted a review of existing background ambient air monitoring data collected within Arizona. This included a review of arsenic data for seven IMPROVE monitoring stations located in Arizona. Haley & Aldrich (2014) proposed that existing data from both the Organ Pipe National Monument (NM) and the Tonto NM be used to represent the range of background air quality conditions for the Study Area. These data encompass the lowest and nearly the highest arsenic concentrations for the IMPROVE stations closest to Hayden, excluding the Douglas and Chiricahua NM stations where much higher levels of arsenic were identified. The Organ Pipe NM and Tonto NM stations were both previously identified as suitable for representing background conditions in Hayden (CH2M Hill, 2008a). See Section 2.5 of the Air RI Report for further detail.

In order to evaluate risks associated with background conditions, data from 03 July 2013 to 29 June 2015 from the Organ Pipe and Tonto stations were utilized. The date range for background data was selected to match the date range for Site-specific data. In accordance with USEPA guidance, background conditions were addressed as a component of the Risk Characterization (USEPA, 2002c). Summary statistics of background ambient air data are presented in Table 2.6. The evaluation of risks associated with air background conditions is discussed further in Section 5.

2.3 DATA NOT USED IN HHRA

The following types of data were not evaluated in the HHRA:

- Phase I RI data, with the exception of Phase I soil data for background locations which were used to support the Phase I RI and risk assessments. As established in the Work Plan, data quality objectives for the Phase I sampling of the areas evaluated in the Phase II RI were not sufficient and/or not met; therefore, Phase I data were not used in the Phase II RI or Phase II risk assessments.
- Subsurface soil data, as these were collected only to determine the vertical extent of COPCs at designated locations and the potential for adverse effects on groundwater quality.
- XRF data, which were used in field investigations to help define extent and locate samples to be submitted for laboratory analysis.
- Samples and data collected in support of leaching studies.
- Phase II RI data obtained from analysis of MiniVol samples collected at the air monitoring stations, including metals, ions, and elemental and organic carbon. These data were collected for the Phase II source apportionment.
- Phase II emission source characterization data. These data were collected for the Phase II source apportionment and represented detailed chemical profiles.
- Phase II RI ICP data used to verify a portion of the XRF results for ambient air samples.

These data are discussed in detail in the SWS RI Report and Air RI Report.

2.4 DATA SUMMARIZATION METHODS

The analytical data for each data group developed in support of the HHRA are designated descriptors that identify:

- Frequency of detection (number of positively detected results/total number of results);
- Range of detected concentrations;
- Range of non-detected results (range of sample quantitation limits); and
- Arithmetic mean concentration (for summaries developed for each ESA).

Additional statistical measures of the data were derived for each ESA to support identification of EPCs, as described in Section 3.

The following procedures were applied when summarizing the analytical data for the HHRA:

- For samples in which both an original and a field duplicate result are available, both results were used in the data sets. Due to the large numbers of samples included in the data sets[7], inclusion of duplicate sample results is not expected to bias EPCs.
- Rejected data ("R" qualified results) were not used in the risk assessment.
- Results qualified as estimated ("J" qualified) were used in the risk assessment.
- For samples in which analyte concentrations were detected outside the calibration range, such that the samples had to be diluted and reanalyzed, only the re-analysis results were used in the risk assessment.
- When calculating the arithmetic mean concentrations, one-half the non-detect value (usually the MDL) was used for results reported as not-detect.
- Inorganics with data for total and dissolved concentrations (storm water) were summarized separately.

2.5 CHEMICALS OF POTENTIAL CONCERN

COPCs are chemicals that may pose more than a *de minimis* health risk. A concentration-toxicity screening was used to reduce the number of chemicals evaluated in the risk assessment to only those that would potentially pose more than a *de minimis* health risk (USEPA, 1989). The procedure used to select COPCs for the HHRA is consistent with USEPA methodology for risk-based screening (USEPA, 2020a):

A. Comparison to Available Criteria
   - Selected as a COPC in soil if the maximum detected concentration exceeded the USEPA Regional Screening Level (RSL) for residential soils (USEPA, 2020a).
   - Selected as a COPC if the maximum detected concentration exceeded the USEPA RSL for residential air (USEPA, 2020a).
   - Chemicals for which no screening value is available were retained as COPCs unless they met the criteria for exclusion listed in (B) and (C) below.

[7] The ESA data sets that include field duplicate results range in sample size from between 7 and 500 samples. Uncertainties associated with the inclusion of field duplicates in data sets with fewer than 20 samples are discussed in detail in Section 5.4.

The RSLs for soil are protective for direct contact (ingestion and dermal contact) exposures, as well as for inhalation of constituents that may be released to air under the assumption that exposure occurs 24 hours per day, 350 days per year, for 26 years. The use of the residential RSLs to select the COPCs in soil was a highly conservative approach since none of the ESAs evaluated in the HHRA would be contacted at such a frequency or intensity. This approach resulted in the selection of some chemicals as COPCs for soil that, under the Phase II RI Study Area-specific exposure conditions, would correlate to less than a *de minimis* risk.

The RSLs for air are protective for inhalation of constituents that may be released to air under the assumption that exposure occurs 24 hours per day, 350 days per year, for 26 years. The RSLs are derived for a 1 in 1 million ($1x10^{-6}$) cancer risk level or a non-cancer hazard quotient (HQ) of 1. For use in screening data for COPC selection, the RSLs based on non-carcinogenic effects were adjusted to represent a HQ of 0.1.

There are no available screening levels for storm water. Therefore, risk-based screening was not used for storm water.

B. Consistent with Background Values

Constituents in soil were eliminated as COPCs if they were detected at maximum concentrations below the background value. Although background values were derived for storm water and ambient air, they were not used to select COPCs due to limitations of the background data sets.[8]

C. Low Frequency of Detection

Despite other criteria, an analyte could be eliminated as a COPC if the frequency of detection is 5 percent or less and the chemical is not known to be associated with historical operations at the Site (USEPA, 1989). This criterion is not applicable to the soil, sediment, or storm water data sets because none of the constituents analyzed for were detected in fewer than 5 percent of the samples. This criterion was potentially applicable to cobalt in air, which was detected above the laboratory reporting limit in only 1.4 percent of the air samples. However, to provide a conservative assessment of potential risks, cobalt was retained as a COPC.

D. Additional Considerations

COPCs in soil, storm water, or air that were detected at maximum concentrations below USEPA's risk-based screening values, were essential nutrients, or were included in the analyte list solely to inform the source apportionment described in the Air RI Report were not carried through the HHRA for quantitative evaluation of potential exposures and risks.

The COPC selection process and results are summarized in Tables 2.1 through 2.3. The following notes are used in the tables to denote the reasons that the COPC were or were not carried through the HHRA for the quantitative evaluation of potential exposures and risks.

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[8] The storm water data set for total metals was too small (three samples) to reliably estimate a BTV for total metals. Background air data were not collected from site-specific sample locations so existing regional ambient air data sets were used to estimate risks associated with background ambient air concentrations.

ASL: The concentration used for COPC screening (the maximum detected concentration) is greater than the USEPA risk-based screening level; the analyte is therefore selected as a COPC.

BSL: The concentration used for COPC screening (the maximum detected concentration) is less than the USEPA risk-based screening level; the analyte is therefore not selected as a COPC.

B: COPC screening (the maximum detected concentration) is less than the background value; the analyte is therefore not selected as a COPC.

E: The analyte is an essential nutrient and is therefore not selected as a COPC.

SAI: The analyte is a Source Apportionment Indicator and is not applicable or relevant for evaluation of health risks associated with ambient air. The analyte was therefore not selected as a COPC.

NSL: There is no screening value available; the analyte is therefore selected as a COPC.

The results of the COPC selection are discussed below, by medium.

2.5.1 Soil

All inorganics detected in soil were retained as COPCs except beryllium, boron, chromium, and calcium (Table 2.1). Beryllium, boron, and chromium were detected at maximum concentrations below the RSL values, and calcium is an essential nutrient. The highest detection limits for beryllium, boron, and chromium were also below the RSL values. No analytes were eliminated as COPCs based on a comparison to background values because maximum detected concentrations of all constituents were greater than the background values.

2.5.2 Storm Water

There are no screening values analogous to RSLs for use in evaluating storm water. Due to the limited sample size of the total metals data set for storm water, COPCs were not selected using a comparison to the background screening values. As shown in Table 2.2, all detected constituents were retained as COPCs in storm water with the exception of essential nutrients (calcium, magnesium, potassium, and sodium).

2.5.3 Ambient Air

The following analytes were retained as a COPC because the maximum detected concentration in ambient air samples exceeded the residential air RSL (Table 2.3): aluminum, antimony, arsenic, barium, cadmium, cobalt, lead, manganese, nickel, and vanadium.

The following analytes were retained as a COPC because no screening level is available, and the analyte is not an essential nutrient or a source apportionment indicator: chromium, copper, iron, molybdenum, silver, thallium, and zinc.

The following analytes were eliminated as a COPC because the maximum detected concentration did not exceed the residential air RSL: mercury and selenium. The maximum reporting limits for these two analytes do not exceed the residential RSL value based on a hazard index (HI) of 1, indicating that analytical detection limits were sufficient to detect concentrations in ambient air that could potentially contribute risks in excess of USEPA risk thresholds.

In addition, hexavalent chromium was not retained as a COPC in ambient air. A total of ten air samples were analyzed for hexavalent chromium by TSP. As discussed in the Air RI Report, hexavalent chromium was not detected or was detected at very low concentrations that are consistent with negligible background levels measured in rural and urban areas across the United States (USEPA, 2013c). Hexavalent chromium is not associated with beneficiation and process materials at Hayden Operations. The detected concentrations in ambient air are associated with risks equivalent to or below the lower bound of the USEPA cancer risk range (1E-06) and were therefore considered to be insignificant. Accordingly, hexavalent chromium was not retained as a COPC, but is instead discussed as a component of the uncertainty analysis.

3. Exposure Assessment

The exposure assessment evaluated the populations of humans that could potentially access the Phase II RI Study Area under the current and reasonably foreseeable land use conditions, the mechanisms or exposure pathways by which those humans could potentially be exposed to COPCs within the Phase II RI Study Area, and the magnitude of exposure that could occur through the potential exposure pathways. This process involved three steps:

1. Characterization of the exposure setting in terms of physical characteristics, current and future uses of the Phase II RI Study Area, and the populations that could potentially be exposed to COPCs under the current and reasonably foreseeable future land uses;
2. Identification of potential exposure pathways and exposure points to which the populations could be exposed; and
3. Quantification of exposure for each population from all exposure pathways. Exposures were quantified by identifying EPCs, developing receptor exposure scenarios, and then calculating chemical intakes.

These components are described in Sections 3.1 through 3.5 below.

3.1 LAND USES

3.1.1 Current Land Use

The current land uses of the Phase II RI Study Area consist of open space areas within Hayden and adjacent to Winkelman, facility operational areas that are secured, facility operational areas that are unsecured, and remote open space areas. With the exception of some portions of the remote areas, all of the property in these areas is owned by Asarco. Persons other than Asarco employees or invitees are not permitted on property owned by Asarco. Aside from the secured facility operational areas, the Asarco-owned property is not fenced and therefore is potentially accessible to trespassers. Open space areas within Hayden border residential neighborhoods, which may increase the chance of trespassing in those areas.

3.1.2 Future Land Use

The future use of the Phase II RI Study Area is not expected to change from the current use. The town of Hayden is not growing in population, so expansion of residential or other types of development into the areas evaluated in the HHRA is not expected. Furthermore, the majority of the areas evaluated in the HHRA are on property owned by Asarco. Asarco does not have plans to change the land uses of property it owns. Therefore, the HHRA evaluates a group of exposure scenarios that are associated with current and continuing future land use, as opposed to separate exposure scenarios for current and future land use.

3.2 EXPOSURE PATHWAYS, EXPOSURE STUDY AREAS, AND POTENTIALLY EXPOSED POPULATIONS

3.2.1 Exposure Pathways

An exposure pathway describes the course a chemical theoretically takes from the source to the exposed individual. Exposure pathway analysis links the sources, locations, and types of environmental releases with population locations and activity patterns to determine the significant pathways of human exposure. Exposure pathways generally consist of four elements: (1) a source and mechanism of chemical release, (2) a retention or transport medium, (3) a point of potential human contact with the contaminated medium (known as the exposure point), and (4) an exposure route at the contact point (USEPA, 1989). In order for the exposure pathway to be considered potentially complete, all four elements must be present. Exposure pathways were identified by considering the activities performed by each potential receptor (e.g., hiking; all-terrain vehicle [ATV] riding), the location of COPCs (e.g., surface soil, storm water, ambient air), and the fate and transport characteristics of those COPCs (e.g., volatile, fixed). The updated CSM provides a summary of this information.

There are three exposure routes by which humans can be exposed to COPCs in environmental media: ingestion, dermal contact, and inhalation. More than one exposure route may be applicable to each of the exposure media evaluated in the HHRA.

- Ingestion. Ingestion exposures occur when substances are swallowed. When an environmental medium such as soil or storm water containing chemicals is swallowed, the chemicals can be absorbed into the blood stream from the gastrointestinal (GI) tract and/or directly interact with tissues within the GI tract. Most ingestion exposures to environmental media are incidental in nature, meaning that they are non-intentional. For example, soil can be incidentally ingested if it is touched and adheres to the hand, and the hand (fingers) is then placed into the mouth where the soil can be transferred to the mouth and swallowed. Storm water can be incidentally ingested if it is accidentally swallowed during wading in the water. An example of ingestion exposure to an environmental medium that is *not* incidental (but is intentional) would be groundwater used as a source of drinking water.
- Dermal Contact. Dermal exposures occur when a substance is absorbed through the skin following direct contact with the substance in an environmental medium. For soil, this process requires adherence of the soil to the skin, desorption of a chemical from the soil, and subsequent absorption through the skin. For water, this process involves direct absorption of a chemical from water, through the skin. Dermal exposures to soil and storm water could potentially occur if these media are contacted.
- Inhalation. Inhalation exposures can occur when a substance is present in an individual's breathing zone. Once inhaled, a substance can be either exhaled or retained in the pulmonary system. Retained substances can diffuse through respiratory-tract surfaces into the blood stream, interact directly with lung cells, or become entrained in airway mucous, translocate up to the pharynx, and be swallowed into the GI tract. Inhalation of dust or particulates can occur from emissions or if soil is disturbed by wind, vehicle traffic, or human activity, and releases dust into the breathing zone of the air. Generally, only the particulate fraction in air that is 10 micrometers or smaller, termed the PM_{10} fraction, is available for inhalation.

3.2.2 Exposure Study Areas and Potentially Exposed Populations

The Work Plan established 19 RI Areas within which soil and sediment samples were collected during the Phase II RI. As requested by USEPA, and in recognition that portions of certain RI areas were characterized by more than a single exposure scenario, the RI areas were reconfigured into 11 ESAs (Haley & Aldrich, 2015a). To facilitate the HHRA, each ESA was assigned one of four exposure scenarios (i.e., In-Town Area, Restricted Facility Area, Isolated Facility Area, or Remote Facility Area), which applied to the entire ESA.

The Phase II HHRA process used the ESAs for assessing and characterizing risk. The ESAs are the geographic areas of the Phase II RI Study Area where exposures could occur. The ESAs may include one or more RI Areas identified in USEPA's Work Plan, exposure points, and exposure pathways. ESAs for the Phase II RI Study Area were identified by considering:

- Land uses and associated potentially exposed populations;
- Physical setting of the Phase II RI Study Area, including topography and relative effort to access the area; and
- COPC concentrations and spatial distribution.

The land uses of the ESAs were grouped into four general categories:

1. In-Town Areas;
2. Restricted Facility Areas;
3. Isolated Facility Areas; and
4. Remote Facility Areas.

Sections 3.2.2.1 through 3.2.2.4 provide the rationale for the identification of ESAs, potential receptors, and potentially complete exposure pathways to the media at each ESA. From that information, receptor exposure scenarios were developed based on the combinations of populations and pathways that combine to represent the reasonable maximum exposure (RME) for each land use.

Table 3.1 provides a complete summary of all potential exposure pathways for all media and ESAs in the Phase II RI Study Area. Table 3.1 identifies the exposure setting of each of the soil exposure areas and ambient air monitoring stations and identifies the receptor populations that would be expected to spend the most amount of time in the microenvironment that is represented by each ESA and air monitoring station. Table 3.1 also identifies how risks for soil, storm water, and air exposure scenarios will be combined; this information was used to facilitate evaluation of cumulative (multi-media) risks (see Section 5). The ESAs and ambient air monitoring stations are shown in Figure 3.1.

3.2.2.1 In-Town ESAs

This category includes portions of the Phase II RI Study Area that are located near or adjacent to residential areas and may be readily accessed by nearby residents who trespass into these areas. Since soil at residential properties was evaluated in the Phase I HHRA and subsequently remediated, as applicable, residential population exposures to soil within residential properties were not evaluated in the HHRA. However, residential populations could hypothetically be exposed to soil if they access In-Town ESAs as trespassers. Residential populations could be exposed to COPCs in ambient air at their place of residence (i.e., as residents) or during activities outside the home but within Hayden or Winkelman.

In-Town Areas include open space areas that are within proximity to residential neighborhoods, as well as open space that exists between Winkelman and the active operations area. Due to the physical separation of these two areas, each was designated as a separate ESA:

- ESA D – near Residential Areas in Hayden; and
- ESA H – near Residential Areas in Winkelman.

These ESAs are shown in red in Figure 3.1 and further described in Sections 3.2.4 and 3.2.8 of the SWS RI Report.

In-Town Areas could be used as either a “hang out” or a “short cut” to pass from one area of town to another. In general, active intervention measures to prohibit access to these areas or remove people from them would not be implemented unless substantial illegal activity or public nuisance conditions were occurring. The proximity of these areas to residential development and the relative absence of physical barriers prohibiting access (i.e., land forms or fencing) indicate that access to these ESAs would be more likely than in other portions of the Phase II RI Study Area. Trespassers within these areas could potentially be exposed to COPCs in soil by incidental ingestion, dermal contact, and inhalation of dust that is generated by wind erosion.

The San Pedro, Kennecott Avenue, and Power House washes are located within the In-Town ESA D; the open spaces surrounding the washes bisect residential neighborhoods in Hayden. The washes contain water only during major storm events. During such events, it is hypothetically possible that trespassing populations in the In-Town areas could access the washes and be exposed to storm water by incidentally ingesting or dermally contacting it. Storm water, when present, is only deep enough to permit shallow wading activities (i.e., not swimming). Storm water in the washes was evaluated as a distinct exposure medium within ESA D.

Since residential properties are located in close proximity to the In-Town Areas at ESA D, air monitoring stations located within ESA D were used to conservatively represent the air quality in ESA D that residential receptors in Hayden would potentially be exposed to, as well as visitors and employees that spend time in Hayden, and In-Town trespasser populations within the open spaces of ESA D. The air monitoring stations within or near ESA D include ST-01, ST-16, ST-23, and ST-26.

In summary, the receptor populations that were assumed to potentially be exposed to media at In-Town Area ESA D are:

- Residents who may inhale ambient air;
- Visitors who may inhale ambient air;
- In-Town trespassers who may inhale ambient air and contact soil and storm water; and
- Employees at businesses within the area who may inhale ambient air.

ESA H includes land adjacent to an active railway segment. However, this area is near town and hiking and ATV riding are activities that potentially occur within the overall region around the Facility, and use of this area for such purposes cannot be conclusively ruled out. Air monitoring station ST-09 is located within ESA H. Consequently, the receptor populations that were assumed to be exposed to ambient air at In-Town Area ESA H are:

- In-Town trespassers who may inhale ambient air and contact soil.

The high school is located adjacent to ESA H (Figures 1.2 and 3.1). Ambient air monitoring station ST-02 is located at the high school. Students, faculty, and janitorial/maintenance/grounds keeping workers at the high school were assumed to be exposed to ambient air represented by ST-02 (Figure 3.1).

3.2.2.2 Restricted Facility ESA

This category includes portions of the Hayden Operations where active industrial operations are conducted on a daily basis. These areas are secured by fencing or land form barriers, and regularly patrolled by facility security personnel and occupied by a significant number of other facility workers. The portions of the Phase II RI Study Area evaluated as Restricted Facility Areas were as follows and are shown in blue on Figure 3.1:

- ESA F – Concentrator and Smelter Operations.

Although there may be attractive features within ESA F, including on-going industrial operations and opportunities for theft of materials or equipment, these areas pose significant industrial safety risks (e.g., movement of heavy equipment) that would cause most trespassers to avoid attempting to access these areas. Trespassers who access these areas would need to be significantly motivated to do so (e.g., theft) and would run the risk of incurring an injury due to significant hazards associated with the industrial operation. Additionally, Hayden Operations maintains a significant security force to continually patrol the concentrator and smelter areas, thereby minimizing the time that any trespasser would be present within the Restricted Facility Areas. Consequently, only infrequent access by adolescents and adults (and not younger children) is considered to be plausible for Restricted Facility Area, and repeated access is unlikely.

Trespassers who do access Restricted Facility Areas could potentially be exposed to soil by incidental ingestion, dermal contact, and dust inhalation from wind erosion. Air monitoring station ST-14 is located within ESA F and was used to represent ambient air that a trespasser within the Restricted Area could potentially be exposed to.

Because all portions of the Hayden Operations representing the Restricted Facility Areas are contiguous, one ESA (ESA F) has been identified for the Restricted Facility Areas (Figure 3.1). This ESA is further described in Section 3.2.6 of the SWS RI Report.

3.2.2.3 Isolated Facility ESAs

This category includes portions of the Hayden Operations where active industrial operations are conducted on a daily basis but which are generally located further from residential areas. These areas are not constantly occupied by a significant number of facility workers, and access is not generally prohibited by fencing or landform barriers, indicating they could be accessed by town residents who trespass into these areas. The portions of the Phase II RI Study Area evaluated as Isolated Facility Areas were as follows and are shown in yellow in Figure 3.1:

- ESA A – Tailings Impoundment D. This area is distant from In-Town Areas and physically separated from other ESAs by the Gila River, and is typically occupied by fewer Hayden Operations personnel compared to ESA F. This ESA is further described in Section 3.2.1 of the SWS RI Report.

- ESA B – Tailings Impoundment AB/BC. This area is distant from In-Town Areas and physically separated from most other ESAs by Highway 177, and is typically occupied by fewer Hayden Operations personnel compared to ESA F. This ESA is further described in Section 3.2.2 of the SWS RI Report.
- ESA G – Power House Wash near Residential Area. This area is located between residential properties and the remainder of Power House Wash that is located within ESA F. This ESA is further described in Section 3.2.7 of the SWS RI Report.
- ESA I – Administration Building and Vicinity. This area has less exposure potential than In-Town Areas because it is largely separated from the In-Town Areas by fencing and has facility worker presence, but has more exposure potential than Restricted Facility Areas because the area is located outside of the facility's active operations area security fencing. However, anyone "hanging out" would be quickly noticed by Hayden Operations personnel and asked to leave. In addition, a person could not use this area as a "short cut" to access other town areas; walking into the area only leads to the manned security gate and is therefore a "dead end." This ESA is further described in Section 3.2.9 of the SWS RI Report.
- ESA J – Northern Hayden Operations. This represents the most northern/northeastern portion of the Hayden Operations, and is physically separated from In-Town and Restricted Facility Areas. It is typically occupied by fewer Hayden Operations personnel compared to ESA F. This ESA is further described in Section 3.2.11 of the SWS RI Report.

The remote nature of these areas makes it unlikely that younger children would access them without being accompanied by adults or adolescents. In contrast to In-Town Areas where access can occur by happenstance, "hanging out" within or passing through the Isolated Facility Areas (i.e., "short cuts") would require an intentional, dedicated purpose and a long walk/hike. Trespassers at Isolated Facility Areas could potentially be exposed to soil by incidental ingestion, dermal contact, and dust inhalation. There are no ambient air monitoring stations located within Isolated Facility ESAs with the possible exception of ST-18 used for evaluation of remote area trespassers (below); therefore, populations potentially accessing these ESAs were not evaluated for potential exposures to ambient air.

3.2.2.4 Remote ESAs

Remote Areas include portions of the Phase II RI Study Area that are located away from any developed residential and industrial areas and have limited points of access. The areas evaluated as Remote Areas were as follows and are shown as the areas in grey on Figure 3.1:

- ESA C – Water Reclamation Ponds and Vicinity. This area is distant from In-Town Areas and physically separated from most other ESAs, and is typically occupied by fewer Hayden Operations personnel compared to ESA F. This ESA is further described in Section 3.2.3 of the SWS RI Report.
- ESA E – Historical Tailings. This area is located between residential properties and the southwestern portion of ESA F. It is fenced to minimize access, but it is less secured than ESA F and typically is not occupied by Hayden Operations personnel.
- ESA K – Upland Areas. These areas are largely undeveloped and have no specific uses. No dedicated hiking or ATV trails exist within this ESA. Most of this ESA consists of very rough and steep terrain and would require a dedicated and physically exhausting hike to gain access. Although a few access roads exist, there are no attractive features that would cause a trespasser

to venture away from the roads. ESA K includes small portions of the Hayden Operations near the Copper Basin Railway and below the active slag pile. This ESA is further described in Section 3.2.10 of the SWS RI Report.

Trespassers at Remote Areas could potentially be exposed to soil by incidental ingestion, dermal contact, and dust inhalation. Ambient air monitoring stations ST-05 and ST-18 are located in or adjacent to remote areas at ESA K. Consequently, remote area trespassers could potentially be exposed to air represented by these stations.

3.2.3 Incomplete Exposure Pathways

The results of the RI suggest that the following exposure pathways are not complete within the Phase II RI Study Area and, therefore, the following pathways were not evaluated in the HHRA:

- Direct contact or dust inhalation exposure to subsurface soil: The ESAs evaluated in the HHRA are not associated with land uses that would involve excavation activities and subsequent exposures to subsurface soils by trespassers.
- Direct contact with surface water and sediment: The Phase I HHRA demonstrated that potential exposures to surface water and sediment were associated with acceptable risks. Therefore, these media were not evaluated in the HHRA.
- Potable use of groundwater: Analytical data for groundwater samples collected from both monitoring and water supply wells in the river alluvium aquifer indicated that all metals are below MCLs and AWQSs. In addition, the hydrogeological investigation demonstrates that potential migration of Site-related constituents to supply wells is incomplete. Therefore, there are no complete exposure pathways to groundwater used as potable water.
- Ingestion of COPCs in home-grown produce: Gardening typically only occurs within private residential properties, and residential properties in Hayden and Winkelman have been remediated to the extent necessary (CH2M Hill, 2015). Therefore, any exposure that may occur via consumption of home-grown produce was deemed negligible and not quantitatively evaluated.
- Inhalation of COPCs in attic dust: Exposure to attic dust was previously evaluated by USEPA (CH2M Hill, 2008b). Remediation of surface soil on residential properties has since been completed. Residents' exposure to indoor dust is qualitatively evaluated in this HHRA. Over time, attic dust characteristics will approach those of indoor dust, and exposure to attic dust is less frequent. Therefore, any exposure that may occur via inhalation of attic dust is not significantly different than exposure to indoor dust and was not quantitatively evaluated.

3.2.4 Summary of Exposure Pathways

The HHRA Work Plan specified that the following receptors and exposure points were to be evaluated for the HHRA:

1. Trespasser exposure to surface soil and ambient air throughout the Phase II RI Study Area;
2. Residents' exposure to storm water in specified washes near residential areas in the Phase II RI Study Area;
3. Residents' exposure to groundwater/drinking water supplied to the Phase II RI Study Area;

4. Residents' consumption of home-grown produce;
5. Residents' exposure to indoor dust; and
6. Residents' exposure to ambient air.

As described in Section 1, the Phase II RI Study Area does not include residential or public-use properties; those areas were evaluated in the Phase I HHRA. However, the Phase II RI for Air included In-Town areas where air measurements were potentially representative of air to which residential populations were exposed prior to the implementation of the 2015 Consent Decree. As described in Section 3.2.3, exposure pathways to groundwater and home-grown produce are not complete.

In accordance with the Work Plan, industrial worker scenarios were not considered. An industrial worker scenario is not appropriate for In-town and Remote exposure areas because these areas are not associated with activities that involve full-time industrial worker activities. Industrial workers would only be potentially exposed to soil at these areas as trespassers and were therefore accounted for in the trespasser exposure scenarios evaluated in the HHRA. Isolated Facility and Restricted Facility exposure areas are, in some cases, associated with full-time industrial worker activities. However, industrial workers who occupy those areas with regular frequency are employed by Asarco and are therefore not trespassers. Industrial workers who are employed by Asarco or elsewhere within or outside of Hayden are subject to health and safety requirements of the Occupational Safety and Health Administration and the Mine Safety and Health Administration, which ensures that potential workplace exposures are mitigated such that they will not result in adverse health effects. Therefore, potential exposures to industrial employees that may occur in association with their employment were not evaluated.

Consequently, and with the exceptions identified above, the HHRA did not evaluate residential, recreational, or commercial/industrial receptor populations because potential exposure areas for those populations do not exist within the Phase II RI Study Area. Potential exposures to indoor dust were evaluated in the Phase I risk assessment. Nevertheless, the soil ingestion rates used for the trespasser exposure scenarios in the HHRA, as described in Section 3.3, incorporate incidental ingestion of indoor dust. Therefore, the HHRA accounts for potential exposures to soil that could hypothetically be tracked indoors from the ESAs and be re-suspended as indoor dust.

3.3 EXPOSURE QUANTIFICATION

The process for calculating health risks requires quantifying exposure, or intake, of COPCs and then combining the quantified intake with a toxicity value that relates the intake to a measure of health risk. Exposures to COPCs were quantified by calculating intakes for representative receptor populations that may use or access the Phase II RI Study Area under the various current and continuing future land use conditions. This section describes the process that was used to quantify COPC exposure in each of the media evaluated in the HHRA.

The process for calculating intakes involves two principal components:

1. Quantifying the amount of each medium that a receptor population is exposed to. This is derived by considering the types of activities that a receptor population would be engaged in and the ages of the receptor population (e.g., children vs. adults). From this information, receptor exposure scenarios were developed that relate the activities that could result in exposure to values that can be used to quantify exposure. The quantitative values are called exposure parameters. The types of exposure parameters and descriptions of the exposure scenarios used to quantify exposure are provided in Section 3.3.1.

2. Quantifying the concentration of COPCs in each medium that a receptor population is exposed to. This term is called the EPC. EPCs were derived for each ESA, exposure medium, and exposure route for which potentially complete exposure pathways may exist, as described in Section 3.2. The methods used to derive EPCs are provided in Section 3.3.2.

Fundamentally, therefore, intake is a function of EPC and exposure parameters:

Intake = (EPC) x (Exposure Parameters)

Section 3.3.3 provides an overview of the algorithms that were used to combine EPCs and exposure parameters to quantify intakes.

3.3.1 Exposure Scenarios

Exposure scenarios are used to quantitatively describe the COPC exposures that could theoretically occur for each land use and exposure pathway evaluated. The exposure scenarios are used in conjunction with EPCs to derive quantitative estimates of COPC intake or exposure. The ultimate goal of developing exposure scenarios, as defined in USEPA guidance, is to identify the combination of exposure parameters that results in the most intense level of exposure that may "reasonably" be expected to occur under the current and future site conditions (USEPA, 1989). As such, a single exposure scenario is often selected to provide a conservative evaluation for the range of possible receptors and populations that could be exposed within the Phase II RI Study Area under a given land use. The exposure scenarios that were used to evaluate health risks associated with the potentially complete exposure pathways under current and continuing future land use conditions are described in detail below.

Exposures to COPCs were quantified by using numerical parameters that include:

- Exposure frequencies, which describe the number of days per year that a receptor visits an ESA; exposure routes were assumed to be complete each day that visitation to an ESA occurs.
- Exposure durations, which describe the number of years over which repeated exposure to an ESA may occur.
- Ingestion rates, which quantify the amount of environmental medium (e.g., soil or storm water) that is incidentally ingested each day that visitation to an ESA occurs.
- Dermal contact rates, which quantify the amount of environmental medium that is absorbed through the skin each day that visitation to an ESA occurs. Dermal contact rates were quantified by identifying the skin area that is exposed to the environmental medium and, for soil, the amount of soil that may adhere to the exposed skin (adherence factor), and for storm water, the length of time that water may stay on the exposed skin.
- Exposure times, which quantify how many hours a receptor may spend at an ESA each day that visitation occurs.
- Body weights, which are derived as the average of 50^{th} percentile body weights for males and females over the age ranges of each receptor sub-population (e.g., children ages 6 - <11).

The specific numerical values for each of the parameters listed above were selected for each exposure scenario in consideration of the receptor activities and ages that the exposure scenarios modeled. They were generally selected as the upper-end (generally 95th percentile) values for each quantitative parameter. Using receptor scenarios that are protective for all potentially exposed populations associated with a given land use, with numerical parameters that are generally based on the upper-end distributions, provide RME scenarios. Exposure parameters were developed from USEPA national guidance (USEPA, 2002b; 2004; 2011; 2014), as well as professional judgment based on the land use conditions specific to the various ESAs. Exposure parameters are provided in Tables 3.2 through 3.4:

- Table 3.2: Exposure Factors – Soil;
- Table 3.3: Exposure Factors – Storm Water; and
- Table 3.4: Exposure Factors – Ambient Air.

3.3.1.1 Overview of Trespassing Exposure Scenarios

In accordance with the Work Plan, four separate trespassing scenarios were developed to accommodate each of the four types of ESAs and ambient air exposures were evaluated for resident, trespasser, and high school student and staff populations; this approach accommodates the differences in land use activities and associated exposure that may be associated with each type of ESA.

The trespasser exposure scenarios are based on consideration of three age groups: children ages 6 - <11, adolescents ages 11 - <16, and adults. These age groups were selected because they coincide with the age ranges for many of the default exposure parameter recommendations in the 2011 edition of the EFH (USEPA, 2011), and are commensurate with the age ranges defined in USEPA's Supplemental Cancer Guidance (USEPA, 2008). Consistent with the Work Plan, the exposure scenarios did not evaluate very young children (under age 6) for trespassing scenarios, as it is not realistic to consider young children accessing the ESAs, either alone or under adult supervision.

The purpose of evaluating the three populations separately was to ensure that risks were appropriately recognized for children, which are considered to be more sensitive to the toxicological effects of COPCs, and have a higher intake to body weight ratio. The child subpopulation was evaluated as a 5-year exposure duration, the adolescent subpopulation was evaluated as a 5-year exposure duration, and the adult sub-population was evaluated as 16-year exposure duration, to yield a cumulative exposure duration of 26 years. Twenty-six years is USEPA's standard consensus RME total exposure duration for residential land use. Use of that value for the trespassing scenarios incorporates the assumption that trespassing populations grow up and remain in the vicinity of the Phase II RI Study Area over a 26-year period.

3.3.1.2 In-Town Trespasser – Soil and Ambient Air

The In-Town Trespasser scenario assumes that adolescents (ages 11 -<16) use the In-Town Areas to "hang out" 1 hour per day, 5 days per week, 50 weeks per year (i.e., 250 days per year). Younger children (ages 6 - <11) were assumed to use the In-Town Areas to "hang out" or to "explore." It was assumed that children in this age range would access these areas for 1 hour per day, but slightly less frequently than adolescents, at 3 days per week, over a 50-week period (i.e., 150 days per year). Adults would have little reason to access the In-Town Areas, except perhaps as a short cut to go from one area of town to another. It was assumed that adults would access the In-Town Areas 2 days per week (0.5 hour per day, 100 days per year).

It is unlikely that the In-Town Trespasser would have intensive contact with soil, as activities such as "hanging out" and walking through the areas are unlikely to result in much, if any, direct contact with soil. The In-Town Areas are not suitable for sports or active recreational activities due to terrain that is not flat, scrub/shrub vegetation, and other obstacles. Nonetheless, the scenario assumes that incidental ingestion, dermal contact, and dust inhalation of soil occurs. Consistent with the Work Plan, the soil ingestion rate used for child and adolescent receptors is 200 milligrams per day (mg/day). However, the 200 mg/day value is an upper percentile value applicable to children ages 3 to <6 years of age (USEPA, 2011). The value is based on the total daily soil ingestion from all sources, including outdoor soil, indoor containerized soil used to support growth of plants, inhalation and subsequent swallowing of suspended particulates, and indoor exposure to soil-derived dust (from sources such as outdoor soil that is tracked indoors, indoor settled dust, and inhalation and subsequent swallowing of suspended particulates indoors). Given the basis of the value, USEPA recommends this value as the default RME soil ingestion for children 0 - <6 years for residential land use exposure conditions (USEPA, 2014).

Potential exposures to soil during trespassing at In-Town ESAs would occur for only a portion of each day (i.e., 1 hour per day). Therefore, the portion of total daily soil ingestion that occurs at an ESA would represent only a portion of the 200 mg/day total soil ingestion rate. To accommodate this, a fraction-ingested value of 0.5 was used to quantify exposure by incidental ingestion; use of this value represents an assumption that no more than one half of all daily exposure to soil would occur within the In-Town ESAs. This value was derived using information developed by USEPA concerning the percentage of time spent in the "neighborhood" versus percentage of time spent either "at home in the yard" or "outdoors on school grounds" (USEPA, 2011[9]). The percentage of time spent in the neighborhood (i.e., assumed to be equivalent to time spent trespassing within an In-Town ESA) is 32 percent for a child, 21 percent for an adolescent, and 27 percent for an adult. Rounding these factors up to 50 percent provides a conservative estimate of the portion of total daily soil exposure that would occur in In-Town ESAs. A value of 50 percent is also supported by the average total outdoor time for ages 6 through 21, which ranges between 100 and 132 minutes per day (USEPA, 2011); the exposure scenario assumes that In-Town Trespassers access the In-Town ESAs 1 hour per day, or approximately one-half of the 110 to 132 minute value cited.

Dermal contact with soil was assumed to occur over the area of the lower legs, forearms, hands, and face at an intensity that is based on USEPA default assumptions for children and adults performing activities that involve soil contact (USEPA, 2011).

Exposure parameters for ingestion, dermal contact, and dust inhalation exposure to soil are shown in Table 3.2 and exposure parameters for inhalation exposure to ambient air are provided in Table 3.4.

3.3.1.3 In-Town Trespasser – Storm Water

The In-Town Trespasser scenario also assumes that children (ages 6 - <11), adolescents (ages 11 -<16), and adults are exposed to storm water in the San Pedro, Kennecott Avenue, and Power House washes during rain events.

In order for exposure to storm water to occur, surface water must be present in the washes. However, surface water is only present in the washes during and immediately following precipitation events. Meteorological records for the Hayden area indicate that measurable precipitation (defined as more than 0.01 inch of precipitation) occurs, on average, 40 days per year[10]. This indicates that the washes

[9] 2011 Exposure Factors Handbook, Tables 6-20 and 6-21.
[10] https://www.myforecast.com/

could contain storm water, on average, 40 days per year. However, it is not realistic to assume that every precipitation event results in accumulation of water in the washes that would allow for 'play' in the water, nor is it realistic to assume that children and adolescents play in the storm water every time it accumulates. In fact, the following storm events in September 2015 resulted in no measurable storm water flow at the distant ends of the three washes:

- 5 September 2015 - 0.09 inch (3 hours);
- 13 September 2015 - 0.07 inch (4 hours);
- 14 September 2015 - 0.04 inch (1 hour);
- 21 September 2015 - 0.55 inch (mostly over 8 hours, total over 12 hours); and
- 22 September 2015 - 0.27 inch (mostly over 4 hours, total over 9 hours).

This indicates that even up to nearly a half inch of rain in 8 hours does not produce significant storm water flow in the washes. Therefore, it is not realistic to assume that children or adolescents would be exposed to storm water on every rain event; realistically, exposure would be unlikely during most rain events.

Therefore, the exposure frequency for children and adolescents has been established at 10 days per year, based on the assumption that storm water would be present in the washes an average of 40 days per year *and* these populations would play in the water on 25 percent of the total precipitation events. It is unlikely that adults would intentionally access the washes during storm events, but incidental exposure cannot be ruled out. Therefore, the exposure frequency for adults was assumed to be 5 days per year.

Except in extreme storm events, the depth of the storm water—when it is present[11]—is shallow (e.g., less than 6 inches). In the event that water levels are higher than that, the water would be moving through the washes at a rate that would be dangerous to access/play in the washes. Consequently, only portions of the lower body would contact the water. However, since activities such as play/exploration could involve splashing water onto other body parts, it is assumed that feet, lower legs, forearms, and hands are essentially continuously immersed in the storm water for a 1-hour period each day that contact with storm water occurs. The mechanism for dermal uptake of inorganics in water requires that the inorganics be present in a dissolved form and not bound to particulate matter. Therefore, EPCs for dissolved metals were used to quantify exposure by the dermal route.

Activities such as wading and play in storm water can result in incidental ingestion of water. However, because whole body submersion, and in particular upper body submersion, in storm water would not occur, incidental ingestion rates that have been published for swimming exposures are not applicable. The USEPA default ingestion rate for swimming is 50 milliliters per hour, or about 3.3 tablespoons per hour. Since the water in the washes is less than 6 inches in depth, which is even too shallow to wade in, the water ingestion rate will be substantially less than the rate used for swimming exposures. Any water ingestion would be incidental in nature – e.g., due to water being splashed on the face. Therefore, incidental ingestion rates for storm water were assumed to be equal to one-tenth the USEPA recommended water ingestion rates for swimming (USEPA, 2011). EPCs for total metals were used to

[11] Storm water flow monitoring conducted by Asarco since the SWS RI demonstrates that measurable amounts of storm water in washes are infrequent and do not approach the assumptions used for the HHRA.

quantify exposures by the incidental ingestion route. Exposure parameters for ingestion and dermal contact with storm water are shown in Table 3.3.

3.3.1.4 Resident – ESA D Ambient Air

The resident was evaluated as a young child (ages 0 - <6) subpopulation with a 6-year exposure duration, child (ages 6 - <11) subpopulation with a 5-year exposure duration, adolescent (ages 11 - <16) subpopulation with a 5-year exposure duration, and adult sub-population with a 10-year exposure duration, to yield a cumulative exposure duration of 26 years. Twenty-six years is USEPA's standard consensus RME total exposure duration for residential land use (USEPA, 2014) and was used in lieu of the 30-year exposure duration cited in the Work Plan (ITSI, 2012a). Use of that value for the residential exposure scenario incorporates the assumption that the same individual grows up and remains in the vicinity of the Phase II Study Area over a 26-year period. The subpopulation age groups were selected because they coincide with the age ranges for many of the default exposure parameter recommendations in the 2011 edition of the EFH (USEPA, 2011), and are commensurate with the age ranges defined in USEPA's Supplemental Cancer Guidance (USEPA, 2008).

In accordance with USEPA guidance and the Work Plan, the resident was assumed to spend time at their place of residence 350 days per year (USEPA, 2014). The Work Plan did not identify an exposure time for residential populations (ITSI, 2012a). Therefore, residential exposures for time spent indoors and time spent outdoors were identified from USEPA guidance (USEPA, 2011) and are presented in Table 3.4. As indicated in Table 3.4, average daily exposure times spent indoors at the place of residence ranged from 14.8 hours per day for adolescents to 16.7 hours per day for young children (ages 0 - <6). Average daily exposure times spent outdoors at a place of residence ranged from 1.9 hours per day for adolescents to 2.6 hours per day for children (ages 6 - <11). Although the indoor and outdoor exposure times vary slightly among residential age groups, they are generally consistent (Table 3.4). For the purposes of characterization of ambient air inhalation risks in the HHRA, the combined indoor and outdoor exposure times for the young child resident were used to represent the exposure times for the residential receptor. These values were used to derive a time-weighted EPC for evaluation of residential risks, as described in Section 3.3.3.

The residential scenario provides a conservative evaluation of ambient air exposures by In-Town trespassers at open space areas within ESA D, as well as other receptor populations that may visit or work at ESA D because the scenario includes exposure time and frequency assumptions that are higher than those associated with other receptor populations such as visitors and employees working in the area.

3.3.1.5 High School Student – In-Town Area Adjacent to ESA H Ambient Air

The high school student was evaluated as an adolescent age 14 to 18 who is assumed to attend the school over a 4-year period. The exposure frequency was established as 180 days per year based on the number of days in a typical school year. Exposure time was assumed to be 6 hours per school day indoors, and 2 hours per school day outdoors, under the assumption that the student participates in three-season outdoor athletic activities after classroom hours. Exposure parameters are shown in Table 3.4.

3.3.1.6 High School Staff – In-Town Area Adjacent to ESA H Ambient Air

The high school staff member was evaluated as an outdoor groundskeeper/maintenance worker who was modeled using USEPA default parameters for commercial use exposures, which assume a full-time employee (5 days per week, 50 weeks per year) over a 25-year period (USEPA, 2014). The scenario incorporates the conservative assumption that all work time is spent outdoors (i.e., 8 hours per day). Exposure parameters are shown in Table 3.4.

3.3.1.7 Restricted Area Trespasser

The Restricted Facility Area Trespasser scenario assumes that adolescents (ages 11 - <16) and adults gain access to Restricted Facility Areas once per month, for one-half hour per visit. Exposures to soil were assumed to occur by incidental ingestion, dermal contact, and dust inhalation.

The Restricted Facility Area Trespasser scenario considers trespassers who gain access to areas of the facility that are physically restricted either by security, fencing, or landforms, and for which a high level of industrial activity occurs daily. Trespassers to these areas would likely be observed by facility workers soon after gaining access and would then be removed by security or administrative personnel. It is unreasonable to assume that younger children would ever access these areas of the facility. Therefore, the scenario employed the assumption that adolescents (ages 11 - <16) and adults gain access to Restricted Facility Areas once per month, for one-half hour per visit. Exposures to soil were assumed to occur by incidental ingestion, dermal contact, and dust inhalation. However, trespassers gaining access to the Restricted Facility Areas are not likely to have intensive soil contact. Therefore, the ingestion rate, fraction ingested, and dermal contact parameters were based on the same assumptions used for the In-Town Trespasser scenario. The exposure time used to quantify ambient air exposures for the Restricted Facility Area Trespasser scenario was one-half hour per day. Exposure parameters are shown in Table 3.2.

3.3.1.8 Isolated Area Trespasser

The Isolated Facility Area Trespasser scenario considers children, adolescents, and adults who live in or near Hayden and who may occasionally access more isolated parts of the facility. Active industrial operations are conducted on a daily basis in these areas, but they are generally located further from residential areas, and access is not generally prohibited by fencing or landform barriers. In contrast to In-Town Areas where access can occur by happenstance or with relative ease from a residential neighborhood, "hanging out" within or passing through the Isolated Facility Areas (i.e., "short cuts") would require an intentional, dedicated purpose and a long walk/hike from residential areas. Therefore, it was assumed that exposures by adolescents (ages 11 - <16) and adults occur over a 4-hour period, once every other week. Younger children (ages 6 - <11) are less likely to access the Isolated Facility Areas given their distances from residential areas. Therefore, younger children were assumed to accompany an older sibling or adult on one-half the trips that those populations make to the Isolated Facility Areas (i.e., once per month).

Incidental ingestion, dermal contact, and dust inhalation exposure pathways were assumed to be complete and incorporate the USEPA default exposure parameters shown in Table 3.2. Because the exposure time for the Isolated Facility Area scenarios were assumed to be 4 hours per visit, it was assumed that on the days when visitation to these areas occurs, all daily soil ingestion occurs within these areas. Therefore, the fraction-ingested term for these areas is established at a value of 1. As noted previously, there are no ambient air monitoring stations in Isolated Facility Areas; therefore, exposure to COPCs in ambient air was not quantified for Isolated Area Trespassers.

Given that access to the Isolated Facility Areas may involve activities associated with more intensive incidental soil contact (e.g., hiking through the areas/climbing steeper terrain), it was assumed that soil contact occurs over the face, forearms, hands, lower legs, and feet, with a greater soil adherence than is assumed for the In-Town and Restricted Facility Trespasser scenarios.

3.3.1.9 Remote Area Trespasser

The Remote Area Trespasser scenario assumes that trespassers engage in hiking or ATV riding activities at Remote Areas that have limited points of access and are located outside of the Facility operational area, away from any developed residential and industrial areas. It was assumed that these trespassers engage in hiking or ATV riding activities that result in incidental ingestion, dermal contact, and dust inhalation exposures to soil. In addition, these receptors were evaluated for inhalation exposure to ambient air as represented by air monitoring stations within the Remote Areas. The scenario assumes that trespassers use the Remote Areas for activities such as ATV riding for 8 hours, once per week, over 52 weeks. Incidental ingestion, dermal contact, and dust inhalation exposure pathways were assumed to be complete and incorporate the USEPA exposure parameters shown in Table 3.2. Because the exposure time for the Remote Area scenario was assumed to be 8 hours per visit, it was assumed that on the days when visitation to these areas occurs, all daily soil ingestion occurs within these areas. Therefore, the fraction-ingested term for these areas is established at a value of 1. The exposure time used to quantify ambient air exposures for the Restricted Facility Area Trespasser scenario was 8 hours per day.

It was assumed that soil contact occurs over the face, forearms, hands, lower legs, and feet, with a greater soil adherence than was assumed for the In-Town and Restricted Facility Trespasser scenarios.

3.3.2 Exposure Point Concentrations for Soil and Storm Water

USEPA defines the EPC as the representative chemical concentration a receptor may contact in an ESA over the exposure period (USEPA, 1989). Separate EPCs were calculated for each exposure pathway at each point. The typical concept of human exposure within a defined ESA is that an individual contacts the associated environmental medium on a periodic and random basis. Because of the repeated nature of such contact, the human exposure does not really occur at a fixed point but rather at a variety of points with equal likelihood that any given point within the ESA will be the contact location on any given day. Thus, USEPA states that the EPCs should be the arithmetic averages of the chemical concentrations within the ESA (USEPA, 2002c). However, to account for uncertainty in estimating the arithmetic mean concentration that may occur due to matrix heterogeneity, spatial variability, and temporal variability, the USEPA recommends that an upper confidence limit (UCL) be used to represent the EPC (USEPA, 2002c).

In accordance with USEPA guidance, RME EPCs were derived for each COPC and each ESA based on the lesser of the 95 percent UCL on the arithmetic mean concentration (95% UCL value) or the maximum detected concentration in the data set (USEPA, 2002c).

The 95% UCL values were calculated using the ProUCL software (V. 5.0.00; USEPA, 2013a). The ProUCL software performs a goodness-of-fit test that accounts for data sets without any non-detect observations, as well as data sets with non-detect observations. The software then determines the distribution of the data set for which the EPC is being derived (e.g., normal, lognormal, gamma, or non-discernible), and then calculates a 95 percent UCL of the mean concentration, which represents a conservative estimate of the arithmetic mean concentration, in accordance with the framework described in "Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites" (USEPA, 2002c). The software includes numerous algorithms for calculating 95% UCL values and provides a recommended UCL value based on the algorithm that is most applicable to the statistical nature of the data set. In cases where more than one recommended UCL was provided, the maximum of the recommended values was selected as the EPC.

In accordance with USEPA guidance (USEPA, 2015), UCLs were not calculated for datasets with less than four detections or less than 10 samples. For such datasets with low detection frequencies, the population central tendency (CT) is better represented by the median or mode (USEPA, 2015). The median concentration of the full dataset (detect and non-detect values) was therefore used as the EPC in these cases.

Soil EPCs are provided in Tables 3.5 through 3.15. ProUCL input data and output sheets are provided in Appendix B. For storm water, data are available for total (unfiltered) samples and dissolved (filtered) samples. EPCs were derived for both total and dissolved data (Table 3.16).

3.3.2.1 Modeled EPCs for Dust in Ambient Air

EPCs may be based on COPC concentrations that are directly measured, or on COPC concentrations that are modeled. EPCs that were used to quantify ingestion and dermal contact exposures were based on measured concentration data. Since the true exposure medium for inhalation exposures is air, EPCs that were used to evaluate inhalation exposures must be either measured or modeled from source media concentrations. There are two potential sources of particulate COPCs in air associated with the Phase II RI Study Area: 1) particulate generation from soil (soil-derived dust) from receptor activities (e.g., hiking, ATV riding) and wind erosion that occurs at an ESA, and 2) particulate generation from facility-associated operations. EPCs associated with wind erosion and particulate generation from receptor activities were modeled from soil EPCs. EPCs associated with particulate generation from facility-associated operations were quantified using measured ambient air data, as described in Section 3.3.3.

EPCs for soil-derived dust in the HHRA were derived by modeling particulate emissions from soil as a source medium. The Jury model, as presented in USEPA guidance (2002a), is used to estimate a particulate emission factor (PEF) that can then be used to derive dust concentrations in ambient air. Separate models were used for dust generation from wind erosion and dust generation from human activities.

- Wind Erosion: The QA/QC parameters used in the model were calculated for each ESA based on the acreage of each ESA (Appendix C). Site-specific wind speed data was used in the model (Appendix C). Other parameters used in the model are USEPA default values. The ambient air dust EPCs were used to evaluate inhalation of dust in ambient air for all receptor scenarios. Modeling documentation is provided in Appendix C.
- Human Activities: ATV riding was selected as a human activity that could potentially generate elevated levels of dust. PEFs based on ATV riding were modeled using a USEPA model designed to estimate dust emissions from vehicles on unpaved roads (USEPA, 1996; USEPA, 2002a). These PEFs were applied to Remote Area ESAs (ESAs C, E, and K). Modeling is based on the

assumption that two ATVs each weighing 1,000 pounds travel 10 kilometers in each given remote area, each day that ATV riding occurs (which is based on the exposure factors for the Remote Area trespasser scenario). Modeling documentation is provided in Appendix C.

3.3.2.2 EPCs for Lead

In accordance with USEPA guidance concerning the identification of EPCs for evaluating health risks associated with lead exposures, the arithmetic mean lead concentration at the exposure point was used as the EPC (USEPA, 2007). USEPA recommends use of the arithmetic mean as the EPC because the biokinetic models that are used to characterize lead exposure risks were specifically calibrated to characterize the CT estimate of blood lead exposures.

3.3.3 Exposure Point Concentrations for Ambient Air

As illustrated in Table 3.1, each air monitoring station was evaluated as a separate exposure point. Consequently, some ESAs have multiple exposure points that were characterized in the HHRA. Deriving EPCs for ambient air requires 1) identifying the PM_{10} concentration of each COPC at each exposure point that will be used to represent air quality; and 2) deriving the concentration of each COPC that receptors may be exposed to at each exposure study area.

3.3.3.1 Representative PM10 Concentrations in Ambient Air

As described in Section 3.3.2, EPCs should be based on the arithmetic averages of the chemical concentrations within the ESA. However, to account for uncertainty in estimating the arithmetic mean concentration that may occur due to matrix heterogeneity, spatial variability, and temporal variability, a UCL on the data set used to represent the exposure point was used to represent the EPC (USEPA, 2002b).

The ambient air sampling program used at the Phase II Study Area substantially reduced the uncertainties in these variables:

- Each ambient air monitoring station was used to represent a discrete exposure point. As such, each receptor scenario evaluated exposure to ambient air under the assumption that all of the air in the exposure environment (at the exposure point) was represented by the PM_{10} concentrations reported for the air sampling at that station. Consequently, the premise that 'human exposure does not occur at a fixed point, but rather at variety of points with equal likelihood' does not apply to the methodology that was used in the HHRA to represent exposure to PM_{10}. Rather, each exposure scenario modeled repeated exposure to air at a fixed point. Consequently, receptor exposure patterns did not introduce uncertainties related to the spatial variability of receptor exposure within the ESA.
- Since the medium evaluated in the HHRA was ambient air, and all air data used in the HHRA were analyzed using the same analytical method, uncertainties introduced by matrix and analytical variability were minimized.
- The air monitoring stations were located at fixed points that remained constant over the 2-year air monitoring period. Spatial variability of the air being sampled was attributable only to the wind speed and direction of the air flowing past the monitoring station during the sampling interval. PM_{10} air samples were collected as 24-hour continuous samples once every 6 days, over a continuous 24-month period. The 24-hour duration of air sample collection captured the range of wind speed and direction changes that occur daily. The high sampling frequency and 24-month sampling period captured the range of seasonal weather conditions and facility-

related activities that could contribute to PM_{10} within the air samples. Collectively, these variables minimized uncertainties introduced by changes in temporal and spatial conditions.

Because the air monitoring program, combined with the approach used to evaluate receptor exposure to ambient air, minimized uncertainties related to using the arithmetic mean as the EPC, the mean was selected to represent the PM_{10} air concentrations at each air monitoring station. Specifically, the Kaplan-Meier mean (KM-mean) was used to represent the arithmetic mean PM_{10} concentrations.

The advantage to using the KM-mean was that it addressed non-detects by estimating a probability distribution of the data set and then assigning values to non-detect results based on the probability distribution. Since KM is non-parametric, it does not attempt to fit the distribution into a known distribution. For data sets with non-detects, statisticians conducted an extensive simulation study to compare the performances of the various estimation methods in terms of bias in the mean estimate, and demonstrated that the nonparametric KM method performs well in terms of bias in estimates of mean (USEPA, 2002b). The KM-mean was calculated using ProUCL software (ProUCL, v. 5.0.00; USEPA, 2013a). Tables 3.17 through 3.26 provide summary statistics, including the KM-mean, for each air monitoring station.

3.3.3.2 Calculation of EPCs in Ambient Air

The PM_{10} concentrations were used to represent the PM_{10} concentrations in outdoor air to which receptors within the same ESAs as the air monitoring stations were assumed to be exposed.

However, because buildings are enclosed, and windows and doors are often kept closed, the PM_{10} concentration of COPCs in outdoor air was deemed to be filtered as is migrates to indoor air. This filtration effect has been documented in the literature. For example Wilson et al. (2000) derived outdoor to indoor filtration factors for fine ($PM_{2.5}$) particulates of 0.4 for closed homes and 0.85 for open homes, and for course (PM_{10}) particulates of 0.1 for closed homes and 0.4 for open homes. In recognition of this filtration effect, USEPA has published an outdoor to indoor attenuation factor of 0.4 (USEPA, 2000). In addition, USEPA's Integrated Exposure Uptake Biokinetic model (IEUBK) for estimation of blood lead levels uses an outdoor to indoor air attenuation factor of 0.3 to account for the filtration of outdoor PM_{10} as it migrates to indoor environments. Accordingly, EPCs were derived for both indoor and outdoor environments:

- Outdoor air EPCs are represented by the PM_{10} ambient air concentrations described in section 3.3.2.1.
- Indoor air EPCs are represented by the outdoor air PM_{10} concentrations multiplied by an outdoor to indoor attenuation factor of 0.4.

For receptor scenarios where both indoor and outdoor exposures were evaluated (i.e., residential and high school student scenarios), the indoor and outdoor EPCs were each multiplied by the indoor and outdoor exposure times (Section 3.2), and then divided by total exposure time, to derive time-weighted EPCs. EPCs are provided in Tables 3.17 through 3.26.

3.3.4 Overview of Intake Calculations

For ingestion and dermal exposure routes, the general equation for calculating intake is as follows:

$$\text{Intake} = \frac{\text{EPC x CF x CR x ABS x EF x ED}}{\text{AT x BW}}$$

Where:

Intake	=	Average daily intake of COPC from soil at the exposure point during the period of exposure (grams/kilogram/day [g/kg/day])
EPC	=	Exposure Point Concentration (mg/kg or mg/L)
CF	=	Conversion Factor (kg/mg)
CR	=	Contact Rate (mg/day) Ingestion: Ingestion rate (mg/day) Dermal absorption: Skin surface area (cm^2/day) x adherence factor (mg/cm^2) (for soil only) x absorption factor (unitless)
ABS	=	Absorption Efficiency (%)
EF	=	Exposure Frequency (days/year)
ED	=	Exposure Duration (years)
AT	=	Averaging Time (days) (equal to ED for non-cancer evaluation; equal to 70 years for cancer evaluation)
BW	=	Body Weight (kg)

The intake is calculated as an average daily intake or an average daily lifetime intake in units of milligrams chemical per kilogram body weight per day. The average daily intake represents the total intake that occurs over the period of exposure, divided by duration of exposure. This intake term is used to quantify intakes for evaluating non-carcinogenic effects. The average daily lifetime intake represents the total intake that occurs over the period of exposure, divided by the length of a lifetime (defined by USEPA as 70 years). This intake term is used to quantify intakes for evaluating carcinogenic effects. An important concept inherent in deriving intakes is that the intake is intended to represent the mass of chemical (per kilogram body weight) that is actually absorbed into the blood stream and therefore potentially available for biological interaction. The ABS term is used account for the chemical and exposure route-specific bioavailability, which is further discussed in Section 4.

The methodology for evaluating inhalation exposures differs from that used for ingestion and dermal exposures because exposure concentration, and not absorbed intake (or dose) is the basis for the toxicity values used to evaluate risks from inhalation exposure. Therefore, body weight and contact rate (i.e., respiration rate) are not directly used in calculating inhalation exposures. The general equation for calculating chemical exposure via inhalation is as follows:

$$\textit{Exposure Concentration} = \frac{CA \times ET \times EF \times ED}{CF \times AT}$$

Where:

Exposure Concentration = representative concentration of COPC in the air at the exposure point during the period of exposure (milligrams per cubic meter [mg/m^3])

CA	=	concentration of the COPC in air (mg/m^3),
EF	=	exposure frequency (days/year),
ED	=	exposure duration (years),

ET	=	exposure time (hours/day)
CF	=	conversion factor (24 hours/day)
AT	=	averaging time (for carcinogens, AT = 70 years times 365 days per year; for noncarcinogens, AT = ED times 365 days per year).

The specific equations used to calculate intake and exposure are those presented in USEPA guidance (USEPA, 1989; 2004; 2009), and are provided in Appendix E.

3.3.4.1 Methodology for Evaluating Exposure to Lead

Exposures associated with potential inhalation of air containing lead were characterized using lead biokinetic uptake models. These models provide estimates of lead concentrations in blood (termed blood lead concentration measured in units of micrograms per deciliter [µg/dl]), as opposed to dose of lead (measured in units of milligrams lead per kilogram body weight per day), that may result from chronic exposures to lead in various exposure media.

To aid in screening sites for the purposes of determining whether lead concentrations in soil may pose more than a *de minimis* risk and, therefore, require quantitative risk analysis (using biokinetic models), USEPA developed a screening value for lead in soil. The screening value was derived using the child lead model (known as the IEUBK) based on residential land use exposure assumptions. The value derived by USEPA of 400 mg/kg lead is deemed to be protective for potential exposures to lead in soil by young children under residential exposure conditions (USEPA, 1994). Because children are more susceptible to lead toxicity than adults, lead concentrations that are protective for children are also protective for adults, including females who may be pregnant.

As indicated in Tables 3.5 to 3.15, lead EPCs in soil for almost all of the ESAs are below the USEPA residential soil screening level of 400 mg/kg, indicating that lead at those areas would not pose an unacceptable risk even for residential exposure. Nonetheless, the HHRA used biokinetic modeling to evaluate risks associated with potential exposures to lead during trespassing activities.

USEPA has published two biokinetic models for use in evaluating potential exposures to lead: the IEUBK (USEPA, 2007), and the Adult Lead Model (ALM) (USEPA, 2003a). The IEUBK is calibrated to evaluate continuous exposures to lead from ingestion exposure to soil, drinking water, and diet, and inhalation exposure to air, under residential land use conditions in children ages six and under. The ALM is designed to evaluate continuous or intermittent ingestion exposures to lead in soil, water, or diet under non-residential exposure conditions; the ALM does not quantify exposure to lead via inhalation exposures. Based on the applicability of the models, they were applied to the HHRA as follows:

- ALM: Since the trespassing exposure scenarios evaluated in the HHRA consider children ages six and older, and do not consider continuous residential exposure conditions, the IEUBK is not applicable for evaluating potential exposures to lead in soil at the ESAs.

  In accordance with USEPA guidance, the ALM may be used to evaluate adolescent trespassing exposure to lead, provided that modeling parameters are selected using numerical values applicable to the trespassing population (USEPA, 2020b). Based on this guidance, the ALM was used to calculate blood lead levels associated with the trespassing exposure scenarios. The most sensitive trespassing receptor is the fetus of a female adolescent trespasser who develops a body burden as a result of non-residential exposure to lead. Based on the available scientific data, a fetus is more sensitive to the adverse effects of lead than an adult (USEPA, 2020b).

Input variables were changed from model default values (i.e., those applicable to commercial/industrial worker exposures) as follows:

- Exposure frequency parameters were those applicable to each of the trespassing scenarios, as presented in Table 3.2. However, USEPA does not recommend use of the ALM for exposures that occur less frequently than once per week. The Isolated Facility Area Trespasser and Restricted Facility Area Trespasser, as well as the In-Town Trespasser storm water exposure, are associated with exposure frequencies less than once per week. To enable evaluation of potential exposures to lead, the exposure frequency for the Isolated Facility Area Trespasser was set to 26 days in 26 weeks, and the In-Town Trespasser storm water exposure was set to 10 days in 10 weeks. The Restricted Facility Area Trespasser scenario was not quantitively evaluated for lead exposure because the scenario is more aligned with an acute exposure for which the ALM is not intended to evaluate.
- Baseline blood lead level[12] was identified from as the average blood lead value for ages 12 to 19 for the 2015/2016 reporting period, from the National Health and Nutrition Examination Survey study (U.S. Centers for Disease Control [CDC], 2018).
- Soil ingestion rate was set at 100 mg/day, representing the CT soil ingestion rate because the model is calibrated to derive CT blood lead estimates (and as discussed previously, a soil ingestion rate of 100 mg/day is more appropriate for the adolescent age group).

The ALM was also used to derive blood lead estimates for potential exposures to storm water, using the exposure parameters provided in Table 3.3.

EPCs for each of the ESAs were used with the modeling parameters to derive estimated blood lead levels. Calculations are provided in Appendix F.

- IEUBK: The IEUBK is applicable for the evaluation of potential exposures to lead in ambient air for the residential exposure scenario. Since the trespassing and high school exposure scenarios evaluated in the HHRA considered receptor groups older than age six, and did not consider continuous residential exposure conditions, the IEUBK was not applicable for evaluating potential exposures to lead for those receptor scenarios. Similarly, the ALM was not applicable for evaluation of lead exposure in air.

  Consequently, the IEUBK was used to evaluate blood lead levels for the residential scenario, using EPCs for air monitoring stations that are near ESA D. The resulting blood lead estimates would be protective for other populations evaluated in the HHRA. Because children are more susceptible to lead toxicity than adults, blood lead estimates that are protective for children would also be protective for adults, including females who may be pregnant.

  Since the IEUBK calculates blood lead levels resulting from multi-media exposures, lead concentrations in drinking water, diet, soil, and air were used in the modeling. Default model parameters were used for all inputs except the following:

  - Ambient air concentration. The IEUBK incorporated an outdoor to indoor air attenuation factor, as discussed above. Therefore, separate indoor air EPCs were not

[12] Site-specific blood lead level information is available from the Agency for Toxic Substances and Disease Registry's (ATSDR's) 2015 Hayden and Winkelman exposure investigation (ATSDR, 2017). However, using the median blood lead level for the study population as the baseline blood lead level would result in over-stating modeled lead intake from exposure media, since the measured blood lead levels already reflect multi-media exposure in the study area.

derived for use in the IEUBK modeling. The KM-mean PM_{10} concentrations for the air monitoring stations at ESA D (ST-01, ST-16, ST-23, and ST-26) were used as the lead EPCs in the biokinetic model.

- A soil concentration of 400 mg/kg was used to represent the soil lead concentration to which children in the residential scenario were assumed to be exposed. This soil lead concentration represents USEPA's residential soil lead screening level (USEPA, 2020a) and is also equal to the soil lead cleanup value that was used at residential properties in Hayden (ITSI, 2012b). Analytical data collected during the Phase I RI indicates that residential properties in Hayden had soil lead concentrations less than 400 mg/kg. Therefore, use of a 400 mg/kg lead concentration in the IEUBK model was a conservative assumption.

The IEUBK modeling is documented in Appendix E.

4. Toxicity Assessment

The objective of the toxicity assessment was to quantify the relationship between the intake, or dose, of COPCs and the likelihood that adverse health effects may result from exposure to the COPCs. A Toxicity Assessment was conducted for the Site and is provided in Appendix D; the appendix includes:

- Toxicity assessment for carcinogenic effects;
- Toxicity assessment for non-carcinogenic effects;
- Adjustment for dermal exposure;
- Adjustment for early-life exposures to carcinogens with a mutagenic mode of action (MOA);
- Chemical-specific considerations for the Site;
- Sources of dose-response values; and
- Toxicity profiles for the COPCs at the Site.

A summary of the toxicity assessment is below. Toxicity values used in the HHRA are provided in Tables 4.1 through 4.4.

- **Carcinogenic Health Effects:** USEPA has established cancer toxicity values termed cancer slope factors (CSFs) for oral and dermal exposure routes, and unit risks (URs) for the inhalation exposure route. A discussion of the modeling that has been conducted to describe the expected quantitative relationship between dose of a carcinogen and associated risk of developing cancer is provided in Appendix D.

  USEPA uses both an alphanumeric system and a weight-of-evidence-based descriptive narrative to describe the carcinogenic potential of an agent. Descriptors are provided in Appendix D.
- **Chronic Non-Carcinogenic Health Effects:** USEPA has established chronic non-carcinogenic health criteria termed reference doses (RfDs) for oral and dermal exposure routes, and reference concentrations (RfCs) for the inhalation exposure route. The derivation of RFDs and RfCs is described in Appendix D. The RfD and RfC are each a daily intake level for the human population, including sensitive subpopulations, that are not expected to cause adverse health effects over a lifetime of exposure (USEPA, 1989). RfDs and RfCs are generally very conservative (i.e., health protective) due to the use of large uncertainty (safety) factors.
- **Toxicity Values for Dermal Exposure:** Route-specific toxicity values are generally not available for the dermal pathway and are therefore extrapolated from the oral pathway, as described further in Appendix D.
- **Early Life Exposures to Carcinogens with a Mutagenic Mode of Action:** USEPA has developed guidance for characterizing cancer susceptibility associated with early life exposures to potentially carcinogenic chemicals (Supplemental Cancer Guidance; USEPA, 2005b). In accordance with the Supplemental Cancer Guidance, for chemicals that initiate carcinogenesis through genetic mutation (i.e., by a mutagenic MOA), adjustments were made to the cancer risk calculations to reflect USEPA's conclusion that cancer risks for chemicals that act by a mutagenic MOA are generally higher from early-life exposure than from similar exposures later in life.

None of the COPCs for air in the HHRA have been identified by USEPA as a chemical which initiates carcinogenesis through a mutagenic MOA. Among the COPCs for soil identified in the HHRA, only hexavalent chromium has been identified by USEPA as a chemical which initiates carcinogenesis through a mutagenic MOA. EPCs for hexavalent chromium in soil are generally lower than residential soil RSL values, which are protective for mutagenic MOA cancer risk at the $1x10^{-6}$ risk level. Given that the trespasser exposure scenarios evaluated in the HHRA are associated with substantially lower exposures than those which form the basis of the residential soil RSLs, risks associated with the hexavalent chromium as a carcinogen that acts through a mutagenic MOA will be insignificant. Consequently, the implications of the mutagenic MOA for hexavalent chromium cancer risks were addressed qualitatively in the uncertainty analysis.

- **Chemical-specific Considerations:**
  - <u>Cadmium</u>. USEPA publishes two RfD values for cadmium: one is to be used to evaluate cadmium in food, and one is to be used to evaluate cadmium in water. The RfD for food was used in the HHRA because exposure to cadmium in the United States (for nonsmoking adults and children) is primarily through diet (as outlined in the cadmium toxicological profile [ATSDR, 2012]).
  - <u>Chromium</u>. USEPA publishes separate RfD values for hexavalent chromium and trivalent chromium; hexavalent chromium is associated with a higher order of toxicity than trivalent chromium. Hexavalent chromium is normally only present in environmental media at notable concentrations if released as hexavalent chromium. Historical operations used water treatment chemicals containing chromate compounds in cooling towers. Soil and sediment samples were analyzed for hexavalent chromium at a rate of about 10 percent, based on the results of in-situ XRF screening or preliminary laboratory results indicating the presence of total chromium exceeding 100 mg/kg. A review of the analytical summary of soil data confirms hexavalent chromium was not detected in most samples, and exhibited detected levels to a maximum concentration of only 4 mg/kg. However, because the maximum detected concentration of hexavalent chromium exceeded the residential soil RSL value, hexavalent chromium was retained as a COPC for soil. Hexavalent chromium was evaluated using toxicity values specific to hexavalent chromium.
  - <u>Lead</u>. In accordance with CERCLA risk assessment procedures, risks associated with potential exposures to lead in soil were characterized using lead biokinetic uptake models (USEPA, 2003a). Lead uptake models provide estimates of blood lead levels that may result from multi-media exposures to lead. The blood lead levels are then compared to threshold blood lead levels established by USEPA. Section 5 discusses the risk characterization for lead.
  - <u>Manganese</u>. The RfD for manganese that is published in Integrated Risk Information System (IRIS) is protective for a total daily intake of manganese (0.14 mg/kg/day). The IRIS file for manganese indicates that evaluation of risks for potential exposures to manganese in non-drinking water media (e.g., food, soil) should be quantified using an RfD that accounts for manganese exposures from food sources (stated to be 5 milligrams per day, or one-half the value of the RfD). Therefore, the RfD for manganese that was used for non-drinking water media is 0.071 mg/kg/day.
  - <u>Nickel</u>. IRIS publishes a unit risk for nickel refinery dust. That unit risk value was used to evaluate cancer risk for exposure to nickel in ambient air.

- Vanadium. ATSDR publishes a minimum risk level (MRL) value for vanadium that is derived for chronic-duration inhalation exposure to vanadium pentoxide dust. That value was used as the RfC to evaluate non-cancer hazards for exposure to vanadium in ambient air.
- Withdrawn and unavailable dose-response values. USEPA publishes a screening RfD for thallium as a Provisional Peer Reviewed Toxicity Value; the RfD is intended to be used for screening only and not for quantitative risk characterization. Uncertainties associated with the lack of toxicity values were evaluated in the Uncertainty Analysis (Section 5.4).

- **Sources of Dose-Response Values:** The sources used to identify dose-response values for the HHRA are provided in Appendix D.
- **Toxicity Profiles:** Toxicity profiles for COPCs in the HHRA are presented in Appendix D.

5. Risk Characterization

Risk characterization, including uncertainty analysis, is the final step in the risk assessment process. The risk characterization integrates the exposure and toxicity information generated in previous sections to qualitatively or quantitatively evaluate the potential health risks associated with exposure to chemicals within the Phase II RI Study Area. Risk estimates are then evaluated through a comparison to risk threshold criteria. Section 5.1 provides the methodology used to calculate risks for each COPC and sum risk estimates among COPCs, exposure pathways, and exposure media to derive cumulative receptor risks. Section 5.2 provides the risk assessment results for each of the land use scenarios evaluated in the HHRA by ESA. Section 5.3 provides an evaluation of risks associated with potential multi-media exposures. Section 5.4 provides an assessment of uncertainties in the HHRA.

5.1 RISK CHARACTERIZATION METHODS

Quantitative estimates of both carcinogenic and non-carcinogenic risks were calculated for each exposure scenario selected for evaluation in the exposure assessment, in accordance with USEPA (1989) guidance.

5.1.1 Risk Calculation Methodology

5.1.1.1 Cancer Risks

Cancer risks associated with exposure to each COPC were calculated by multiplying the exposure route pathway-specific intake (e.g., oral exposure to soil) or exposure concentration (e.g., inhalation of dust) by its exposure route-specific CSF (e.g., oral CSF) or UR.

$$\textit{Intake (mg/kg/day or } \mu g/m^3\textit{) x CSF (mg/kg/day)}^{-1} \textit{ or UR (}\mu g/m^3\textit{)}^{-1} = \textit{ILCR}$$

The calculated value is an incremental lifetime cancer risk (ILCR) and represents an upper bound of the probability of an individual developing cancer over a lifetime as the result of exposure to a COPC. This process is repeated for all exposure pathways for each receptor at each ESA.

5.1.1.2 Non-Cancer Hazards

Non-cancer hazards associated with exposure to each COPC were calculated by dividing the exposure route pathway-specific intake (e.g., oral exposure to soil) or exposure concentration (e.g., inhalation of dust) by its exposure route-specific RfD or RfC.

$$\textit{Intake (mg/kg/day or } \mu g/m^3\textit{) / RfD (mg/kg/day) or RfC (}\mu g/m^3\textit{)} = \textit{HQ}$$

The calculated value is an HQ. Chemical-specific HQs were then summed among all exposure pathways for each receptor at each ESA to produce an HI. An HI less than 1 indicates that non-carcinogenic toxic effects are unlikely to occur as a result of COPC exposure. HIs greater than 1 may be indicative of a possible non-carcinogenic toxic effect. As the HI increases, so does the likelihood that adverse effects might be associated with exposure.

HI values were derived separately for each receptor subpopulation (i.e., child, adolescent, adult) and are not additive across receptor subpopulations. Therefore, HI values are only reported for the receptor sub-population for which the highest exposure (i.e., dose) was derived. Generally, the highest dose was derived for the youngest-aged receptor sub-population because those receptors have the highest intake rate to body weight ratios. In the HHRA, the doses derived for child (ages 6 - <11) and adolescent (ages 11 - <16) receptors are nearly equivalent because the same soil ingestion rate has been assigned to both sub-populations, and although the child body weight is nearly half the adolescent body weight, the adolescent exposure frequency is typically two-times greater than the child exposure frequency. Consequently, for all but the In-Town ESAs, the doses derived for the adolescent sub-population are slightly greater than those derived for the child subpopulation. Consequently, HI values shown in the risk summary tables and reported in the risk characterization are based on adolescent sub-population for the Isolated, Restricted, and Remote ESAs, and on the child sub-population for the In-Town ESAs.

Risk calculations are documented in Appendix D.

5.1.1.3 Risks for Potential Exposures to Lead

As described in Section 3.3, risks associated with potential exposures to lead were characterized using the ALM and IEUBK models, which provide estimates of blood lead levels that may result from chronic exposures to lead in various exposure media. To evaluate the significance of the estimated blood lead concentrations, the blood lead concentrations derived using the model are compared to a threshold blood lead level of 5 µg/dL. In 2012, CDC changed their blood lead management recommendations from a recommendation that blood lead not exceed a target of 10 µg/dL 'level of concern' to blood lead not exceeding a 5 µg/dL 'reference level'. This 'reference level' is based on the background blood lead level that corresponds to the upper 2.5 percent blood lead level in U.S. children. USEPA has published guidance stating that lead risk assessments should include a discussion of the CDC blood lead reference level of 5 µg/dL (USEPA, 2017). The protection of sensitive populations is assumed to also provide protection for adults. USEPA indicates that 95 percent of the exposed population should have a geometric mean blood lead level that does not exceed 10 µg/dL.

5.1.2 Risk Summation and Evaluation

The risk estimates calculated for each receptor scenario are summarized in Tables 5.1 through 5.13. These risks are summarized as follows:

- By exposure study area – total site risk (Tables 5.1 through 5.5): Risks were summed across all COPCs for each exposure route, for each exposure medium, at each ESA, to yield a cumulative risk for each exposure scenario at each ESA (e.g., In-Town Trespasser risk at Area D). Cancer risks are reported as the ILCR for the aggregate receptor population. Non-cancer risks were calculated for the receptor sub-population with the highest daily average intake, which is the child trespasser for the In-Town scenarios, and the adolescent trespasser for all other scenarios. COPC contribution to total risks for each ESA are provided and COPCs that contribute significantly to the total risk estimates are identified the supporting text.
- By exposure study area – incremental site risk (Tables 5.6 through 5.9): Incremental risks represent the difference between risk for exposure to Site EPCs and risk for exposure to background levels. An understanding of incremental risks is important for risk management decision making (USEPA, 2002a). This is particularly the case when naturally occurring constituents, as opposed to releases at the Site, contribute to total site risks. Incremental risks

were calculated by subtracting the ILCR or HI calculated for exposure to background concentrations from the ILCR and HI calculated for the ESAs at the Site. Risks for background concentrations were calculated using the same exposure scenarios that were used to calculate risks for the Site. The EPCs for background data are the 95% UCL for soil and storm water and the KM-mean of the PM_{10} concentrations for air.

- By multiple media (Tables 5.10 through 5.13): Risks across multiple exposure media (i.e., soil, storm water, and ambient air) were summed to yield cumulative cancer and non-cancer HI values for each receptor population using the approach shown in Table 3.1. This provides an estimate of potential receptor risk associated with multi-media exposures. Multi-media risks are summarized in Section 5.3.

The HHRA results are discussed in terms of cancer risks being below or equal to an ILCR of 10^{-6}, within the range of 10^{-6} to 10^{-4}, or greater than 10^{-4}, and HI values are discussed in terms of being greater than or less than 1.

With respect to the HI, the HI value calculated by summing the HQs for all COPCs generally provides an overestimation of potential non-cancer HI. This is because the HI for each COPC represents the ratio of the estimated COPC intake to the threshold dose for a *specific* adverse health effect, where the adverse health effect is determined by the basis of the RfD and RfC. Summing HQs that are based on risks for different adverse health effects does not provide an estimate of total risk for a specific adverse health effect. Therefore, according to USEPA (1989) guidance, a total HI that is above one and is based on exposures to multiple COPCs does not necessarily indicate that the potential for adverse health effects is unacceptable <u>if</u> the risks for the COPCs are not additive. Consequently, in the HHRA, separate HI values for specific target organ effects may be calculated by summing the HQ values for COPCs that affect the same target organ(s). This approach generally was used only when there were no COPCs with HQs greater than one but the sum of HQs among all COPCs resulted in an HI greater than one.

5.2 EXPOSURE STUDY AREA RISKS

Risk estimates are discussed in the following subsections by receptor exposure scenario, and identify the relative significance of the risks relative to the NCP cancer risk range and hazard index of 1. The subsections are supported by the following tables:

- Tables 5.1 and 5.2: provide summaries of risks and COPC contribution to risks calculated for soil and storm water for the current and continuing future land use exposure scenarios for each ESA.
- Tables 5.3 and 5.4: provide summaries of risks and COPC contribution to risks calculated for ambient air for the current and continuing future land use exposure scenarios for each ESA.
- Table 5.5: provides estimates of blood lead levels for soil and storm water, for each ESA.
- Tables 5.6 and 5.7: provide incremental risk above background for ESA and COPCs in soil and storm water at each ESA.
- Table 5.8 and 5.9: provide incremental risk above background for ESA and COPCs in ambient air at each ESA.

Calculations are presented in Appendix E.

5.2.1 Resident

As shown in Table 5.3, risks for potential residential exposures to ambient air among the four air monitoring stations in or near ESA D (ST-01, ST-16, ST-23, and ST-26) are:

- ST-01: a cancer risk of 1E-05 and an HI of 1.
- ST-16: a cancer risk of 2E-05 and an HI of 1.
- ST-23: a cancer risk of 2E-05 and an HI of 1.
- ST-26: a cancer risk of 1E-05 and an HI of 0.8.

Ambient air risks calculated for the residential scenario were within the NCP cancer risk range of 1×10^{-6} to 1×10^{-4}, and did not exceed an HI of 1.

Risks summarized by COPC are provided in Table 5.4. As shown in Table 5.4, cancer risks for ambient air are principally contributed by arsenic. Total non-cancer hazards are principally contributed by arsenic, aluminum, cobalt, and manganese (each of these COPCs contribute an HQ greater than 0.1).

To evaluate the extent to which total risks in ambient air for these four COPCs may be contributed by background conditions in air, incremental risks above background ("incremental risks") were calculated. Incremental risks represent the difference between risks associated with Site and background conditions. Background analytical data for air were obtained from the IMPROVE air monitoring program for stations at Organ Pipe NM and Tonto NM. As discussed in Section 2.2.4, these two stations were used to represent the range of background air quality conditions for Hayden (Haley & Aldrich, 2014). Data were downloaded from 3 July 2013 through 29 June 2015 to match the date range of site-specific data used in the HHRA. Background analytical data are available in the $PM_{2.5}$ fraction, and are converted to PM_{10} by the following equation (using arsenic as an example):

$$\text{Arsenic } PM_{10} = (\text{Mass Fraction } PM_{10} / \text{Mass Fraction } PM_{2.5}) * \text{Arsenic } PM_{2.5}.$$

The converted PM_{10} data were used to derive background ambient air EPCs using the same approach that was used to establish EPCs for air monitoring stations at the study area (i.e., EPCs were established as the K-M mean). Background data are provided in Appendix A; calculations for background EPCs are provided in Appendix B.

Incremental risk was calculated for ambient air (Table 5.8) by subtracting risks associated with background from total risks:

Exposure Point	Risks Associated with Background		Incremental Risks	
	Cancer Risks	Non-Cancer Hazards	Incremental Cancer Risks	Incremental Non-Cancer Hazards
Ambient Air, ST-01	1E-06	0.2	1E-05	0.8
Ambient Air, ST-16			2E-05	1
Ambient Air, ST-23			2E-05	1
Ambient Air, ST-26			1E-05	0.6

Incremental risks and hazards for ambient air, summarized by COPC, are provided in Table 5.9.

As indicated, risks associated with background concentrations of COPCs in ambient air do not significantly contribute to total site risks.

BTVs for aluminum and manganese in ambient air were derived for air sampling data generated by the IMPROVE program. The BTVs were then compared to ambient air data for stations at the Site (Appendix A). More than 99 percent of Site ambient air measurements for aluminum and manganese were below the BTVs, suggesting that aluminum and manganese in ambient air are consistent with background conditions. To further explore aluminum and manganese as a background condition, analytical data for soil samples, as evaluated in the Phase II RI for Soil, Water, and Sediment, were compared to soil background values using statistical techniques. The results of those evaluations demonstrate that there are no statistically significant differences between aluminum and manganese concentrations in Study Area surface soil, and aluminum and manganese concentrations in background soil (Appendix A).

Estimated blood lead levels associated with inhalation of lead in ambient air were calculated using the IEUBK model, as described in Section 3. Because the IEUBK model evaluates multi-media exposures to lead, a default soil lead concentration of 400 mg/kg was used in the model. This was the soil lead cleanup value used at residential properties in Hayden (ITSI, 2012b). To evaluate the significance of lead in air, the soil lead concentration was used with two different assumptions concerning lead concentrations in ambient air:

1. No detectable lead in ambient air.
2. The highest ambient air lead PM_{10} concentration among the four air monitoring stations near ESA D (0.08 µg/m^3).

As shown in the following table, lead in ambient air is associated with insignificant contribution to blood lead. Blood lead calculations are provided in Appendix F.

Soil lead (400 mg/kg) + ambient air lead at:	Geometric mean blood lead
0 µg/m^3	4.39 µg/dl
0.08 µg/m^3	4.45 µg/dl

Notes:
µg/m^3 = micrograms per cubic meter
µg/dl = micrograms per deciliter

Estimated blood lead levels are below USEPA threshold levels, and ambient air overall does not appreciably add to calculated blood lead level. As described previously, risks and blood lead levels calculated for the residential scenario are protective of other populations that may spend time within ESA D, including workers, visitors, and trespassers.

5.2.2 In-Town Trespasser

As shown in Table 5.1 for soil and storm water and Table 5.3 for ambient air, the following are the estimated cancer risks and HIs for the In-Town Trespasser.

- Risks for the In-Town Trespasser exposed to soil at ESA-D are a cancer risk of $6x10^{-6}$ and an HI of 0.8.
- Risks for the In-Town Trespasser exposed to soil at ESA-H are a cancer risk of $2x10^{-5}$ and an HI of 1.
- Risks for the In-Town Trespasser exposed to storm water in the washes are a cancer risk of $2x10^{-6}$ and an HI of 0.4.
- Blood lead levels for In-Town Trespassers range from a geometric mean of 0.9 to 2.0 µg/dl, with no more than 4.4 percent of the population estimated to have a blood lead level that would exceed 5 µg/dl.
- Risks for potential exposures to ambient air, as represented by air monitoring station ST-09 within the In-Town ESA H, are a cancer risk of 4E-07 and an HI of 0.04.

Risks calculated for the In-Town Trespasser are within the NCP cancer risk range of $1x10^{-6}$ to $1x10^{-4}$ and do not exceed an HI of 1. Estimated blood lead levels are below USEPA threshold levels (Table 5.5).

Risks and hazards, summarized by COPC, are presented in Tables 5.2 for soil and storm water and 5.4 for ambient air. Cancer risks for soil and storm water are principally contributed by arsenic, whereas cancer risks for ambient air are primarily contributed by arsenic and cobalt. Non-cancer hazards are principally contributed by arsenic, cobalt, and copper in soil and stormwater, and by aluminum, arsenic, cobalt, and manganese ambient air.

As outlined in Section 5.2.1, risks associated with In-Town Trespasser exposure to background concentrations of arsenic, aluminum, cobalt, and manganese in air were calculated (Appendix E). Risks were also calculated for In-Town Trespasser exposure to background concentrations of COPCs in soil and storm water.

Incremental risks and hazards are summarized below and are provided in Table 5.6, and by COPC in Table 5.7 (soil and storm water) and Table 5.9 (ambient air). The COPC determined to be the primary contributor of risk is specified below.

Exposure Point	Risks Associated with Background		Incremental Risks		Primary Contributor of Risk
	Cancer Risks	Non-Cancer Hazards	Incremental Cancer Risks	Incremental Non-Cancer Hazards	
Soil – ESA-D	1E-06	0.3	5E-06	0.5	Arsenic
Soil – ESA-H			2E-05	0.9	Arsenic
Stormwater – ESA-D	1E-07	0.005	2E-06	0.4	Arsenic
Ambient Air	2E-08	0.004	4E-07	0.03	Arsenic

5.2.3 High School Staff and Student

As shown in Table 5.3, risks for potential exposures to ambient air, as represented by the air monitoring station at the high school (ST-02) were:

- High School Staff: cancer risk of $2x10^{-6}$ and an HI of 0.2.
- High School Student: cancer risk of $1x10^{-7}$ and an HI of 0.08.

Ambient air risks calculated for the high school student and staff scenarios were below or within the NCP cancer risk range of $1x10^{-6}$ to $1x10^{-4}$ and did not exceed an HI of 1. Risks and hazards, summarized by COPC, are presented in Table 5.4.

As outlined in Section 5.2.1, risks associated with high school staff and student exposure to background concentrations of arsenic, aluminum, cobalt, and manganese in air were calculated (Appendix E).

Incremental risks are presented in Table 5.8 and summarized below and by COPC in Table 5.9. The COPC determined to be the primary contributor of risk is specified below.

Receptor	Risks Associated with Background		Incremental Risks		Primary Contributor of Risk
	Cancer Risks	Non-Cancer Hazards	Incremental Cancer Risks	Incremental Non-Cancer Hazards	
High School Staff	3E-07	0.06	2E-06	0.1	Arsenic
High School Student	4E-08	0.04	1E-07	0.03	

5.2.4 Restricted Facility Area Trespasser

As shown in Table 5.1 for soil and Table 5.3 for ambient air, the following are the cancer risks and HIs that were calculated for the Restricted Facility Area Trespasser.

- Risks for the Restricted Facility Area Trespasser exposed to soil at ESA F were a cancer risk of $2x10^{-5}$ and an HI of 0.5.
- Risks for potential exposures to ambient air, as represented by air monitoring station ST-14 within the Restricted Facility Area ESA F, was 2E-07 and the HI was 0.008.
- The ALM should not be used to evaluate acute, intermittent exposures to lead of less than 1 day per week (USEPA, 2020b). Because the Restricted Area Trespasser exposure scenario assumes an exposure frequency of 1 day per month, the ALM should not be used to evaluate lead uptake from soil in this exposure scenario. Consequently, blood lead levels associated with this exposure scenario were not estimated.

Risks calculated for the Restricted Facility Area Trespasser are within the NCP cancer risk range of $1x10^{-6}$ to $1x10^{-4}$ and do not exceed an HI of 1. Risks and hazards, summarized by COPC, are presented in Tables 5.2 for soil and 5.4 for ambient air. Arsenic contributes most significantly to cancer risk in soil and ambient air. Arsenic also contributes most significantly to non-cancer hazard in soil and ambient air.

As outlined in Section 5.2.1, risks associated with Restricted Area Trespasser exposure to background concentrations of arsenic, aluminum, cobalt, and manganese in air were calculated (Appendix E). Risks were also calculated for exposure to background concentrations of COPCs in soil.

Incremental risks are presented in Table 5.6 (soil) and Table 5.8 (ambient air) and summarized below. Incremental risks and hazards, summarized by COPC, are provided in Table 5.7 (soil) and Table 5.9 (ambient air). The COPC determined to be the primary contributor of risk is specified below.

Exposure Point	Risks Associated with Background		Incremental Risks		Primary Contributor of Risk
	Cancer Risks	Non-Cancer Hazards	Incremental Cancer Risks	Incremental Non-Cancer Hazards	
Soil – ESA-F	7E-08	0.01	2E-05	0.5	Arsenic
Ambient Air – ESA-F (Station ST-14)	1E-09	0.0002	2E-07	0.008	Arsenic

5.2.5 Isolated Facility Area Trespasser

As shown in Table 5.1, the following are the cancer risks and HIs that were estimated for the Isolated Facility Area Trespasser.

- Risks for the Isolated Facility Area Trespasser exposed to soil at ESA-A were a cancer risk of 2×10^{-6} and an HI of 0.1.
- Risks for the Isolated Facility Area Trespasser exposed to soil at ESA-B were a cancer risk of 2×10^{-6} and an HI of 0.1.
- Risks for the Isolated Facility Area Trespasser exposed to soil at ESA-G were a cancer risk of 6×10^{-6} and an HI of 0.3.
- Risks for the Isolated Facility Area Trespasser exposed to soil at ESA-I were a cancer risk of 5×10^{-6} and an HI of 0.4.
- Risks for the Isolated Facility Area Trespasser exposed to soil at ESA-J were a cancer risk of 1×10^{-5} and an HI of 0.5.
- Blood lead levels for Isolated Area Trespassers range from a geometric mean of 0.5 to 0.7 µg/dl, with less than 0.1 percent of the population estimated to have a blood lead level that would exceed 5 µg/dl.

Risks calculated for the Isolated Facility Area Trespasser are within the NCP cancer risk range of 1×10^{-6} to 1×10^{-4} and do not exceed an HI of 1. Estimated blood lead levels are below USEPA threshold levels (Table 5.5). Risks and hazards, summarized by COPC, are presented in Table 5.2. Cancer risks are contributed by significantly by arsenic, and non-cancer hazards are contributed principally by arsenic and copper.

Risks were also calculated for Isolated Facility Area Trespasser exposure to background concentrations of COPCs in soil.

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Incremental risks are presented in Table 5.6 and summarized below. Incremental risks and hazards, summarized by COPC, are provided in Table 5.7. The COPC determined to be the primary contributor of risk is specified below.

Exposure Point	Risks Associated with Background		Incremental Risks		Primary Contributor of Risk
	Cancer Risks	Non-Cancer Hazards	Incremental Cancer Risks	Incremental Non-Cancer Hazards	
Soil, ESA-A	5E-07	0.07	1E-06	0.02	Arsenic
Soil, ESA-B			2E-06	0.04	Arsenic
Soil, ESA-G			6E-06	0.2	Arsenic
Soil, ESA-I			4E-06	0.3	Arsenic
Soil, ESA-J			1E-05	0.4	Arsenic

5.2.6 Remote Trespasser

As shown in Table 5.1 for soil and Table 5.3 for ambient air, the following are the cancer risks and HIs that were estimated for the Remote Trespasser.

- Risks for the Remote Trespasser exposed to soil at ESA-C were a cancer risk of $3x10^{-6}$ and an HI of 0.2.
- Risks for the Remote Trespasser exposed to soil at ESA-E were a cancer risk of $1x10^{-5}$ and an HI of 2.
- Risks for the Remote Trespasser exposed to soil at ESA-K were a cancer risk of $1x10^{-5}$ and an HI of 0.4.
- Risks for potential exposures to ambient air, as represented by the air monitoring stations within or adjacent to remote ESA K (ST-05 and ST-18), are:
  - ST-05: a cancer risk of $2x10^{-6}$ and an HI of 0.1.
  - ST-18: a cancer risk of $3x10^{-6}$ and an HI of 0.2
- Blood lead levels for Remote Area Trespassers range from a geometric mean of 0.5 to 0.6 µg/dl, with less than 0.1 percent of the population estimated to have a blood lead level that would exceed 5 µg/dl.

Risks calculated for the Remote Trespasser were within the NCP cancer risk range of $1x10^{-6}$ to $1x10^{-4}$ and below an HI of 1 at all ESAs except ESA-E, where the total HI value of 2 exceeds an HI of 1. Estimated blood lead levels are below USEPA threshold levels (Table 5.5). Risks and hazards, summarized by COPC, are presented in Tables 5.2 for soil and 5.4 for ambient air. Cancer risks in soil and ambient air are contributed principally by arsenic. Non-cancer hazards in soil are contributed most significantly by cobalt, copper, manganese, and molybdenum, but HQs for each of the COPCs are below 1. Non-cancer hazards in ambient air are largely contributed by arsenic, cadmium, and manganese.

As outlined in Section 5.2.1, risks associated Remote Trespasser exposure to background concentrations of arsenic, aluminum, cobalt, and manganese in air were calculated (Appendix E). Risks were also calculated for exposure to background concentrations of COPCs in soil.

Incremental risks are presented in Tables 5.6 (soil) and 5.8 (ambient air) and summarized below. Incremental risks and hazards, summarized by COPC, are provided in Table 5.7 (soil) and Table 5.9 (ambient air). The COPC determined to be the primary contributor of risk is specified below. As shown below, the incremental non-cancer HI calculated for the Remote Trespasser exposure to soil at ESA-E does not exceed a HI of 1.

Exposure Point	Risks Associated with Background		Incremental Risks		Primary Contributor of Risk
	Cancer Risks	Non-Cancer Hazards	Incremental Cancer Risks	Incremental Non-Cancer Hazards	
Soil, ESA-C	1E-06	0.2	2E-06	0.03	Arsenic
Soil, ESA-E			1E-05	1	Arsenic
Soil, ESA-K			9E-06	0.2	Arsenic
Ambient Air, ESA-K, ST-05	6E-08	0.01	2E-06	0.08	Arsenic
Ambient Air, ESA-K, ST-18			3E-06	0.2	Arsenic

Furthermore, the HI value that is calculated by summing the HQs for all COPCs generally provides an overestimation of potential non-cancer HI. This is because the HI for each COPC represents the ratio of the estimated COPC intake to the threshold dose for a *specific* adverse health effect, where the adverse health effect is determined by the basis of the RfC. Summing HQs that are based on risks for different adverse health effects does not provide an estimate of total risk for a specific adverse health effect. As presented in Section 5.3, in accordance with USEPA guidance (USEPA, 1989), separate HI values for specific target organ effects were calculated in the HHRA by summing the HQ values for COPCs that affect the same target organ(s).

5.3 MULTI-MEDIA RISKS

This section provides estimates of cancer and non-cancer risk for potential combined exposures to ambient air, soil, and storm water.

The receptors evaluated in the HHRA for exposure to soil and storm water include four different trespasser scenarios (In-Town Trespasser, Restricted Facility Area Trespasser, Remote Area Trespasser, and Isolated Area Trespasser). The receptors evaluated for exposure to ambient air in the HHRA include residents, three different trespasser scenarios (In-Town Trespasser, Restricted Facility Area Trespasser, and Remote Area Trespasser), as well as residential and high school staff and student scenarios. The approach used to combine risks for air and soil/storm water exposure scenarios to evaluate cumulative risks is shown in Table 3.1. For the ESAs and receptors reflected in Table 3.1, ambient air risk estimates were combined with soil and storm water risk estimates; Tables 5.10 and 5.11 summarize cumulative risks for residential and non-residential exposure scenarios, respectively. In accordance with USEPA guidance (USEPA, 1989), separate HI values for specific target organ effects were calculated in the HHRA by summing the HQ values for COPCs that affect the same target organ(s). Tables 5.12 and 5.13 show cumulative target organ HI summary for residential and non-residential scenarios, respectively. Supporting documentation is provided in Appendix E.

No air monitoring stations were located in proximity to Isolated Facility Area ESAs; therefore, multi-media risks were not evaluated for those exposure scenarios. Although no air monitoring stations are located in proximity to Remote Area C and E ESAs to allow for evaluation of multi-media risks, a target organ HI summary is provided for the Remote Area Trespasser exposed to soil at ESA E because the total HI (independent of incremental risk or target organ segregation) was a value of 2.

5.3.1 Resident/In-Town Trespasser (ESA D)

Air monitoring stations at or near ESA D (ST-01, ST-16, ST-23, and ST-26) were evaluated for ambient air risks based on residential exposure scenarios. The residential receptor was assumed to be the In-Town Trespasser who spends outdoor time at ESA D. Therefore, the residential ambient air risks for each air monitoring station were summed with the soil risks and storm water risks for the In-Town Trespasser (ESA D) to calculate cancer and non-cancer risk estimates for potential exposure to ambient air, soil, and storm water. The results of the cumulative risk analysis are provided in Table 5.10 for residential scenarios. As indicated in this table, cumulative multi-media risks for the residential scenario were within the range of $1x10^{-6}$ to $1x10^{-4}$ and the total HI values of between 2 and 3 exceeded an HI of 1. As shown in Table 5.12, the cumulative target organ HIs for the residential scenario do not exceed an HI of 1.

5.3.2 In-Town Trespasser (ESA H)

Air monitoring station ST-09, within In-Town ESA H, was evaluated for ambient air risks based on an In-Town Trespasser scenario. The ambient air risks were summed with the soil risks for the In-Town Trespasser (ESA H). The results of the cumulative risk analysis are provided in Table 5.11 for non-residential scenarios. As indicated in this table, the cumulative multi-media risks for the In-Town Trespasser (ESA H) scenario were within the range of $1x10^{-6}$ to $1x10^{-4}$ and HI values did not exceed 1. Target organ HI values are also below 1 (Table 5.13).

5.3.3 High School Student/In-Town Trespasser (ESA H)

Air monitoring station ST-02, located at Winkelman High School, was evaluated for ambient air risks based on high school student and faculty scenarios. The high school student was considered to be an In-Town Trespasser and therefore potentially exposed to soil at ESA H as an In-Town Trespasser. The high school faculty were assumed to have no exposure to soil because the high school is not part of the soil Phase II Study Area so risks were not calculated for high school receptor exposures to soil at the school grounds. Therefore, the ambient air risks for the high school student associated with ST-02 was summed with the In-Town Trespasser risks for ESA H. The results of the cumulative risk analysis are provided in Table 5.11 for non-residential scenarios. As indicated in this table, the cumulative multi-media risks for the high school student scenario were within the range of $1x10^{-6}$ to $1x10^{-4}$ and HI values did not exceed 1. Target organ HI values are also below 1 (Table 5.13).

5.3.4 Restricted Facility Trespasser

The air monitoring station in the Restricted Facility Area (ST-14) was evaluated for ambient air risks based on the Restricted Area Trespasser scenario. The ambient air risks for that station were summed with the soil risks for the Restricted Area Trespasser (ESA F) scenario. The results of the cumulative risk analysis are provided in Table 5.11 for non-residential scenarios. As indicated in this table, the cumulative multi-media risks for the Restricted Facility Trespasser scenario were within the range of $1x10^{-6}$ to $1x10^{-4}$ and HI values did not exceed 1. Target organ HI values are also below 1 (Table 5.13).

5.3.5 Remote Trespasser

Air monitoring stations in or adjacent to remote areas (ST-05 and ST-18) were evaluated for ambient air risks based on the Remote Area Trespasser scenario. The ambient air risks for those stations were summed with the soil risks for the Remote Area Trespasser (ESA K). The results of the cumulative risk analysis are provided in Table 5.11 for non-residential scenarios. As indicated in this table, the cumulative multi-media risks for the Remote Trespasser scenario were within the range of $1x10^{-6}$ to $1x10^{-4}$ and HI values did not exceed 1. Target organ HI values are below 1 (Table 5.13).

Other permutations of combined receptor exposures could exist. For example, a resident in Hayden could be a high school student and an In-Town Trespasser who contacts soil and air at ESA H and ESA D and air at ESA H and the high school. However, the exposure scenarios used to quantify potential exposures and risks for each scenario assumed that all exposure would occur at a specific ESA. For example, the In-Town Trespasser soil and ambient air scenarios assumed that all outdoor time would be spent at the ESA for which the In-Town Trespasser scenario was being evaluated. Similarly, residential ambient air risks were based on the assumption that all time is spent at a place of residence (i.e., not in other areas). If risks were to be summed to account for potential exposures across multiple exposure study areas, then risks for each of those areas would need to be apportioned according to the percentage of total time spent in each area, prior to summing risks. Such an approach would not yield conclusions regarding cumulative risk different from the conclusions stated in this HHRA report.

As indicated in Tables 5.10 and 5.11, cumulative multi-media risks for all scenarios were within the range of $1x10^{-6}$ to $1x10^{-4}$ and, with the exception of the residential scenarios, HI values did not exceed 1. Furthermore, as noted above, the HI value that is calculated by summing the HQs for all COPCs generally provides an overestimation of potential non-cancer HI. Summing HQs that are based on risks for different adverse health effects does not provide an estimate of total risk for a specific adverse health effect. The cumulative target organ HI summary for residential scenarios (Table 5.12) and non-residential scenarios (Table 5.13) indicate that all target organ HI values did not exceed 1. Likewise, the HI values associated with exposure to background aluminum and manganese in soil and ambient air were less than 1.

5.4 UNCERTAINTY ANALYSIS

This section identifies and discusses uncertainties in the risk assessment. These uncertainties are identified to place the results in context or perspective. Risk assessments rely not just on measured or certain facts, but also on assumptions and estimates, and also policy decisions, in the face of limited or nonexistent data. Historically, risk assessments have used highly conservative assumptions in the place of unavailable data, with the net result often being a substantial overestimation of potential risks. Consequently, the interpretation of risk estimates should be performed with the understanding that risk estimates are conservative values resulting from multiple layers of assumptions inherent in the risk assessment process, with the objective of erring on the side of overestimating risks, rather than underestimating risks, in the interest of protecting public health.

5.4.1 General Sources of Uncertainty

The following types of uncertainties are relevant in any human-health risk evaluation:

- uncertainties in the nature and extent of the release of a COPC;

- uncertainties associated with assigning exposure parameters to a heterogeneous population that includes both men and women and young and old;
- uncertainties in estimating CSFs and URs and/or non-carcinogenic measures of toxicity (e.g., RfDs or RfCs); and
- uncertainties about possible synergistic or antagonistic chemical interactions of a chemical mixture.

These generic uncertainties, which are applicable to all risk assessments, were not further evaluated in this uncertainty analysis. Rather, this uncertainty analysis focuses on Site-specific uncertainties that could have a bearing on the interpretation of the risk assessment results for the Phase II RI Study Area.

5.4.2 Site-Specific Sources of Uncertainty

5.4.2.1 Data Used in the HHRA

5.4.2.1.1. Soil Sample Depths Included in the HHRA

As noted in the CSM, surface soil and sediment (0 to 2 inches bgs) are the primary receiving media from all potential sources. A subset of soil samples was collected from 10 to 12 inches to evaluate vertical extent, which demonstrate that COPC concentrations are typically equal to or lower than concentrations reported in the 0 to 2-inch interval. Therefore, characterization of risks for surface soil provides a conservative representation of risks associated with potential exposures to soil 2 to 12 inches bgs.

5.4.2.1.2. Field Duplicates Included in the Soil Data Sets

As noted in Section 2.4, due to the large numbers of samples included in the majority of the soil data sets, inclusion of duplicate sample results as unique samples is not expected to bias EPCs. EPCs for data sets with fewer than 20 samples were evaluated to confirm that inclusion of duplicate results as unique samples does not materially affect the conclusions of the HHRA. The following data sets include fewer than 20 samples and at least one field duplicate: ESA A, ESA C, ESA E, and ESA G. The evaluation was performed by combining field duplicate results with original samples by selecting the maximum detected result or the minimum reporting limit if both the duplicate and primary result were not detected and counting the combined result as a single result for the duplicate pair. As shown in Tables 5.14 through 5.17, EPCs calculated after combining field duplicate results were at most 1.2 times higher than those used in the HHRA, indicating that inclusion of field duplicates in these data sets did not materially affect the conclusions of the HHRA.

5.4.2.2 UCL Statistic Selected as Basis of Soil and Storm Water EPCs

The ProUCL software provides recommended UCL values for use as EPCs. For some data sets, ProUCL provides more than one recommended UCL statistic. In cases where more than one UCL was recommended, the highest of the recommended values was selected as the UCL value for use in identifying the EPC. This imparts a conservative bias on the risk assessment results but did not result in affecting any conclusions stated in this HHRA report.

5.4.2.3 COPCs Lacking Dose-Response Values

Dose-response values are published in sources approved by USEPA for all of the COPCs evaluated in the HHRA except thallium. USEPA publishes a screening RfD for thallium, which should not be used for quantitative risk assessment, but can be used for establishing screening values; the RfD was used by USEPA to derive the USEPA RSL (USEPA, 2020a). A review of thallium EPCs in soil indicates that most EPCs are within a range of 0.7 mg/kg to 1.4 mg/kg. These EPCs are, at most, two-times the residential RSL value of 0.78 mg/kg, indicating that risks for thallium based on the trespasser exposure scenarios evaluated in the HHRA would be below an HQ of 1.

As indicated in Table 4.4, non-cancer inhalation RfC values are not published in sources approved by USEPA for the following COPCs: trivalent chromium, copper, iron, molybdenum, silver, thallium, and zinc. None of these COPCs are considered by USEPA to be potentially carcinogenic. However, the absence of RfC values for these constituents means that HI values for them cannot be calculated. Therefore, the HI values presented in the risk summaries do not include potential risk contribution from these COPCs.

5.4.2.4 Reference Concentrations for Cadmium

Cadmium RfC values are not published in USEPA Tier 1 or Tier 2 sources (Section 4.4). Two RfC values are published in Tier 3 sources: 1) California Environmental Protection Agency (CalEPA) reference exposure level (REL) of 2E-05 mg/m^3, and 2) ATSDR Chronic MRL of 1E-05 mg/m^3. The CalEPA REL was used as the RfC to evaluate inhalation non-cancer risks in the HHRA. Had the ATSDR MRL been used, cadmium HQ values would be two-times greater than those presented in this HHRA report. Cadmium HQ values and associated target organ HI values were generally below 0.2. Therefore, doubling the HQ or target organ HI values would still result in HI values well below 1. Therefore, this uncertainty does not change the conclusions of the HHRA.

5.4.2.5 Cancer Risks Associated with Hexavalent Chromium

As discussed in Section 4, hexavalent chromium was detected at low frequency and low concentration; EPCs for all ESAs except ESA F and ESA K are below the RSL for residential soil. For ESAs F and K, hexavalent chromium EPCs are approximately two-times greater than the residential soil RSL values. The residential soil RSL values were developed using USEPA's Supplemental Cancer Guidance and incorporate age-dependent adjustment factors (ADAFs) to address increased carcinogenic potency due to a mutagenic MOA. The residential soil RSLs are conservative for application to the trespassing scenarios evaluated in the HHRA because:

1. The trespassing scenarios do not include children under age 6, which is the age group identified by USEPA as being the most susceptible to carcinogenic potency for mutagens and for which higher ADAF values are used to quantify risk; and
2. The trespassing exposure scenarios are associated with much lower exposure frequency values than residential exposures.

Based on this information, cancer risks associated with potential exposures to hexavalent chromium in soil, in consideration of a mutagenic MOA for oral, dermal, and dust inhalation exposure routes, would be below $1x10^{-6}$ and, therefore, would not appreciably add to total cancer risks derived in the HHRA.

As discussed in Section 2, hexavalent chromium was detected in ambient air at a maximum concentration of 0.000013 µg/m^3, which is marginally greater than the residential air RSL value of 0.000012 µg/m^3, and consistent with negligible background levels measured in rural and urban areas across the United States (USEPA, 2013c). At the maximum detected hexavalent chromium concentration in ambient air, the residential cancer risk would be $1x10^{-6}$. This additive risk does not appreciably add to the ELCR values for ambient air, indicating that hexavalent chromium does not pose a significant risk in ambient air.

5.4.2.6 Ambient Air Risks across Exposure Study Areas

It is possible that a resident living in Hayden and assumed to be exposed to air within ESA D under residential exposure conditions could also trespass in Remote, In-Town, or Restricted Facility Areas. It is also possible that a resident could attend high school, or that a high school student could spend time in In-Town ESA H (adjacent to the high school) after school hours. The exposure time parameters used for each of the exposure scenarios represent plausible total daily outdoor time values. Therefore, summing ambient air risks across ESAs inherently assumes that more time is spent outdoors than is represented by the exposure scenarios, and results in an overestimation of inhalation risk.

Table 5.3 indicates that if residential air risks were summed with risks for any of the other exposure scenarios evaluated, ELCR values would remain within the NCP cancer risk range of $1x10^{-6}$ to $1x10^{-4}$ and would not exceed a HI of 1. The same conclusion would be reached for a high school student who is assumed to attend high school and then spend after school hours at ESA D or other ESAs within the Phase II Study Area.

5.4.3 Sensitivity Analysis

A sensitivity analysis is a form of quantitative uncertainty analysis which provides a range of point-estimate risks that place bounds on the RME risks calculated in the HHRA. The sensitivity analysis is conducted by adjusting key exposure variables (such as exposure frequency) and re-calculating risks. The sensitivity analysis employed in the HHRA was a one-directional analysis that places an upper bound on the RME risks. A two-directional sensitivity analysis would place both upper and lower bounds on RME risks, and would help show where the RME risks lie in the full spectrum of possible risks. Probabilistic risk assessment is a more comprehensive form of two-directional sensitivity analysis which involves specifying distributions for key exposure variables, and then using computer software to perform thousands of risk calculations that use input variables from the distributions. Probabilistic risk assessment provides a probability distribution of risks; the RME risk estimate can be placed in the context of risk probability. The sensitivity analysis described in this subsection is not a probabilistic risk assessment.

The one-directional upper bound sensitivity analysis presented below was completed by sequentially adjusting key exposure assumptions to be increasingly conservative. The results of this analysis help to resolve the question '*If exposure variables were even more conservative than the RME values, would the conclusions of the risk assessment be different?'*

The sensitivity analysis is discussed below for soil and storm water (Section 5.4.3.1) and air (Section 5.4.3.2).

5.4.3.1 Sensitivity Analysis – Soil and Storm Water

Table 5.18 identifies the parameters that were adjusted and how the adjusted parameters were used in combination with each other to create different sensitivity analysis scenarios. The rationale for the exposure variable adjustments shown in Table 5.18 is described below.

- Soil ingestion rate: The RME parameters used in the HHRA included the soil ingestion rate of 200 mg/day, which was applied to ages 6 - <16, and the ingestion rate of 50 mg/day, which was applied to adults. As discussed in Section 3, application of the 200 mg/day soil ingestion rate is not consistent with USEPA default exposure parameters set forth in current (USEPA, 2014; Office of Solid Waste and Emergency Response [OSWER] 9200.1-120) and previous (USEPA, 1991; OSWER 9285.6-03) guidance. Specifically, OSWER 9200.1-120 stipulates that the default ingestion rate of 200 mg/kg is applicable to children, which the directive further defines as children <6 years of age. The source of the 200 mg/day ingestion rate provided in OSWER 9200.1-120 is cited as Table 5.1 of the EFH (USEPA, 2011). Table 5.1 of the EFH indicates that the 200 mg/day value is an upper percentile value applicable to children ages 3 to <6 years of age; the only value published for ages >6 is a central tendency value of 100 mg/day for combined soil and dust exposure to children ages 6 to <21. Because the soil ingestion rate of 200 mg/day was used for the HHRA, it already represents a highly conservative value, and no further adjustment of the soil ingestion rate for children and adolescents was performed.

  For adults, the RME ingestion rate of 50 mg/day was selected from Table 5.1 of the EFH because it represents the adult general population central tendency combined ingestion of soil (20 mg/day) and dust (30 mg/day) and no upper percentile value is published for adults. However, this sensitivity analysis uses the general population central tendency value for children ages 3 to <6 of 100 mg/day for adults. This value is the USEPA OSWER 9200.1-120 default RME ingestion rate for residential adult exposures.

  All soil ingestion rates used in the HHRA account for ingestion of outdoor soil, inhalation and subsequent swallowing of outdoor soil-derived dust, ingestion of soil that may be tracked indoors, ingestion of indoor dust that has settled on surfaces, and inhalation and subsequent swallowing of indoor dust. Consequently, these ingestion rates reflect total daily soil ingestion from all sources.

- Fraction ingested: The In-Town Trespasser scenario assumes that one-half the average daily outdoor exposure time is spent at In-Town ESAs; therefore, the RME fraction ingested term was set at 0.5. The sensitivity analysis adjusts the fraction ingested term to a value of 1, representing an assumption that all daily exposure to soil and soil-derived dust occurs within the In-Town ESAs.

  The Isolated Area Trespasser and Remote Area Trespasser scenarios assumed that all exposure to soil on the days when trespassing within these areas occurs would occur in the Isolated Area and Remote Area ESAs. Therefore, no further adjustment of the fraction ingested term was used for the sensitivity analysis of those areas. For the Restricted Area Trespasser, a fraction ingested term of 0.5 was used to represent the reality that persons trespassing in restricted areas would be identified and removed shortly after gaining access (e.g., within half an hour of accessing the area). Given that an exposure time of 0.5 hours represents only one-quarter of the average daily outdoor exposure time (Section 3), a fraction ingested term of 0.5 already represents an upper bound on the RME (i.e., a more appropriate fraction ingested term would be 0.25). Therefore, no further adjustment of the fraction ingested term was used for the sensitivity analysis of this area.

- Soil exposure frequency: The exposure frequency values were selected in consideration of the exposure setting for each of the types of ESAs, and are considered to be representative of conservative exposure assumptions. In reality, trespassers have generally not been observed in Isolated, Remote, and Restricted Areas.

  In-Town Areas are located closer to residential properties, and therefore have a higher potential for trespassing as compared to the other types of ESAs. Consistent with the Work Plan, for the In-Town Trespasser scenario, the RME exposure frequency for adolescents was set at 5 days per week (250 days per year), the RME exposure frequency for children (ages 6 - <11) was established at 3 days per week (150 days per year), and the RME exposure frequency for adults was established at 2 days per week (100 days per year). An exposure frequency of 250 days per year is considered to be very conservative for trespassing within the In-Town Areas as anecdotal information from Asarco personnel indicates that people are rarely present in the In-Town areas. However, the sensitivity analysis applies an exposure frequency of 250 days per year to the child (ages 6 - <11 year) In-Town Trespasser.

- Storm water ingestion rate, exposure time, and exposure frequency: As discussed in Section 3, storm water is only present in the washes during a portion of the total storm events (average of 40 measurable rain events per year). The RME exposure parameters included an assumption that enough storm water could be present in the washes to allow for contact with water ten days per year (one-quarter of the rain events) and that incidental ingestion of water could occur over a one-hour period of exploration/play in the washes at a rate equal to one-tenth the USEPA default value for swimming exposures (Table 3.5 of EFH). The sensitivity analysis is based on doubling each of these exposure parameters; the most conservative scenario assumes 20 days of exposure (half the rain events per year), 2 hours per visit, with an ingestion rate of 10 milliliters per event (2 teaspoons per event).

- Arsenic bioavailability: Oral bioavailability refers to the portion of substance that may be absorbed from the GI tract into the blood stream, and therefore potentially 'available' for biological interaction. USEPA has compiled bioavailability data for arsenic in soil based on review of published studies that used assays with laboratory animals (swine, monkeys, and mice) to derive bioavailability estimates (USEPA, 2012). From this data base of bioavailability data, USEPA selected a value of 60 percent as a default oral bioavailability factor for evaluating exposure to arsenic in soil in human health risk assessments. The RME and bounding risks in the HHRA were calculated using this default value.

  The default bioavailability factor of 60 percent (or 0.6) is based on an upper percentile (generally the 95% UCL) of bioavailability estimates derived from 103 studies reviewed by USEPA (2012). Oral bioavailability of arsenic is influenced by mineralogy; the highest bioavailability identified in these studies was 78 percent and the lowest was 4.1 percent, with an average value of 31 percent. Several of the studies evaluated soils collected from mining and smelting sites, including Asarco-Ruston (WA), and Iron King (AZ). Arsenic oral bioavailability ranged from 14 to 60 percent at Iron King, and from 26 to 49 percent at Asarco-Ruston, depending on soil tested and animal model (mouse or swine).

  Although arsenic bioavailability was not characterized for the soils within the Phase II RI Study Area, the data presented in USEPA (2012) suggests that arsenic oral bioavailability would likely be lower than 60 percent. To help evaluate uncertainties associated with arsenic bioavailability on the risk estimates made in the HHRA, risks were calculated for a range of arsenic bioavailability values that include: maximum reported in USEPA data base (78 percent), range reported from Iron King (14 to 60 percent), range reported from Asarco-Ruston (26 to

49 percent), arithmetic mean of data base (31 percent), and minimum of data base (4.1 percent).

Because this sensitivity analysis is focused on defining an upper bound on the RME risks, only the ESAs with the highest risks for each exposure scenario were evaluated (Table 5.18), with the exception of the In-Town trespasser where both ESAs for that scenario were evaluated.

HI values calculated in this sensitivity analysis are presented by target organ and summarized in Table 5.19; target organs were identified from the information provided in Table 4.3. Risk calculations are provided in Appendix G.

The results of the sensitivity analysis indicate the following:

1. None of the Isolated Facility Area, Remote Area, or Restricted Facility Area sensitivity analysis scenarios are associated with risks that exceed an HI of 1 or ILCR of $1x10^{-4}$; ILCR values for these scenarios range from $7x10^{-6}$ to $2x10^{-5}$ and total HI values range from 0.4 to 0.5. This indicates that even under exposure assumptions that provide an upper bound on the RME, risks do not exceed USEPA thresholds.
2. For the In-Town Areas (ESAs D and H), ILCR values under all sensitivity analysis scenarios remain below $1x10^{-4}$, with values ranging from $7x10^{-6}$ to $5x10^{-5}$. Target organ HI values remain below 1 for all sensitivity analysis scenarios except scenario 5, where the HQ for copper marginally exceeds 1. This is discussed in more detailed below.
3. For storm water, ILCR values under all sensitivity analysis scenarios remain below $1x10^{-4}$, with values ranging from $3x10^{-6}$ to $7x10^{-6}$. Target organ HI values remain below 1 for all sensitivity analysis scenarios except scenario 3, where the HQ for copper marginally exceeds 1. This is discussed in more detailed below.

In-Town Trespasser sensitivity scenario 5 layers all of the sensitivity parameters shown in Table 5.18 to create an overall scenario that models a child ages 6 to <11 who spends all of their average daily outdoor time at In-Town Areas, each week day, all year, and ingests soil at a rate that was derived for young children (ages 3 to <6) who are recognized as ingesting larger amounts of soil than older children and adults. Similarly, storm water sensitivity scenario 3 layers all of the sensitivity parameters shown in Table 5.18 to create an overall scenario that models a child ages 6 to <11 who spends one-half of all rain events in the washes for 2 hours per event (i.e., all of their average daily outdoor exposure time), ingesting 2 teaspoons of storm water. This scenario assumes that rain water would collect in the washes to a depth where exposure could occur on one half of all rain events, an assumption that has not been proven out by recent storm water flow measurements. For ESA D and ESA H sensitivity scenario 5, and storm water sensitivity scenario 3, all target organ HI values are below 1, except for GI system, for which HI values of 1.4, 1.5, and 1.1 were calculated for ESA D, ESA H, and storm water, respectively.

The two COPCs that contribute to the HI for GI system effects are copper and iron. Specifically:

- For copper, the RfD is based on the lowest observed adverse effect level (LOAEL) in humans following a one-time ingestion exposure of copper that produced GI irritation. This health effect is not considered to be serious (ATSDR, 2004). In fact, the majority of toxicological studies performed on copper, using both human and laboratory animals, did not identify any health effects that would be considered serious (ATSDR, 2004). As summarized by ATSDR (2004), the only health effects associated with exposure to copper that are considered to be serious, such as effects on the kidney, liver, or loss of body weight, occurred at doses administered to laboratory animals that were nearly 2,000 times greater than the dose that the RfD is based on. The HQs for copper in soil at ESAs D and H, and in storm water, range from 1.1 to 1.3, indicating that calculated exposures to copper under highly conservative exposure conditions are approximately on par with a level of exposure that may cause GI irritation.

- For iron, the RfD is based on GI effects (epigastric pain, nausea, vomiting, constipation, and diarrhea) that occur following therapeutic use of iron as iron supplements. The RfD for iron was derived from a LOAEL that is considered to be a minimal LOAEL because GI effects were characterized by most study participants as minor in severity. An uncertainty factor of 1.5 was applied to account for extrapolation from a minimal LOAEL to no observed adverse effect level for a non-serious effect (USEPA). USEPA notes that these effects are not associated with dietary intakes of iron at the same level. HQs for iron in soil at ESAs D and H, and in storm water are all approximately 0.2.

To streamline the evaluation of arsenic bioavailability on risk estimates, risks were calculated for In-Town ESA H because that ESA is associated with the highest estimated risks for arsenic. Evaluations were performed for both the RME and most conservative sensitivity analysis evaluation (scenario 5). Results are presented in Table 5.20. As shown in Table 5.20, more realistic estimates of arsenic risk, based on a plausible range of bioavailability for the mineralogy of arsenic in soils within the Phase II RI Study Area, are ILCRs between $4x10^{-6}$ and $2x10^{-5}$ and target organ HI values between 0.9 and 0.26 for the RME scenario. For the most conservative sensitivity analysis evaluation at ESA H (scenario 5), ILCR values for a plausible range of arsenic bioavailability range from $1x10^{-5}$ to $4x10^{-5}$, and target organ HI values range from 0.29 to 0.87. These values are lower than the risks estimated in the HHRA, which are based on USEPA's default recommended bioavailability factor of 0.6, representing the 95% UCL from the data base of arsenic bioavailability factors. Even under the highest bioavailability factor cited in USEPA's data base of 0.78, ILCR and HI values do not exceed USEPA thresholds under RME conditions, and HQ values only marginally exceed 1 for the sensitivity analysis scenario 5 (HQ = 1.3). Given the highly conservative nature of scenario 5 and the implausibility of average arsenic bioavailability within the Phase II RI Study Area being as high 78 percent, an HQ of 1.3 for arsenic is deemed to be unrealistic. Overall, this evaluation indicates that arsenic does not pose risks within the Phase II RI Study Area at levels that exceed USEPA risk thresholds.

Overall, the sensitivity analysis for soil and storm water indicates that even under exposure assumptions which are considerably more conservative than the RME, cancer risks do not exceed the upper end of the NCP cancer risk range of $1x10^{-4}$ and, for all but two ESAs, do not exceed an HI of 1. For In-Town ESA D and H, the HI for GI system effects marginally exceeds 1 under the assumption that children (ages 6 to <11) spend all of their average daily outdoor time at In-Town Areas, each week day, all year, and ingest soil at a rate that is applicable to children of a younger age group. Similarly, the HI for GI system effects marginally exceeds 1 for storm water under the assumption that children (ages 6 to <11) play in storm water on one-half of the rain events per year and ingest 2 teaspoons of water each event; storm water flow data being collected in the washes suggests that it is improbable that storm water even collects in the washes at the frequency assumed in the sensitivity analysis. The soil and storm water HI values are due primarily to copper. 'Serious' health effects related to copper (ATSDR, 2004) occur at exposures nearly 2,000 times greater than those estimated in the HHRA.

5.4.3.2 Sensitivity Analysis - Air

Table 5.21 identifies the parameters that were adjusted and indicates how the adjusted parameters were used in combination with each other to create different sensitivity analysis scenarios. The rationale for the exposure variable adjustments shown in Table 5.21 is described below.

- Exposure Time: USEPA guidance indicates that residential air exposure time is 24 hours per day, which is cited as an assumption of ‘the whole day’ (USEPA, 2014). That value is consistent with the 95th percentile of residential time spent indoors at a residence (USEPA, 2011) and is typically applied to characterize risks associated with indoor air inhalation exposures. Available USEPA guidance for evaluating particulate inhalation exposures in ambient air (e.g., USEPA, 2002b) indicates that the particulate inhalation pathway is typically evaluated for outdoor exposures. It is not plausible to consider outdoor ambient air inhalation occurring 24 hours per day, 350 days per year. In reality, it is not even realistic to consider a 24-hour per day, 350 day per year exposure at a single place of residence (cumulative indoor and outdoor) as it inherently assumes that people *never leave their home*. Even stay-at-home parents, people who work from their homes, and people who home-school their children, leave their homes occasionally.

  The information presented in Table 3.4 demonstrates that typical residential exposure patterns involve a number of hours per day not spent at the home. It is possible, however, that people could spend more time outdoors at their home than is reflected in the values presented in Table 3.4. Specifically, the 90th percentile values for time spent outdoors at a place of residence are as follows[13]:

  - Young child (0 to <6) - 7.1 hrs/day;
  - Child (6 to <11) - 6.1 hrs/day;
  - Adolescent (11 to <16) - 5.0 hrs/day;
  - Adult - 6.0 hrs/day; and
  - Composite receptor (age-weighted) - 6.1 hrs/day.

  The 90th percentile young child (0 to <6 years old) outdoor exposure time, when added to the indoor exposure time for that age group (16.7 hours/day; Table 3.4) is approximately 24 hours per day. To place an upper bound on exposure time, risks were characterized using the PM_{10} COPC concentrations at each of the four residential air monitoring stations with the young child resident outdoor and indoor exposure times listed above.

- Variability in Exposure across ESA D: Risks for potential exposures to ESA D were characterized using the KM-mean concentrations for COPCs at each of the four air monitoring stations. However, a single air monitoring station may not be representative of the ambient air quality across the entirety of ESA D, particularly for receptors that hypothetically spend time outdoors commensurate with the upper bound assumptions discussed above. Therefore, a sensitivity analysis was performed on the EPC by deriving the 95% UCL using all of the air sampling data among the four stations in or near ESA D (ST-01, ST-16, ST-23, and ST-26). The 95% UCL values were calculated using the ProUCL software (V. 5.0.00; USEPA, 2013a). The ProUCL software performs a goodness-of-fit test that accounts for data sets without any non-detect observations, as well as data sets with non-detect observations. The software then determines the distribution of the data set for which the EPC is being derived (e.g., normal, lognormal, gamma, or non-discernible), and then calculates a conservative and stable 95% UCL value in accordance with the framework described in “Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites” (USEPA, 2002c). The software includes numerous algorithms for calculating 95% UCL values, and provides a recommended UCL value based on the algorithm that is most applicable to the statistical nature of the data set.

[13] 90th percentile values from Table 6-20 of USEPA (2011), category "cumulative outdoors".

Risks were then calculated for the UCLs using the exposure times shown in Table 5.21.

The exposure variables described above were used in the sensitivity analysis to evaluate three different residential exposure scenarios (Table 5.21):

- Scenario 1: Residents were assumed to be at their place of residence 350 days per year, 26 years, and spend 16.7 hours per day indoors and 7.1 hours per day outdoors. This scenario assumes that an individual never leaves their place of residence from birth to age 26.
- Scenario 2: Residents were assumed to be at their place of residence 350 days per year, 26 years, and spend 16.7 hours per day indoors and 2.3 hours per day outdoors. However, ambient air PM_{10} concentration is represented by the 95% UCL of the air measurements recorded across all four monitoring stations within ESA D.
- Scenario 3: This is same as Scenario 2 but uses exposure times of 16.7 hours per day indoors and 7.1 hours per day outdoors. This scenario assumes that an individual never leaves the town of Hayden from birth to age 26.

The results of the sensitivity analysis are summarized in Table 5.22. Calculations are documented in Appendix G. The following conclusions may be drawn from the results of the sensitivity analysis.

- Increasing exposure time to the point where it is assumed that a resident never leaves their place of residence from birth to age 26, and spends up to 7 hours outdoors each day at their place of residence, is associated with ELCR values that are within the range of $1x10^{-6}$ to $1x10^{-4}$ and HI values that do not exceed 1.
- If it is assumed that a resident is exposed to ambient air represented by an upper-bound estimate of PM_{10} concentrations measured throughout ESA D, under the assumption that the resident never leaves their place of residence from birth to age 26, and spends up to 7 hours outdoors each day at their place of residence, ELCR values remain within the range of $1x10^{-6}$ to $1x10^{-4}$ and HI values that do not exceed 1.

Overall, the conclusions of the sensitivity analysis are that even when exposure assumptions that model implausible exposure conditions are used, risks do not exceed USEPA thresholds.

6. HHRA Summary and Conclusions

The Phase II HHRA characterized potential cancer and non-cancer hazards within the Phase II RI Study Area prior to the implementation of the 2015 Consent Decree and 2018 conforming Title V Permit.

The conclusions of the Phase II HHRA are as follows:

- Combined risk: Combined risks for potential exposures to ambient air, soil, and storm water, under the assumption that a Hayden resident is an In-Town trespasser, were within the NCP cancer risk range of $1x10^{-6}$ to $1x10^{-4}$, ranging between $2x10^{-5}$ and $3x10^{-5}$, and HI values did not exceed the HI threshold of 1, ranging from less than 0.001 to 0.7.
- Ambient air, cancer risk: The RME cancer risk for potential inhalation exposures to ambient air for all receptors in all evaluated exposure scenarios was below or within the NCP cancer risk range of $1x10^{-6}$ to $1x10^{-4}$, ranging from $1x10^{-7}$ and $2x10^{-5}$.
- Ambient air, non-cancer risk: The RME non-cancer HI for potential inhalation exposures to ambient air for all receptors in all evaluated exposure scenarios did not exceed the HI threshold of 1, ranging from 0.008 and 0.7.
- Soil, cancer risk: RME cancer risks for potential incidental ingestion, dermal contact, and dust inhalation exposures to soil for all trespassing receptors were within the NCP cancer risk range of $1x10^{-6}$ to $1x10^{-4}$, ranging between $2x10^{-6}$ and $2x10^{-5}$.
- Soil, non-cancer risk: RME non-cancer HI for potential incidental ingestion, dermal contact, and dust inhalation exposures to soil for all trespassing receptors (with the exception of the Remote Area trespasser at ESA E), did not exceed the HI threshold of 1, ranging from 0.09 and 1.
- Soil, non-cancer risk, target organ specific: RME non-cancer HI for potential incidental ingestion, dermal contact, and dust inhalation exposures to soil for all trespassing receptors did not exceed the HI threshold of 1.
- Storm water, cancer risk: The RME cancer risk for potential incidental ingestion and dermal contact exposures to storm water during possible trespassing activities in the washes (during storm events) was within the NCP cancer risk range of $1x10^{-6}$ to $1x10^{-4}$, at $2x10^{-6}$.
- Storm water, non-cancer risk: The RME non-cancer HI for potential incidental ingestion and dermal contact exposures to storm water during possible trespassing activities in the washes (during storm events) was 0.4, which is less than the HI threshold of 1.
- Blood lead levels, contact with soil and storm water: Blood lead levels estimated using biokinetic uptake modeling indicate that values for trespassing populations would be below USEPA threshold levels, with geometric mean blood lead levels for all exposure study areas at or below 2.0 µg/dl and 4.4 percent or less probability of fetal blood lead levels exceeding 5 µg/dl.
- Blood lead levels estimated using biokinetic uptake modeling indicate that lead concentrations in ambient air contribute negligibly to blood lead levels.

Overall, the results of the HHRA indicate that cancer risks and non-cancer hazards associated with the Phase II RI Study Area do not exceed acceptable risk thresholds as established in the NCP.

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TABLES

TABLE 2.1
SUMMARY STATISTICS OF SURFACE SOIL (O-2 INCHES) ANALYTICAL RESULTS
AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

Chemical Name	Frequency of Detection	Range of Reporting Limits for Non-Detects	Range of Detected Concentrations	USEPA Residential Soil RSL May 2020 HI = 0.1		Background Value	COPC? (Yes/No)	Rationale for Contaminant Deletion or Selection
Inorganics (mg/kg)								
Aluminum	1225 / 1227	330 : 330	341 - 37500	7700	n	22,901	Yes	ASL
Antimony	597 / 1227	0.093 : 50	0.11 - 2190	3.1	n	5.6	Yes	ASL
Arsenic	1143 / 1232	0.23 : 55	0.97 - 37400	0.68	c**R	9.6	Yes	ASL
Barium	1210 / 1227	10 : 10	8.9 - 15100	1500	n	147	Yes	ASL
Beryllium	558 / 1227	0.09 : 5	0.012 - 5.7	16	n	1.8	No	BSL
Boron	349 / 1232	0.81 : 90	0.72 - 242	1600	n	11	No	BSL
Cadmium	1052 / 1227	0.065 : 2.5	0.12 - 3080	7.1	n	2.3	Yes	ASL
Calcium	1226 / 1227	370 : 370	400 - 375000	NA		110,000	No	E
Chromium	1136 / 1227	0.32 : 22	0.46 - 2100	12000		28	No	BSL
Chromium VI (Hexavalent)	35 / 115	0.04 : 0.4	0.016 - 4	0.3	c*	ND	Yes	ASL
Cobalt	1204 / 1227	0.11 : 53	0.44 - 404	2.3	n	31	Yes	ASL
Copper	1227 / 1227		25.7 - 721000	310	n	1,135	Yes	ASL
Iron	1227 / 1227		290 - 290000	5500	n	33,590	Yes	ASL
Lead	1218 / 1227	0.14 : 14	4.7 - 343000	400		43	Yes	ASL
Manganese	1221 / 1227	7.1 : 7.1	4.4 - 12300	180	n	617	Yes	ASL
Mercury	1072 / 1226	0.005 : 0.11	0.0053 - 591	1.1	n	0.058	Yes	ASL
Molybdenum	1182 / 1227	0.076 : 5.7	0.69 - 340000	39	n	3.5	Yes	ASL
Nickel	1169 / 1227	17 : 18	0.85 - 1170	150	n	30	Yes	ASL
Selenium	876 / 1232	0.39 : 56	0.61 - 2270	39	n	2.8	Yes	ASL
Silver	736 / 1232	0.042 : 14	0.16 - 1180	39	n	ND	Yes	ASL
Thallium	215 / 1232	0.15 : 310	0.27 - 357	0.078	n	0.87	Yes	ASL
Vanadium	982 / 1227	0.52 : 5100	2 - 1100	39	n	113	Yes	ASL
Zinc	1197 / 1227	17 : 170	10.5 - 52400	2300	n	104	Yes	ASL

ABBREVIATIONS AND NOTES:
ASL = Concentration used for screening is greater than the screening toxicity value; the analyte was selected as a COPC
BSL = Concentration used for screening is less than the screening toxicity value; the analyte was not selected as a COPC
COPC = chemicals of potential concern
E = Compound is an essential nutrient
HI = Hazard Index
mg/kg = milligrams per kilogram
NA = Not Applicable
ND = Non-Detect
NSL = No screening level available; the anlayte was selected as a COPC
RSL = Regional Screening Level
Soil Regional Screening Level (HI = 0.1), May 2020
c**R: cancer where n SL < 10X c SL RBA applied (See User Guide for Arsenic notice)
c*: cancer where n SL < 100X c SL
n: noncancer
ns:
USEPA = U.S. Environmental Protection Agency

TABLE 2.2

SUMMARY STATISTICS OF STORM WATER ANALYTICAL RESULTS AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Chemical Name	Frequency of Detection	Range of Reporting Limits for Non-Detects	Range of Detected Concentrations	Average of All Samples	Background Threshold Value [a]	BTV Statistic	COPC? (Yes/No)	Rationale for Contaminant Deletion or Selection
Metals, Total (mg/L)								
Aluminum, Total	27 / 27		0.796 - 3700	158	NC	NC	Yes	NSL
Antimony, Total	24 / 27	0.025 : 0.06	0.0012 - 0.066	0.015	NC	NC	Yes	NSL
Arsenic, Total	27 / 27		0.0051 - 8.66	0.57	NC	NC	Yes	NSL
Barium, Total	27 / 27		0.0206 - 13.9	0.68	NC	NC	Yes	NSL
Beryllium, Total	4 / 27	0.005 : 0.025	0.00035 - 0.134	0.0095	NC	NC	Yes	NSL
Boron, Total	13 / 27	0.15 : 0.75	0.0274 - 1.29	0.22	NC	NC	Yes	NSL
Cadmium, Total	23 / 27	0.003 : 0.003	0.0038 - 3.52	0.16	NC	NC	No	E
Calcium, Total	27 / 27		26.3 - 8240	505	NC	NC	Yes	NSL
Chromium, Total	23 / 27	0.01 : 0.05	0.0016 - 5.31	0.22	NC	NC	Yes	NSL
Cobalt, Total	27 / 27		0.0024 - 5.26	0.41	NC	NC	Yes	NSL
Copper, Total	27 / 27		1.1 - 6630	425	NC	NC	Yes	NSL
Iron, Total	27 / 27		1.07 - 8380	336	NC	NC	Yes	NSL
Lead, Total	26 / 27	0.01 : 0.01	0.0116 - 109	4.6	NC	NC	Yes	NSL
Magnesium, Total	27 / 27		7.47 - 2350	128	NC	NC	No	E
Manganese, Total	27 / 27		0.0881 - 82	5.0	NC	NC	Yes	NSL
Mercury, Total	25 / 27	0.0002 : 0.0002	0.000093 - 0.081	0.0048	NC	NC	Yes	NSL
Molybdenum, Total	27 / 27		0.0146 - 70.5	2.8	NC	NC	Yes	NSL
Nickel, Total	21 / 27	0.02 : 0.1	0.0036 - 5.38	0.40	NC	NC	Yes	NSL
Potassium, Total	26 / 27	12.5 : 12.5	2.7 - 809	43	NC	NC	No	E
Selenium, Total	27 / 27		0.0024 - 0.483	0.062	NC	NC	Yes	NSL
Silver, Total	17 / 27	0.01 : 0.05	0.00063 - 5.84	0.24	NC	NC	Yes	NSL
Sodium, Total	27 / 27		2.61 - 2930	272	NC	NC	No	E
Thallium, Total	23 / 27	0.0001 : 0.02	0.000051 - 0.0509	0.0033	NC	NC	Yes	NSL
Vanadium, Total	25 / 27	0.075 : 0.075	0.0011 - 9.68	0.41	NC	NC	Yes	NSL
Zinc, Total	27 / 27		0.0887 - 328	15.5	NC	NC	Yes	NSL
Metals, Dissolved (mg/L)								
Aluminum, Dissolved	25 / 34	0.2 : 1	0.0282 - 2.16	0.27	6.674	95% UTL 95% Coverage (Kaplan Meier)	Yes	NSL
Antimony, Dissolved	33 / 34	0.025 : 0.025	0.00042 - 0.0476	0.0084	0.0142	95% UTL 95% Coverage (Kaplan Meier)	Yes	NSL
Arsenic, Dissolved	32 / 34	0.0025 : 0.025	0.0012 - 0.319	0.035	0.144	95% UTL 95% Coverage (Kaplan Meier)	Yes	NSL
Barium, Dissolved	32 / 34	0.01 : 0.05	0.0029 - 0.385	0.062	0.161	95% UTL 95% Coverage (Kaplan Meier)	Yes	NSL
Beryllium, Dissolved	0 / 34	0.005 : 0.025		0.0037	ND	NC	No	ND
Boron, Dissolved	18 / 34	0.15 : 0.75	0.0137 - 0.698	0.15	0.184	95% UTL 95% Coverage (Kaplan Meier)	Yes	NSL
Cadmium, Dissolved	19 / 34	0.003 : 0.015	0.0014 - 0.143	0.015	0.003	95% UTL 95% Coverage	Yes	NSL
Calcium, Dissolved	34 / 34		12.7 - 755	199	117	95% UTL 95% Coverage	No	E
Chromium, Dissolved	14 / 34	0.01 : 0.05	0.00082 - 0.0455	0.0071	0.011	95% UTL 95% Coverage (Kaplan Meier)	Yes	NSL
Cobalt, Dissolved	33 / 34	0.0005 : 0.0005	0.00016 - 2.73	0.14	0.0034	95% BCA Bootstrap UTL with 95% Coverage	Yes	NSL
Copper, Dissolved	34 / 34		0.03 - 3080	152	1.765	95% UTL 95% Coverage (Kaplan Meier)	Yes	NSL
Iron, Dissolved	28 / 34	0.05 : 0.25	0.019 - 53.9	2.4	5.56	95% UTL 95% Coverage	Yes	NSL
Lead, Dissolved	24 / 34	0.01 : 0.05	0.0016 - 3.04	0.23	0.0323	95% UTL 95% Coverage (Kaplan Meier)	Yes	NSL
Magnesium, Dissolved	34 / 34		1.27 - 144	31	14.14	95% UTL 95% Coverage	No	E

TABLE 2.2

SUMMARY STATISTICS OF STORM WATER ANALYTICAL RESULTS AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Chemical Name	Frequency of Detection	Range of Reporting Limits for Non-Detects	Range of Detected Concentrations	Average of All Samples	Background Threshold Value [a]	BTV Statistic	COPC? (Yes/No)	Rationale for Contaminant Deletion or Selection
Metals, Dissolved (mg/L)								
Manganese, Dissolved	34 / 34		0.0071 - 6.27	0.93	0.309	95% BCA Bootstrap UTL with 95% Coverage	Yes	NSL
Mercury, Dissolved	22 / 34	0.0002 : 0.0002	0.00003 - 0.0092	0.00079	NC	NC	Yes	NSL
Molybdenum, Dissolved	33 / 34	0.015 : 0.015	0.0118 - 1.04	0.14	0.122	95% UTL 95% Coverage (Kaplan Meier)	Yes	NSL
Nickel, Dissolved	16 / 34	0.02 : 0.1	0.0032 - 2.13	0.12	0.00859	95% UTL 95% Coverage (Kaplan Meier)	Yes	NSL
Potassium, Dissolved	34 / 34		2.3 - 44.1	11.1	33.3	95% BCA Bootstrap UTL with 95% Coverage	No	E
Selenium, Dissolved	34 / 34		0.0014 - 0.133	0.022	0.0336	95% BCA Bootstrap UTL with 95% Coverage	Yes	NSL
Silver, Dissolved	5 / 34	0.01 : 0.05	0.00064 - 0.0983	0.012	ND	NC	Yes	NSL
Sodium, Dissolved	34 / 34		1.63 - 2810	230	9.1	95% BCA Bootstrap UTL with 95% Coverage	No	E
Thallium, Dissolved	14 / 34	0.0001 : 0.01	0.000033 - 0.00047	0.00048	0.00013391	95% UTL 95% Coverage (Kaplan Meier)	Yes	NSL
Vanadium, Dissolved	14 / 34	0.015 : 0.075	0.0013 - 0.195	0.016	0.0289	95% UTL 95% Coverage (Kaplan Meier)	Yes	NSL
Zinc, Dissolved	30 / 34	0.02 : 0.1	0.0045 - 7.43	0.70	0.0727	95% UTL 95% Coverage (Kaplan Meier)	Yes	NSL
General Chemistry (mg/L)								
Alkalinity, Bicarbonate	1 / 1		464 - 464	464	-		No	NA
Alkalinity, Carbonate	0 / 1	5 : 5		2.5	-		No	NA
Alkalinity, Total (as $CaCO_3$)	29 / 29		14.6 - 4030	415	NC	NC	No	NA
Chloride	29 / 29		1.2 - 1080	157	NC	NC	No	NA
Cyanide	23 / 33	0.01 : 0.05	0.0054 - 0.0501	0.014	NC	NC	No	NA
Fluoride	21 / 29	1 : 1	0.12 - 14	1.3	NC	NC	No	NA
Nitrite/Nitrate Nitrogen	33 / 34	0.02 : 0.02	0.061 - 7.3	1.6	NC	NC	No	NA
Sulfate	29 / 29		19.3 - 15900	1247	NC	NC	No	NA
Total Dissolved Solids (TDS)	28 / 28		112 - 26500	2602	NC	NC	No	NA
Total Organic Carbon (TOC)	24 / 24		5.8 - 9600	546	NC	NC	No	NA
Total Suspended Solids (TSS)	29 / 29		5 - 17600	3040	NC	NC	No	NA

ABBREVIATIONS AND NOTES:

- = Not Analyzed
BCA = Bias-corrected and accelerated
BTV = Background threshold value
$CaCO_3$ = Calcium carbonate
COPC = Chemical of potential concern
E = Compound is an essential nutrient; hence, not selected as a COPC
mg/L = milligrams per liter
NA = Not Applicable
NC = Not Calculated; ProUCL version 5.1.002 recommends that the sample size be at least 10 samples for calculating BTVs.
ND = Non-Detect
NSL = No screening level available; the analyte was selected as a COPC.
UTL = Upper Tolerance Limit

[a] BTVs for each constituent were selected based on the underlying distribution of the data. For normally or lognormally distributed dataset, 95% upper tolerance limit (UTL) with 95% coverage was selected as the BTV. For nonparametric datasets, the 95% BCA bootstrap UTL with 95% coverage was selected as the BTV.

TABLE 2.3

SUMMARY STATISTICS OF AMBIENT AIR (PM_{10}) ANALYTICAL RESULTS AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Chemical Name	Frequency of Detection	Percent Detected	Range of Reporting Limits for Non-Detects		Range of Detected Results		Arithmetic Average of Detected Results	USEPA Residential Air RSL May 2020 HI = 0.1		COPC? (Yes/No)	Rationale for Chemical Deletion or Selection
			min	max	min	max					
Aluminum	1011 / 1017	99.4%	2.17E-02	1.22E-01	1.41E-02	8.16E+00	1.05E+00	5.20E-01	n	Yes	ASL
Antimony	109 / 1016	10.7%	5.00E-03	5.59E-02	1.80E-03	3.31E-02	9.01E-03	2.10E-02	n [a]	Yes	ASL
Arsenic	914 / 1012	90.3%	2.30E-03	1.56E-02	5.00E-04	1.52E+00	3.08E-02	6.50E-04	c**	Yes	ASL
Barium	630 / 1017	61.9%	6.00E-03	3.97E-02	2.30E-03	5.91E-01	2.01E-02	5.20E-02	n	Yes	ASL
Bismuth	800 / 1014	78.9%	3.80E-03	1.51E-02	1.20E-03	5.02E-01	1.66E-02			No	SAI
Bromine	953 / 1012	94.2%	1.90E-03	1.55E-02	5.00E-04	1.18E-02	3.18E-03			No	SAI
Cadmium	430 / 1015	42.4%	3.50E-03	1.88E-02	7.00E-04	1.22E-01	6.34E-03	1.00E-03	n	Yes	ASL
Caesium	28 / 1017	2.8%	2.30E-03	1.06E-01	1.50E-03	2.08E-02	6.15E-03			No	SAI
Calcium	1015 / 1017	99.8%	6.10E-03	1.88E-02	2.20E-03	8.02E+00	1.10E+00			No	E
Chlorine	988 / 1014	97.4%	7.50E-03	1.94E-01	3.50E-03	9.19E-01	1.14E-01	NA [b]		No	SAI
Chromium	728 / 1018	71.5%	2.80E-03	1.37E-02	8.00E-04	1.57E-01	4.21E-03			Yes	NSL
Cobalt	14 / 1018	1.4%	2.30E-03	1.83E-01	2.30E-03	2.02E-02	7.89E-03	3.10E-04	c**	Yes	ASL
Copper	1014 / 1017	99.7%	3.30E-03	4.30E-03	1.20E-03	1.96E+01	8.43E-01			Yes	NSL
Iron	1014 / 1016	99.8%	5.20E-03	1.22E-02	1.80E-03	1.33E+01	1.46E+00			Yes	NSL
Lead	988 / 1014	97.4%	4.70E-03	1.13E-02	1.40E-03	2.32E+00	8.25E-02	1.50E-01	NAAQS	Yes	ASL
Magnesium	960 / 1018	94.3%	4.19E-02	2.21E+00	1.68E-02	5.39E+00	3.65E-01			No	E
Manganese	996 / 1018	97.8%	3.80E-03	2.50E-02	1.10E-03	3.44E-01	1.88E-02	5.20E-03	n	Yes	ASL
Mercury	144 / 1018	14.1%	1.20E-03	7.10E-02	1.10E-03	2.42E-02	4.22E-03	3.10E-02	n	No	BSL
Molybdenum	847 / 1018	83.2%	5.20E-03	1.64E-02	1.20E-03	4.15E-01	1.93E-02			Yes	NSL
Nickel	262 / 1018	25.7%	1.10E-03	2.12E-01	4.00E-04	1.97E-02	1.92E-03	9.40E-03	n [c]	Yes	ASL
Phosphorus	445 / 1018	43.7%	7.50E-03	1.92E-01	2.30E-03	1.87E-01	1.65E-02			No	SAI
Potassium	1012 / 1017	99.5%	6.60E-03	7.50E-03	6.40E-03	2.70E+00	4.49E-01			No	E
Rubidium	759 / 1018	74.6%	9.00E-04	1.08E-02	5.00E-04	1.93E-02	2.80E-03			No	SAI
Scandium	233 / 1016	22.9%	8.00E-04	4.22E-02	8.00E-04	4.44E-02	3.65E-03			No	SAI
Selenium	869 / 1017	85.4%	1.40E-03	6.10E-03	5.00E-04	6.58E-01	1.58E-02	2.10E+00	n	No	BSL
Silicon	1015 / 1017	99.8%	1.46E-02	1.88E-02	7.10E-03	2.08E+01	2.78E+00			No	SAI
Silver	151 / 1018	14.8%	2.10E-03	1.61E-02	8.00E-04	1.80E-02	4.00E-03			Yes	NSL
Sodium	560 / 1018	55.0%	1.00E-01	7.07E+00	4.21E-02	1.41E+00	2.63E-01			No	E
Strontium, Stable	950 / 1018	93.3%	2.40E-03	7.10E-03	6.00E-04	5.90E-02	6.11E-03			No	SAI
Sulfur	1015 / 1016	99.9%	1.18E-02	1.18E-02	2.70E-03	1.39E+01	1.02E+00			No	SAI
Thallium	188 / 1018	18.5%	4.20E-03	4.88E-02	8.00E-04	3.76E-02	4.49E-03			Yes	NSL
Tin	569 / 998	57.0%	2.90E-03	3.70E-02	1.30E-03	1.23E-01	8.22E-03			No	SAI
Titanium	1011 / 1017	99.4%	2.80E-03	4.70E-03	2.40E-03	9.14E-01	9.11E-02			No	SAI
Vanadium	637 / 1018	62.6%	2.30E-03	9.05E-02	8.00E-04	3.22E-02	3.59E-03	1.00E-02	n [d]	Yes	ASL
Zinc	1005 / 1014	99.1%	2.80E-03	4.20E-03	1.00E-03	2.78E+00	1.37E-01			Yes	NSL
Zironium	481 / 1018	47.2%	3.30E-03	1.50E-02	9.00E-04	2.24E-02	4.28E-03			No	SAI

ABBREVIATIONS AND NOTES:

[a] = RSL is for antimony trioxide

ASL = Concentration used for screening is greater than the screening toxicity value; the analyte was selected as a COPC.

BSL = Concentration used for screening is less than the screening toxicity value; the analyte was not selected as a COPC.

[c] = RSL is for nickel soluble salts

c** - cancer where n SL < 10 X c SL

COPC = chemical of potential concern

[d] = RSL is for vanadium and compounds

E = Compound is an essential nutrient.

HI = Hazard Index

n: noncancer

NA = Not Applicable

NAAQS: National Ambient Air Quality Standard

NSL = No screening level available; the analyte was selected as a COPC.

Residential Air RSL = Residential Air Regional Screening Level (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables)

SAI = Source apportionment indicator; not applicable or relevant for evaluation of health risks associated with ambient air.

SL: Screening Level

USEPA = U.S. Environmental Protection Agency

TABLE 2.4
SUMMARY STATISTICS OF BACKGROUND SOIL ANALYTICAL RESULTS
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

Chemical Name	Frequency of Detection	Range of Reporting Limits for Non-Detects	Range of Detected Concentrations	Average of All Samples	Background Threshold Value [a]	Distribution	Statistic	COPC? (Yes/No)	Median	95% UCL	EPC	Statistic	Distribution
Metals, Total (mg/kg)													
Aluminum	10 / 10		18000 - 22000	19800	22901	Normal	95% UTL with 90% Coverage	Yes	20000	20563	20563	95% Student's-t	Normal
Antimony	14 / 20	5 : 10.2	0.26 - 1.3	1.81	5.6	Normal	95% UTL with 90% Coverage	Yes	0.73	0.73	0.73	95% KM (t)	Normal
Arsenic	58 / 58		1.9 - 12.5	5.93	9.6	Normal	95% UTL with 90% Coverage	Yes	5.55	6.43	6.43	95% Student's-t	Normal
Barium	12 / 12		27 - 120	55.7	147	Lognormal	95% UTL with 90% Coverage	Yes	43.5	77.3	77.3	95% Adjusted Gamma	Gamma
Beryllium	12 / 12		0.7 - 1.6	1.20	1.8	Normal	95% UTL with 90% Coverage	Yes	1.25	1.34	1.34	95% Student's-t	Normal
Boron	12 / 12		7 - 10	8.58	11	Normal	95% UTL with 90% Coverage	Yes	8.60	9.07	9.07	95% Student's-t	Normal
Cadmium	20 / 22	0.29 : 0.44	0.2 - 2.1	0.77	2.3	Lognormal	95% UTL with 90% Coverage	Yes	0.61	0.96	0.96	95% KM (t)	Normal
Chromium	12 / 12		13 - 28	19.4	28	Normal	95% UTL with 90% Coverage	Yes	18.0	21.5	21.5	95% Student's-t	Normal
Chromium VI (Hexavalent)	0 / 12	0.79 : 0.81		0.40	ND			Yes	0.80	ND	0.80	Median	
Cobalt	12 / 12		8.3 - 22	17.2	31	Lognormal	95% UPL	Yes	18.5	19.7	19.7	95% Student's-t	Normal
Copper	60 / 60		1.1 - 1700	508	1135	Normal	95% UTL with 90% Coverage	Yes	490	593	593	95% Student's-t	Normal
Iron	16 / 16		13000 - 30000	21888	33590	Normal	95% UTL with 90% Coverage	Yes	23000	24410	24410	95% Student's-t	Normal
Lead	50 / 50		5.2 - 52.3	25.2	43	Normal	95% UTL with 90% Coverage	Yes	23.9	27.8	27.8	95% Student's-t	Normal
Manganese	9 / 9		430 - 560	509	617	Normal	95% UTL with 90% Coverage	Yes	530	536	536	95% Student's-t	Normal
Mercury	3 / 12	0.1 : 0.1	0.038 - 0.051	0.05	0.058	Normal	95% UTL with 90% Coverage	Yes	0.10	NC	0.10	Median	
Molybdenum	18 / 18		0.73 - 3.76	2.12	3.5	Normal	95% UTL with 90% Coverage	Yes	2.05	2.41	2.41	95% Student's-t	Normal
Nickel	12 / 12		12 - 28	18.8	30	Normal	95% UTL with 90% Coverage	Yes	18.0	21.4	21.4	95% Student's-t	Normal
Selenium	12 / 12		1.5 - 2.6	2.01	2.8	Normal	95% UTL with 90% Coverage	Yes	2.00	2.20	2.20	95% Student's-t	Normal
Silver	0 / 12	2.5 : 2.5		1.25	ND			Yes	2.50	ND	2.50	Median	
Thallium	1 / 22	0.42 : 5	0.87 - 0.87	1.58	0.87			Yes	5.00	NC	5.00	Median	
Vanadium	22 / 22		26.8 - 110	63.0	113	Normal	95% UTL with 90% Coverage	Yes	63.0	72.7	72.7	95% Student's-t	Normal
Zinc	12 / 12		39 - 98	64.8	104	Normal	95% UTL with 90% Coverage	Yes	64.0	74.0	74.0	95% Student's-t	Normal

ABBREVIATIONS AND NOTES:
COPC = chemicals of potential concern
mg/kg: milligram per kilogram

Notes:
(1) Chemicals of potential concern (COPCs) are identified in Table 2.1.
(2) Arithmetic mean is calculated using the detection limit divided by 2 (DL/2) substitution method for not detected results.
(3) 95% UCL is calculated using ProUCL software (V. 5.1.00); calculations presented in Appendix B.
(4) The maximum detected concentration is used as the EPC because it is lower than the calculated 95% UCL, or no 95% UCL is calculated.
(5) The 95% UCL is used as the EPC because the calculated 95% UCL is less than the maximum detected concentration.
(6) In accordance with USEPA guidance for evaluating lead exposure, the arithmetic mean concentration is used as the EPC.
-- = Chemical not detected above laboratory reporting limits

TABLE 2.5

SUMMARY STATISTICS OF BACKGROUND STORM WATER ANALYTICAL RESULTS

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Chemical Name	Frequency of Detection	Range of Reporting Limits for Non-Detects	Range of Detected Concentrations	Average of All Samples	Background Threshold Value [a]	Distribution	Statistic	COPC? (Yes/No)	Median	95% UCL	EPC	Statistic	Distribution
Metals, Total (mg/L)													
Aluminum, Total	3 / 3		10.9 - 188	73	NC			Yes	20.7	241	20.7	Median	
Antimony, Total	3 / 3		0.0013 - 0.0107	0.0073	NC			Yes	0.01	0.0162	0.01	Median	
Arsenic, Total	3 / 3		0.0936 - 0.341	0.18	NC			Yes	0.101	0.416	0.101	Median	
Barium, Total	3 / 3		0.121 - 0.937	0.45	NC			Yes	0.297	1.18	0.297	Median	
Beryllium, Total	2 / 3	0.005 : 0.005	0.00093 - 0.0061	0.0032	NC			Yes	0.005	0.0151	0.005	Median	
Boron, Total	2 / 3	0.3 : 0.3	0.0805 - 0.177	0.14	NC			Yes	0.177		0.177	Median	
Cadmium, Total	3 / 3		0.0064 - 0.0223	0.016	NC			Yes	0.0204	0.031	0.0204	Median	
Calcium, Total	3 / 3		77.6 - 400	221	NC			Yes	185	498	185	Median	
Chromium, Total	3 / 3		0.0167 - 0.16	0.075	NC			Yes	0.0493	0.202	0.0493	Median	
Cobalt, Total	3 / 3		0.0058 - 0.0936	0.038	NC			Yes	0.0156	0.119	0.0156	Median	
Copper, Total	3 / 3		3.93 - 18.7	10.9	NC			Yes	9.97	23.4	9.97	Median	
Iron, Total	3 / 3		8.17 - 164	64	NC			Yes	18.7	210	18.7	Median	
Lead, Total	3 / 3		0.139 - 0.564	0.36	NC			Yes	0.381	0.721	0.4	Median	
Magnesium, Total	3 / 3		10.1 - 145	59	NC			Yes	22.5	185	22.5	Median	
Manganese, Total	3 / 3		0.397 - 4.31	1.7	NC			Yes	0.539	5.49	0.539	Median	
Mercury, Total	3 / 3		0.00031 - 0.00088	0.00062	NC			Yes	0.00068	0.00111	0.00068	Median	
Molybdenum, Total	3 / 3		0.0393 - 0.131	0.072	NC			Yes	0.0459	0.158	0.0459	Median	
Nickel, Total	3 / 3		0.0158 - 0.158	0.069	NC			Yes	0.0334	0.2	0.0334	Median	
Potassium, Total	3 / 3		8.42 - 27.5	18.9	NC			Yes	20.9	35.3	20.9	Median	
Selenium, Total	3 / 3		0.0112 - 0.0428	0.024	NC			Yes	0.0184	0.0521	0.0184	Median	
Silver, Total	2 / 3	0.01 : 0.01	0.0071 - 0.0074	0.0065	NC			Yes	0.0074		0.0074	Median	
Sodium, Total	3 / 3		1.62 - 12.1	6.6	NC			Yes	5.93	15.4	5.93	Median	
Thallium, Total	3 / 3		0.00031 - 0.00085	0.00055	NC			Yes	0.00048	0.00101	0.00048	Median	
Vanadium, Total	3 / 3		0.013 - 0.39	0.15	NC			Yes	0.036	0.503	0.036	Median	
Zinc, Total	3 / 3		0.223 - 1.35	0.71	NC			Yes	0.545	1.69	0.545	Median	
Metals, Dissolved (mg/L)												Median	
Aluminum, Dissolved	3 / 10	0.2 : 0.2	0.397 - 6.84	0.85	6.674	Normal	95% UTL 95% Coverage (Kaplan Meier)	Yes	0.2	2.32	0.2	Median	
Antimony, Dissolved	10 / 10		0.00015 - 0.0112	0.0032	0.0142	Normal	95% UTL 95% Coverage (Kaplan Meier)	Yes	0.00145	0.00538	0.00538	Median	Normal
Arsenic, Dissolved	10 / 10		0.00075 - 0.12	0.033	0.144	Normal	95% UTL 95% Coverage (Kaplan Meier)	Yes	0.01675	0.0551	0.0551	Median	Normal
Barium, Dissolved	8 / 10	0.01 : 0.01	0.01 - 0.127	0.039	0.161	Normal	95% UTL 95% Coverage (Kaplan Meier)	Yes	0.0141	0.066	0.066	Median	Normal
Beryllium, Dissolved	0 / 10	0.005 : 0.005		0.0025	ND			No			0	Median	
Boron, Dissolved	4 / 10	0.15 : 0.15	0.0107 - 0.162	0.075	0.184	Normal	95% UTL 95% Coverage (Kaplan Meier)	Yes	0.15	0.0964	0.15	Median	
Cadmium, Dissolved	2 / 10	0.003 : 0.003	0.0015 - 0.0016	0.0015	0.003	Non-paramateric	95% UTL 95% Coverage	Yes	0.003	0.00164	0.003	Median	
Calcium, Dissolved	10 / 10		5.7 - 96.5	33	117	Normal	95% UTL 95% Coverage	Yes	22.25	50	50	Median	Normal
Chromium, Dissolved	4 / 10	0.01 : 0.01	0.0016 - 0.0079	0.0044	0.011	Normal	95% UTL 95% Coverage (Kaplan Meier)	Yes	0.01	0.00621	0.01	Median	
Cobalt, Dissolved	10 / 10		0.000064 - 0.0034	0.0010	0.0034	Non-paramateric	95% BCA Bootstrap UTL with 95% Coverage	Yes	0.000235	0.00267	0.00267	Median	Lognormal
Copper, Dissolved	9 / 10	0.01 : 0.01	0.0024 - 1.19	0.47	1.765	Normal	95% UTL 95% Coverage (Kaplan Meier)	Yes	0.3645	0.742	0.742	Median	Normal
Iron, Dissolved	8 / 10	0.05 : 0.05	0.0135 - 5.56	0.67	5.56	Non-paramateric	95% UTL 95% Coverage	Yes	0.05	6.71	5.56	Median	Gamma
Lead, Dissolved	4 / 10	0.01 : 0.01	0.0018 - 0.0295	0.0087	0.0323	Normal	95% UTL 95% Coverage (Kaplan Meier)	Yes	0.01	0.0126	0.01	Median	
Magnesium, Dissolved	10 / 10		0.612 - 10.2	4.2	14.14	Normal	95% UTL 95% Coverage	Yes	3.11	6.16	6.16	Median	Normal
Manganese, Dissolved	10 / 10		0.0067 - 0.309	0.11	0.309	Non-paramateric	95% BCA Bootstrap UTL with 95% Coverage	Yes	0.05805	0.177	0.177	Median	Normal
Mercury, Dissolved	1 / 10	0.0002 : 2E-04	0.000094 - 0.000094	0.000099	NC			Yes	0.0002		0.0002	Median	
Molybdenum, Dissolved	4 / 10	0.015 : 0.015	0.0179 - 0.12	0.027	0.122	Normal	95% UTL 95% Coverage (Kaplan Meier)	Yes	0.015	0.0521	0.015	Median	
Nickel, Dissolved	3 / 10	0.02 : 0.02	0.0022 - 0.0059	0.0083	0.00859	Normal	95% UTL 95% Coverage (Kaplan Meier)	Yes	0.02	0.00614	0.02	Median	
Potassium, Dissolved	10 / 10		1.58 - 33.3	7.9	33.3	Non-paramateric	95% BCA Bootstrap UTL with 95% Coverage	Yes	3.12	18.5	18.5	Median	Gamma
Selenium, Dissolved	10 / 10		0.00038 - 0.0336	0.0071	0.0336	Non-paramateric	95% BCA Bootstrap UTL with 95% Coverage	Yes	0.0033	0.0197	0.0197	Median	Gamma
Silver, Dissolved	0 / 10	0.01 : 0.01		0.0050	ND			Yes			0	Median	
Sodium, Dissolved	10 / 10		0.632 - 9.1	3.0	9.1	Non-paramateric	95% BCA Bootstrap UTL with 95% Coverage	Yes	1.58	5.96	5.96	Median	Gamma
Thallium, Dissolved	4 / 10	0.0001 : 5E-04	0.000027 - 0.000093	0.000073	1.34E-04	Normal	95% UTL 95% Coverage (Kaplan Meier)	Yes	0.0001	0.0000845	0.0001	Median	
Vanadium, Dissolved	5 / 10	0.015 : 0.015	0.0027 - 0.0218	0.0095	0.0289	Normal	95% UTL 95% Coverage (Kaplan Meier)	Yes	0.015	0.0138	0.0138	95% KM (t) UCL	Normal
Zinc, Dissolved	7 / 10	0.02 : 0.02	0.0062 - 0.0587	0.021	0.0727	Normal	95% UTL 95% Coverage (Kaplan Meier)	Yes	0.02	0.0322	0.0322	95% KM (t) UCL	Normal
General Chemistry (mg/L)													
Alkalinity, Total (as CaCO3)	4 / 4		35.8 - 434	173	NC			Yes	111.9	391	111.9	Median	
Chloride	2 / 4	2 : 2	1.4 - 1.6	1.3	NC			Yes	1.8	1.74	1.8	Median	
Cyanide	4 / 6	0.01 : 0.01	0.0066 - 0.0239	0.012	NC			Yes	0.01	0.0195	0.01	Median	
Fluoride	3 / 4	0.2 : 0.2	0.12 - 0.36	0.23	NC			Yes	0.27	0.401	0.27	Median	

TABLE 2.5

SUMMARY STATISTICS OF BACKGROUND STORM WATER ANALYTICAL RESULTS

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Chemical Name	Frequency of Detection	Range of Reporting Limits for Non-Detects	Range of Detected Concentrations	Average of All Samples	Background Threshold Value [a]	Distribution	Statistic	COPC? (Yes/No)	Median	95% UCL	EPC	Statistic	Distribution
Nitrite/Nitrate Nitrogen	4 / 4		4.8 - 26.1	13.0	NC			Yes	0.625	1.906	0.625	Median	
Sulfate	6 / 6		0.26 - 3.1	1.0	NC			Yes	10.55	25.1	3.1	Median	
Total Dissolved Solids (TDS)	4 / 4		58.6 - 166	106	NC			Yes	99.85	160	99.85	Median	
Total Organic Carbon (TOC)	4 / 4		6.5 - 17	10.0	NC			Yes	8.3	15.7	8.3	Median	
Total Suspended Solids (TSS)	4 / 4		19.4 - 8600	2233	NC			Yes	156	7230	156	Median	

ABBREVIATIONS AND NOTES:

COPC = chemicals of potential concern

mg/L = milligram per liter

NC = Not Calculated; ProUCL version 5.1.002 recommends that the sample size be at least 10 samples for calculating BTVs

ND = Not Detected

EPC = Exposure Point Concentration

UCL = Upper Confidence Limit

Notes:

(1) Chemicals of potential concern (COPCs) are identified in Table 2.3.

(2) Arithmetic mean is calculated using the detection limit divided by 2 (DL/2) substitution method for not detected results.

(3) Revised 95% UCL is calculated using ProUCL software (V. 5.0.00); calculations presented in Appendix B.

(4) The maximum detected concentration is used as the EPC because it is lower than the calculated 95% UCL, or no 95% UCL is calculated.

(5) The 95% UCL is used as the EPC because the calculated 95% UCL is less than the maximum detected concentration.

(6) In accordance with USEPA guidance for evaluating lead exposure, the arithmetic mean concentration is used as the EPC.

-- = Chemical not detected above laboratory reporting limits

[a] BTVs for each constituent were selected based on the underlying distribution of the data. For normally or lognormally distributed dataset, 95% upper tolerance limit (UTL) with 95% coverage was selected as the BTV. For nonparametric datasets, the 95% BCA bootstrap UTL with 95% coverage was selected as the BTV.

TABLE 2.6

SUMMARY STATISTICS OF BACKGROUND AIR PM_{10} RESULTS

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Chemical Name	Frequency of Detection	Range of Reporting Limits for Non-Detects	Range of Detected Concentrations	Average of All Samples	Background Threshold Value [a]	Distribution	Statistic	COPC? (Yes/No)
ORPL Station: July 2013-June 2015								
Metals, PM10 (µg/m³)								
Aluminum	239 - 239	NA - NA	0.008 - 6.97	0.42	6.97	Non-parametric	95% USL	Yes
Arsenic	77 - 77	NA - NA	0.0001 - 0.002	0.0008	NC	NC	NC	Yes
Manganese	235 - 238	0.00009 - 0.0003	0.00033 - 0.097	0.0065	0.10	Non-parametric	95% USL	Yes
TONT Station: July 2013-June 2015								
Metals, PM10 (µg/m³)								
Aluminum	230 - 230	NA - NA	0.0043 - 6.62	0.37	6.619	Non-parametric	95% USL	Yes
Arsenic	91 - 91	NA - NA	0.00005 - 0.008	0.001	NC	NC	NC	Yes
Manganese	225 - 229	0.00008 - 0.00027	0.000028 - 0.099	0.0056	0.0987	Non-parametric	95% USL	Yes

ABBREVIATIONS AND NOTES:

µg/m3 = micrograms per cubic meter

mg/kg: milligram per kilogram

NC: Not Calculated

Notes:

(1) Chemicals of potential concern (COPCs) are identified in Table 2.3.

(2) Arithmetic mean is calculated using the detection limit divided by 2 (DL/2) substitution method for not detected results.

(3) KM Mean is calculated using ProUCL software (V. 5.1.00) for combined data from ORPL and TONT stations.

Metals, PM10 (µg/m³)	KM Mean
Aluminum	0.397
Arsenic	0.00088
Manganese	0.00597

TABLE 3.1

SUMMARY OF POTENTIAL EXPOSURE PATHWAYS AND EXPOSURE SCENARIOS

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Exposure Area	Soil Exposure Scenario	Soil Exposure Point and Exposure Route	Storm Water Exposure Point and E	Air Exposure Point and Exposure Route	Air Exposure Scenario	Summation of Risks
In-Town Area	In-town trespasser [a]	Area D (Near residential areas in Hayden) / Incidental ingestion, dermal contact, dust inhalation from wind erosion	Area D storm water / Incidental ingestion, dermal contact	ST-01 Rooftop of building for Town of Hayden maintenance yard within Hayden residential area / Ambient air inhalation	Resident	In-town trespasser (soil Area D) + In-town trespasser (storm water) + Resident (air - ST-01)
				ST-16 Southern end of Hayden residential area / Ambient air inhalation	Resident	In-town trespasser (soil Area D) + In-town trespasser (storm water) + Resident (air - ST-16)
				ST-23 Eastern portion of Hayden residential area, bordering active plant area F / Ambient air inhalation	Resident	In-town trespasser (soil Area D) + In-town trespasser (storm water) + Resident (air - ST-23)
				ST-26 Eastern portion of Hayden residential area, bordering active plant area F / Ambient air inhalation	Resident	In-town trespasser (soil Area D) + In-town trespasser (storm water) + Resident (air - ST-26)
		Area H (Near residential areas in Winkelman) / Incidental ingestion, dermal contact, dust inhalation from ATV riding	Not applicable	ST-09 Within undeveloped land in Area H / Ambient air inhalation	In-town trespasser	In-town trespasser (soil Area H) + In-town trespasser (air - ST-09)
				ST-02 Rooftop of high school / Ambient air inhalation	High school student High school staff	In-town trespasser (soil Area H) + High school student (air - ST-02) High school staff (air - ST-02)
Restricted Area	Restricted area trespasser	Area F (Concentrator and smelter operations) / Incidental ingestion, dermal contact, dust inhalation from wind erosion	Not applicable	ST-14 Within active plant area in Area F / Ambient air inhalation	Restricted area trespasser	Restricted area trespasser (soil Area F) + Restricted area tresapsser (air - ST-14)
Isolated Facility Area	Isolated area trespasser	Area A (Tailings impoundment D) / Incidental ingestion, dermal contact, dust inhalation from wind erosion	Not applicable	No air stations in proximity to isolated facility areas	Not applicable	Isolated facility area trespasser (soil - Area A)
		Area B (Tailings impoundment AB/BC) / Incidental ingestion, dermal contact, dust inhalation from wind erosion				Isolated facility area trespasser (soil - Area B)
		Area G (Power House Wash near residential area) / Incidental ingestion, dermal contact, dust inhalation from wind erosion				Isolated facility area trespasser (soil - Area G)
		Area I (Adminstration building and vicinity) / Incidental ingestion, dermal contact, dust inhalation from wind erosion				Isolated facility area trespasser (soil - Area I)
		Area J (Northern Hayden operations) / Incidental ingestion, dermal contact, dust inhalation from wind erosion				Isolated facility area trespasser (soil - Area J)
Remote Area	Remote area trespassser	Area K (Upland areas) / Incidental ingestion, dermal contact, dust inhalation from ATV riding and wind erosion	Not applicable	ST-05 Alongside of state highway / Ambient air inhalation	Remote area trespasser	Remote area trespasser (soil Area K) + Remote area tresapsser (air - ST-05)
				ST-18 Within undeveloped land in Area K, north of residential area / Ambient air inhalation	Remote area trespasser	Remote area trespasser (soil Area K) + Remote area tresapsser (air - ST-18)
		Area C (Water Reclamation Ponds and Vicinity) / Incidental ingestion, dermal contact, dust inhalation from ATV riding and wind erosion	Not applicable	No air stations in proximity to this Remote Area	Not Applicable	Remote area trespasser (soil Area C)
		Area E (Historical Tailings) / Incidental ingestion, dermal contact, dust inhalation from ATV riding and wind erosion	Not applicable	No air stations in proximity to this Remote Area	Not Applicable	Remote area trespasser (soil Area E)

ABBREVIATIONS AND NOTES:

[a] = In-town trespassers are assumed to be either residential populations who spend outdoor time in ESA D; non-residential trespassers who do not live or attend high school in the area; or high school students who spend outdoor time in ESA H.

TABLE 3.2
EXPOSURE FACTORS - SOIL
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

SCENARIO USED TO CALCULATE RISKS			IN-TOWN TRESPASSER							
RECEPTOR			CHILD (AGE 6 - <11)		ADOLESCENT (AGE 11 - <16)		ADULT		CHILD, ADOLESCENT, and ADULT (AGES 6 - 36)	
Standard Parameters										
Body Weight	BW	kg	31.8	EPA, 2011 [1]	56.8	EPA, 2011 [1]	80	EPA, 2014	NA	
Exposure Frequency	EF	day/year	150	Site-specific [3]	250	Site-specific [3]	100	Site-specific [3]	138	Site-specific
Exposure Duration	ED	year	5	Ages 6 - <11	5	Ages 11 - <16	16	Balance of 26-yr exposure	26	EPA, 2014
Non–carcinogenic Averaging Time	AT	day	1825	Exposure duration expressed in days	1825	Exposure duration expressed in days	5840	Exposure duration expressed in days	9490	Exposure duration expressed in days
Carcinogenic Averaging Time	$AT_{lifetime}$	day	25550	70 year lifetime	25550	70 year lifetime	25550	70 year lifetime	25550	70 year lifetime
Incidental Ingestion of Soil										
Soil Ingestion Rate	IR	mg/day	200	EPA, 2014	200	EPA, 2014	50	EPA, 2011 [5]	NA	
Fraction Ingested	FI	unitless	0.5	Site-specific [4]	0.5	Site-specific [4]	0.5	Site-specific [4]	0.5	Site-specific [4]
Age-Adjusted Soil Ingestion Rate	IFSadj	mg-yr/kg-day	NA		NA		NA		59	
Dermal Exposure with Soil										
Exposed Skin Surface Area	SA	cm^2	2570	EPA, 2011 [7]	3740	EPA, 2011 [7]	4900	EPA, 2011 [7]	NA	
Soil Adherence Factor	AF	mg/cm^2	0.040	EPA, 20111 [8]	0.040	EPA, 20111 [8]	0.11	EPA, 20111 [8]	NA	
Fraction Dermal	EV	event/day	0.5	Site-specific [6]	0.5	Site-specific [6]	0.5	Site-specific [6]	0.5	Site-specific
Age-Adjusted Dermal Contact Factor	DFSadj	mg-yr/kg-day	NA		NA		NA		137	
Particulate Inhalation										
Exposure Time	ET_{Part}	hours/day	1	Site-specific [3]	1	Site-specific [3]	0.5	Site-specific [3]	0.69	Site-specific

SCENARIO USED TO CALCULATE RISKS			ISOLATED FACILITY AREA TRESPASSER							
RECEPTOR			CHILD (AGE 6 - <11)		ADOLESCENT (AGE 11 - <16)		ADULT		CHILD, ADOLESCENT, and ADULT (AGES 6 - 36)	
Standard Parameters										
Body Weight	BW	kg	31.8	EPA, 2011 [1]	56.8	EPA, 2011 [1]	80	EPA, 2014	NA	
Exposure Frequency	EF	day/year	13	Site-specific [10]	26	Site-specific [10]	26	Site-specific [10]	23.5	Site-specific
Exposure Duration	ED	year	5	Ages 6 - <11	5	Ages 11 - <16	16	Balance of 26-yr exposure	26	EPA, 2014
Non–carcinogenic Averaging Time	AT	day	1825	Exposure duration expressed in days	1825	Exposure duration expressed in days	5840	Exposure duration expressed in days	9490	Exposure duration expressed in days
Carcinogenic Averaging Time	$AT_{lifetime}$	day	25550	70 year lifetime	25550	70 year lifetime	25550	70 year lifetime	25550	70 year lifetime
Incidental Ingestion of Soil										
Soil Ingestion Rate	IR	mg/day	200	EPA, 2014	200	EPA, 2014	50	EPA, 2011 [5]	NA	
Fraction Ingested	FI	unitless	1.0	Site-specific [6]	1.0	Site-specific [6]	1.0	Site-specific [6]	1.0	Site-specific
Age-Adjusted Soil Ingestion Rate	IFSadj	mg-yr/kg-day	NA		NA		NA		59	
Dermal Exposure with Soil										
Exposed Skin Surface Area	SA	cm^2	3300	EPA, 2011 [11]	4790	EPA, 2011 [11]	6200	EPA, 2011 [11]	NA	
Soil Adherence Factor	AF	mg/cm^2	0.10	EPA, 2011 [9]	0.10	EPA, 2011 [9]	0.07	EPA, 2011 [9]	NA	
Fraction Dermal	EV	event/day	1.0	Site-specific [6]	1.0	Site-specific [6]	1.0	Site-specific [6]	1.0	Site-specific
Age-Adjusted Dermal Contact Factor	DFSadj	mg-yr/kg-day	NA		NA		NA		181	
Particulate Inhalation										
Exposure Time	ET_{Part}	hours/day	4	Site-specific [10]	4	Site-specific [10]	4	Site-specific [10]	4	Site-specific

TABLE 3.2
EXPOSURE FACTORS - SOIL
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

SCENARIO USED TO CALCULATE RISKS			RESTRICTED FACILITY AREA TRESPASSER						REMOTE TRESPASSER							
RECEPTOR			ADOLESCENT (AGE 11 - <16)		ADULT		ADOLESCENT and ADULT (AGES 11 - 36)		CHILD (AGE 6 - <11)		ADOLESCENT (AGE 11 - <16)		ADULT		CHILD, ADOLESCENT, and ADULT (AGES 6 - 36)	
Standard Parameters																
Body Weight	BW	kg	56.8	EPA, 2011 [1]	80	EPA, 2014	NA		31.8	EPA, 2011 [1]	56.8	EPA, 2011 [1]	80	EPA, 2014	NA	
Exposure Frequency	EF	day/year	12.0	Site-specific [12]	12	Site-specific [12]	12	Site-specific	26	Site-specific [13]	52	Site-specific [13]	52	Site-specific [13]	47	Site-specific
Exposure Duration	ED	year	5	Ages 11 - <16	21	Balance of 26-yr exposure [2]	26	EPA, 2014	5	Ages 6 - <11	5	Ages 11 - <16	16	Balance of 16-yr exposure	26	EPA, 2014
Non–carcinogenic Averaging Time	AT	day	1825	Exposure duration expressed in days	7665	Exposure duration expressed in days	9490	Exposure duration expressed in days	1825	Exposure duration expressed in days	1825	Exposure duration expressed in days	5840	Exposure duration expressed in days	9490	Exposure duration expressed in days
Carcinogenic Averaging Time	$AT_{lifetime}$	day	25550	70 year lifetime	25550	70 year lifetime	25550	70 year lifetime	25550	70 year lifetime	25550	70 year lifetime	25550	70 year lifetime	25550	70 year lifetime
Incidental Ingestion of Soil																
Soil Ingestion Rate	IR	mg/day	200	EPA, 2014	50	EPA, 2014	NA		200	EPA, 2014	200	EPA, 2014	50	EPA, 2011 [5]	NA	
Fraction Ingested	FI	unitless	0.5	Site-specific [4]	0.5	Site-specific [4]	0.5	Site-specific [4]	1.0	Site-specific [6]	1.0	Site-specific [6]	1.0	Site-specific [6]	1.0	Site-specific
Age-Adjusted Soil Ingestion Rate	IFSadj	mg-yr/kg-day	NA		NA		31		NA		NA		NA		59	
Dermal Exposure with Soil																
Exposed Skin Surface Area	SA	cm^2	3740	EPA, 2011 [7]	4900	EPA, 2011 [7]	NA		3300	EPA, 2011 [11]	4790	EPA, 2011 [11]	6200	EPA, 2011 [11]	NA	
Soil Adherence Factor	AF	mg/cm^2	0.04	EPA, 2011 [8]	0.11	EPA, 2011 [8]	NA		0.10	EPA, 2011 [9]	0.10	EPA, 2011 [9]	0.07	EPA, 2011 [9]	NA	
Fraction Dermal	EV	event/day	1.0	Site-specific [6]	1.0	Site-specific [6]	1.0	Site-specific	1.0	Site-specific [6]	1.0	Site-specific [6]	1.0	Site-specific [6]	1.0	Site-specific
Age-Adjusted Dermal Contact Factor	DFSadj	mg-yr/kg-day	NA		NA		155		NA		NA		NA		181	
Particulate Inhalation																
Exposure Time	ET_{Part}	hours/day	0.5	Site-specific [12]	0.5	Site-specific [12]	0.5	Site-specific	8	Site-specific [13]	8	Site-specific [13]	8	Site-specific [13]	8	Site-specific

TABLE 3.2
EXPOSURE FACTORS - SOIL
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

Notes and Abbreviations
EPA, 2011 - Exposure Factors Handbook. EPA/600/R-10/030. October, 2011.
EPA, 2014 - Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. OSWER 9200.1-120. February 6, 2014.
[1] - Table 8-1 of EPA (2011), Recommended Values for children ages 6 - <11 and 11 - <16; See below
[2] - The adult receptor is evaluated for a longer duration of exposure (21 years versus 16 years in the other scenarios) to maintain the default 26-year residential exposure duration.
[3] - Assumes one hour per day, five days per week for adolescents who are assumed to 'hang out' in In-Town Areas, one hour per day, three days per week for children (6 - <11) who are assumed to explore/play in In-Town Areas, and one-half hour per day, two days per week for adults who are assumed to pass through In-Town Areas while accessing other portions of town.
[4] - One-half of daily outdoor time is spent at this exposure area, based on one-hour per day out of 100 to 132 minutes total outdoor exposure time/day (EPA, 2011; Table 16-21)
[5] - Table 8-1 of EPA (2011), Recommended Values for adults.
[6] - Assumes that on days when visitation to the Site occurs , all daily exposure to soil is derived from locations at the Site.
[7] - Based on surface area of face, hands, forearms, lower legs - see calculations below.
[8] - Based on weighted skin adherence factor for 'sports-outdoors' - see calculations below.
[9] - Based on weighted skin adherence factor for 'activates with soil' -see calculations below.
[10] - Assumes four hours per day, one day every other week for access to Remote Facility Areas. Child (6 - <11) scenario assumes that this age group accompanies an older sibling or adult every other week.
[11] - Based on surface area of face, hands, forearms, lower legs, and feet - see calculations below.
[12] - Assumes one-half hour per day, one day per month for access to Restricted Facility Areas; by adolescents and adults only.
[13] - Assumes eight hours per day, one day per week for adolescents and adults assumed to access Off-Property Remote Areas. Assumes that younger children (ages 6 - <11) accompany adults or siblings every other time.
Values are based on time-weighted average of child, adolescent, and adult exposure values, calculated as follows:
EF = (child EF x child ED) + (adolescent EF x adolescent ED) + (adult EF x adult ED) / total scenario ED
IFSadj = (child ED x child IR / child BW) + (adolescent ED x adolescent IR / adolescent BW) + (adult ED x adult IR / adult BW)
DFSadj = (child ED x child SA x child AF / child BW) + (adolescdent ED x adolescent SA x adolescent AF / adolescent BW) + (adult ED x adult SA x adult AF / adult BW)
ET = (child ET x child ED) + (adolescent ET x adolescent ED) + (adult ET x adult ED) / total scenario ED

Body Surface Area and Adherence Factor Calculations

Age	Whole body surface area (cm2)	Body parts (% total body surface area)						Surface Area Exposed (cm2)			
		Head	Trunk	Arms	Hands	Legs	Feet				
6 - <11	7600	6.1	39.6	14	4.7	28.8	6.8	2124	Face, hands, forearms, lower legs [1]	2641	Face, hands, forearms, lower legs, feet [1]
11 - <16	10800	4.6	39.6	14.3	4.5	30.4	6.6	3050	Face, hands, forearms, lower legs [1]	3763	Face, hands, forearms, lower legs, feet [1]
Adult	19300	6.4	37.8	14	5	32.7	6.65	5846	Face, hands, forearms, lower legs [1]	7129	Face, hands, forearms, lower legs, feet [1]

	Adherence Factors (mg/cm2)					Weighted skin adhernece Factor
	Head	Arms	Hands	Legs	Feet	
Sports Outdoors - Children 6 -<11	0.012	0.011	0.11	0.031		0.038
Sports Outdoors - Children 11 - <16	0.012	0.011	0.11	0.031		0.038
Activites with Soil - Children 6 - <11	0.054	0.046	0.17	0.051	0.2	0.056
Activites with Soil - Children 11 - <16	0.054	0.046	0.17	0.051	0.2	0.056
Sports Outdoors - Adults	0.0314	0.0872	0.1336	0.1223		0.11
Activites with Soil - Adults	0.024	0.0379	0.1595	0.0189	0.1393	0.04

[1] - Area of face is represented by using one-third area of head; area of forearms is represented by using one-half area of arms, and area of lower legs is represented by using one-half area of legs

TABLE 3.3

EXPOSURE FACTORS - STORM WATER

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

RECEPTOR				CHILD (AGE 6-<11)		ADOLESCENT (AGE 11 - <16)		ADULT		CHILD, ADOLESCENT, and ADULT (AGES 6 - 31)	
Standard Parameters											
	Body Weight	BW	kg	31.8	EPA, 2011 [1]	56.8	EPA, 2011 [1]	80	EPA, 2014	NA	
	Exposure Frequency	EF	day/year	10	Site-specific [2]	10	Site-specific [2]	5	Site-specific [2]	7	Site-specific
	Exposure Duration	ED	year	5	Ages 6 - <11	5	Ages 11 - <16	16	Balance of 26-yr exposure	26	EPA, 2014
	Non–carcinogenic Averaging Time	AT	day	1825	Exposure duration expressed in days	1825	Exposure duration expressed in days	5840	Exposure duration expressed in days	9490	Exposure duration expressed in days
	Carcinogenic Averaging Time	$AT_{lifetime}$	day	25550	70 year lifetime	25550	70 year lifetime	25550	70 year lifetime	25550	70 year lifetime
Ingestion of Water											
	Water Ingestion Rate	IR	L/day	0.005	EPA, 2011 [3]	0.005	EPA, 2011 [3]	0.002	EPA, 2011 [4]	NA	
	Fraction Ingested	FI	unitless	1.0	Site-specific [5]	1.0	Site-specific [5]	1.0	Site-specific [5]	1.0	Site-specific
	Age-Adjusted Water Ingestion Rate	IFWadj	L/kg	NA		NA		NA		0.01	
Dermal Exposure with Water											
	Exposed Skin Surface Area	SA	cm^2	3090	EPA, 2011 [6]	4550	EPA, 2011 [6]	5790	EPA, 2011 [6]	NA	
	Exposure Time	Tevent	hr/event	1	Site-specific [5]	1	Site-specific [5]	1	Site-specific [5]	1	
	Events per Day	EV	event/day	1.0	Site-specific [5]	1.0	Site-specific [5]	1.0	Site-specific [5]	1.0	Site-specific
	Age-Adjusted Dermal Contact Factor	DFWadj	events-cm^2/kg	NA		NA		NA		14654	

ABBREVIATIONS AND NOTES:

[1] = Table 8-1 of EPA (2011), Recommended Values for children ages 6 - <11 and 11 - <16

[2] = Based on the total number of days with precipitation greater than 0.01 inch in Hayden, AZ (http://www.myforecast.com/bin/climate.m?city=10857&metric=false)

[3] = One-tenth of the value for swimming (49 ml/hour; Table 3-5 of EPA (2011)) used to approximate incidental ingestion during wading in washes during storm water events

[4] = One-tenth of the value for swimming (21 ml/hour; Table 3-5 of EPA (2011)) used to approximate incidental ingestion during wading in washes during storm water events

[5] = Assumes two hours per event and that on days when play in storm water occurs , all daily exposure to storm water is derived from locations at the Site

[6] = Based on surface area of hands, forearms, lower legs, and feet

$AT_{lifetime}$ = Carcinogenic averaging time (lifetime)

cm^2 = cubic centimeter

cm_2/kg = cubic centimeter per kilogram

EPA, 2011 - Exposure Factors Handbook. EPA/600/R-10/030. October, 2011.

EPA, 2014 - Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. OSWER 9200.1-120. February 6, 2014.

EV = Event

event/day = event per day

FI = Fraction ingested

hr/event = hours per event

IR = Ingestion Rate

L/day = Liters per day

L/kg = Liters per kilogram

NA = Not Applicable

SA = Surface area

Tevent = Exposure time

Values are based on time-weighted average of child, adolescent, and adult exposure values, calculated as follows:

EF = (child EF x child ED) + (adolescent EF x adolescent ED) + (adult EF x adult ED) / total scenario ED

IFWadj = (child EF x child ED x child IR / child BW) + (adolescent EF x adolescent ED x adolescent IR / adolescent BW) + (adult EF x adult ED x adult IR / adult BW)

DFWadj = (child EF x child ED x child SA x child EV / child BW) + (adolescdent EF x adolescent ED x adolescent SA x adolescent EV / adolescent BW) + (adult EF x adult ED x adult SA x adult EV / adult BW)

ET = (child ET x child ED) + (adolescent ET x adolescent ED) + (adult ET x adult ED) / total scenario ED

TABLE 3.4
EXPOSURE FACTORS - AMBIENT AIR
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

SCENARIO USED TO CALCULATE RISKS			RESIDENT										WINKELMAN HIGH SCHOOL STAFF		WINKELMAN HIGH SCHOOL STUDENT	
RECEPTOR			CHILD (AGE 0-<6)		CHILD (AGE 6-<11)		ADOLESCENT (AGE 11 - <16)		ADULT		YOUNG CHILD, CHILD, ADOLESCENT, and ADULT		FULL-TIME WORKER (ADULT)		HIGH SCHOOL STUDENT	
Exposure Frequency	EF	day/year	350	EPA, 2014	350	EPA, 2014	350	EPA, 2014	350	EPA, 2014	350	EPA, 2014 [7]	250	EPA, 2014	180	Assumption [1]
Exposure Duration	ED	year	6	Ages 0- <6	5	Ages 6 - <11	5	Ages 11 - <16	10	Balance of 26-yr exposure	26	EPA, 2014	25	EPA, 2014	4	Assumption [1]
Non–carcinogenic Averaging Time	AT	day	2190	Exposure duration expressed in days	1825	Exposure duration expressed in days	1825	Exposure duration expressed in days	3650	Exposure duration expressed in days	9490	Exposure duration expressed in days	9125	Exposure duration expressed in days	1460	Exposure duration expressed in days
Carcinogenic Averaging Time	$AT_{lifetime}$	day	25550	70 year lifetime	25550	70 year lifetime	25550	70 year lifetime	25550	70 year lifetime	25550	70 year lifetime	25550	70 year lifetime	25550	70 year lifetime
Exposure Time - indoors	ET	hours/day	16.7	EPA, 2011 [8]	14.9	EPA, 2011 [8]	14.8	EPA, 2011 [8]	15.8	EPA, 2011 [8]	15.6	[7]			6	Assumption [2]
Exposure Time - outdoors	ET	hours/day	2.3	EPA, 2011 [9]	2.6	EPA, 2011 [9]	1.9	EPA, 2011 [9]	2.3	EPA, 2011 [9]	2.3	[7]	8	EPA, 2014	2	Assumption [2]

SCENARIO USED TO CALCULATE RISKS			IN-TOWN TRESPASSER								RESTRICTED FACILITY AREA TRESPASSER					
RECEPTOR			CHILD (AGE 6-<11)		ADOLESCENT (AGE 11 - <16)		ADULT		CHILD, ADOLESCENT, and ADULT		ADOLESCENT (AGE 11 - <16)		ADULT		ADOLESCENT and ADULT	
Exposure Frequency	EF	day/year	150	Site-specific [3]	250	Site-specific [3]	100	Site-specific [3]	138	Site-specific [7]	12	Site-specific [4]	12	Site-specific [4]	12	Site-specific [7]
Exposure Duration	ED	year	5	Ages 6 - <11	5	Ages 11 - <16	16	Balance of 26-yr exposure	26	EPA, 2014	5	Ages 11 - <16	21	Balance of 26-yr exposure [6]	26	EPA, 2014
Non–carcinogenic Averaging Time	AT	day	1825	Exposure duration expressed in days	1825	Exposure duration expressed in days	5840	Exposure duration expressed in days	9490	Exposure duration expressed in days	1825	Exposure duration expressed in days	7665	Exposure duration expressed in days	9490	Exposure duration expressed in days
Carcinogenic Averaging Time	$AT_{lifetime}$	day	25550	70 year lifetime	25550	70 year lifetime	25550	70 year lifetime	25550	70 year lifetime	25550	70 year lifetime	25550	70 year lifetime	25550	70 year lifetime
Exposure Time - outdoors	ET	hours/day	1	Site-specific [3]	1	Site-specific [3]	0.5	Site-specific [3]	0.69	Site-specific [7]	0.5	Site-specific [4]	0.5	Site-specific [4]	0.5	Site-specific [7]

SCENARIO USED TO CALCULATE RISKS			REMOTE TRESPASSER							
RECEPTOR			CHILD (AGE 6-<11)		ADOLESCENT (AGE 11 - <16)		ADULT		CHILD, ADOLESCENT, and ADULT	
Exposure Frequency	EF	day/year	26	Site-specific [5]	52	Site-specific [5]	52	Site-specific [5]	31	Site-specific [7]
Exposure Duration	ED	year	5	Ages 6 - <11	5	Ages 11 - <16	16	Balance of 26-yr exposure	26	EPA, 2014
Non–carcinogenic Averaging Time	AT	day	1825	Exposure duration expressed in days	1825	Exposure duration expressed in days	5840	Exposure duration expressed in days	9490	Exposure duration expressed in days
Carcinogenic Averaging Time	$AT_{lifetime}$	day	25550	70 year lifetime	25550	70 year lifetime	25550	70 year lifetime	25550	70 year lifetime
Exposure Time - outdoors	ET	hours/day	8	Site-specific [5]	8	Site-specific [5]	8	Site-specific [5]	8	Site-specific [7]

ABBREVIATIONS AND NOTES:

[1] = Assumes High School student is present 180 days per year for 4 years.

[2] = Assumes 6 hours per school-day indoors (classroom, study hall, lunch), and 2 hours per day outdoors (athletics participation)

[3] = Scenario is the In-Town Trespasser scenario from the Phase II HHRA for Soil, Water, and Sediment (H&A, 2015). Assumes one hour per day, five days per week (50 weeks/year) for adolescents who are assumed to 'hang out' in In-Town Areas; one hour per day, three days per week for children (6 - <11) who are assumed to explore/play in In-Town Areas, and one-half hour per day, two days per week for adults who are assumed to pass through In-Town Areas while accessing other portions of town.

[4] = Scenario is the Restricted Area Trespasser scenario from the Phase II HHRA for Soil, Water, and Sediment (H&A, 2015). Assumes one-half hour per day, one day per month for access to Restricted Facility Areas by adolescents and adults only.

[5] = Scenario is the Remote Area Trespasser scenario from the Phase II HHRA for Soil, Water, and Sediment (H&A, 2015). Assumes eight hours per day, one day per week for adolescents and adults assumed to access Off-Property Remote Areas. Assumes that younger children (ages 6 - <11) accompany adults or siblings every other time.

[6] = The adult receptor is evaluated for a longer duration of exposure (21 years versus 16 years in the other scenarios) to maintain the default 26-year residential exposure duration.

[7] = Values are based on time-weighted average of child, adolescent, and adult exposure values, calculated as follows:

EF = (child EF x child ED) + (adolescent EF x adolescent ED) + (adult EF x adult ED) / total scenario ED

ET = (child ET x child ED) + (adolescent ET x adolescent ED) + (adult ET x adult ED) / total scenario ED

[8] = Values are the mean values from Table 6-1, category "time indoors at residence", EPA, 2011.

[9] = Values are the mean values from Table 6-20, category "outdoors at home, yard, or other outside location at the home", EPA, 2011.

AT = Averaging time

$AT_{lifetime}$ = Carcinogenic averaging time (lifetime)

ED = Exposure duration

EF = Exposure frequency

EPA, 2011 - Exposure Factors Handbook. EPA/600/R-10/030. October, 2011.

EPA, 2014 - Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. OSWER 9200.1-120. February 6, 2014.

ET = Exposure time

TABLE 3.5

EXPOSURE POINT CONCENTRATIONS - SOIL EXPOSURE STUDY AREA A

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Chemical Name	Frequency of Detection	Range of Reporting Limits for Non-Detects	Range of Detected Concentrations	Average of All Samples	Background Value	95% UCL	EPC	Rationale	Statistic	Distribution
Inorganics (mg/kg)										
Aluminum	19 / 19		9880 - 36300	18709	22,901	21600	21600	(5)	95% Student's-t UCL	normal
Antimony	8 / 19	0.38 : 0.42	0.4 - 5	1	5.6	1.82	1.8	(5)	95% KM (t) UCL	nonparameteric
Arsenic	19 / 19		9.4 - 40.9	24	9.6	27.9	28	(5)	95% Student's-t UCL	normal
Barium	19 / 19		76.2 - 253	120	147	141	141	(5)	95% Modified-t UCL	normal
Cadmium	12 / 19	0.29 : 0.31	0.39 - 0.89	0	2.3	0.547	0.547	(5)	95% KM (t) UCL	nonparameteric
Chromium VI (Hexavalent)	0 / 2	0.15 : 0.15		0.08	ND	--	--	--	--	--
Cobalt	19 / 19		12.6 - 46.9	30	31	33.4	33.4	(5)	95% Student's-t UCL	normal
Copper	19 / 19		268 - 3570	1338	1,135	1650	1650	(5)	95% Student's-t UCL	normal
Iron	19 / 19		19900 - 71100	41853	33,590	47000	47000	(5)	95% Student's-t UCL	normal
Lead	19 / 19		19.4 - 88.1	53	43	62.0	53	(6)	Mean	normal
Manganese	19 / 19		267 - 644	404	617	447	447	(5)	95% Adjusted Gamma UCL	Gamma
Mercury	10 / 19	0.0051 : 0.0059	0.0053 - 0.021	0.0	0.058	0.0127	0.013	(5)	95% GROS Adjusted Gamma UCL	Gamma
Molybdenum	19 / 19		11.7 - 179	67	3.5	88.1	88.1	(5)	95% Student's-t UCL	normal
Nickel	19 / 19		12.3 - 39.5	28	30	31.0	31.0	(5)	95% Student's-t UCL	normal
Selenium	5 / 19	0.95 : 1	1.1 - 5.2	1	2.8	2.04	2.0	(5)	95% KM (t) UCL	nonparameteric
Silver	0 / 19	0.13 : 1.1		0	ND	--	--	--	--	--
Thallium	0 / 19	0.62 : 3.2		0.4	0.87	--	--	--	--	--
Vanadium	19 / 19		44.1 - 203	103	113	119	119	(5)	95% Student's-t UCL	normal
Zinc	19 / 19		61.7 - 483	232	104	291	291	(5)	95% Student's-t UCL	normal

ABBREVIATIONS AND NOTES:

-- = Chemical not detected above laboratory reporting limits

EPC = Exposure point concentration

mg/kg = milligrams per kilogram

ND = Non-Detect

UCL = Upper confidence limit

(1) Chemicals of potential concern (COPCs) are identified in Table 2.1.

(2) Arithmetic mean is calculated using the detection limit divided by 2 (DL/2) substitution method for not detected results.

(3) Revised 95% UCL is calculated using ProUCL software (V. 5.0.00); calculations presented in Appendix B.

(4) The maximum detected concentration is used as the EPC because it is lower than the calculated 95% UCL, or no 95% UCL is calculated.

(5) The 95% UCL is used as the EPC because the calculated 95% UCL is less than the maximum detected concentration.

(6) In accordance with USEPA guidance for evaluating lead exposure, the arithmetic mean concentration is used as the EPC.

TABLE 3.6

EXPOSURE POINT CONCENTRATION - SOIL EXPOSURE STUDY AREA B

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Chemical Name	Frequency of Detection	Range of Reporting Limits for Non-Detects	Range of Detected Concentrations	Average of All Samples	Background Value	95% UCL	EPC	Rationale	Statistic	Distribution
Inorganics (mg/kg)										
Aluminum	99 / 99		3340 - 30000	15030	22,901	16100	16100	(5)	95% Student's-t UCL	Normal
Antimony	13 / 99	0.38 : 2.1	0.55 - 80.3	1	5.6	3.02	3.02	(5)	95% KM (BCA) UCL	Nonparametric
Arsenic	98 / 99	0.67 : 0.67	5.5 - 628	31	9.6	44.3	44.3	(5)	95% KM (BCA) UCL	Nonparametric
Barium	99 / 99		20.1 - 688	97	147	106	106	(5)	95% Approximate Gamma UCL	Gamma
Cadmium	63 / 99	0.29 : 0.31	0.31 - 15.4	1	2.3	1.70	1.70	(5)	95% KM (BCA) UCL	Nonparametric
Chromium VI (Hexavalent)	0 / 3	0.15 : 0.15		0.08	ND			--		
Cobalt	99 / 99		4.8 - 98.8	29	31	31.5	31.5	(5)	95% Approximate Gamma UCL	Gamma
Copper	99 / 99		349 - 30900	3769	1,135	4400	4400	(5)	95% Approximate Gamma UCL	Gamma
Iron	99 / 99		6860 - 156000	39099	33,590	42400	42400	(5)	95% Approximate Gamma UCL	Gamma
Lead	99 / 99		8.6 - 9050	161	43	558	161	(6)	Mean	Nonparametric
Manganese	99 / 99		90.4 - 12300	510	617	1040	1040	(5)	95% Chebyshev (Mean, Sd) UCL	Nonparametric
Mercury	70 / 99	0.0051 : 0.006	0.0055 - 0.2	0.0	0.058	0.0487	0.0487	(5)	95% KM (Chebyshev) UCL	Nonparametric
Molybdenum	98 / 99	1.5 : 1.5	5.7 - 372	92	3.5	124	124	(5)	95% KM (Chebyshev) UCL	Nonparametric
Nickel	99 / 99		5.5 - 70.2	27	30	28.9	28.9	(5)	95% Approximate Gamma UCL	Gamma
Selenium	52 / 99	0.95 : 5.1	2.5 - 35	4	2.8	5.27	5.27	(5)	95% KM (% Bootstrap) UCL	Nonparametric
Silver	9 / 99	0.13 : 1.9	0.16 - 7.3	0	ND	0.724	0.724	(5)	95% KM (Percentile Bootstrap) UCL	Nonparametric
Thallium	4 / 99	0.62 : 3.4	1.3 - 9.9	0.9	0.87	0.976	0.67	(7)	Median	
Vanadium	99 / 99		14.3 - 207	81	113	87.6	87.6	(5)	95% Approximate Gamma UCL	Gamma
Zinc	99 / 99		26.3 - 14700	407	104	1050	1050	(5)	95% Chebyshev (Mean, Sd) UCL	Nonparametric

ABBREVIATIONS AND NOTES:

-- = Chemical not detected above laboratory reporting limits

EPC = Exposure point concentration

mg/kg = milligrams per kilogram

UCL = Upper confidence limit

(1) Chemicals of potential concern (COPCs) are identified in Table 2.1.

(2) Arithmetic mean is calculated using the detection limit divided by 2 (DL/2) substitution method for not detected results.

(3) Revised 95% UCL is calculated using ProUCL software (V. 5.0.00); calculations presented in Appendix B.

(4) The maximum detected concentration is used as the EPC because it is lower than the calculated 95% UCL, or no 95% UCL is calculated.

(5) The 95% UCL is used as the EPC because the calculated 95% UCL is less than the maximum detected concentration.

(6) In accordance with USEPA guidance for evaluating lead exposure, the arithmetic mean concentration is used as the EPC.

(7) In accordance with USEPA guidance for analytes that are detected in four or fewer samples, the EPCs are based on the median of the full data set.

TABLE 3.7

EXPOSURE POINT CONCENTRATIONS - SOIL EXPOSURE STUDY AREA C

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Chemical Name	Frequency of Detection	Range of Reporting Limits for Non-Detects	Range of Detected Concentrations	Average of All Samples	Background Value	95% UCL	EPC	Rationale	Statistic	Distribution
Inorganics (mg/kg)										
Aluminum	14 / 14		3590 - 29800	15212	22,901	19100	19100	(5)	95% Student's-t UCL	Normal
Antimony	3 / 14	0.38 : 0.42	0.43 - 2.2	0	5.6	0.795	0.4	(7)	Median	
Arsenic	13 / 14	0.67 : 0.67	6.6 - 24.5	14	9.6	17.6	17.6	(5)	95% KM (t) UCL	Nonparametric
Barium	14 / 14		19.9 - 188	103	147	126	126	(5)	95% Student's-t UCL	Normal
Cadmium	7 / 14	0.29 : 0.3	0.37 - 0.93	0	2.3	0.53	0.53	(5)	95% KM (t) UCL	Nonparametric
Chromium VI (Hexavalent)	0 / 1	0.15 : 0.15		0.08	ND			--		
Cobalt	14 / 14		3.7 - 33.6	16	31	20.3	20.3	(5)	95% Student's-t UCL	Normal
Copper	14 / 14		59.1 - 2080	793	1,135	1560	1560	(5)	95% Adjusted Gamma UCL	Gamma
Iron	14 / 14		7560 - 47300	26319	33,590	31700	31700	(5)	95% Student's-t UCL	Normal
Lead	14 / 14		8.1 - 54.2	30	43	37.5	30	(6)	Mean	Normal
Manganese	14 / 14		11.5 - 561	355	617	431	431	(5)	95% Student's-t UCL	Normal
Mercury	6 / 14	0.0051 : 0.006	0.0085 - 0.046	0.0	0.058	0.0203	0.0203	(5)	95% KM (t) UCL	Nonparametric
Molybdenum	9 / 14	1.4 : 1.5	1.6 - 177	37	3.5	62.0	62	(5)	95% KM (t) UCL	Nonparametric
Nickel	14 / 14		3.7 - 37.6	18	30	23.2	23.2	(5)	95% Student's-t UCL	Normal
Selenium	5 / 14	0.91 : 1	3.1 - 6.4	2	2.8	2.99	2.99	(5)	95% KM (t) UCL	Nonparametric
Silver	0 / 14	0.13 : 0.14		0	ND			(5)		
Thallium	0 / 14	0.6 : 0.67		0.3	0.87			(5)		
Vanadium	14 / 14		16.6 - 160	69	113	99.9	99.9	(5)	95% Adjusted Gamma UCL	Gamma
Zinc	14 / 14		20.2 - 287	111	104	156	156	(5)	95% Student's-t UCL	Normal

ABBREVIATIONS AND NOTES:

-- = Chemical not detected above laboratory reporting limits
EPC = Exposure point concentration
mg/kg = milligrams per kilogram
ND = Non-Detect
UCL = Upper confidence limit

(1) Chemicals of potential concern (COPCs) are identified in Table 2.1.
(2) Arithmetic mean is calculated using the detection limit divided by 2 (DL/2) substitution method for not detected results.
(3) Revised 95% UCL is calculated using ProUCL software (V. 5.0.00); calculations presented in Appendix B.
(4) The maximum detected concentration is used as the EPC because it is lower than the calculated 95% UCL, or no 95% UCL is calculated.
(5) The 95% UCL is used as the EPC because the calculated 95% UCL is less than the maximum detected concentration.
(6) In accordance with USEPA guidance for evaluating lead exposure, the arithmetic mean concentration is used as the EPC.
(7) In accordance with USEPA guidance for analytes that are detected in four or fewer samples, the EPCs are based on the median of the full data set.

TABLE 3.8

EXPOSURE POINT CONCENTRATIONS - SOIL EXPOSURE STUDY AREA D

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Chemical Name	Frequency of Detection	Range of Reporting Limits for Non-Detects	Range of Detected Concentrations	Average of All Samples	Background Value	95% UCL	EPC	Rationale	Statistic	Distribution
Inorganics (mg/kg)										
Aluminum	165 / 165		1280 - 27800	13706	22,901	16000	16000	(5)	95% Chebyshev (Mean, Sd) UCL	Nonparametric
Antimony	29 / 165	0.37 : 37	0.39 - 48	5	5.6	2.54	2.54	(5)	95% KM (BCA) UCL	Nonparametric
Arsenic	159 / 165	0.65 : 55	2.1 - 150	30	9.6	39.2	39.2	(5)	95% KM (Chebyshev) UCL	Nonparametric
Barium	165 / 165		10.2 - 779	96	147	121	121	(5)	95% Chebyshev (Mean, Sd) UCL	Nonparametric
Cadmium	142 / 165	0.068 : 2.5	0.35 - 21	4	2.3	5.07	5.07	(5)	95% KM (Chebyshev) UCL	Nonparametric
Chromium VI (Hexavalent)	3 / 16	0.15 : 0.15	0.15 - 0.31	0.10	ND	0.188	0.15	(7)	Median	
Cobalt	165 / 165		1.1 - 273	24	31	32.1	32.1	(5)	95% Chebyshev (Mean, Sd) UCL	Nonparametric
Copper	165 / 165		25.7 - 65800	8057	1,135	11400	11400	(5)	95% H-UCL	Log Normal
Iron	165 / 165		5880 - 133000	32452	33,590	39300	39300	(5)	95% Chebyshev (Mean, Sd) UCL	Nonparametric
Lead	164 / 165	14 : 14	5.9 - 2000	136	43	204	136	(6)	Mean	Nonparametric
Manganese	165 / 165		16.6 - 2170	460	617	567	567	(5)	95% Chebyshev (Mean, Sd) UCL	Nonparametric
Mercury	156 / 164	0.0053 : 0.1	0.0073 - 1.5	0.2	0.058	0.223	0.223	(5)	95% KM (Chebyshev) UCL	Nonparametric
Molybdenum	162 / 165	0.41 : 1.5	2.6 - 1020	78	3.5	94.5	94.5	(5)	95% KM (BCA) UCL	Nonparametric
Nickel	162 / 165	17 : 18	2.4 - 201	27	30	29.7	29.7	(5)	95% KM (BCA) UCL	Nonparametric
Selenium	115 / 165	0.94 : 56	1.2 - 59	11	2.8	8.13	8.13	(5)	95% KM (BCA) UCL	Nonparametric
Silver	67 / 165	0.13 : 14	0.21 - 24.5	3	ND	2.58	2.58	(5)	95% Approximate Gamma KM-UCL	Gamma
Thallium	4 / 165	0.59 : 32	2 - 6.9	3.7	0.87	0.797	0.67	(7)	Median	
Vanadium	153 / 165	51 : 52	6.8 - 149	63	113	67.3	67.3	(5)	95% KM (BCA) UCL	Nonparametric
Zinc	163 / 165	170 : 170	10.5 - 2680	329	104	450	450	(5)	95% KM (Chebyshev) UCL	Nonparametric

ABBREVIATIONS AND NOTES:

EPC = Exposure point concentration

mg/kg = milligrams per kilogram

ND = Non-Detect

UCL = Upper confidence limit

(1) Chemicals of potential concern (COPCs) are identified in Table 2.1.

(2) Arithmetic mean is calculated using the detection limit divided by 2 (DL/2) substitution method for not detected results.

(3) Revised 95% UCL is calculated using ProUCL software (V. 5.0.00); calculations presented in Appendix B.

(4) The maximum detected concentration is used as the EPC because it is lower than the calculated 95% UCL, or no 95% UCL is calculated.

(5) The 95% UCL is used as the EPC because the calculated 95% UCL is less than the maximum detected concentration.

(6) In accordance with USEPA guidance for evaluating lead exposure, the arithmetic mean concentration is used as the EPC.

(7) In accordance with USEPA guidance for analytes that are detected in four or fewer samples, the EPCs are based on the median of the full data set.

TABLE 3.9

EXPOSURE POINT CONCENTRATIONS - SOIL EXPOSURE STUDY AREA E

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Chemical Name	Frequency of Detection	Range of Reporting Limits for Non-Detects	Range of Detected Concentrations	Average of All Samples	Background Value	95% UCL	EPC	Rationale	Statistic	Distribution
Inorganics (mg/kg)										
Aluminum	17 / 17		4090 - 28500	12664	22,901	15400	15400	(5)	95% Student's-t UCL	Normal
Antimony	1 / 17	0.38 : 18	8.4 - 8.4	2	5.6	--	0.85	(7)	Median	
Arsenic	17 / 17		15.8 - 118	49	9.6	59.0	59.0	(5)	95% Student's-t UCL	Normal
Barium	17 / 17		32.8 - 175	84	147	101	101	(5)	95% Student's-t UCL	Normal
Cadmium	17 / 17		0.79 - 19	7	2.3	8.70	8.70	(5)	95% Student's-t UCL	Normal
Chromium VI (Hexavalent)	0 / 2	0.15 : 0.15		0.08	ND			--		
Cobalt	17 / 17		5.6 - 404	100	31	169	169	(5)	95% Adjusted Gamma UCL	Gamma
Copper	17 / 17		3790 - 135000	43813	1,135	58000	58000	(5)	95% Student's-t UCL	Normal
Iron	17 / 17		11600 - 74500	41641	33,590	48900	48900	(5)	95% Student's-t UCL	Normal
Lead	17 / 17		39.2 - 244	138	43	164	138	(6)	Mean	Normal
Manganese	17 / 17		84.3 - 2290	572	617	878	878	(5)	95% Adjusted Gamma UCL	Gamma
Mercury	17 / 17		0.038 - 0.31	0.2	0.058	0.191	0.191	(5)	95% Student's-t UCL	Normal
Molybdenum	17 / 17		99.8 - 2960	424	3.5	1130	1130	(5)	95% Chebyshev (Mean, Sd) UCL	Nonparametric
Nickel	17 / 17		8.2 - 242	75	30	114	114	(5)	95% Adjusted Gamma UCL	Gamma
Selenium	17 / 17		3.5 - 23.5	14	2.8	15.9	15.9	(5)	95% Student's-t UCL	Normal
Silver	16 / 17	0.14 : 0.14	2.2 - 13.4	6	ND	10.3	10.3	(5)	95% KM (Chebyshev) UCL	Nonparametric
Thallium	11 / 17	0.61 : 1.2	0.68 - 4.6	1.2	0.87	1.74	1.74	(5)	95% KM (BCA) UCL	Nonparametric
Vanadium	17 / 17		19.1 - 115	53	113	62.5	62.5	(5)	95% Student's-t UCL	Normal
Zinc	17 / 17		77.8 - 1540	595	104	886	886	(5)	95% Adjusted Gamma UCL	Gamma

ABBREVIATIONS AND NOTES:

-- = Chemical not detected above laboratory reporting limits
EPC = Exposure point concentration
mg/kg = milligrams per kilogram
ND = Non-Detect
UCL = Upper confidence limit

(1) Chemicals of potential concern (COPCs) are identified in Table 2.1.
(2) Arithmetic mean is calculated using the detection limit divided by 2 (DL/2) substitution method for not detected results.
(3) Revised 95% UCL is calculated using ProUCL software (V. 5.0.00); calculations presented in Appendix B.
(4) The maximum detected concentration is used as the EPC because it is lower than the calculated 95% UCL, or no 95% UCL is calculated.
(5) The 95% UCL is used as the EPC because the calculated 95% UCL is less than the maximum detected concentration.
(6) In accordance with USEPA guidance for evaluating lead exposure, the arithmetic mean concentration is used as the EPC.
(7) In accordance with USEPA guidance for analytes that are detected in four or fewer samples, the EPCs are based on the median of the full data set.

TABLE 3.10

EXPOSURE POINT CONCENTRATIONS - SOIL EXPOSURE STUDY AREA F

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Chemical Name	Frequency of Detection	Range of Reporting Limits for Non-Detects	Range of Detected Concentrations	Average of All Samples	Background Value	95% UCL	EPC	Rationale	Statistic	Distribution
Inorganics (mg/kg)										
Aluminum	495 / 497	330 : 330	341 - 30000	11221	22,901	11700	11700	(5)	95% KM (BCA) UCL	Nonparametric
Antimony	348 / 500	0.37 : 50	0.43 - 2190	82	5.6	132	132	(5)	97.5% KM (Chebyshev) UCL	Nonparametric
Arsenic	478 / 500	1.2 : 55	3 - 37400	990	9.6	1910	1910	(5)	97.5% KM (Chebyshev) UCL	Nonparametric
Barium	494 / 497	10 : 10	8.9 - 10800	278	147	418	418	(5)	95% KM (Chebyshev) UCL	Nonparametric
Cadmium	458 / 497	0.071 : 2.5	0.33 - 3080	96	2.3	174	174	(5)	97.5% KM (Chebyshev) UCL	Nonparametric
Chromium VI (Hexavalent)	21 / 47	0.04 : 0.4	0.02 - 4	0.38	ND	0.612	0.612	(5)	95% Adjusted Gamma KM-UCL	Gamma
Cobalt	490 / 497	1 : 53	0.44 - 351	47	31	49.8	49.8	(5)	95% KM (BCA) UCL	Nonparametric
Copper	497 / 497		51 - 721000	68583	1,135	85600	85600	(5)	95% Chebyshev (Mean, Sd) UCL	Nonparametric
Iron	497 / 497		290 - 290000	77149	33,590	88700	88700	(5)	95% Chebyshev (Mean, Sd) UCL	Nonparametric
Lead	493 / 497	13 : 14	10.4 - 343000	5556	43	14000	5556	(6)	Mean	Nonparametric
Manganese	496 / 497	7.1 : 7.1	4.4 - 2720	429	617	454	454	(5)	95% KM (BCA) UCL	Nonparametric
Mercury	463 / 497	0.0055 : 0.11	0.0069 - 591	9.6	0.058	23.5	23.5	(5)	97.5% KM (Chebyshev) UCL	Nonparametric
Molybdenum	493 / 497	5.5 : 5.7	2.7 - 340000	1438	3.5	5720	5720	(5)	97.5% KM (Chebyshev) UCL	Nonparametric
Nickel	475 / 497	17 : 18	0.85 - 1170	76	30	85.3	85.3	(5)	95% KM (BCA) UCL	Nonparametric
Selenium	408 / 500	0.56 : 56	1.6 - 2270	83	2.8	115	115	(5)	95% KM (Chebyshev) UCL	Nonparametric
Silver	407 / 500	0.13 : 14	0.32 - 1180	68	ND	107	107	(5)	95% KM (Chebyshev) UCL	Nonparametric
Thallium	141 / 500	0.32 : 310	0.81 - 357	11.9	0.87	10.7	10.7	(5)	95% KM (BCA) UCL	Nonparametric
Vanadium	352 / 497	0.52 : 5100	2 - 1100	65	113	67.3	67.3	(5)	95% KM (BCA) UCL	Nonparametric
Zinc	490 / 497	170 : 170	29 - 52400	3243	104	4210	4210	(5)	95% KM (Chebyshev) UCL	Nonparametric

ABBREVIATIONS AND NOTES:

EPC = Exposure point concentration
mg/kg = milligrams per kilogram
ND = Non-Detect
UCL = Upper confidence limit

(1) Chemicals of potential concern (COPCs) are identified in Table 2.1.
(2) Arithmetic mean is calculated using the detection limit divided by 2 (DL/2) substitution method for not detected results.
(3) Revised 95% UCL is calculated using ProUCL software (V. 5.0.00); calculations presented in Appendix B.
(4) The maximum detected concentration is used as the EPC because it is lower than the calculated 95% UCL, or no 95% UCL is calculated.
(5) The 95% UCL is used as the EPC because the calculated 95% UCL is less than the maximum detected concentration.
(6) In accordance with USEPA guidance for evaluating lead exposure, the arithmetic mean concentration is used as the EPC.

TABLE 3.11

EXPOSURE POINT CONCENTRATIONS - SOIL EXPOSURE STUDY AREA G

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Chemical Name	Frequency of Detection	Range of Reporting Limits for Non-Detects	Range of Detected Concentrations	Average of All Samples	Background Value	95% UCL	EPC	Rationale	Statistic	Distribution
Inorganics (mg/kg)										
Aluminum	7 / 7		14400 - 24600	19557	22,901	22500	22500	(5)	95% Student's-t UCL	Normal
Antimony	3 / 7	0.4 : 36	4.6 - 7.5	5	5.6	6.01	4.6	(7)	Median	
Arsenic	7 / 7		73.2 - 142	97	9.6	115	115	(5)	95% Student's-t UCL	Normal
Barium	7 / 7		109 - 232	149	147	182	182	(5)	95% Student's-t UCL	Normal
Cadmium	7 / 7		3.4 - 18.2	11	2.3	14.4	14.4	(5)	95% Student's-t UCL	Normal
Chromium VI (Hexavalent)	0 / 1	0.15 : 0.15		0.08	ND			--		
Cobalt	7 / 7		29.3 - 72.7	40	31	51.9	51.9	(5)	95% Student's-t UCL	Normal
Copper	7 / 7		8140 - 21000	15506	1,135	18500	18500	(5)	95% Student's-t UCL	Normal
Iron	7 / 7		43700 - 73200	50957	33,590	59000	59000	(5)	95% Student's-t UCL	Normal
Lead	7 / 7		211 - 473	315	43	391	315	(6)	Mean	Normal
Manganese	7 / 7		457 - 691	615	617	674	674	(5)	95% Student's-t UCL	Normal
Mercury	7 / 7		0.097 - 0.37	0.3	0.058	0.332	0.332	(5)	95% Student's-t UCL	Normal
Molybdenum	7 / 7		86.2 - 970	252	3.5	778	778	(5)	95% Chebyshev(Mean, Sd) UCL	Nonparametric
Nickel	7 / 7		37.6 - 54	45	30	49.6	49.6	(5)	95% Student's-t UCL	Normal
Selenium	6 / 7	55 : 55	7.1 - 12.7	12	2.8	11.9	11.9	(5)	95% KM (t) UCL	Nonparametric
Silver	7 / 7		1.2 - 18	10	ND	14.6	14.6	(5)	95% Student's-t UCL	Normal
Thallium	2 / 7	0.64 : 32	0.71 - 0.75	2.7	0.87	0.719	0.67	(7)	Median	
Vanadium	6 / 7	52 : 52	71.7 - 107	87	113	106	106	(5)	95% KM (t) UCL	Nonparametric
Zinc	7 / 7		512 - 1430	865	104	1120	1120	(5)	95% Student's-t UCL	Normal

ABBREVIATIONS AND NOTES:

-- = Chemical not detected above laboratory reporting limits
EPC = Exposure point concentration
mg/kg = milligrams per kilogram
ND = Non-Detect
UCL = Upper confidence limit

(1) Chemicals of potential concern (COPCs) are identified in Table 2.1.
(2) Arithmetic mean is calculated using the detection limit divided by 2 (DL/2) substitution method for not detected results.
(3) Revised 95% UCL is calculated using ProUCL software (V. 5.0.00); calculations presented in Appendix B.
(4) The maximum detected concentration is used as the EPC because it is lower than the calculated 95% UCL, or no 95% UCL is calculated.
(5) The 95% UCL is used as the EPC because the calculated 95% UCL is less than the maximum detected concentration.
(6) In accordance with USEPA guidance for evaluating lead exposure, the arithmetic mean concentration is used as the EPC.
(7) In accordance with USEPA guidance for analytes that are detected in four or fewer samples, the EPCs are based on the median of the full data set.

TABLE 3.12

EXPOSURE POINT CONCENTRATIONS - SOIL EXPOSURE STUDY AREA H

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Chemical Name	Frequency of Detection	Range of Reporting Limits for Non-Detects	Range of Detected Concentrations	Average of All Samples	Background Value	95% UCL	EPC	Rationale	Statistic	Distribution
Inorganics (mg/kg)										
Aluminum	70 / 70		5670 - 25000	15685	22,901	16600	16600	(5)	95% Student's-t UCL	Normal
Antimony	36 / 70	0.37 : 2.1	0.64 - 135	8	5.6	20.1	20.1	(5)	95% KM (Chebyshev) UCL	Nonparametric
Arsenic	67 / 70	0.55 : 0.7	1.4 - 550	56	9.6	111	111	(5)	95% KM (Chebyshev) UCL	Nonparametric
Barium	70 / 70		38 - 999	116	147	181	181	(5)	95% Chebyshev (Mean, Sd) UCL	Nonparametric
Cadmium	68 / 70	1.5 : 1.5	0.14 - 129	7	2.3	18.5	18.5	(5)	95% KM (Chebyshev) UCL	Nonparametric
Chromium VI (Hexavalent)	2 / 2		0.016 - 0.17	0.09	ND		0.093	(7)	Median	
Cobalt	70 / 70		8.8 - 86.7	23	31	30.1	30.1	(5)	95% Chebyshev (Mean, Sd) UCL	Nonparametric
Copper	70 / 70		170 - 105000	8976	1,135	12300	12300	(5)	95% H-UCL	Log Normal
Iron	70 / 70		15400 - 128000	33347	33,590	37500	37500	(5)	95% Modified-t UCL	Normal
Lead	70 / 70		9.8 - 11000	479	43	1400	479	(6)	Mean	Nonparametric
Manganese	70 / 70		251 - 6560	737	617	1190	1190	(5)	95% Chebyshev (Mean, Sd) UCL	Nonparametric
Mercury	59 / 70	0.0051 : 0.038	0.0055 - 3.7	0.1	0.058	0.353	0.353	(5)	95% KM (Chebyshev) UCL	Nonparametric
Molybdenum	59 / 70	1.4 : 1.6	1.2 - 673	73	3.5	182	182	(5)	97.5% KM (Chebyshev) UCL	Nonparametric
Nickel	70 / 70		14.2 - 188	35	30	52.3	52.3	(5)	95% Chebyshev(Mean, Sd) UCL	Nonparametric
Selenium	69 / 70	0.95 : 0.95	0.98 - 194	11	2.8	18	18	(5)	95% KM (BCA) UCL	Nonparametric
Silver	43 / 70	0.13 : 0.71	0.16 - 463	14	ND	57.2	57.2	(5)	97.5% KM (Chebyshev) UCL	Nonparametric
Thallium	10 / 70	0.32 : 3.4	0.76 - 9.8	0.8	0.87	1.24	1.24	(5)	95% Approximate Gamma KM-UCL	Gamma
Vanadium	70 / 70		29 - 136	74	113	78.9	78.9	(5)	95% Student's-t UCL	Normal
Zinc	70 / 70		42 - 15500	708	104	2020	2020	(5)	95% Chebyshev (Mean, Sd) UCL	Nonparametric

ABBREVIATIONS AND NOTES:

EPC = Exposure point concentration

mg/kg = milligrams per kilogram

ND = Non-Detect

UCL = Upper confidence limit

(1) Chemicals of potential concern (COPCs) are identified in Table 2.1.

(2) Arithmetic mean is calculated using the detection limit divided by 2 (DL/2) substitution method for not detected results.

(3) Revised 95% UCL is calculated using ProUCL software (V. 5.0.00); calculations presented in Appendix B.

(4) The maximum detected concentration is used as the EPC because it is lower than the calculated 95% UCL, or no 95% UCL is calculated.

(5) The 95% UCL is used as the EPC because the calculated 95% UCL is less than the maximum detected concentration.

(6) In accordance with USEPA guidance for evaluating lead exposure, the arithmetic mean concentration is used as the EPC.

(7) In accordance with USEPA guidance for analytes that are detected in four or fewer samples, the EPCs are based on the median of the full data set.

TABLE 3.13

EXPOSURE POINT CONCENTRATIONS - SOIL EXPOSURE STUDY AREA I

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Chemical Name	Frequency of Detection	Range of Reporting Limits for Non-Detects	Range of Detected Concentrations	Average of All Samples	Background Value	95% UCL	EPC	Rationale	Statistic	Distribution
Inorganics (mg/kg)										
Aluminum	5 / 5		6450 - 17000	11188	22,901	15100	15100	(5)	95% Student's-t UCL	Normal
Antimony	4 / 5	36 : 36	3.1 - 17.4	11	5.6	17.0	13.4	(7)	Median	
Arsenic	4 / 5	1.3 : 1.3	52.9 - 210	97	9.6	176	87	(7)	Median	
Barium	5 / 5		140 - 230	178	147	213	213	(5)	95% Student's-t UCL	Normal
Cadmium	4 / 5	2.5 : 2.5	4.9 - 21	8	2.3	15.8	6.2	(7)	Median	
Cobalt	5 / 5		12 - 35	20.74	31	29.5	29.5	(5)	95% Student's-t UCL	Normal
Copper	5 / 5		1400 - 46000	21020	1,135	36600	36600	(5)	95% Student's-t UCL	Normal
Iron	5 / 5		28600 - 64000	41440	33,590	54800	54800	(5)	95% Student's-t UCL	Normal
Lead	5 / 5		29 - 570	233	43	434	233	(6)	Mean	Normal
Manganese	5 / 5		274 - 510	396	617	496	496	(5)	95% Student's-t UCL	Normal
Mercury	5 / 5		0.11 - 1.9	1	0.058	2.03	1.9	(4)	95% Chebyshev (Mean, Sd) UCL	Nonparametric
Molybdenum	5 / 5		11 - 450	174.0	3.5	330	330	(5)	95% Student's-t UCL	Normal
Nickel	4 / 5	18 : 18	14.3 - 41	26	30	38.9	32.5	(7)	Median	
Selenium	4 / 5	55 : 55	4.3 - 14.5	13	2.8	14.7	12.8	(7)	Median	
Silver	3 / 5	0.22 : 14	6.6 - 31	12	ND	25.2	14	(7)	Median	
Thallium	1 / 5	0.75 : 32	1.4 - 1.4	4	0.87		1.2	(7)	Median	
Vanadium	4 / 5	51 : 51	42.3 - 68	48.4	113	62.1	52	(7)	Median	
Zinc	4 / 5	170 : 170	938 - 3700	1376	104	2720	956	(7)	Median	

ABBREVIATIONS AND NOTES:

EPC = Exposure point concentration
mg/kg = milligrams per kilogram
UCL = Upper confidence limit

(1) Chemicals of potential concern (COPCs) are identified in Table 2.1.
(2) Arithmetic mean is calculated using the detection limit divided by 2 (DL/2) substitution method for not detected results.
(3) Revised 95% UCL is calculated using ProUCL software (V. 5.0.00); calculations presented in Appendix B.
(4) The maximum detected concentration is used as the EPC because it is lower than the calculated 95% UCL, or no 95% UCL is calculated.
(5) The 95% UCL is used as the EPC because the calculated 95% UCL is less than the maximum detected concentration.
(6) In accordance with USEPA guidance for evaluating lead exposure, the arithmetic mean concentration is used as the EPC.
(7) In accordance with USEPA guidance for analytes that are detected in four or fewer samples, the EPCs are based on the median of the full data set.

TABLE 3.14

EXPOSURE POINT CONCENTRATIONS - SOIL EXPOSURE STUDY AREA J

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Chemical Name	Frequency of Detection	Range of Reporting Limits for Non-Detects	Range of Detected Concentrations	Average of All Samples	Background Value	95% UCL	EPC	Rationale	Statistic	Distribution
Inorganics (mg/kg)										
Aluminum	171 / 171		1000 - 29000	12195	22,901	14600	14600	(5)	95% Chebyshev (Mean, Sd) UCL	Nonparametric
Antimony	68 / 173	0.37 : 37	0.75 - 299	23	5.6	30.1	30.1	(5)	95% KM (Chebyshev) UCL	Nonparametric
Arsenic	141 / 173	54 : 55	1.1 - 1590	126	9.6	231	231	(5)	97.5% KM (Chebyshev) UCL	Nonparametric
Barium	159 / 171	10 : 10	15 - 15100	302	147	537	537	(5)	95% KM (BCA) UCL	Nonparametric
Cadmium	132 / 171	0.16 : 2.5	0.14 - 210	16	2.3	25.1	25.1	(5)	95% KM (Chebyshev) UCL	Nonparametric
Chromium VI (Hexavalent)	5 / 16	0.15 : 0.4	0.15 - 0.65	0.16	ND	0.247	0.247	(5)	95% KM (% Bootstrap) UCL	Nonparametric
Cobalt	155 / 171	0.11 : 5.5	0.84 - 190	32	31	36.1	36.1	(5)	95% KM (BCA) UCL	Nonparametric
Copper	171 / 171		110 - 280000	24431	1,135	34500	34500	(5)	95% H-UCL	Log Normal
Iron	171 / 171		4500 - 220000	50448	33,590	55800	55800	(5)	95% H-UCL	Log Normal
Lead	167 / 171	0.14 : 14	7.3 - 7890	382	43	658	382	(6)	Mean	Nonparametric
Manganese	167 / 171	7.1 : 7.1	22 - 980	416	617	445	445	(5)	95% KM (t) UCL	Nonparametric
Mercury	139 / 171	0.034 : 0.1	0.01 - 297	3.5	0.058	12.9	12.9	(5)	95% KM (Chebyshev) UCL	Nonparametric
Molybdenum	160 / 171	0.43 : 5.7	3.9 - 1500	210	3.5	308	308	(5)	95% KM (Chebyshev) UCL	Nonparametric
Nickel	141 / 171	17 : 18	1.8 - 260	36	30	41.3	41.3	(5)	95% KM (BCA) UCL	Nonparametric
Selenium	65 / 173	0.55 : 56	0.61 - 401	28	2.8	33.8	33.8	(5)	95% KM (Chebyshev) UCL	Nonparametric
Silver	89 / 173	0.14 : 14	0.35 - 540	17	ND	39.4	39.4	(5)	97.5% KM (Chebyshev) UCL	Nonparametric
Thallium	22 / 173	0.32 : 32	0.52 - 6.4	8.7	0.87	1.39	1.39	(5)	95% KM (t) UCL	Nonparametric
Vanadium	95 / 171	0.52 : 52	6.5 - 170	50	113	54.7	54.7	(5)	95% KM (t) UCL	Nonparametric
Zinc	156 / 171	170 : 170	31 - 31000	846	104	1220	1220	(5)	95% KM (BCA) UCL	Nonparametric

ABBREVIATIONS AND NOTES:

EPC = Exposure point concentration

mg/kg = milligrams per kilogram

ND = Non-Detect

UCL = Upper confidence limit

(1) Chemicals of potential concern (COPCs) are identified in Table 2.1.

(2) Arithmetic mean is calculated using the detection limit divided by 2 (DL/2) substitution method for not detected results.

(3) Revised 95% UCL is calculated using ProUCL software (V. 5.0.00); calculations presented in Appendix B.

(4) The maximum detected concentration is used as the EPC because it is lower than the calculated 95% UCL, or no 95% UCL is calculated.

(5) The 95% UCL is used as the EPC because the calculated 95% UCL is less than the maximum detected concentration.

(6) In accordance with USEPA guidance for evaluating lead exposure, the arithmetic mean concentration is used as the EPC.

TABLE 3.15

EXPOSURE POINT CONCENTRATIONS - SOIL EXPOSURE STUDY AREA K

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Chemical Name	Frequency of Detection	Range of Reporting Limits for Non-Detects	Range of Detected Concentrations	Average of All Samples	Background Value	95% UCL	EPC	Rationale	Statistic	Distribution
Inorganics (mg/kg)										
Aluminum	163 / 163		420 - 37500	15870	22,901	16800	16800	(5)	95% Student's-t UCL	Normal
Antimony	84 / 158	0.093 : 37	0.11 - 290	9	5.6	16.6	16.6	(5)	95% KM (Chebyshev) UCL	Nonparametric
Arsenic	140 / 163	0.23 : 55	0.97 - 1000	43	9.6	78.0	78.0	(5)	95% KM (Chebyshev) UCL	Nonparametric
Barium	161 / 163	10 : 10	18.8 - 313	93	147	101	101	(5)	95% Approximate Gamma KM-UCL	Gamma
Cadmium	142 / 163	0.065 : 2.5	0.12 - 85	8	2.3	12.5	12.5	(5)	95% KM (Chebyshev) UCL	Nonparametric
Chromium VI (Hexavalent)	4 / 25	0.15 : 0.4	0.3 - 2	0.29	ND	0.526	0.15	(7)	Median	
Cobalt	163 / 163		2.9 - 72.3	21	31	23.6	23.6	(5)	95% H-UCL	Log Normal
Copper	163 / 163		41.7 - 100000	8611	1,135	15300	15300	(5)	95% H-UCL	Log Normal
Iron	163 / 163		5240 - 140000	36959	33,590	46000	46000	(5)	95% Chebyshev (Mean, Sd) UCL	Nonparametric
Lead	163 / 163		4.7 - 9200	222	43	498	222	(6)	Mean	Nonparametric
Manganese	162 / 163	7.1 : 7.1	48 - 2330	530	617	564	564	(5)	95% KM (Percentile Bootstrap) UCL	Nonparametric
Mercury	140 / 163	0.005 : 0.038	0.0062 - 50	0.7	0.058	2.67	2.67	(5)	97.5% KM (Chebyshev) UCL	Nonparametric
Molybdenum	153 / 163	0.076 : 1.6	0.69 - 2400	96	3.5	232	232	(5)	97.5% KM (Chebyshev) UCL	Nonparametric
Nickel	161 / 163	18 : 18	3.7 - 150	29	30	32.2	32.2	(5)	95% KM (BCA) UCL	Nonparametric
Selenium	130 / 163	0.39 : 56	0.93 - 110	9	2.8	8.51	8.51	(5)	95% KM (BCA) UCL	Nonparametric
Silver	95 / 163	0.042 : 14	0.31 - 28	4	ND	5.40	5.40	(5)	95% KM (Chebyshev) UCL	Nonparametric
Thallium	20 / 163	0.15 : 32	0.27 - 11.1	2.5	0.87	0.707	0.707	(5)	95% Approximate Gamma KM-UCL	Gamma
Vanadium	153 / 163	51 : 52	7 - 162	63	113	66.9	66.9	(5)	95% KM (t) UCL	Nonparametric
Zinc	158 / 163	17 : 170	21.2 - 5900	465	104	757	757	(5)	95% KM (Chebyshev) UCL	Nonparametric

ABBREVIATIONS AND NOTES:

EPC = Exposure point concentration

mg/kg = milligrams per kilogram

ND = Non-Detect

UCL = Upper confidence limit

(1) Chemicals of potential concern (COPCs) are identified in Table 2.1.

(2) Arithmetic mean is calculated using the detection limit divided by 2 (DL/2) substitution method for not detected results.

(3) Revised 95% UCL is calculated using ProUCL software (V. 5.0.00); calculations presented in Appendix B.

(4) The maximum detected concentration is used as the EPC because it is lower than the calculated 95% UCL, or no 95% UCL is calculated.

(5) The 95% UCL is used as the EPC because the calculated 95% UCL is less than the maximum detected concentration.

(6) In accordance with USEPA guidance for evaluating lead exposure, the arithmetic mean concentration is used as the EPC.

(7) In accordance with USEPA guidance for analytes that are detected in four or fewer samples, the EPCs are based on the median of the full data set.

TABLE 3.16
EXPOSURE POINT CONCENTRATIONS - STORM WATER
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

Chemical Name	Frequency of Detection	Range of Reporting Limits for Non-Detects	Range of Detected Concentrations	Average of All Samples	Background Threshold Value [a]	95% UCL	EPC	Rationale	Statistic	Distribution
Metals, Total (mg/L)										
Aluminum, Total	27 / 27		0.796 - 3700	158	NC	752	752	(5)	95% Chebyshev (Mean, Sd) UCL	Lognormal
Antimony, Total	24 / 27	0.025 : 0.06	0.0012 - 0.066	0.015	NC	0.0354	0.0354	(5)	97.5% KM (Chebyshev) UCL	Lognormal
Arsenic, Total	27 / 27		0.0051 - 8.66	0.57	NC	1.96	1.96	(5)	95% Chebyshev (Mean, Sd) UCL	Lognormal
Barium, Total	27 / 27		0.0206 - 13.9	0.68	NC	2.9	2.9	(5)	95% Chebyshev (Mean, Sd) UCL	Nonparametric
Beryllium, Total	4 / 27	0.005 : 0.025	0.00035 - 0.134	0.0095	NC	0.0158	0.0158	(5)	95% KM (t) UCL	Normal
Boron, Total	13 / 27	0.15 : 0.75	0.0274 - 1.29	0.22	NC	0.703	0.703	(5)	95% Adjusted Gamma KM-UCL	Gamma
Cadmium, Total	23 / 27	0.003 : 0.003	0.0038 - 3.52	0.16	NC	1.45	1.45	(5)	99% KM (Chebyshev) UCL	Lognormal
Chromium, Total	23 / 27	0.01 : 0.05	0.0016 - 5.31	0.22	NC	2.18	2.18	(5)	99% KM (Chebyshev) UCL	Lognormal
Cobalt, Total	27 / 27		0.0024 - 5.26	0.41	NC	1.75	1.75	(5)	97.5% Chebyshev (Mean, Sd) UCL	Lognormal
Copper, Total	27 / 27		1.1 - 6630	425	NC	2080	2080	(5)	97.5% Chebyshev (Mean, Sd) UCL	Nonparametric
Iron, Total	27 / 27		1.07 - 8380	336	NC	1680	1680	(5)	95% Chebyshev (Mean, Sd) UCL	Lognormal
Lead, Total	26 / 27	0.01 : 0.01	0.0116 - 109	4.6	NC	44.6	4.6	(6)	99% KM (Chebyshev) UCL	Lognormal
Manganese, Total	27 / 27		0.0881 - 82	5.0	NC	18.1	18.1	(5)	95% Chebyshev (Mean, Sd) UCL	Lognormal
Mercury, Total	25 / 27	0.0002 : 0.0002	0.000093 - 0.081	0.0048	NC	0.0344	0.0344	(5)	99% KM (Chebyshev) UCL	Lognormal
Molybdenum, Total	27 / 27		0.0146 - 70.5	2.8	NC	14.1	14.1	(5)	95% Chebyshev (Mean, Sd) UCL	Nonparametric
Nickel, Total	21 / 27	0.02 : 0.1	0.0036 - 5.38	0.40	NC	2.50	2.5	(5)	99% KM (Chebyshev) UCL	Lognormal
Selenium, Total	27 / 27		0.0024 - 0.483	0.062	NC	0.131	0.131	(5)	95% H-UCL	Lognormal
Silver, Total	17 / 27	0.01 : 0.05	0.00063 - 5.84	0.24	NC	2.41	2.41	(5)	99% KM (Chebyshev) UCL	Lognormal
Thallium, Total	23 / 27	0.0001 : 0.02	0.000051 - 0.0509	0.0033	NC	0.0219	0.0219	(5)	99% KM (Chebyshev) UCL	Lognormal
Vanadium, Total	25 / 27	0.075 : 0.075	0.0011 - 9.68	0.41	NC	3.96	3.96	(5)	99% KM (Chebyshev) UCL	Lognormal
Zinc, Total	27 / 27		0.0887 - 328	15.5	NC	68.1	68.1	(5)	95% Chebyshev (Mean, Sd) UCL	Lognormal
Metals, Dissolved (mg/L)										
Aluminum, Dissolved	25 / 34	0.2 : 1	0.0282 - 2.16	0.27	6.674	0.751	0.751	(5)	97.5% KM (Chebyshev) UCL	Lognormal
Antimony, Dissolved	33 / 34	0.025 : 0.025	0.00042 - 0.0476	0.0084	0.0142	0.0162	0.0162	(5)	95% KM (Chebyshev) UCL	Lognormal
Arsenic, Dissolved	32 / 34	0.0025 : 0.025	0.0012 - 0.319	0.035	0.144	0.0986	0.0986	(5)	97.5% KM (Chebyshev) UCL	Lognormal
Barium, Dissolved	32 / 34	0.01 : 0.05	0.0029 - 0.385	0.062	0.161	0.113	0.113	(5)	95% KM (Chebyshev) UCL	Lognormal
Beryllium, Dissolved	0 / 34	0.005 : 0.025			ND		ND			
Boron, Dissolved	18 / 34	0.15 : 0.75	0.0137 - 0.698	0.15	0.184	0.188	0.188	(5)	95% KM (t) UCL	Normal
Cadmium, Dissolved	19 / 34	0.003 : 0.015	0.0014 - 0.143	0.015	0.003	0.0281	0.0281	(5)	95% Adjusted Gamma KM-UCL	Gamma
Chromium, Dissolved	14 / 34	0.01 : 0.05	0.00082 - 0.0455	0.0071	0.011	0.00765	0.00765	(5)	95% KM (BCA) UCL	Nonparametric
Cobalt, Dissolved	33 / 34	0.0005 : 0.0005	0.00016 - 2.73	0.14	0.0034	0.987	0.987	(5)	99% KM (Chebyshev) UCL	Lognormal
Copper, Dissolved	34 / 34		0.03 - 3080	152	1.765	762.7	762.7	(5)	97.5% Chebyshev (Mean, Sd) UCL	Lognormal
Iron, Dissolved	28 / 34	0.05 : 0.25	0.019 - 53.9	2.4	5.56	18.9	18.9	(5)	99% KM (Chebyshev) UCL	Nonparametric
Lead, Dissolved	24 / 34	0.01 : 0.05	0.0016 - 3.04	0.23	0.0323	1.29	0.23	(6)	99% KM (Chebyshev) UCL	Lognormal
Manganese, Dissolved	34 / 34		0.0071 - 6.27	0.93	0.309	1.51	1.51	(5)	95% Adjusted Gamma UCL	Gamma
Mercury, Dissolved	22 / 34	0.0002 : 0.0002	0.00003 - 0.0092	0.00079	NC	0.00406	0.00406	(5)	99% KM (Chebyshev) UCL	Lognormal
Molybdenum, Dissolved	33 / 34	0.015 : 0.015	0.0118 - 1.04	0.14	0.122	0.346	0.346	(5)	97.5% KM (Chebyshev) UCL	Lognormal
Nickel, Dissolved	16 / 34	0.02 : 0.1	0.0032 - 2.13	0.12	0.00859	0.436	0.436	(5)	95% Adjusted Gamma KM-UCL	Gamma
Selenium, Dissolved	34 / 34		0.0014 - 0.133	0.022	0.0336	0.0298	0.0298	(5)	95% Adjusted Gamma UCL	Gamma
Silver, Dissolved	5 / 34	0.01 : 0.05	0.00064 - 0.0983	0.012	ND	0.019	0.019	(5)	95% KM (Percentile Bootstrap) UCL	Normal
Thallium, Dissolved	14 / 34	0.0001 : 0.01	0.000033 - 0.00047	0.00048	0.00013391	0.000139	0.000139	(5)	95% KM (t) UCL	Normal
Vanadium, Dissolved	14 / 34	0.015 : 0.075	0.0013 - 0.195	0.016	0.0289	0.0246	0.0246	(5)	95% KM (BCA) UCL	Nonparametric
Zinc, Dissolved	30 / 34	0.02 : 0.1	0.0045 - 7.43	0.70	0.0727	3.23	3.23	(5)	99% KM (Chebyshev) UCL	Lognormal

TABLE 3.16
EXPOSURE POINT CONCENTRATIONS - STORM WATER
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

Chemical Name	Frequency of Detection	Range of Reporting Limits for Non-Detects	Range of Detected Concentrations	Average of All Samples	Background Threshold Value [a]	95% UCL	EPC	Rationale	Statistic	Distribution
General Chemistry (mg/L)										
Alkalinity, Bicarbonate	1 / 1		464 - 464	464			464	(4)		
Alkalinity, Carbonate	0 / 1	5 : 5					ND			
Alkalinity, Total (as CaCO3)	29 / 29		14.6 - 4030	415	NC	624	624	(5)	95% Adjusted Gamma UCL	Gamma
Chloride	29 / 29		1.2 - 1080	157	NC	280	280	(5)	95% Adjusted Gamma UCL	Gamma
Cyanide	23 / 33	0.01 : 0.05	0.0054 - 0.0501	0.014	NC	0.016	0.016	(5)	95% KM (BCA) UCL	Lognormal
Fluoride	21 / 29	1 : 1	0.12 - 14	1.3	NC	3.38	3.38	(5)	95% KM (Chebyshev) UCL	Gamma
Nitrite/Nitrate Nitrogen	33 / 34	0.02 : 0.02	0.061 - 7.3	1.6	NC	2.78	2.78	(5)	95% KM (Chebyshev) UCL	Gamma
Sulfate	29 / 29		19.3 - 15900	1247	NC	2090	2090	(5)	95% Adjusted Gamma UCL	Gamma
Total Dissolved Solids (TDS)	28 / 28		112 - 26500	2602	NC	4180	4180	(5)	95% Adjusted Gamma UCL	Gamma
Total Organic Carbon (TOC)	24 / 24		5.8 - 9600	546	NC	2280	2280	(5)	95% Chebyshev (Mean, Sd) UCL	Nonparametric
Total Suspended Solids (TSS)	29 / 29		5 - 17600	3040	NC	5320	5320	(5)	95% Adjusted Gamma UCL	Gamma

ABBREVIATIONS AND NOTES:
[a] BTVs for each constituent were selected based on the underlying distribution of the data. For normally or lognormally distributed dataset, 95% upper
BTV = Background threshold value
EPC = Exposure point concentration
mg/L: milligrams per liter
NC = Not calculated; ProUCL version 5.1.002 recommends that the sample size be at least 10 samples for calcuating BTVs.
ND: Non-Detect
UCL = Upper confidence limit

(1) Chemicals of potential concern (COPCs) are identified in Table2.2.
(2) Arithmetic mean is calculated using the detection limit divided by 2 (DL/2) substitution method for not detected results.
(3) Revised 95% UCL is calculated using ProUCL software (V. 5.0.00); calculations presented in Appendx B.
(4) The maximum detected concentration is used as the EPC because it is lower than the calculated 95% UCL, or no 95% UCL is calculated.
(5) The 95% UCL is used as the EPC because the calculated 95% UCL is less than the maximum detected concentration.
(6) In accordance with USEPA guidance for evaluating lead exposure, the arithmetic mean concentration is used as the EPC.

TABLE 3.17
EXPOSURE POINT CONCENTRATIONS - ST-01 - RESIDENT
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

COPC (1)	Frequency of Detection	Range of Reporting Limits for Non-Detects (µg/m3)	Range of Detected Concentrations (µg/m3)	Kaplan-Meier Mean PM10 Concentration (2) (µg/m3)	EPC Outdoors (3) (µg/m3)	EPC Indoors (4) (µg/m3)	Time-weighted EPC (5) (µg/m3)
Inorganics PM10 µg/m3							
Aluminum	89 / 89	N/A N/A	2.04E-01 - 4.79E+00	1.40E+00	1.40E+00	5.62E-01	6.64E-01
Antimony	8 / 89	7.00E-03 : 5.59E-02	2.50E-03 - 1.23E-02	4.17E-03	4.17E-03	1.67E-03	1.97E-03
Arsenic	82 / 89	2.30E-03 : 9.40E-03	2.10E-03 - 1.27E-01	1.75E-02	1.75E-02	7.00E-03	8.27E-03
Barium	54 / 89	1.04E-02 : 2.91E-02	6.10E-03 - 8.55E-02	1.75E-02	1.75E-02	7.00E-03	8.27E-03
Cadmium	30 / 89	4.20E-03 : 1.88E-02	1.10E-03 - 3.61E-02	4.55E-03	4.55E-03	1.82E-03	2.15E-03
Chromium	74 / 89	3.80E-03 : 9.90E-03	1.20E-03 - 8.70E-03	3.55E-03	3.55E-03	1.42E-03	1.68E-03
Cobalt	2 / 89	3.80E-03 : 8.96E-02	2.80E-03 - 4.10E-03	3.13E-03	3.13E-03	1.25E-03	1.48E-03
Copper	89 / 89	N/A N/A	3.84E-02 - 6.83E+00	5.51E-01	5.51E-01	2.20E-01	2.60E-01
Iron	89 / 89	N/A N/A	2.37E-01 - 7.17E+00	1.59E+00	1.59E+00	6.36E-01	7.51E-01
Lead	89 / 89	N/A N/A	1.40E-03 - 4.57E-01	5.10E-02	5.10E-02	2.04E-02	2.41E-02
Manganese	89 / 89	N/A N/A	4.00E-03 - 6.93E-02	2.40E-02	2.40E-02	9.60E-03	1.13E-02
Molybdenum	78 / 89	8.00E-03 : 1.55E-02	1.80E-03 - 8.95E-02	1.34E-02	1.34E-02	5.36E-03	6.33E-03
Nickel	26 / 89	1.70E-03 : 4.55E-02	6.00E-04 - 2.10E-03	1.16E-03	1.16E-03	4.64E-04	5.48E-04
Silver	8 / 89	3.30E-03 : 1.55E-02	8.00E-04 - 7.70E-03	1.72E-03	1.72E-03	6.88E-04	8.13E-04
Thallium	18 / 89	5.20E-03 : 1.27E-02	1.90E-03 - 7.50E-03	3.36E-03	3.36E-03	1.34E-03	1.59E-03
Vanadium	73 / 89	2.30E-03 : 6.10E-03	1.30E-03 - 1.39E-02	4.57E-03	4.57E-03	1.83E-03	2.16E-03
Zinc	89 / 89	N/A N/A	6.10E-03 - 7.83E-01	9.37E-02	9.37E-02	3.75E-02	4.43E-02

ABBREVIATIONS AND NOTES:
µg/m3 = micrograms per cubic meter
COPC = Chemical of potential concern
EPC = Exposure point concentration
ET = Exposure time
N/A = Not applicable

(1) Chemicals of potential concern (COPCs) are identified in Table 2.1
(2) Kaplan-Meier Mean value is calculated using ProUCL software (V. 5.0.00); calculations presented in Appendix B.
(3) The EPC for outdoor air is the Kaplan-Meier Mean PM10 concentration
(4) The EPC for indoor air is the Kaplan-Meier Mean PM10 concentration multiplied by an outdoor to indoor PM10 attenuation factor of 0.4 (USEPA, 2000).
(5) The time-weighted EPC represents the EPC to which a residential receptor is exposed over a 24-hour period, taking into account time spent indoors and outdoors.
The EPC is derived as: [(EPC Outdoors x Outdoor ET) + (EPC Indoors x Indoor ET)] / total time (i.e., indoor ET + outdoor ET)
The outdoor and indoor exposure time (ET; hours/day) are based on the young-child resident (Table 3.2); Indoor ET = 16.7; Outdoor ET = 2.3

TABLE 3.18
EXPOSURE POINT CONCENTRATIONS - ST-02 - HIGH SCHOOL STUDENT
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

COPC (1)	Frequency of Detection	Range of Reporting Limits for Non-Detects (µg/m3)	Range of Detected Concentrations (µg/m3)	Kaplan-Meier Mean PM10 Concentration (2) (µg/m3)	EPC Outdoors (3) (µg/m3)	EPC Indoors (4) (µg/m3)	Time-weighted EPC (5) (µg/m3)
Inorganics PM10 µg/m3							
Aluminum	119 / 119	N/A N/A	1.67E-02 - 5.44E+00	5.91E-01	5.91E-01	2.36E-01	3.25E-01
Antimony	9 / 119	6.40E-03 : 5.23E-02	2.80E-03 - 1.05E-02	4.76E-03	4.76E-03	1.90E-03	2.62E-03
Arsenic	95 / 119	3.80E-03 : 1.13E-02	1.00E-03 - 4.74E-02	5.38E-03	5.38E-03	2.15E-03	2.96E-03
Barium	59 / 119	1.03E-02 : 3.30E-02	3.60E-03 - 7.86E-02	1.01E-02	1.01E-02	4.04E-03	5.56E-03
Cadmium	13 / 119	3.90E-03 : 1.70E-02	1.00E-03 - 7.00E-03	2.10E-03	2.10E-03	8.40E-04	1.16E-03
Chromium	46 / 119	3.30E-03 : 1.04E-02	8.00E-04 - 2.65E-02	2.23E-03	2.23E-03	8.92E-04	1.23E-03
Cobalt	0 / 119	2.40E-03 : 4.90E-02	N/A N/A	N/A	N/A	N/A	N/A
Copper	119 / 119	N/A N/A	3.40E-03 - 6.82E-01	1.32E-01	1.32E-01	5.28E-02	7.26E-02
Iron	119 / 119	N/A N/A	1.30E-02 - 3.89E+00	4.86E-01	4.86E-01	1.94E-01	2.67E-01
Lead	112 / 119	6.10E-03 : 1.13E-02	1.70E-03 - 4.44E-02	1.36E-02	1.36E-02	5.44E-03	7.48E-03
Manganese	114 / 119	4.70E-03 : 7.10E-03	1.50E-03 - 1.02E-01	9.95E-03	9.95E-03	3.98E-03	5.47E-03
Molybdenum	45 / 119	6.10E-03 : 1.64E-02	1.30E-03 - 8.90E-03	3.37E-03	3.37E-03	1.35E-03	1.85E-03
Nickel	26 / 119	1.90E-03 : 4.20E-03	5.00E-04 - 2.30E-03	9.18E-04	9.18E-04	3.67E-04	5.05E-04
Silver	6 / 119	2.80E-03 : 1.61E-02	9.00E-04 - 4.40E-03	1.49E-03	1.49E-03	5.96E-04	8.20E-04
Thallium	2 / 119	4.20E-03 : 1.04E-02	9.00E-04 - 1.40E-03	1.15E-03	1.15E-03	4.60E-04	6.33E-04
Vanadium	50 / 119	2.40E-03 : 6.60E-03	9.00E-04 - 1.07E-02	1.97E-03	1.97E-03	7.88E-04	1.08E-03
Zinc	118 / 119	3.30E-03 : 3.30E-03	1.00E-03 - 9.39E-02	2.36E-02	2.36E-02	9.44E-03	1.30E-02

ABBREVIATIONS AND NOTES:

µg/m3 = micrograms per cubic meter
COPC = Chemical of potential concern
EPC = Exposure point concentration
ET = Exposure time
N/A = Not applicable

(1) Chemicals of potential concern (COPCs) are identified in Table 2.1
(2) Kaplan-Meier Mean value is calculated using ProUCL software (V. 5.0.00); calculations presented in Appendix B.
(3) The EPC for outdoor air is the Kaplan-Meier Mean PM10 concentration
(4) The EPC for indoor air is the Kaplan-Meier Mean PM10 concentration multiplied by an outdoor to indoor PM10 attenuation factor of 0.4 (USEPA, 2000).
(5) The time-weighted EPC represents the EPC to which a High School student is exposed over an 8-hour school day, taking into account time spent indoors and outdoors.
The EPC is derived as: [(EPC Outdoors x Outdoor ET) + (EPC Indoors x Indoor ET)] / 8 hours
The indoor and outdoor exposure time (ET; hours/day) assumes 6 hours per school-day indoors (classroom, study hall, lunch), and 2 hours per day outdoors (athletics participation).

TABLE 3.19

EXPOSURE POINT CONCENTRATIONS - ST-02 - HIGH SCHOOL STAFF

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

COPC (1)	Frequency of Detection	Range of Reporting Limits for Non-Detects (µg/m3)	Range of Detected Concentrations (µg/m3)	Kaplan-Meier Mean PM10 Concentration (2) (µg/m3)	EPC Outdoors (3) (µg/m3)
Inorganics PM10 µg/m3					
Aluminum	119 / 119	N/A N/A	1.67E-02 - 5.44E+00	5.91E-01	5.91E-01
Antimony	9 / 119	6.40E-03 : 5.23E-02	2.80E-03 - 1.05E-02	4.76E-03	4.76E-03
Arsenic	95 / 119	3.80E-03 : 1.13E-02	1.00E-03 - 4.74E-02	5.38E-03	5.38E-03
Barium	59 / 119	1.03E-02 : 3.30E-02	3.60E-03 - 7.86E-02	1.01E-02	1.01E-02
Cadmium	13 / 119	3.90E-03 : 1.70E-02	1.00E-03 - 7.00E-03	2.10E-03	2.10E-03
Chromium	46 / 119	3.30E-03 : 1.04E-02	8.00E-04 - 2.65E-02	2.23E-03	2.23E-03
Cobalt	0 / 119	2.40E-03 : 4.90E-02	N/A N/A	N/A	N/A
Copper	119 / 119	N/A N/A	3.40E-03 - 6.82E-01	1.32E-01	1.32E-01
Iron	119 / 119	N/A N/A	1.30E-02 - 3.89E+00	4.86E-01	4.86E-01
Lead	112 / 119	6.10E-03 : 1.13E-02	1.70E-03 - 4.44E-02	1.36E-02	1.36E-02
Manganese	114 / 119	4.70E-03 : 7.10E-03	1.50E-03 - 1.02E-01	9.95E-03	9.95E-03
Molybdenum	45 / 119	6.10E-03 : 1.64E-02	1.30E-03 - 8.90E-03	3.37E-03	3.37E-03
Nickel	26 / 119	1.90E-03 : 4.20E-03	5.00E-04 - 2.30E-03	9.18E-04	9.18E-04
Silver	6 / 119	2.80E-03 : 1.61E-02	9.00E-04 - 4.40E-03	1.49E-03	1.49E-03
Thallium	2 / 119	4.20E-03 : 1.04E-02	9.00E-04 - 1.40E-03	1.15E-03	1.15E-03
Vanadium	50 / 119	2.40E-03 : 6.60E-03	9.00E-04 - 1.07E-02	1.97E-03	1.97E-03
Zinc	118 / 119	3.30E-03 : 3.30E-03	1.00E-03 - 9.39E-02	2.36E-02	2.36E-02

ABBREVIATIONS AND NOTES:

µg/m3 = micrograms per cubic meter

COPC = Chemical of potential concern

EPC = Exposure point concentration

N/A = Not applicable

(1) Chemicals of potential concern (COPCs) are identified in Table 2.1

(2) Kaplan-Meier Mean value is calculated using ProUCL software (V. 5.0.00); calculations presented in Appendix B.

(3) The EPC for outdoor air is the Kaplan-Meier Mean PM10 concentration

TABLE 3.20
EXPOSURE POINT CONCENTRATIONS - ST-05 - REMOTE TRESPASSER
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

COPC (1)	Frequency of Detection	Range of Reporting Limits for Non-Detects (µg/m3)	Range of Detected Concentrations (µg/m3)	Kaplan-Meier Mean PM10 Concentration (2) (µg/m3)	EPC Outdoors (3) (µg/m3)
Inorganics PM10 µg/m3					
Aluminum	113 / 113	N/A N/A	1.41E-02 - 4.93E+00	5.72E-01	5.72E-01
Antimony	8 / 113	6.60E-03 : 5.30E-02	2.00E-03 - 2.19E-02	4.12E-03	4.12E-03
Arsenic	95 / 113	2.30E-03 : 9.90E-03	8.00E-04 - 1.64E-01	2.11E-02	2.11E-02
Barium	74 / 113	1.08E-02 : 3.54E-02	2.30E-03 - 1.01E-01	1.74E-02	1.74E-02
Cadmium	47 / 113	3.50E-03 : 1.70E-02	1.10E-03 - 2.41E-02	4.79E-03	4.79E-03
Chromium	54 / 113	2.80E-03 : 1.04E-02	9.00E-04 - 9.60E-03	2.84E-03	2.84E-03
Cobalt	0 / 113	2.80E-03 : 6.03E-02	N/A N/A	N/A	N/A
Copper	112 / 113	3.80E-03 : 3.80E-03	3.10E-03 - 2.07E+00	3.50E-01	3.50E-01
Iron	113 / 113	N/A N/A	8.60E-03 - 4.82E+00	6.58E-01	6.58E-01
Lead	104 / 113	5.60E-03 : 1.13E-02	2.10E-03 - 3.45E-01	6.82E-02	6.82E-02
Manganese	110 / 113	4.20E-03 : 4.20E-03	1.30E-03 - 1.03E-01	1.02E-02	1.02E-02
Molybdenum	81 / 113	6.10E-03 : 1.64E-02	1.20E-03 - 4.91E-02	9.50E-03	9.50E-03
Nickel	11 / 113	1.90E-03 : 5.60E-03	5.00E-04 - 5.20E-03	1.08E-03	1.08E-03
Silver	10 / 113	3.30E-03 : 1.61E-02	8.00E-04 - 2.70E-03	1.48E-03	1.48E-03
Thallium	24 / 113	4.20E-03 : 1.41E-02	8.00E-04 - 9.60E-03	3.81E-03	3.81E-03
Vanadium	33 / 113	2.30E-03 : 7.10E-03	8.00E-04 - 7.90E-03	2.04E-03	2.04E-03
Zinc	110 / 113	2.80E-03 : 3.30E-03	1.40E-03 - 5.74E-01	1.13E-01	1.13E-01

ABBREVIATIONS AND NOTES:
µg/m3: = micrograms per cubic meter
COPC = Chemical of potential concern
EPC = Exposure point concentration
N/A = Not applicable

(1) Chemicals of potential concern (COPCs) are identified in Table 2.1
(2) Kaplan-Meier Mean value is calculated using ProUCL software (V. 5.0.00); calculations presented in Appendix B.
(3) The EPC for outdoor air is the Kaplan-Meier Mean PM10 concentration

TABLE 3.21
EXPOSURE POINT CONCENTRATIONS - ST-09 - IN-TOWN TRESPASSER
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

COPC (1)	Frequency of Detection	Range of Reporting Limits for Non-Detects (µg/m3)	Range of Detected Concentrations (µg/m3)	Kaplan-Meier Mean PM10 Concentration (2) (µg/m3)	EPC Outdoors (3) (µg/m3)
Inorganics PM10 µg/m3					
Aluminum	108 / 108	N/A N/A	7.00E-02 - 5.14E+00	7.38E-01	7.38E-01
Antimony	14 / 108	7.00E-03 : 5.23E-02	2.30E-03 - 1.77E-02	5.30E-03	5.30E-03
Arsenic	98 / 108	4.30E-03 : 1.03E-02	1.30E-03 - 1.63E-01	1.61E-02	1.61E-02
Barium	65 / 108	1.08E-02 : 3.73E-02	3.00E-03 - 2.13E-01	1.41E-02	1.41E-02
Cadmium	34 / 108	4.20E-03 : 1.70E-02	1.00E-03 - 2.99E-02	4.08E-03	4.08E-03
Chromium	71 / 108	3.30E-03 : 9.90E-03	8.00E-04 - 1.57E-01	6.43E-03	6.43E-03
Cobalt	3 / 108	2.40E-03 : 9.38E-02	2.90E-03 - 2.02E-02	2.92E-03	2.92E-03
Copper	108 / 108	N/A N/A	3.08E-02 - 1.09E+01	7.81E-01	7.81E-01
Iron	108 / 108	N/A N/A	1.57E-01 - 7.21E+00	1.06E+00	1.06E+00
Lead	106 / 108	9.00E-03 : 9.90E-03	2.00E-03 - 5.52E-01	4.31E-02	4.31E-02
Manganese	105 / 108	6.60E-03 : 1.27E-02	1.90E-03 - 9.90E-02	1.25E-02	1.25E-02
Molybdenum	72 / 108	5.70E-03 : 1.56E-02	1.90E-03 - 8.15E-02	8.98E-03	8.98E-03
Nickel	30 / 108	1.90E-03 : 6.10E-03	7.00E-04 - 1.97E-02	1.83E-03	1.83E-03
Silver	11 / 108	3.30E-03 : 1.56E-02	8.00E-04 - 1.75E-02	1.98E-03	1.98E-03
Thallium	9 / 108	4.20E-03 : 1.50E-02	1.90E-03 - 1.16E-02	3.38E-03	3.38E-03
Vanadium	62 / 108	2.30E-03 : 1.61E-02	9.00E-04 - 9.00E-03	2.31E-03	2.31E-03
Zinc	108 / 108	N/A N/A	4.50E-03 - 7.63E-01	7.09E-02	7.09E-02

ABBREVIATIONS AND NOTES:
µg/m3 = micrograms per cubic meter
COPC = Chemical of potential concern
EPC = Exposure point concentration
N/A = Not applicable

(1) Chemicals of potential concern (COPCs) are identified in Table 2.1
(2) Kaplan-Meier Mean value is calculated using ProUCL software (V. 5.0.00); calculations presented in Appendix B.
(3) The EPC for outdoor air is the Kaplan-Meier Mean PM10 concentration

TABLE 3.22
EXPOSURE POINT CONCENTRATIONS - ST-14 - RESTRICTED AREA TRESPASSER
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

COPC (1)	Frequency of Detection	Range of Reporting Limits for Non-Detects (µg/m3)	Range of Detected Concentrations (µg/m3)	Kaplan-Meier Mean PM10 Concentration (2) (µg/m3)	EPC Outdoors (3) (µg/m3)
Inorganics PM10 µg/m3					
Aluminum	107 / 108	1.22E-01 : 1.22E-01	1.16E-01 - 5.78E+00	9.40E-01	9.40E-01
Antimony	32 / 107	7.00E-03 : 5.30E-02	2.30E-03 - 3.31E-02	6.65E-03	6.65E-03
Arsenic	104 / 105	7.50E-03 : 7.50E-03	5.10E-03 - 1.52E+00	1.36E-01	1.36E-01
Barium	88 / 108	1.36E-02 : 3.14E-02	4.20E-03 - 5.91E-01	5.94E-02	5.94E-02
Cadmium	87 / 107	4.70E-03 : 1.51E-02	1.30E-03 - 1.22E-01	1.86E-02	1.86E-02
Chromium	94 / 108	3.30E-03 : 1.13E-02	8.00E-04 - 2.58E-02	5.17E-03	5.17E-03
Cobalt	4 / 108	3.80E-03 : 1.83E-01	4.30E-03 - 1.53E-02	4.53E-03	4.53E-03
Copper	108 / 108	N/A N/A	1.06E-01 - 1.96E+01	2.49E+00	2.49E+00
Iron	108 / 108	N/A N/A	2.53E-01 - 1.33E+01	2.34E+00	2.34E+00
Lead	107 / 107	N/A N/A	4.90E-03 - 2.32E+00	3.37E-01	3.37E-01
Manganese	106 / 108	9.40E-03 : 2.50E-02	3.20E-03 - 1.05E-01	1.69E-02	1.69E-02
Molybdenum	107 / 108	9.90E-03 : 9.90E-03	1.30E-03 - 4.15E-01	5.88E-02	5.88E-02
Nickel	27 / 108	1.90E-03 : 2.12E-01	8.00E-04 - 9.70E-03	1.60E-03	1.60E-03
Silver	46 / 108	3.30E-03 : 1.80E-02	1.00E-03 - 1.80E-02	4.26E-03	4.26E-03
Thallium	38 / 108	4.20E-03 : 4.88E-02	2.60E-03 - 3.76E-02	6.25E-03	6.25E-03
Vanadium	62 / 108	2.30E-03 : 9.05E-02	8.00E-04 - 1.46E-02	2.98E-03	2.98E-03
Zinc	107 / 107	N/A N/A	8.60E-03 - 2.78E+00	4.65E-01	4.65E-01

ABBREVIATIONS AND NOTES:
µg/m3 = micrograms per cubic meter
COPC = Chemical of potential concern
EPC = Exposure point concentration
N/A = Not applicable

(1) Chemicals of potential concern (COPCs) are identified in Table 2.1
(2) Kaplan-Meier Mean value is calculated using ProUCL software (V. 5.0.00); calculations presented in Appendix B.
(3) The EPC for outdoor air is the Kaplan-Meier Mean PM10 concentration

TABLE 3.23
EXPOSURE POINT CONCENTRATIONS - ST-16 - RESIDENT
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

COPC (1)	Frequency of Detection	Range of Reporting Limits for Non-Detects (µg/m3)	Range of Detected Concentrations (µg/m3)	Kaplan-Meier Mean PM10 Concentration (2) (µg/m3)	EPC Outdoors (3) (µg/m3)	EPC Indoors (4) (µg/m3)	Time-weighted EPC (5) (µg/m3)
Inorganics PM10 µg/m3							
Aluminum	97 / 98	2.97E-02 : 2.97E-02	1.43E-01 - 8.16E+00	2.12E+00	2.12E+00	8.48E-01	1.00E+00
Antimony	3 / 98	5.00E-03 : 5.23E-02	4.20E-03 - 1.06E-02	4.59E-03	4.59E-03	1.84E-03	2.17E-03
Arsenic	80 / 98	2.30E-03 : 1.14E-02	1.30E-03 - 3.75E-01	2.40E-02	2.40E-02	9.60E-03	1.13E-02
Barium	58 / 98	6.00E-03 : 2.77E-02	5.50E-03 - 1.09E-01	2.12E-02	2.12E-02	8.48E-03	1.00E-02
Cadmium	34 / 98	4.20E-03 : 1.70E-02	7.00E-04 - 3.17E-02	4.23E-03	4.23E-03	1.69E-03	2.00E-03
Chromium	89 / 98	3.80E-03 : 1.04E-02	1.00E-03 - 1.89E-02	5.11E-03	5.11E-03	2.04E-03	2.42E-03
Cobalt	3 / 98	3.30E-03 : 1.11E-01	3.80E-03 - 4.70E-03	3.98E-03	3.98E-03	1.59E-03	1.88E-03
Copper	97 / 98	3.30E-03 : 3.30E-03	5.84E-02 - 3.30E+00	5.32E-01	5.32E-01	2.13E-01	2.51E-01
Iron	97 / 98	5.20E-03 : 5.20E-03	3.15E-01 - 8.84E+00	2.38E+00	2.38E+00	9.50E-01	1.12E+00
Lead	96 / 98	5.60E-03 : 9.40E-03	2.00E-03 - 6.32E-01	5.44E-02	5.44E-02	2.18E-02	2.57E-02
Manganese	97 / 98	6.10E-03 : 6.10E-03	5.00E-03 - 3.44E-01	4.06E-02	4.06E-02	1.62E-02	1.92E-02
Molybdenum	90 / 98	9.80E-03 : 1.56E-02	1.60E-03 - 6.86E-02	1.49E-02	1.49E-02	5.96E-03	7.04E-03
Nickel	41 / 98	1.90E-03 : 5.04E-02	6.00E-04 - 4.80E-03	1.47E-03	1.47E-03	5.88E-04	6.95E-04
Silver	8 / 98	2.10E-03 : 1.56E-02	1.20E-03 - 4.40E-03	1.90E-03	1.90E-03	7.60E-04	8.98E-04
Thallium	18 / 98	4.20E-03 : 1.64E-02	2.00E-03 - 5.00E-03	3.14E-03	3.14E-03	1.26E-03	1.48E-03
Vanadium	88 / 98	2.30E-03 : 1.88E-02	1.00E-03 - 3.22E-02	7.03E-03	7.03E-03	2.81E-03	3.32E-03
Zinc	97 / 98	3.30E-03 : 3.30E-03	5.60E-03 - 7.03E-01	8.81E-02	8.81E-02	3.52E-02	4.16E-02

ABBREVIATIONS AND NOTES:

µg/m3 = micrograms per cubic meter
COPC = Chemical of potential concern
EPC = Exposure point concentration
ET = Exposure time

(1) Chemicals of potential concern (COPCs) are identified in Table 2.1
(2) Kaplan-Meier Mean value is calculated using ProUCL software (V. 5.0.00); calculations presented in Appendix B.
(3) The EPC for outdoor air is the Kaplan-Meier Mean PM10 concentration
(4) The EPC for indoor air is the Kaplan-Meier Mean PM10 concentration multiplied by an outdoor to indoor PM10 attenuation factor of 0.4 (USEPA, 2000).
(5) The time-weighted EPC represents the EPC to which a residential receptor is exposed over a 24-hour period, taking into account time spent indoors and outdoors.
The EPC is derived as: [(EPC Outdoors x Outdoor ET) + (EPC Indoors x Indoor ET)] / total time (i.e., indoor ET + outdoor ET)
The outdoor and indoor exposure time (ET; hours/day) are based on the young-child resident (Table 3.2); Indoor ET = 16.7; Outdoor ET = 2.3

TABLE 3.24

EXPOSURE POINT CONCENTRATIONS - ST-18 - REMOTE TRESPASSER

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

COPC (1)	Frequency of Detection	Range of Reporting Limits for Non-Detects (µg/m3)	Range of Detected Concentrations (µg/m3)	Kaplan-Meier Mean PM10 Concentration (2) (µg/m3)	EPC Outdoors (3) (µg/m3)
Inorganics PM10 µg/m3					
Aluminum	107 / 111	2.17E-02 : 3.67E-02	1.71E-02 - 2.42E+01	9.68E-01	9.68E-01
Antimony	7 / 111	6.60E-03 : 2.03E-01	3.00E-03 - 1.24E-02	3.90E-03	3.90E-03
Arsenic	102 / 111	3.80E-03 : 1.56E-02	5.00E-04 - 1.78E+00	3.51E-02	3.51E-02
Barium	53 / 111	8.50E-03 : 3.64E-02	4.70E-03 - 3.79E-01	1.58E-02	1.58E-02
Cadmium	57 / 111	4.20E-03 : 1.70E-02	1.00E-03 - 2.23E-01	5.46E-03	5.46E-03
Chromium	79 / 111	3.30E-03 : 1.37E-02	8.00E-04 - 7.57E-02	3.89E-03	3.89E-03
Cobalt	2 / 111	2.30E-03 : 2.83E-01	3.40E-03 - 4.20E-03	2.68E-03	2.68E-03
Copper	110 / 111	4.30E-03 : 4.30E-03	1.20E-03 - 4.57E+01	1.76E+00	1.76E+00
Iron	110 / 111	1.22E-02 : 1.22E-02	1.80E-03 - 5.84E+01	2.26E+00	2.26E+00
Lead	106 / 111	4.70E-03 : 8.00E-03	2.50E-03 - 3.20E+00	8.55E-02	8.55E-02
Manganese	104 / 111	3.80E-03 : 1.32E-02	1.50E-03 - 4.33E-01	1.73E-02	1.73E-02
Molybdenum	107 / 111	5.20E-03 : 1.55E-02	1.30E-03 - 7.97E-01	3.64E-02	3.64E-02
Nickel	14 / 111	1.90E-03 : 1.13E-01	6.00E-04 - 2.60E-03	1.13E-03	1.13E-03
Silver	28 / 111	3.30E-03 : 1.36E-01	1.00E-03 - 7.50E-03	2.38E-03	2.38E-03
Thallium	23 / 111	4.20E-03 : 2.94E-01	1.80E-03 - 5.10E-03	3.29E-03	3.29E-03
Vanadium	63 / 111	2.30E-03 : 1.18E-02	1.00E-03 - 7.46E-02	2.98E-03	2.98E-03
Zinc	107 / 111	2.80E-03 : 4.20E-03	1.80E-03 - 6.01E+00	2.05E-01	2.05E-01

ABBREVIATIONS AND NOTES:

µg/m3 = micrograms per cubic meter

COPC = Chemical of potential concern

EPC = Exposure point concentration

N/A = Not applicable

(1) Chemicals of potential concern (COPCs) are identified in Table 2.1

(2) Kaplan-Meier Mean value is calculated using ProUCL software (V. 5.0.00); calculations presented in Appendix B.

(3) The EPC for outdoor air is the Kaplan-Meier Mean PM10 concentration

TABLE 3.25
EXPOSURE POINT CONCENTRATIONS - ST-23 - RESIDENT
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

COPC (1)	Frequency of Detection	Range of Reporting Limits for Non-Detects (µg/m3)	Range of Detected Concentrations (µg/m3)	Kaplan-Meier Mean PM10 Concentration (2) (µg/m3)	EPC Outdoors (3) (µg/m3)	EPC Indoors (4) (µg/m3)	Time-weighted EPC (5) (µg/m3)
Inorganics PM10 µg/m3							
Aluminum	113 / 113	N/A N/A	8.48E-02 - 6.06E+00	1.42E+00	1.42E+00	5.66E-01	6.69E-01
Antimony	14 / 112	6.80E-03 : 5.24E-02	1.80E-03 - 1.57E-02	4.33E-03	4.33E-03	1.73E-03	2.05E-03
Arsenic	108 / 113	6.60E-03 : 1.46E-02	2.80E-03 - 2.57E-01	2.90E-02	2.90E-02	1.16E-02	1.37E-02
Barium	82 / 112	1.32E-02 : 3.97E-02	4.90E-03 - 1.67E-01	2.22E-02	2.22E-02	8.88E-03	1.05E-02
Cadmium	54 / 113	4.20E-03 : 2.88E-02	1.30E-03 - 4.76E-02	5.31E-03	5.31E-03	2.12E-03	2.51E-03
Chromium	96 / 113	3.80E-03 : 1.04E-02	9.00E-04 - 1.38E-02	3.79E-03	3.79E-03	1.52E-03	1.79E-03
Cobalt	1 / 113	2.40E-03 : 7.78E-02	2.30E-03 - 2.30E-03	2.30E-03	2.30E-03	9.20E-04	1.09E-03
Copper	113 / 113	N/A N/A	7.22E-02 - 5.86E+00	7.35E-01	7.35E-01	2.94E-01	3.47E-01
Iron	112 / 112	N/A N/A	1.17E-01 - 6.21E+00	1.67E+00	1.67E+00	6.66E-01	7.87E-01
Lead	113 / 113	N/A N/A	2.30E-03 - 5.82E-01	7.98E-02	7.98E-02	3.19E-02	3.77E-02
Manganese	113 / 113	N/A N/A	1.20E-03 - 1.36E-01	2.60E-02	2.60E-02	1.04E-02	1.23E-02
Molybdenum	111 / 113	6.10E-03 : 9.80E-03	2.00E-03 - 1.39E-01	1.87E-02	1.87E-02	7.48E-03	8.84E-03
Nickel	42 / 113	1.10E-03 : 8.50E-03	4.00E-04 - 5.60E-03	1.41E-03	1.41E-03	5.64E-04	6.66E-04
Silver	18 / 113	2.90E-03 : 2.88E-02	8.00E-04 - 7.60E-03	2.00E-03	2.00E-03	8.00E-04	9.45E-04
Thallium	23 / 113	4.20E-03 : 2.27E-02	1.60E-03 - 1.54E-02	3.55E-03	3.55E-03	1.42E-03	1.68E-03
Vanadium	94 / 113	3.30E-03 : 7.30E-03	1.10E-03 - 1.63E-02	4.68E-03	4.68E-03	1.87E-03	2.21E-03
Zinc	113 / 113	N/A N/A	9.70E-03 - 9.71E-01	1.36E-01	1.36E-01	5.44E-02	6.43E-02

ABBREVIATIONS AND NOTES:

µg/m3 = micrograms per cubic meter
COPC = Chemical of potential concern
EPC = Exposure point concentration
ET = Exposure Time
N/A = Not applicable

(1) Chemicals of potential concern (COPCs) are identified in Table 2.1
(2) Kaplan-Meier Mean value is calculated using ProUCL software (V. 5.0.00); calculations presented in Appendix B.
(3) The EPC for outdoor air is the Kaplan-Meier Mean PM10 concentration
(4) The EPC for indoor air is the Kaplan-Meier Mean PM10 concentration multiplied by an outdoor to indoor PM10 attenuation factor of 0.4 (USEPA, 2000).
(5) The time-weighted EPC represents the EPC to which a residential receptor is exposed over a 24-hour period, taking into account time spent indoors and outdoors.
The EPC is derived as: [(EPC Outdoors x Outdoor ET) + (EPC Indoors x Indoor ET)] / total time (i.e., indoor ET + outdoor ET)
The outdoor and indoor exposure time (ET; hours/day) are based on the young-child resident (Table 3.2); Indoor ET = 16.7; Outdoor ET = 2.3

TABLE 3.26

EXPOSURE POINT CONCENTRATIONS - ST-26 - RESIDENT

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

COPC (1)	Frequency of Detection	Range of Reporting Limits for Non-Detects (µg/m3)	Range of Detected Concentrations (µg/m3)	Kaplan-Meier Mean PM10 Concentration (2) (µg/m3)	EPC Outdoors (3) (µg/m3)	EPC Indoors (4) (µg/m3)	Time-weighted EPC (5) (µg/m3)
Inorganics PM10 µg/m3							
Aluminum	162 / 162	N/A N/A	7.47E-02 - 5.90E+00	1.12E+00	1.12E+00	4.46E-01	5.27E-01
Antimony	14 / 163	6.60E-03 : 5.23E-02	1.90E-03 - 1.38E-02	3.76E-03	3.76E-03	1.50E-03	1.78E-03
Arsenic	154 / 160	2.30E-03 : 9.90E-03	2.00E-03 - 1.16E-01	1.87E-02	1.87E-02	7.48E-03	8.84E-03
Barium	101 / 163	8.20E-03 : 3.31E-02	3.20E-03 - 7.58E-02	1.51E-02	1.51E-02	6.04E-03	7.14E-03
Cadmium	77 / 161	4.20E-03 : 1.70E-02	1.00E-03 - 1.52E-02	3.70E-03	3.70E-03	1.48E-03	1.75E-03
Chromium	129 / 163	3.30E-03 : 1.09E-02	9.00E-04 - 1.15E-02	3.53E-03	3.53E-03	1.41E-03	1.67E-03
Cobalt	0 / 163	3.80E-03 : 8.33E-02	N/A N/A	N/A	N/A	N/A	N/A
Copper	162 / 162	N/A N/A	5.88E-02 - 6.30E+00	7.49E-01	7.49E-01	3.00E-01	3.54E-01
Iron	162 / 162	N/A N/A	1.22E-01 - 8.51E+00	1.52E+00	1.52E+00	6.07E-01	7.17E-01
Lead	159 / 160	1.09E-02 : 1.09E-02	1.70E-03 - 2.37E-01	5.55E-02	5.55E-02	2.22E-02	2.62E-02
Manganese	162 / 163	8.50E-03 : 8.50E-03	1.10E-03 - 1.05E-01	2.03E-02	2.03E-02	8.12E-03	9.59E-03
Molybdenum	160 / 163	6.60E-03 : 9.80E-03	1.90E-03 - 1.59E-01	1.69E-02	1.69E-02	6.76E-03	7.99E-03
Nickel	45 / 163	1.90E-03 : 9.40E-03	6.00E-04 - 4.00E-03	1.29E-03	1.29E-03	5.16E-04	6.10E-04
Silver	16 / 163	2.80E-03 : 1.61E-02	9.00E-04 - 7.10E-03	1.80E-03	1.80E-03	7.20E-04	8.51E-04
Thallium	33 / 163	4.20E-03 : 1.46E-02	2.20E-03 - 5.60E-03	3.22E-03	3.22E-03	1.29E-03	1.52E-03
Vanadium	116 / 163	2.30E-03 : 7.10E-03	8.00E-04 - 1.64E-02	3.47E-03	3.47E-03	1.39E-03	1.64E-03
Zinc	160 / 160	N/A N/A	5.60E-03 - 6.64E-01	1.11E-01	1.11E-01	4.44E-02	5.25E-02

ABBREVIATIONS AND NOTES:

µg/m3 = micrograms per cubic meter
COPC = Chemical of potential concern
EPC = Exposure point concentration
ET = Exposure Time
N/A = Not applicable

(1) Chemicals of potential concern (COPCs) are identified in Table 2.1
(2) Kaplan-Meier Mean value is calculated using ProUCL software (V. 5.0.00); calculations presented in Appendix B.
(3) The EPC for outdoor air is the Kaplan-Meier Mean PM10 concentration
(4) The EPC for indoor air is the Kaplan-Meier Mean PM10 concentration multiplied by an outdoor to indoor PM10 attenuation factor of 0.4 (USEPA, 2000).
(5) The time-weighted EPC represents the EPC to which a residential receptor is exposed over a 24-hour period, taking into account time spent indoors and outdoors.
The EPC is derived as: [(EPC Outdoors x Outdoor ET) + (EPC Indoors x Indoor ET)] / total time (i.e., indoor ET + outdoor ET)
The outdoor and indoor exposure time (ET; hours/day) are based on the young-child resident (Table 3.2); Indoor ET = 16.7; Outdoor ET = 2.3

TABLE 4.1
CANCER TOXICITY VALUES AND SOURCES - ORAL/DERMAL
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

Chemical of Potential Concern	Oral Cancer Slope Factor		Oral Absorption Efficiency for Dermal (1)	Absorbed Cancer Slope Factor for Dermal (2)		Weight of Evidence/ Cancer Guideline Description	Oral Cancer Slope Factor	
	Value	Units		Value	Units		Source(s)	Date(s)
Aluminum	ND			ND		ND		
Antimony	ND			ND		ND	IRIS	September-20
Arsenic	1.5E+00	$(mg/kg/day)^{-1}$	60%	1.5E+00	$(mg/kg/day)^{-1}$	A	IRIS	September-20
Barium	NA			NA		D	IRIS	September-20
Beryllium	NA			NA		Cannot be determined	IRIS	September-20
Boron	NA			NA		Inadequate evidence	IRIS	September-20
Cadmium	ND			ND		ND	IRIS	September-20
Chromium VI	NA			NA		D	IRIS	September-20
Cobalt	ND			ND		ND		
Copper	NA			NA		D	IRIS	September-20
Iron	ND			ND		ND		
Lead	NA			NA		B2	IRIS	September-20
Manganese	NA			NA		D	IRIS	September-20
Mercury (as elemental mercury)	NA			NA		D	IRIS	September-20
Molybdenum	ND			ND		ND	IRIS	September-20
Nickel	ND			ND		ND	IRIS	September-20
Selenium	NA			NA		D	IRIS	September-20
Silver	NA			NA		D	IRIS	September-20
Thallium	NA			NA		D	IRIS	September-20
Vanadium	ND			ND		ND		
Zinc	NA			NA		Inadequate evidence	IRIS	September-20

ABBREVIATIONS AND NOTES:

In accordance with OSWER 9285.7-53, slope factors are identified from the following heirarchy of sources:

Tier 1:

IRIS = Integrated Risk Information System: Sep-20

Tier 2:

PPRTV = Preliminary Peer-Reviewed Reference Toxicity Valu Sep-20 Obtained from Oak Ridge National Laboratory Regional Screening Levels for Chemical Contaminants at Superfund Sites

Tier 3:

HEAST97= Health Effects Assessment Summary Tables: Sep-20 From HEAST FY 1997 Update

HEAST= Health Effects Assessment Summary Tables: Sep-20 Obtained from Oak Ridge National Laboratory Regional Screening Levels for Chemical Contaminants at Superfund Sites

CALEPA - California Environmental Protection Agency Sep-20

In addition, provisional RfDs developed by NCEA are presented for informational purposes and to be used on a case-by-case basis:

ECAE = Environmental Criteria Assessment Office: Sep-20 Obtained from Oak Ridge National Laboratory Regional Screening Levels for Chemical Contaminants at Superfund Sites

WHO = World Health Organization Sep-20 Obtained from Oak Ridge National Laboratory Regional Screening Levels for Chemical Contaminants at Superfund Sites

(1) Values obtained from RAGS Volume 1 (Part E, Supplemental Guidance for Dermal Risk Assessment, Interim Guidance) (EPA, 2004)
Per this guidance, a value of 100% is used for analytes without published values.

(2) Adjusted Dermal SF = Oral SF / Oral to Dermal Adjustment Factor. Per RAGS Part E (USEPA, 2004), adjustments are only performed for chemicals that have an oral absorption efficiency of less than 50%.

mg = milligram
kg = kilogram
NA = Not applicable
ND = No data available

Weight of Evidence:
A - Human carcinogen
B1 - Probable human carcinogen - indicates that limited human data are available
B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans
C - Possible human carcinogen
D - Not classifiable as a human carcinogen

TABLE 4.2
CANCER TOXICITY VALUES AND SOURCES - INHALATION
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

Chemical of Potential Concern	Ambient Air COPC	Unit Risk		Inhalation Cancer Slope Factor (1)		Weight of Evidence/ Cancer Guideline Description	Unit Risk: Inhalation Cancer Slope Factor	
		Value	Units	Value	Units		Source(s)	Date(s)
Aluminum	x	ND		ND		ND		
Antimony	x	ND		ND		ND	IRIS	September-20
Arsenic	x	4.3E-03	$(\mu g/m^3)^{-1}$	1.5E+01	$(mg/kg/day)^{-1}$	A	IRIS	September-20
Barium	x	NA		NA		D	IRIS	September-20
Beryllium		2.4E-03	$(\mu g/m^3)^{-1}$	8.5E+00	$(mg/kg/day)^{-1}$	Likely to be carcinogenic in humans	IRIS	September-20
Boron		NA		NA		Inadequate data	IRIS	September-20
Cadmium	x	1.8E-03	$(\mu g/m^3)^{-1}$	6.4E+00	$(mg/kg/day)^{-1}$	B1	IRIS	September-20
Chromium III	x	NA		NA		Inadequate data	IRIS	September-20
Chromium VI		1.2E-02	$(\mu g/m^3)^{-1}$	4.3E+01	$(mg/kg/day)^{-1}$	Known human carcinogen	IRIS	September-20
Cobalt	x	9.0E-03		3.2E+01	$(mg/kg/day)^{-1}$	Likely to be carcinogenic in humans	PPRTV	September-20
Copper	x	NA		NA		D	IRIS	September-20
Iron	x	ND		ND		ND		
Lead	x	NA		NA		B2	IRIS	September-20
Manganese	x	NA		NA		D	IRIS	September-20
Mercury (as elemental mercury)		NA		NA		D	IRIS	September-20
Molybdenum	x	ND		ND		ND	IRIS	September-20
Nickel	x	2.40E-04	$(\mu g/m^3)^{-1}$	8.5E-01	$(mg/kg/day)^{-1}$	A	IRIS	September-20
Selenium		NA		NA		D	IRIS	September-20
Silver	x	NA		NA		D	IRIS	September-20
Thallium	x	NA		NA		D	IRIS	September-20
Vanadium	x	ND		ND		ND		
Zinc	x	NA		NA		Inadequate data	IRIS	September-20

ABBREVIATIONS AND NOTES:

In accordance with OSWER 9285.7-53, unit risk values are identified from the following heirarchy of sources:

Tier 1:
IRIS = Integrated Risk Information System: Sep-20
Tier 2:
PPRTV = Preliminary Peer-Reviewed Reference Toxicity Value Sep-20 Obtained from Oak Ridge National Laboratory Regional Screening Levels for Chemical Contaminants at Superfund Sites
Tier 3:
HEAST-97= Health Effects Assessment Summary Tables: FY 1997 From HEAST FY 1997 Update
HEAST= Health Effects Assessment Summary Tables: Sep-20 Obtained from Oak Ridge National Laboratory Regional Screening Levels for Chemical Contaminants at Superfund Sites
CALEPA - California Environmental Protection Agency Sep-20
In addition, provisional RfDs developed by NCEA are presented for informational purposes and to be used on a case-by-case basis:
ECAO = Environmental Criteria Assessment Office: Sep-20 Obtained from Oak Ridge National Laboratory Regional Screening Levels for Chemical Contaminants at Superfund Sites
Sep-20 Obtained from Oak Ridge National Laboratory Regional Screening Levels for Chemical Contaminants at Superfund Sites

(1) - Inhalation cancer dose-response values are typically published as unit risk values. Unit risk values may be converted to slope factors using the following equation (HEAST, 1997):
Adjustment = 70 kg [adult body weight] * 1000 µg/mg [conversion factor] / 20 m3/day [inhalation rate]
and: Inhalation Slope Factor = Unit Risk * Adjustment
For inhalation dose-response values published as slope factors it is assumed that the value has been converted from a Unit Risk value. Therefore, the slope factor is converted back to a unit risk value as follows: 20 m^3/day / 70 kg * 1000 µg/mg
Value for nickel based on nickel as nickel refinery dust

kg = kilogram
µg = microgram
mg = milligram
m˝ = cubic meter
NA = Not applicable
ND = No data available

Weight of Evidence:
A - Human carcinogen
B1 - Probable human carcinogen - indicates that limited human data are available
B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans
C - Possible human carcinogen
D - Not classifiable as a human carcinogen

TABLE 4.3
NON-CANCER TOXICITY VALUES AND SOURCES - ORAL/DERMAL
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD		Oral Absorption Efficiency for Dermal (1)	Adjusted Dermal RfD (2)		Primary Target Organ or System / Critical Effect	Combined Uncertainty/Modifying Factors	RfD: Target Organ(s)	
		Value	Units		Value	Units			Source(s)	Date(s)
Inorganic/Metals										
Aluminum	chronic	1.0E+00	mg/kg/day	100%	1.0E+00	mg/kg/day	Neuorotoxicity	100	PPRTV	September-20
Antimony	chronic	4.0E-04	mg/kg/day	15%	6.0E-05	mg/kg/day	Reduced lifespan; hematological; blood glucose and cholesterol	1,000/1	IRIS	September-20
Arsenic	chronic	3.0E-04	mg/kg/day	60%	3.0E-04	mg/kg/day	Skin; keratosis and hyperpigmentation	3/1	IRIS	September-20
Barium	chronic	2.0E-01	mg/kg/day	7%	1.4E-02	mg/kg/day	Kidney; nephropathy	300/1	IRIS	September-20
Beryllium	chronic	2.0E-03	mg/kg/day	0.7%	1.4E-05	mg/kg/day	Small intestine; small intestinal lesions	300/1	IRIS	September-20
Boron	chronic	2.0E-01	mg/kg/day	100%	2.0E-01	mg/kg/day	Developmental; reduced fetal weight	66/1	IRIS	September-20
Cadmium (food)	chronic	1.0E-03	mg/kg/day	2.5%	2.5E-05	mg/kg/day	Kidney; proteinuria	10/1	IRIS	September-20
Chromium VI	chronic	3.0E-03	mg/kg/day	2.5%	7.5E-05	mg/kg/day	No effects observed	300/3	IRIS	September-20
Cobalt	chronic	3.0E-04	mg/kg/day	100%	3.0E-04	mg/kg/day	Thyroid; decreased iodine updake	3,000	PPRTV	September-20
Copper	chronic	4.0E-02	mg/kg/day	100%	4.0E-02	mg/kg/day	GI system; irritation	130	HEAST	September-20
Iron	chronic	7.0E-01	mg/kg/day	100%	7.0E-01	mg/kg/day	GI system; gastrointestinal effects	1.5	PPRTV	September-20
Lead	chronic	ND			ND				IRIS	September-20
Manganese (non-diet)	chronic	7.1E-02	mg/kg/day	4%	5.6E-03	mg/kg/day	CNS; Impairment of neurobehavioral function	1/1	IRIS	September-20
Mercury (as mercuric chloride)	chronic	3.0E-04	mg/kg/day	7%	2.1E-05	mg/kg/day	Immune system; autoimmune effects	1,000/1	IRIS	September-20
Molybdenum	chronic	5.0E-03	mg/kg/day	100%	5.0E-03	mg/kg/day	Kidney; increased uric acid levels	30/1	IRIS	September-20
Nickel	chronic	2.0E-02	mg/kg/day	4%	8.0E-04	mg/kg/day	Decreased body and organ weights	300/1	IRIS	September-20
Selenium	chronic	5.0E-03	mg/kg/day	80%	5.0E-03	mg/kg/day	Skin and liver; clinical selenosis	3/1	IRIS	September-20
Silver	chronic	5.0E-03	mg/kg/day	4%	2.0E-04	mg/kg/day	Skin, eye, and respiratory tract; argyria	3/1	IRIS	September-20
Thallium	chronic (*)	ND			ND				IRIS	September-20
Vanadium	chronic	5.0E-03	mg/kg/day	2.6%	1.3E-04	mg/kg/day	Decreased hair cysteine	100/1	IRIS	September-20
Zinc	chronic	3.0E-01	mg/kg/day	100%	3.0E-01	mg/kg/day	Liver; decreased erythrocyte superoxide dismutase activity	3/1	IRIS	September-20

ABBREVIATIONS AND NOTES:

In accordance with OSWER 9285.7-53, chronic RfDs are identified from the following heirarchy of sources:

Tier 1:
IRIS = Integrated Risk Information System: Sep-20
Tier 2:
PPRTV = Preliminary Peer-Reviewed Toxicity Value: Sep-20 Obtained from Oak Ridge National Laboratory Regional Screening Levels for Chemical Contaminants at Superfund Sites
Tier 3:
HEAST= Health Effects Assessment Summary Tables: Sep-20 Obtained from Oak Ridge National Laboratory Regional Screening Levels for Chemical Contaminants at Superfund Sites and the Risk Assessment Information System
MRL = Minimum Risk Level (ATSDR: chronic MRLs): Sep-20
REL = Reference Exposure Level Sep-20

(1) Values obtained from RAGS Volume 1 (Part E, Supplemental Guidance for Dermal Risk Assessment, Interim Guidance) (EPA, 2004)
Per this guidance, a value of 100% is used for analytes without published values.
(2) Adjusted Dermal RfD = Oral RfD x Oral to Dermal Adjustment Factor. Per RAGS Part E (USEPA, 2004), adjustments are only performed for chemicals that have an oral absorption efficiency of less than 50%.
(*) For the following chemicals, screening PPRTV RfDs have been published; however, the values are to be used as a screening-level values only due to excessively high uncertainty factors applied to the derivation of the value, and have therefore not been used for quantitative risk assessment:

For non-dietary manganese exposures: As recommended in the IRIS file, a non-dietary RfD is obtained by subtracting typical dietary intake of manganese (5 mg/day) from critical dose (10 mg/day). Non-dietary RfD is then adjusted with a modifying factor of 3, as recommended by IRIS for drinking water exposures.
Vanadium - Value is for vanadium and compounds.
% = percent
chronic = the chronic value is used as the subchronic RfD
kg = kilogram
mg = milligram
ND = No data available

TABLE 4.4

NON-CANCER TOXICITY VALUES AND SOURCES - INHALATION

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Chemical of Potential Concern	Chronic/ Subchronic	Ambient Air COPC	Inhalation RfC (1)		Extrapolated RfD (1)		Primary Target Organ or System / Critical Effect	Combined Uncertainty/Modifying Factors	RfC: Target Organ(s)	
			Value	Units	Value	Units			Source(s)	Date(s)
Aluminum	chronic	x	5.0E-03	mg/m3	1.4E-03	mg/kg/day	Neurotoxicity	300	PPRTV	September-20
Antimony	chronic	x	3.0E-04	mg/m3	8.6E-05	mg/kg/day	Respiratory	30	MRL	September-20
Arsenic	chronic	x	1.5E-05	mg/m3	4.3E-06	mg/kg/day	Developmental; cardiovascular; CNS		REL	September-20
Barium	chronic	x	5.0E-04	mg/m3	1.4E-04	mg/kg/day	Developmental; fetotoxicity	1,000	HEAST	September-20
Beryllium	chronic		2.0E-05	mg/m3	5.7E-06	mg/kg/day	Immune system and respiratory; sensitivity, CBD	10/1	IRIS	September-20
Boron	chronic		2.0E-02	mg/m3	5.7E-03	mg/kg/day	Respiratory; irritation	100	HEAST	September-20
Cadmium	chronic	x	2.0E-05	mg/m3	5.7E-06	mg/kg/day	Kidney; respiratory system		REL	September-20
Chromium III	chronic	x	ND		ND				IRIS	September-20
Chromium VI	chronic		1.0E-04	mg/m3	2.9E-05	mg/kg/day	Lung; enzyme alterations	300/1	IRIS	September-20
Cobalt	chronic	x	6.0E-06	mg/m3	1.7E-06	mg/kg/day	Respiratory; lung function	300	PPRTV	September-20
Copper	chronic	x	ND		ND				IRIS	September-20
Iron	chronic	x	ND		ND					
Lead	chronic	x	ND		ND				IRIS	September-20
Manganese (non-diet)	chronic	x	5.0E-05	mg/m3	1.4E-05	mg/kg/day	CNS; impairment of neurobehavioral function	1,000/1	IRIS	September-20
Mercury (as elemental mercury)	chronic		3.0E-04	mg/m3	8.6E-05	mg/kg/day	CNS; tremors, memory; autonomic dysfunction	30/1	IRIS	September-20
Molybdenum	chronic	x	ND		ND				IRIS	September-20
Nickel	chronic	x	9.0E-05	mg/m3	2.6E-05	mg/kg/day	Respiratory system	30	MRL	September-20
Selenium	chronic		2.0E-02	mg/m3	5.7E-03	mg/kg/day	Liver, CNS, Cardiovascular system		REL	September-20
Silver	chronic	x	ND		ND					
Thallium	chronic	x	ND		ND				IRIS	September-20
Vanadium	chronic	x	1.0E-04	mg/m3	2.9E-05	mg/kg/day	Respiratory	30	MRL	September-20
Zinc	chronic	x	ND		ND				IRIS	September-20

ABBREVIATION AND NOTES:

In accordance with OSWER 9285.7-53, chronic RfDs are identified from the following heirarchy of sources:

Tier 1:

IRIS = Integrated Risk Information System: Sep-20

Tier 2:

PPRTV = Preliminary Peer-Reviewed Toxicity Value: Sep-20 Obtained from Oak Ridge National Laboratory Regional Screening Levels for Chemical Contaminants at Superfund Sites

Tier 3:

HEAST= Health Effects Assessment Summary Tables: Sep-20 Obtained from Oak Ridge National Laboratory Regional Screening Levels for Chemical Contaminants at Superfund Sites or the Risk Assessment Information System

MRL = Minimum Risk Level (ATSDR: chronic MRLs): Sep-20

REL = Reference Exposure Level Sep-20

(1) - Inhalation non-cancer dose-response values are typically published as RfC values. RfC values may be converted to RfDs using the following equation (HEAST, 1997): RfD (mg/kg-d) = RfC (mg/m^3) x 20 m^3/d / 70 kg, unless otherwise indicated

(*) For the following chemicals, screening PPRTV RfCs have been published; however, the values are to be used as a screening-level values only due to excessively high uncertainty factors applied to the derivation of the value, and have therefore not been used for quantitative risk assessment:

[a] - Value is a PPRTV-archive, but is used by EPA to establish inhalation RSL values.

Value for chromium VI particulates; value for chromium VI as dissolved chromium VI aerosols or chromic acid mists is 8E-6 mg/m3

There is a National Ambient Air Quality Standard for lead of 1.5 µg/m^3 averaged over three months

Value for vanadium is for vanadium pentoxide

chronic = the chronic value is used as the subchronic RfD

CNS = Central Nervous System

kg = kilogram

m^3 = cubic meter

µg = microgram

mg = milligram

ND = No data available

TABLE 5.1

RISK AND HAZARD SUMMARY BY EXPOSURE PATHWAY - SOIL AND STORM WATER

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Receptor	Exposure Area	Exposure Pathway	ELCR	Hazard Index
Isolated Facility Area Trespasser	A	Incidental Ingestion	1E-06	9E-02
		Dermal Contact	2E-07	2E-03
		Particulate Inhalation	8E-12	1E-06
		Total	**2E-06**	**0.1**
	B	Incidental Ingestion	2E-06	1E-01
		Dermal Contact	3E-07	3E-03
		Particulate Inhalation	9E-12	2E-06
		Total	**2E-06**	**0.1**
	G	Incidental Ingestion	6E-06	3E-01
		Dermal Contact	9E-07	7E-03
		Particulate Inhalation	9E-12	1E-06
		Total	**6E-06**	**0.3**
	I	Incidental Ingestion	4E-06	4E-01
		Dermal Contact	7E-07	5E-03
		Particulate Inhalation	6E-12	7E-07
		Total	**5E-06**	**0.4**
	J	Incidental Ingestion	1E-05	4E-01
		Dermal Contact	2E-06	1E-02
		Particulate Inhalation	2E-11	2E-06
		Total	**1E-05**	**0.5**
Remote Trespasser	C	Incidental Ingestion	2E-06	1E-01
		Dermal Contact	3E-07	2E-03
		Particulate Inhalation	5E-07	1E-01
		Total	**3E-06**	**0.2**
	E	Incidental Ingestion	6E-06	1E+00
		Dermal Contact	1E-06	8E-03
		Particulate Inhalation	4E-06	3E-01
		Total	**1E-05**	**2**
	K	Incidental Ingestion	8E-06	4E-01
		Dermal Contact	1E-06	1E-02
		Particulate Inhalation	5E-08	6E-03
		Total	**1E-05**	**0.4**
In-Town Trespasser	D	Incidental Ingestion	6E-06	8E-01
		Dermal Contact	7E-07	3E-03
		Particulate Inhalation	7E-12	1E-06
		Total	**6E-06**	**0.8**
	H	Incidental Ingestion	2E-05	1E+00
		Dermal Contact	2E-06	8E-03
		Particulate Inhalation	1E-11	3E-06
		Total	**2E-05**	**1**
Restricted Facility Area Trespasser	F	Incidental Ingestion	1E-05	5E-01
		Dermal Contact	6E-06	2E-02
		Particulate Inhalation	9E-12	4E-07
		Total	**2E-05**	**0.5**
Stormwater Trespasser [a]	D	Incidental Ingestion	2E-06	3E-01
		Dermal Contact	8E-08	6E-02
		Total	**2E-06**	**0.4**

ABBREVIATIONS AND NOTES:

[a] - Risks for incidental ingestion are based on EPCs for total metals and risks for dermal contact are based on EPCs for dissolved metals.

ELCR = Excess Lifetime Cancer Risk

Risk calculations are provided in Appendix E.

TABLE 5.2

RISK SUMMARY BY COPC - SOIL AND STORM WATER

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Hypothetical Receptor	**Isolated Facility Area Trespasser**									
Exposure Medium	Soil									
Exposure Area	A		B		G		I		J	
COPC	ELCR	HI	ELCR	HI	ELCR	HI	ELCR	HI	ELCR	HI
Aluminum		5E-03		4E-03		6E-03		4E-03		4E-03
Antimony		1E-03		2E-03		3E-03		8E-03		2E-02
Arsenic	2E-06	2E-02	2E-06	2E-02	6E-06	6E-02	5E-06	5E-02	1E-05	1E-01
Barium		2E-04		1E-04		2E-04		3E-04		7E-04
Cadmium	2E-14	2E-04	6E-14	5E-04	2E-13	4E-03	1E-13	2E-03	7E-13	7E-03
Chromium VI (hexavalent)									5E-14	2E-04
Cobalt	5E-12	3E-02	5E-12	3E-02	4E-12	4E-02	3E-12	2E-02	5E-12	3E-02
Copper		1E-02		3E-02		1E-01		2E-01		2E-01
Iron		2E-02		2E-02		2E-02		2E-02		2E-02
Lead										
Manganese		2E-03		4E-03		2E-03		2E-03		2E-03
Mercury		1E-05		4E-05		3E-04		2E-03		1E-02
Molybdenum		4E-03		6E-03		4E-02		2E-02		2E-02
Nickel	1E-13	4E-04	1E-13	4E-04	1E-13	6E-04	7E-14	4E-04	2E-13	5E-04
Selenium		1E-04		3E-04		6E-04		6E-04		2E-03
Silver				4E-05		7E-04		7E-04		2E-03
Thallium										
Vanadium		6E-03		4E-03		5E-03		3E-03		3E-03
Zinc		2E-04		9E-04		9E-04		8E-04		1E-03

Hypothetical Receptor	**Remote Area Trespasser**					
Exposure Medium	Soil					
Exposure Area	C		E		K	
COPC	ELCR	HI	ELCR	HI	ELCR	HI
Aluminum		3E-02		2E-02		9E-03
Antimony		5E-04		1E-03		2E-02
Arsenic	2E-06	3E-02	8E-06	9E-02	1E-05	9E-02
Barium		2E-03		1E-03		3E-04
Cadmium	2E-09	4E-04	3E-08	7E-03	2E-09	7E-03
Chromium VI (hexavalent)					2E-10	3E-04
Cobalt	4E-07	5E-02	3E-06	4E-01	2E-08	4E-02
Copper		2E-02		7E-01		2E-01
Iron		2E-02		4E-02		3E-02
Lead						
Manganese		5E-02		1E-01		7E-03
Mercury		3E-05		3E-04		4E-03
Molybdenum		6E-03		1E-01		2E-02
Nickel	1E-08	2E-03	6E-08	1E-02	7E-10	9E-04
Selenium		3E-04		2E-03		9E-04
Silver				1E-03		5E-04
Thallium						
Vanadium		2E-02		1E-02		7E-03
Zinc		3E-04		1E-03		1E-03

TABLE 5.2
RISK SUMMARY BY COPC - SOIL AND STORM WATER
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

Hypothetical Receptor	In-town Trespasser			
Exposure Medium	Soil			
Exposure Area	D		H	
COPC	ELCR	HI	ELCR	HI
Aluminum		2E-02		2E-02
Antimony		8E-03		6E-02
Arsenic	6E-06	1E-01	2E-05	3E-01
Barium		8E-04		1E-03
Cadmium	1E-13	7E-03	5E-13	2E-02
Chromium VI (hexavalent)	3E-14	2E-04	2E-14	1E-04
Cobalt	4E-12	1E-01	4E-12	1E-01
Copper		4E-01		4E-01
Iron		7E-02		7E-02
Lead				
Manganese		1E-02		2E-02
Mercury		1E-03		2E-03
Molybdenum		2E-02		5E-02
Nickel	1E-13	2E-03	2E-13	3E-03
Selenium		2E-03		5E-03
Silver		7E-04		1E-02
Thallium				
Vanadium		2E-02		2E-02
Zinc		2E-03		9E-03

Hypothetical Receptor	Restricted Facility Area Trespasser	
Exposure Medium	Soil	
Exposure Area	F	
COPC	ELCR	HI
Aluminum		7E-04
Antimony		2E-02
Arsenic	2E-05	2E-01
Barium		1E-04
Cadmium	3E-13	1E-02
Chromium VI (hexavalent)	8E-15	8E-05
Cobalt	5E-13	1E-02
Copper		1E-01
Iron		7E-03
Lead		
Manganese		4E-04
Mercury		5E-03
Molybdenum		7E-02
Nickel	2E-14	2E-04
Selenium		1E-03
Silver		1E-03
Thallium		
Vanadium		8E-04
Zinc		8E-04

TABLE 5.2

RISK SUMMARY BY COPC - SOIL AND STORM WATER

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Hypothetical Receptor	**In-town Trespasser**	
Exposure Medium	Stormwater	
Exposure Area	D	
COPC	ELCR	HI
Aluminum		3E-03
Antimony		1E-03
Arsenic	2E-06	3E-02
Barium		8E-05
Cadmium		9E-03
Chromium, Total		7E-06
Cobalt		3E-02
Copper		3E-01
Iron		1E-02
Lead		
Manganese		2E-03
Mercury		1E-03
Molybdenum		1E-02
Nickel		8E-04
Selenium		1E-04
Silver		2E-03
Thallium		
Vanadium		4E-03
Zinc		1E-03

ABBREVIATIONS AND NOTES:

COPC = Chemical of potential concern

ELCR = Excess lifetime cancer risk

HI = Hazard index

Risk calculations are provided in Appendix E.

TABLE 5.3
RISK AND HAZARD SUMMARY - AMBIENT AIR
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

Receptor	Exposure Area	Exposure Medium	ELCR	Hazard Index
Resident	ST-01	Ambient Air Inhalation	1E-05	1E+00
		Total	**1E-05**	**1**
	ST-16	Ambient Air Inhalation	2E-05	1E+00
		Total	**2E-05**	**1**
	ST-23	Ambient Air Inhalation	2E-05	1E+00
		Total	**2E-05**	**1**
	ST-26	Ambient Air Inhalation	1E-05	8E-01
		Total	**1E-05**	**0.8**
High School Staff	ST-02	Ambient Air Inhalation	2E-06	2E-01
		Total	**2E-06**	**0.2**
High School Student	ST-02	Ambient Air Inhalation	1E-07	8E-02
		Total	**1E-07**	**0.08**
Remote Area Trespasser	ST-05	Ambient Air Inhalation	2E-06	1E-01
		Total	**2E-06**	**0.1**
	ST-18	Ambient Air Inhalation	3E-06	2E-01
		Total	**3E-06**	**0.2**
In-Town Trespasser	ST-09	Ambient Air Inhalation	4E-07	4E-02
		Total	**4E-07**	**0.04**
Restricted Facility Area Trespasser	ST-14	Ambient Air Inhalation	2E-07	8E-03
		Total	**2E-07**	**0.008**

ABBREVIATIONS AND NOTES:
ELCR = Excess lifetime cancer risk
Risk calculations are provided in Appendix D.

TABLE 5.4
RISK AND HAZARD SUMMARY BY COPC - AMBIENT AIR
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

Hypothetical Receptor	**Resident**							
Exposure Medium	Ambient Air							
Exposure Area	ST-01		ST-16		ST-23		ST-26	
COPC	ELCR	HI	ELCR	HI	ELCR	HI	ELCR	HI
Aluminum		1E-01		2E-01		1E-01		8E-02
Antimony		5E-03		5E-03		5E-03		4E-03
Arsenic	1E-05	4E-01	1E-05	6E-01	2E-05	7E-01	1E-05	4E-01
Barium		1E-02		2E-02		2E-02		1E-02
Cadmium	1E-06	8E-02	1E-06	8E-02	1E-06	1E-01	9E-07	7E-02
Chromium								
Cobalt	4E-06	2E-01	5E-06	2E-01	3E-06	1E-01		
Copper								
Iron								
Lead								
Manganese		2E-01		3E-01		2E-01		1E-01
Molybdenum								
Nickel	4E-08	5E-03	5E-08	6E-03	5E-08	6E-03	4E-08	5E-03
Silver								
Thallium								
Vanadium		2E-02		3E-02		2E-02		1E-02
Zinc								

Hypothetical Receptor	**High School Staff**	
Exposure Medium	Ambient Air	
Exposure Area	ST-02	
COPC	ELCR	HI
Aluminum		3E-02
Antimony		4E-03
Arsenic	2E-06	8E-02
Barium		5E-03
Cadmium	3E-07	2E-02
Chromium		
Cobalt		
Copper		
Iron		
Lead		
Manganese		5E-02
Molybdenum		
Nickel	2E-08	2E-03
Silver		
Thallium		
Vanadium		4E-03
Zinc		

TABLE 5.4
RISK AND HAZARD SUMMARY BY COPC - AMBIENT AIR
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

Hypothetical Receptor	High School Student	
Exposure Medium	Ambient Air	
Exposure Area	ST-02	
COPC	ELCR	HI
Aluminum		1E-02
Antimony		1E-03
Arsenic	1E-07	3E-02
Barium		2E-03
Cadmium	2E-08	9E-03
Chromium		
Cobalt		
Copper		
Iron		
Lead		
Manganese		2E-02
Molybdenum		
Nickel	1E-09	9E-04
Silver		
Thallium		
Vanadium		2E-03
Zinc		

Hypothetical Receptor	Remote Area Trespasser			
Exposure Medium	Ambient Air			
Exposure Area	ST-05		ST-18	
COPC	ELCR	HI	ELCR	HI
Aluminum		5E-03		9E-03
Antimony		7E-04		6E-04
Arsenic	1E-06	7E-02	2E-06	1E-01
Barium		2E-03		2E-03
Cadmium	1E-07	1E-02	2E-07	1E-02
Chromium				
Cobalt			4E-07	2E-02
Copper				
Iron				
Lead				
Manganese		1E-02		2E-02
Molybdenum				
Nickel	4E-09	6E-04	4E-09	6E-04
Silver				
Thallium				
Vanadium		1E-03		1E-03
Zinc				

TABLE 5.4
RISK AND HAZARD SUMMARY BY COPC - AMBIENT AIR
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

Hypothetical Receptor	**In-town Trespasser**	
Exposure Medium	Ambient Air	
Exposure Area	ST-09	
COPC	ELCR	HI
Aluminum		3E-03
Antimony		3E-04
Arsenic	3E-07	2E-02
Barium		5E-04
Cadmium	3E-08	3E-03
Chromium		
Cobalt	1E-07	8E-03
Copper		
Iron		
Lead		
Manganese		4E-03
Molybdenum		
Nickel	2E-09	3E-04
Silver		
Thallium		
Vanadium		4E-04
Zinc		

Hypothetical Receptor	**Restricted Facility Area Trespasser**	
Exposure Medium	Ambient Air	
Exposure Area	ST-14	
COPC	ELCR	HI
Aluminum		1E-04
Antimony		2E-05
Arsenic	1E-07	6E-03
Barium		8E-05
Cadmium	9E-09	6E-04
Chromium		
Cobalt	1E-08	5E-04
Copper		
Iron		
Lead		
Manganese		2E-04
Molybdenum		
Nickel	1E-10	1E-05
Silver		
Thallium		
Vanadium		2E-05
Zinc		

ABBREVIATIONS AND NOTES:
ELCR = Excess Lifetime Cancer Risk
HI = Hazard Index

TABLE 5.5

SUMMARY OF CALCULATED BLOOD LEAD CONCENTRATIONS (PbBs) - SOIL AND STORM WATER

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Exposure Scenario	Calculated Blood Lead Level (PbB) of receptor, geometric mean	Probability that calculated fetal PbB > Target PbB level of concern (e.g., 5 µg/dL)
In-Town Trespasser - Adolescent (Ages 11 - <16)		
Exposure Area D	0.9	0.1%
Exposure Area H	2.0	4.4%
Storm water	0.6	0.0%
Isolated Area Trespasser - Adolescent (Ages 11 - <16)		
Exposure Area A	0.5	0.0%
Exposure Area B	0.6	0.0%
Exposure Area G	0.7	0.0%
Exposure Area I	0.6	0.0%
Exposure Area J	0.7	0.0%
Restricted Area Trespasser - Adolescent (Ages 11 - <16)		
Exposure Area F	1.4	1.1%
Remote Area Trespasser - Adolescent (Ages 11 - <16)		
Exposure Area C	0.5	0.0%
Exposure Area E	0.6	0.0%
Exposure Area K	0.6	0.0%

ABBREVIATIONS AND NOTES:

µg/dL = micrograms per deciliter

Blood Lead Concentrations (PbBs) are calculated in Appendix F.

PbB - Blood lead concentration

TABLE 5.6

INCREMENTAL RISK AND HAZARD SUMMARY BY EXPOSURE PATHWAY - SOIL AND STORM WATER

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Receptor	Exposure Area	Exposure Pathway	Incremental ELCR	Incremental Hazard Index
Isolated Facility Area Trespasser	Background	Incidental Ingestion	3E-07	4E-02
		Dermal Contact	5E-08	1E-03
		Particulate Inhalation	1E-07	3E-02
		Total	**5E-07**	**0.07**
	A	Incidental Ingestion	1E-06	4E-02
		Dermal Contact	2E-07	6E-04
		Particulate Inhalation	-1E-07	-3E-02
		Total	**1E-06**	**0.02**
	B	Incidental Ingestion	2E-06	7E-02
		Dermal Contact	3E-07	2E-03
		Particulate Inhalation	-1E-07	-3E-02
		Total	**2E-06**	**0.04**
	G	Incidental Ingestion	5E-06	3E-01
		Dermal Contact	8E-07	6E-03
		Particulate Inhalation	-1E-07	-3E-02
		Total	**6E-06**	**0.23**
	I	Incidental Ingestion	4E-06	3E-01
		Dermal Contact	6E-07	4E-03
		Particulate Inhalation	-1E-07	-3E-02
		Total	**4E-06**	**0.29**
	J	Incidental Ingestion	1E-05	4E-01
		Dermal Contact	2E-06	1E-02
		Particulate Inhalation	-1E-07	-3E-02
		Total	**1E-05**	**0.39**
Remote Trespasser	Background	Incidental Ingestion	6E-07	9E-02
		Dermal Contact	1E-07	2E-03
		Particulate Inhalation	4E-07	1E-01
		Total	**1E-06**	**0.20**
	C	Incidental Ingestion	1E-06	4E-02
		Dermal Contact	2E-07	4E-05
		Particulate Inhalation	1E-07	-8E-03
		Total	**2E-06**	**0.0**
	E	Incidental Ingestion	6E-06	1E+00
		Dermal Contact	9E-07	5E-03
		Particulate Inhalation	3E-06	2E-01
		Total	**1E-05**	**1.4**
	K	Incidental Ingestion	8E-06	3E-01
		Dermal Contact	1E-06	8E-03
		Particulate Inhalation	-4E-07	-1E-01
		Total	**9E-06**	**0.2**
In-Town Trespasser	Background	Incidental Ingestion	9E-07	2E-01
		Dermal Contact	1E-07	1E-03
		Particulate Inhalation	1E-07	4E-02
		Total	**1E-06**	**0.27**
	D	Incidental Ingestion	5E-06	5E-01
		Dermal Contact	5E-07	2E-03
		Particulate Inhalation	-1E-07	-4E-02
		Total	**5E-06**	**0.5**
	H	Incidental Ingestion	2E-05	9E-01
		Dermal Contact	2E-06	7E-03
		Particulate Inhalation	-1E-07	-4E-02
		Total	**2E-05**	**0.9**
Restricted Facility Area Trespasser	Background	Incidental Ingestion	4E-08	1E-02
		Dermal Contact	2E-08	2E-04
		Particulate Inhalation	7E-09	2E-03
		Total	**7E-08**	**0.01**
	F	Incidental Ingestion	1E-05	5E-01
		Dermal Contact	6E-06	2E-02
		Particulate Inhalation	-7E-09	-2E-03
		Total	**2E-05**	**0.5**
Stormwater Trespasser	Background	Incidental Ingestion	8E-08	3E-03
		Dermal Contact	5E-08	2E-03
		Total	**1E-07**	**0.005**
	D	Incidental Ingestion	2E-06	3E-01
		Dermal Contact	4E-08	6E-02
		Total	**2E-06**	**0.4**

ABBREVIATIONS AND NOTES:

ELCR = Excess lifetime cancer risk

Risk calculations are provided in Appendix E.

TABLE 5.7

INCREMENTAL RISK SUMMARY BY COPC - SOIL AND STORM WATER

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Hypothetical Receptor	**Isolated Facility Area Trespasser**											
Exposure Medium	Soil											
Exposure Area	Background		A		B		G		I		J	
COPC	ELCR	HI	ELCR	HI	ELCR	HI	ELCR	HI	ELCR	HI	ELCR	HI
Aluminum		1E-02										
Antimony		5E-04		7E-04		1E-03		2E-03		8E-03		2E-02
Arsenic	4E-07	4E-03	1E-06	1E-02	2E-06	2E-02	6E-06	6E-02	5E-06	4E-02	1E-05	1E-01
Barium		3E-04										4E-04
Cadmium	8E-10	3E-04				1E-04		4E-03		1E-03		7E-03
Chromium VI (hexavalent)	4E-09	7E-04										
Cobalt	8E-08	2E-02		7E-03		5E-03		2E-02		4E-03		9E-03
Copper		4E-03		7E-03		2E-02		1E-01		2E-01		2E-01
Iron		9E-03		8E-03		6E-03		1E-02		1E-02		1E-02
Lead												
Manganese		2E-02										
Mercury		8E-05						2E-04		2E-03		1E-02
Molybdenum		1E-04		4E-03		6E-03		4E-02		2E-02		2E-02
Nickel	2E-09	6E-04						2E-05				
Selenium		1E-04				2E-04		5E-04		5E-04		2E-03
Silver		1E-04						6E-04		6E-04		2E-03
Thallium												
Vanadium		5E-03		1E-03				7E-04				
Zinc		6E-05		2E-04		8E-04		9E-04		7E-04		1E-03

Hypothetical Receptor	**Remote Area Trespasser**							
Exposure Medium	Soil							
Exposure Area	Background		C		E		K	
COPC	ELCR	HI	ELCR	HI	ELCR	HI	ELCR	HI
Aluminum		3E-02						
Antimony		9E-04				2E-04		2E-02
Arsenic	8E-07	1E-02	2E-06	2E-02	7E-06	8E-02	9E-06	8E-02
Barium		1E-03		6E-04		3E-04		
Cadmium	3E-09	8E-04			3E-08	6E-03		6E-03
Chromium VI (hexavalent)	2E-08	1E-03						
Cobalt	3E-07	5E-02	4E-08	1E-03	3E-06	4E-01		
Copper		7E-03		1E-02		7E-01		2E-01
Iron		2E-02		5E-03		2E-02		2E-02
Lead								
Manganese		6E-02				4E-02		
Mercury		2E-04				2E-04		4E-03
Molybdenum		2E-04		6E-03		1E-01		2E-02
Nickel	2E-09	2E-03	9E-09	1E-04	5E-08	8E-03		
Selenium		2E-04		8E-05		1E-03		6E-04
Silver		3E-04				8E-04		3E-04
Thallium								
Vanadium		1E-02		4E-03				
Zinc		1E-04		1E-04		1E-03		1E-03

TABLE 5.7

INCREMENTAL RISK SUMMARY BY COPC - SOIL AND STORM WATER

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Hypothetical Receptor	**In-town Trespasser**					
Exposure Medium	Soil					
Exposure Area	Background		D		H	
COPC	ELCR	HI	ELCR	HI	ELCR	HI
Aluminum		3E-02				
Antimony		2E-03		6E-03		6E-02
Arsenic	1E-06	2E-02	5E-06	9E-02	2E-05	3E-01
Barium		8E-04				4E-04
Cadmium	8E-10	1E-03		5E-03		2E-02
Chromium VI (hexavalent)	5E-09	1E-03				
Cobalt	8E-08	9E-02		5E-02		4E-02
Copper		2E-02		3E-01		4E-01
Iron		5E-02		3E-02		2E-02
Lead						
Manganese		3E-02				
Mercury		4E-04		5E-04		1E-03
Molybdenum		6E-04		2E-02		5E-02
Nickel	6E-10	2E-03		6E-05		2E-03
Selenium		6E-04		2E-03		4E-03
Silver		6E-04		2E-05		1E-02
Thallium						
Vanadium		2E-02				2E-04
Zinc		3E-04		2E-03		8E-03

Hypothetical Receptor	**Restricted Facility Area Trespasser**			
Exposure Medium	Soil			
Exposure Area	Background		F	
COPC	ELCR	HI	ELCR	HI
Aluminum		2E-03		
Antimony		1E-04		2E-02
Arsenic	6E-08	8E-04	2E-05	2E-01
Barium		3E-05		9E-05
Cadmium	5E-11	6E-05		1E-02
Chromium VI (hexavalent)	3E-10	1E-04		
Cobalt	5E-09	4E-03		6E-03
Copper		9E-04		1E-01
Iron		2E-03		5E-03
Lead				
Manganese		1E-03		
Mercury		2E-05		5E-03
Molybdenum		3E-05		7E-02
Nickel	2E-10	8E-05		2E-04
Selenium		3E-05		1E-03
Silver		3E-05		1E-03
Thallium				
Vanadium		9E-04		
Zinc		1E-05		8E-04

TABLE 5.7

INCREMENTAL RISK SUMMARY BY COPC - SOIL AND STORM WATER

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Hypothetical Receptor	**In-town Trespasser**			
Exposure Medium	Stormwater			
Exposure Area	Background		D	
COPC	ELCR	HI	ELCR	HI
Aluminum		9E-05		3E-03
Antimony		3E-04		8E-04
Arsenic	1E-07	2E-03	2E-06	3E-02
Barium		2E-05		7E-05
Cadmium		4E-04		9E-03
Chromium, Total		2E-06		6E-06
Cobalt		2E-04		3E-02
Copper		1E-03		3E-01
Iron		1E-04		1E-02
Lead				
Manganese		1E-04		2E-03
Mercury		4E-05		1E-03
Molybdenum		5E-05		1E-02
Nickel		2E-05		8E-04
Selenium		3E-05		1E-04
Silver		6E-06		2E-03
Thallium				
Vanadium		3E-04		4E-03
Zinc		8E-06		1E-03

ABBREVIATIONS AND NOTES:

ELCR = Excess lifetime cancer risk

HI = Hazard index

Risk calculations are provided in Appendix E.

TABLE 5.8

INCREMENTAL RISK AND HAZARD SUMMARY - AMBIENT AIR

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Receptor	Exposure Area	Exposure Medium	Incremental ELCR	Incremental HI
Resident	Background	Ambient Air Inhalation	1E-06	2E-01
		Total	**1E-06**	**0.2**
	ST-01	Ambient Air Inhalation	1E-05	8E-01
		Total	**1E-05**	**0.8**
	ST-16	Ambient Air Inhalation	2E-05	1E+00
		Total	**2E-05**	**1**
	ST-23	Ambient Air Inhalation	2E-05	1E+00
		Total	**2E-05**	**1**
	ST-26	Ambient Air Inhalation	1E-05	6E-01
		Total	**1E-05**	**0.6**
High School Staff	Background	Ambient Air Inhalation	3E-07	6E-02
		Total	**3E-07**	**0.06**
	ST-02	Ambient Air Inhalation	2E-06	1E-01
		Total	**2E-06**	**0.1**
High School Student	Background	Ambient Air Inhalation	4E-08	4E-02
		Total	**4E-08**	**0.04**
	ST-02	Ambient Air Inhalation	1E-07	3E-02
		Total	**1E-07**	**0.03**
Remote Area Trespasser	Background	Ambient Air Inhalation	6E-08	1E-02
		Total	**6E-08**	**0.01**
	ST-05	Ambient Air Inhalation	2E-06	8E-02
		Total	**2E-06**	**0.08**
	ST-18	Ambient Air Inhalation	3E-06	2E-01
		Total	**3E-06**	**0.2**
In-Town Trespasser	Background	Ambient Air Inhalation	2E-08	4E-03
		Total	**2E-08**	**0.004**
	ST-09	Ambient Air Inhalation	4E-07	3E-02
		Total	**4E-07**	**0.03**
Restricted Facility Area Trespasser	Background	Ambient Air Inhalation	1E-09	2E-04
		Total	**1E-09**	**0.0002**
	ST-14	Ambient Air Inhalation	2E-07	8E-03
		Total	**2E-07**	**0.008**

ABBREVIATIONS AND NOTES:

ELCR = Excess lifetime cancer risk

HI = Hazard index

Risk calculations are provided in Appendix D.

TABLE 5.9

INCREMENTAL RISK AND HAZARD SUMMARY BY COPC - AMBIENT AIR

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Hypothetical Receptor	**Resident**									
Exposure Medium	Ambient Air									
Exposure Area	Background		ST-01		ST-16		ST-23		ST-26	
COPC	ELCR	HI	Incremental ELCR	Incremental HI	Incremental ELCR	Incremental HI	Incremental ELCR	Incremental HI	Incremental ELCR	Incremental HI
Aluminum		6E-02		4E-02		9E-02		4E-02		2E-02
Arsenic	1E-06	4E-02	9E-06	4E-01	1E-05	5E-01	2E-05	6E-01	1E-05	4E-01
Manganese		9E-02		8E-02		2E-01		1E-01		6E-02

Hypothetical Receptor	**High School Staff**			
Exposure Medium	Ambient Air			
Exposure Area	Background		ST-02	
COPC	ELCR	HI	Incremental ELCR	Incremental HI
Aluminum		2E-02		9E-03
Arsenic	3E-07	1E-02	2E-06	7E-02
Manganese		3E-02		2E-02

Hypothetical Receptor	**High School Student**			
Exposure Medium	Ambient Air			
Exposure Area	Background		ST-02	
COPC	ELCR	HI	Incremental ELCR	Incremental HI
Aluminum		1E-02		-2E-03
Arsenic	4E-08	1E-02	8E-08	2E-02
Manganese		2E-02		-2E-03

TABLE 5.9
INCREMENTAL RISK AND HAZARD SUMMARY BY COPC - AMBIENT AIR
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

Hypothetical Receptor	Remote Area Trespasser					
Exposure Medium	Ambient Air					
Exposure Area	Background		ST-05		ST-18	
COPC	ELCR	HI	Incremental ELCR	Incremental HI	Incremental ELCR	Incremental HI
Aluminum	6E-08	4E-03	1E-06	2E-03	2E-06	5E-03
Arsenic		3E-03		6E-02		1E-01
Manganese		6E-03		4E-03		1E-02

Hypothetical Receptor	In-town Trespasser			
Exposure Medium	Ambient Air			
Exposure Area	Background		ST-09	
COPC	ELCR	HI	Incremental ELCR	Incremental HI
Aluminum	2E-08	1E-03	3E-07	1E-03
Arsenic		1E-03		2E-02
Manganese		2E-03		2E-03

Hypothetical Receptor	Restricted Facility Area Trespasser			
Exposure Medium	Ambient Air			
Exposure Area	Background		ST-14	
COPC	ELCR	HI	Incremental ELCR	Incremental HI
Aluminum	1E-09	5E-05	1E-07	7E-05
Arsenic		4E-05		6E-03
Manganese		8E-05		1E-04

ABBREVIATIONS AND NOTES:
ELCR = Excess Lifetime Cancer Risk
HI = Hazard Index

TABLE 5.10
CUMULATIVE RISK SUMMARY - RESIDENTIAL SCENARIO
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

Receptor	Exposure Area	Exposure Pathway	ELCR	Hazard Index
In-Town Trespasser	D	Incidental Ingestion	6E-06	8E-01
		Dermal Contact	7E-07	3E-03
		Particulate Inhalation	2E-12	5E-07
Storm Water Trespasser		Incidental Ingestion	2E-06	3E-01
		Dermal Contact	8E-08	6E-02
Resident	ST-01	Ambient Air Inhalation	1E-05	1.0
		Total	**2E-05**	**2**
In-Town Trespasser	D	Incidental Ingestion	6E-06	8E-01
		Dermal Contact	7E-07	3E-03
		Particulate Inhalation	2E-12	5E-07
Storm Water Trespasser		Incidental Ingestion	2E-06	3E-01
		Dermal Contact	8E-08	6E-02
Resident	ST-16	Ambient Air Inhalation	2E-05	1.4
		Total	**3E-05**	**3**
In-Town Trespasser	D	Incidental Ingestion	6E-06	8E-01
		Dermal Contact	7E-07	3E-03
		Particulate Inhalation	2E-12	5E-07
Storm Water Trespasser		Incidental Ingestion	2E-06	3E-01
		Dermal Contact	8E-08	6E-02
Resident	ST-23	Ambient Air Inhalation	2E-05	1.3
		Total	**3E-05**	**2**
In-Town Trespasser	D	Incidental Ingestion	6E-06	8E-01
		Dermal Contact	7E-07	3E-03
		Particulate Inhalation	2E-12	5E-07
Storm Water Trespasser		Incidental Ingestion	2E-06	3E-01
		Dermal Contact	8E-08	6E-02
Resident	ST-26	Ambient Air Inhalation	1E-05	0.8
		Total	**2E-05**	**2**

ABBREVIATIONS AND NOTES:
ELCR = Excess Lifetime Cancer Risk

TABLE 5.11
CUMULATIVE RISK SUMMARY - NON-RESIDENTIAL SCENARIO
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

Receptor	Exposure Area	Exposure Pathway	ELCR	Hazard Index
In-Town Trespasser	H	Incidental Ingestion	2E-05	1E+00
		Dermal Contact	2E-06	8E-03
		Particulate Inhalation	1E-11	3E-06
High School Student	ST-02	Ambient Air Inhalation	1E-07	8E-02
		Total	**2E-05**	**1**
In-Town Trespasser	H	Incidental Ingestion	2E-05	1E+00
		Dermal Contact	2E-06	8E-03
		Particulate Inhalation	1E-11	3E-06
	ST-09	Ambient Air Inhalation	4E-07	4E-02
		Total	**2E-05**	**1**
Restricted Facility Area Trespasser	F	Incidental Ingestion	1E-05	5E-01
		Dermal Contact	6E-06	2E-02
		Particulate Inhalation	9E-12	4E-07
	ST-14	Ambient Air Inhalation	2E-07	8E-03
		Total	**2E-05**	**0.5**
Remote Area Trespasser	K	Incidental Ingestion	8E-06	4E-01
		Dermal Contact	1E-06	1E-02
		Particulate Inhalation	5E-08	6E-03
	ST-05	Ambient Air Inhalation	2E-06	1E-01
		Total	**1E-05**	**0.5**
Remote Area Trespasser	K	Incidental Ingestion	8E-06	4E-01
		Dermal Contact	1E-06	1E-02
		Particulate Inhalation	5E-08	6E-03
	ST-18	Ambient Air Inhalation	3E-06	2E-01
		Total	**1E-05**	**0.6**

ABBREVIATIONS AND NOTES:
ELCR = Excess Lifetime Cancer Risk

TABLE 5.12
CUMULATIVE TARGET ORGAN HAZARD INDEX SUMMARY - RESIDENTIAL SCENARIOS
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

			ST-01	ST-16	ST-23	ST-26
		Ambient Air	1E-05	2E-05	2E-05	1E-05
		Soil - EA D	6E-06	6E-06	6E-06	6E-06
		Storm water - EA D	2E-06	2E-06	2E-06	2E-06
		Total ELCR	**2E-05**	**3E-05**	**3E-05**	**2E-05**
COPC	**Exposure Medium**	**Target Organ**	**HQ**	**HQ**	**HQ**	**HQ**
Arsenic	Ambient air	Reproductive/Development	4E-01	6E-01	7E-01	4E-01
Boron	Storm water - EA D	Developmental	2.E-05	2.E-05	2.E-05	2.E-05
		HI - Reproductive/Development	**0.4**	**0.6**	**0.7**	**0.4**
Antimony	Ambient air	Lung	5E-03	5E-03	5E-03	4E-03
Cadmium	Ambient air	Lung/Kidney	8E-02	8E-02	1E-01	7E-02
Cobalt	Ambient air	Lung	2E-01	2E-01	1E-01	NA
Nickel	Ambient air	Lung	5E-03	6E-03	6E-03	5E-03
Silver	Ambient air		NTV	NTV	NTV	NTV
Silver	Soil - EA D	Skin/ Eye/ Respiratory	7E-04	7E-04	7E-04	7E-04
Silver	Storm water - EA D	Skin/ Eye/ Respiratory	2E-03	2E-03	2E-03	2E-03
Vanadium	Ambient air	Lung	2E-02	3E-02	2E-02	1E-02
		HI - Lung	**0.3**	**0.4**	**0.3**	**0.09**
Barium	Ambient air	Liver	1E-02	2E-02	2E-02	1E-02
Selenium	Soil - EA D	Skin/Liver	2E-03	2E-03	2E-03	2E-03
Selenium	Storm water - EA D	Skin/Liver	1E-04	1E-04	1E-04	1E-04
Vanadium	Soil - EA D	Liver	2E-02	2E-02	2E-02	2E-02
Vanadium	Storm water - EA D	Liver	4E-03	4E-03	4E-03	4E-03
Zinc	Soil - EA D	Liver	2E-03	2E-03	2E-03	2E-03
Zinc	Storm water - EA D	Liver	1E-03	1E-03	1E-03	1E-03
		HI - Liver	**0.04**	**0.04**	**0.04**	**0.04**
Barium	Soil - EA D	Kidney	8E-04	8E-04	8E-04	8E-04
Barium	Storm water - EA D	Kidney	8E-05	8E-05	8E-05	8E-05
Cadmium	Ambient air	Lung/Kidney	8E-02	8E-02	1E-01	7E-02
Cadmium	Soil - EA D	Kidney	7E-03	7E-03	7E-03	7E-03
Cadmium	Storm water - EA D	Kidney	9E-03	9E-03	9E-03	9E-03
Molybdenum	Soil - EA D	Kidney	2E-02	2E-02	2E-02	2E-02
Molybdenum	Storm water - EA D	Kidney	1E-02	1E-02	1E-02	1E-02
		HI - Kidney	**0.1**	**0.1**	**0.1**	**0.1**
Arsenic	Soil - EA D	Skin	1E-01	1E-01	1E-01	1E-01
Arsenic	Storm water - EA D	Skin	3E-02	3E-02	3E-02	3E-02
Selenium	Soil - EA D	Skin/Liver	2E-03	2E-03	2E-03	2E-03
Selenium	Storm water - EA D	Skin/Liver	1E-04	1E-04	1E-04	1E-04
Silver	Soil - EA D	Skin/ Eye/ Respiratory	7E-04	7E-04	7E-04	7E-04
Silver	Storm water - EA D	Skin/ Eye/ Respiratory	2E-03	2E-03	2E-03	2E-03
		HI - Skin	**0.1**	**0.1**	**0.1**	**0.1**
Silver	Soil - EA D	Skin/ Eye/ Respiratory	7E-04	7E-04	7E-04	7E-04
Silver	Storm water - EA D	Skin/ Eye/ Respiratory	2E-03	2E-03	2E-03	2E-03
		HI - Eye	**0.003**	**0.003**	**0.003**	**0.003**
Antimony	Soil - EA D	General Toxicity / Hematological	8.E-03	8.E-03	8.E-03	8.E-03
Antimony	Storm water - EA D	General Toxicity / Hematological	4.E-04	4.E-04	4.E-04	4.E-04
Nickel	Soil - EA D	General Toxicity	2.E-03	2.E-03	2.E-03	2.E-03
Nickel	Storm water - EA D	General Toxicity	9.E-04	9.E-04	9.E-04	9.E-04
		HI - General Toxicity	**0.01**	**0.01**	**0.01**	**0.01**
		HI - Hematological	**0.008**	**0.008**	**0.008**	**0.008**

TABLE 5.12
CUMULATIVE TARGET ORGAN HAZARD INDEX SUMMARY - RESIDENTIAL SCENARIOS
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

			ST-01	ST-16	ST-23	ST-26
		Ambient Air	1E-05	2E-05	2E-05	1E-05
		Soil - EA D	6E-06	6E-06	6E-06	6E-06
		Storm water - EA D	2E-06	2E-06	2E-06	2E-06
		Total ELCR	**2E-05**	**3E-05**	**3E-05**	**2E-05**
COPC	**Exposure Medium**	**Target Organ**	**HQ**	**HQ**	**HQ**	**HQ**
Cobalt	Soil - EAD	Endocrine	1.E-01	1.E-01	1.E-01	1.E-01
Cobalt	Storm water - EA D	Endocrine	3.E-02	3.E-02	3.E-02	3.E-02
		HI - Endocrine	**0.2**	**0.2**	**0.2**	**0.2**
Beryllium	Storm water - EA D	GI system	3.E-05	3.E-05	3.E-05	3.E-05
Copper	Soil - EAD	GI system	4.E-01	4.E-01	4.E-01	4.E-01
Copper	Storm water - EA D	GI system	3.E-01	3.E-01	3.E-01	3.E-01
Iron	Soil - EAD	GI system	7.E-02	7.E-02	7.E-02	7.E-02
Iron	Storm water - EA D	GI system	1.E-02	1.E-02	1.E-02	1.E-02
		HI - GI system	**0.7**	**0.7**	**0.7**	**0.7**
Mercury	Soil - EAD	Immune system	1.E-03	1.E-03	1.E-03	1.E-03
Mercury	Storm water - EA D	Immune system	9.E-04	9.E-04	9.E-04	9.E-04
		HI - Immune system	**0.002**	**0.002**	**0.002**	**0.002**
Chromium	Storm water - EA D	NOAEL	7.E-06	7.E-06	7.E-06	7.E-06
		HI - NOAEL	**0.000007**	**0.000007**	**0.000007**	**0.000007**
Aluminum	Ambient air	Nervous system	1E-01	2E-01	1E-01	8E-02
Aluminum	Soil - EA D	Nervous system	2E-02	2E-02	2E-02	2E-02
Aluminum	Storm water - EA D	Nervous system	3E-03	3E-03	3E-03	3E-03
Manganese	Ambient air	Nervous system	2E-01	3E-01	2E-01	1E-01
Manganese	Soil - EA D	Nervous system	1E-02	1E-02	1E-02	1E-02
Manganese	Storm water - EA D	Nervous system	2E-03	2E-03	2E-03	2E-03
		HI - Nervous System	**0.3**	**0.5**	**0.3**	**0.3**

ABBREVIATIONS AND NOTES:
COPC = Chemical of potential concern
GI = Gastrointestinal
HI = Hazard index
HQ = Hazard quotient
NA = Not applicable
NOAEL = No observed adverse effect level
NTV = No toxicity value available

TABLE 5.13

CUMULATIVE TARGET ORGAN HAZARD INDEX SUMMARY - NON-RESIDENTIAL SCENARIOS

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

			High School Student	Remote Area Trespasser			In-Town Trespasser [Note a]	Restricted Facility Area Trespasser
		Air Exposure Area	*ST-02*	*ST-05*	*ST-18*	*N/A*	*ST-09*	*ST-14*
		Soil Exposure Area	*Area H*	*Area K*		*Area E*	*Area H*	*Area F*
		Ambient Air ELCR	1E-07	2E-06	3E-06	N/A	4E-07	2E-07
		Soil ELCR	2E-05	1E-05	1E-05	1E-05	2E-05	2E-05
		Total ELCR	**2E-05**	**1E-05**	**1E-05**	**1E-05**	**2E-05**	**2E-05**
COPC	Exposure Medium	Target Organ	HQ	HQ	HQ	HQ	HQ	HQ
Arsenic	Ambient air	Reproductive/Development	3E-02	7E-02	1E-01	N/A	2E-02	6E-03
		HI - Reproductive/Development	**0.03**	**0.07**	**0.1**	**0.0**	**0.02**	**0.006**
Antimony	Ambient air	Lung	1E-03	7E-04	6E-04	N/A	3E-04	2E-05
Cadmium	Ambient air	Lung/Kidney	9E-03	1E-02	1E-02	N/A	3E-03	6E-04
Cobalt	Ambient air	Lung	N/A	N/A	2E-02	N/A	8E-03	5E-04
Nickel	Ambient air	Lung	9E-04	6E-04	6E-04	N/A	3E-04	1E-05
Silver	Soil	Skin/ Eye/ Respiratory	1.5E-02	5.4E-04	5.4E-04	1.0E-03	1.5E-02	1.2E-03
Vanadium	Ambient air	Lung	2E-03	1E-03	1E-03	N/A	4E-04	2E-05
		HI - Lung	**0.03**	**0.01**	**0.04**	**0.00**	**0.03**	**0.002**
Barium	Ambient air	Liver	2E-03	2E-03	2E-03	N/A	5E-04	8E-05
Selenium	Soil	Skin/Liver	4.7E-03	8.5E-04	8.5E-04	1.6E-03	4.7E-03	1.3E-03
Vanadium	Soil	Liver	2.0E-02	6.9E-03	6.9E-03	9.7E-03	2.0E-02	7.8E-04
Zinc	Soil	Liver	8.7E-03	1.3E-03	1.3E-03	1.5E-03	8.7E-03	8.1E-04
		HI - Liver	**0.04**	**0.01**	**0.01**	**0.01**	**0.03**	**0.003**
Barium	Soil	Kidney	1.2E-03	3.0E-04	3.0E-04	1.4E-03	1.2E-03	1.2E-04
Cadmium	Ambient air	Lung/Kidney	9E-03	1E-02	1E-02	N/A	3E-03	6E-04
Cadmium	Soil	Kidney	2.4E-02	7.0E-03	7.0E-03	7.2E-03	2.4E-02	1.1E-02
Molybdenum	Soil	Kidney	4.7E-02	2.3E-02	2.3E-02	1.1E-01	4.7E-02	6.6E-02
		HI - Kidney	**0.08**	**0.04**	**0.04**	**0.12**	**0.08**	**0.08**
Arsenic	Soil	Skin	2.9E-01	8.9E-02	8.9E-02	8.8E-02	2.9E-01	2.4E-01
Selenium	Soil	Skin/Liver	4.7E-03	8.5E-04	8.5E-04	1.6E-03	4.7E-03	1.3E-03
Silver	Soil	Skin/ Eye/ Respiratory	1.5E-02	5.4E-04	5.4E-04	1.0E-03	1.5E-02	1.2E-03
		HI - Skin	**0.3**	**0.09**	**0.09**	**0.09**	**0.3**	**0.2**
Silver	Soil	Skin/ Eye/ Respiratory	1.5E-02	5.4E-04	5.4E-04	1.0E-03	1.5E-02	1.2E-03
		HI - Eye	**0.01**	**0.0005**	**0.0005**	**0.0010**	**0.01**	**0.001**
Antimony	Soil	General Toxicity / Hematological	6.5E-02	2.1E-02	2.1E-02	1.1E-03	6.5E-02	1.9E-02
Nickel	Soil	General Toxicity	3.4E-03	8.9E-04	8.9E-04	9.9E-03	3.4E-03	2.5E-04
		HI - General Toxicity	**0.07**	**0.02**	**0.02**	**0.01**	**0.07**	**0.02**
		HI - Hematological	**0.06**	**0.02**	**0.02**	**0.001**	**0.06**	**0.02**
Cobalt	Soil	Endocrine	1.3E-01	4.0E-02	4.0E-02	4.4E-01	1.3E-01	9.6E-03
		HI - Endocrine	**0.1**	**0.04**	**0.04**	**0.44**	**0.1**	**0.01**
Copper	Soil	GI system	4.0E-01	1.9E-01	1.9E-01	7.3E-01	4.0E-01	1.2E-01
Iron	Soil	GI system	6.9E-02	3.3E-02	3.3E-02	3.5E-02	6.9E-02	7.3E-03
		HI - GI system	**0.5**	**0.2**	**0.2**	**0.8**	**0.5**	**0.1**
Mercury	Soil	Immune system	1.5E-03	4.5E-03	4.5E-03	3.2E-04	1.5E-03	4.5E-03
		HI - Immune system	**0.002**	**0.004**	**0.004**	**0.0**	**0.002**	**0.005**
Aluminum	Ambient air	Nervous system	1.E-02	5.E-03	9.E-03	N/A	3.E-03	1.E-04
Aluminum	Soil	Nervous system	2.1E-02	9.2E-03	9.2E-03	2.5E-02	2.1E-02	6.8E-04
Manganese	Ambient air	Nervous system	2.E-02	1.E-02	2.E-02	N/A	4.E-03	2.E-04
Manganese	Soil	Nervous system	2.2E-02	6.6E-03	6.6E-03	1.0E-01	2.2E-02	3.7E-04
		HI - Nervous System	**0.07**	**0.03**	**0.04**	**0.13**	**0.05**	**0.001**

ABBREVIATIONS AND NOTES:

[a] - Soil risks for the In-Town Trespasser, Area H are used to represent potential risks for the high school student during after school-time assumed to be spent in In-Town Area H.

ELCR = Excess lifetime cancer risk

HI = Hazard index

HQ = Hazard quotient

Risk calculations are provided in Appendix D (ambient air) and Appendix H (soil).

Target organs are documented in Table 4.2 (ambient air) and Appendix H (soil).

TABLE 5.14
EXPOSURE POINT CONCENTRATIONS - EXPOSURE AREA A UNCERTAINTY ANALYSIS
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

Chemical Name	Frequency of Detection	COPC? (Yes/No)	EPC	Statistic	EPC - No Duplicates	Statistic - No Duplicates	Difference
Inorganics (mg/kg)							
Aluminum	19 / 19	Yes	21600	95% Student's-t UCL	22505	95% Student's-t UCL	1.0
Antimony	8 / 19	Yes	1.8	95% KM (t) UCL	1.9	95% KM (t) UCL	1.1
Arsenic	19 / 19	Yes	28	95% Student's-t UCL	28	95% Student's-t UCL	1.0
Barium	19 / 19	Yes	141	95% Modified-t UCL	149	95% H UCL	1.1
Chromium VI (Hexavalent)	0 / 2	Yes	--	--	--	--	--
Cobalt	19 / 19	Yes	33	95% Student's-t UCL	34	95% Student's-t UCL	1.0
Copper	19 / 19	Yes	1650	95% Student's-t UCL	1668	95% Student's-t UCL	1.0
Iron	19 / 19	Yes	47000	95% Student's-t UCL	47714	95% Student's-t UCL	1.0
Lead	19 / 19	Yes	53	Mean	54	Mean	1.0
Manganese	19 / 19	Yes	447	95% Adjusted Gamma UCL	452	95% Student's-t UCL	1.0
Molybdenum	19 / 19	Yes	88	95% Student's-t UCL	84	95% Student's-t UCL	0.9
Nickel	19 / 19	Yes	31	95% Student's-t UCL	32	95% Student's-t UCL	1.0
Selenium	5 / 19	Yes	2.0	95% KM (t) UCL	2.1	95% KM (t) UCL	1.1
Silver	0 / 19	Yes	--	--	--	--	--
Thallium	0 / 19	Yes	--	--	--	--	--
Vanadium	19 / 19	Yes	119	95% Student's-t UCL	124	95% Student's-t UCL	1.0
Zinc	19 / 19	Yes	291	95% Student's-t UCL	287	95% Student's-t UCL	1.0

ABBREVIATIONS AND NOTES:
-- = Chemical not detected above laboratory reporting limits
COPC = Chemical of potential concern
EPC = Exposure point concentration
mg/kg = milligrams per kilogram
UCL = upper confidence limit
Note: In accordance with USEPA guidance for evaluating lead exposure, the arithmetic mean concentration is used as the EPC.

TABLE 5.15
EXPOSURE POINT CONCENTRATIONS - EXPOSURE AREA C UNCERTAINTY ANALYSIS
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

Chemical Name	Frequency of Detection	COPC? (Yes/No)	EPC	Statistic	EPC - No Duplicates	Statistic - No Duplicates	Difference
Inorganics (mg/kg)							
Aluminum	14 / 14	Yes	19100	95% Student's-t UCL	18766	95% Student's-t UCL	1.0
Arsenic	13 / 14	Yes	18	95% KM (t) UCL	18	95% KM (t) UCL	1.0
Barium	14 / 14	Yes	126	95% Student's-t UCL	123	95% Student's-t UCL	1.0
Chromium VI (Hexavalent)	0 / 1	Yes	--	--	--	--	--
Cobalt	14 / 14	Yes	20	95% Student's-t UCL	21	95% Student's-t UCL	1.0
Copper	14 / 14	Yes	1560	95% Adjusted Gamma UCL	1643	95% Adjusted Gamma UCL	1.1
Iron	14 / 14	Yes	31700	95% Student's-t UCL	32136	95% Student's-t UCL	1.0
Lead	14 / 14	Yes	30	Mean	28	Mean	0.9
Molybdenum	9 / 14	Yes	62	95% KM (t) UCL	65	95% KM (t) UCL	1.1
Nickel	14 / 14	Yes	23	95% Student's-t UCL	23	95% Student's-t UCL	1.0
Selenium	5 / 14	Yes	3.0	95% KM (t) UCL	3.14	95% KM (t) UCL	1.0
Silver	0 / 14	Yes	--	--	--	--	--
Thallium	0 / 14	Yes	--	--	--	--	--
Vanadium	14 / 14	Yes	100	95% Adjusted Gamma UCL	106	95% Adjusted Gamma UCL	1.1
Zinc	14 / 14	Yes	156	95% Student's-t UCL	189	95% Adjusted Gamma UCL	1.2

ABBREVIATIONS AND NOTES:

-- = Chemical not detected above laboratory reporting limits
COPC = Chemical of potential concern
EPC = Exposure point concentration
mg/kg = milligrams per kilogram
UCL = Upper confidence limit

(1) In accordance with USEPA guidance for evaluating lead exposure, the arithmetic mean concentration is used as the EPC.
(2) In accordance with USEPA guidance for analytes that are detected in four or fewer samples, the EPCs are based on the median of the full data set.

TABLE 5.16
EXPOSURE POINT CONCENTRATIONS - EXPOSURE AREA E UNCERTAINTY ANALYSIS
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

Chemical Name	Frequency of Detection	COPC? (Yes/No)	EPC	Statistic	EPC - No Duplicates	Statistic - No Duplicates	Difference
Inorganics (mg/kg)							
Aluminum	17 / 17	Yes	15400	95% Student's-t UCL	15956	95% Student's-t UCL	1.0
Antimony	1 / 17	Yes	0.85	Median	0.87	Median	1.0
Arsenic	17 / 17	Yes	59	95% Student's-t UCL	63	95% Adjusted Gamma UCL	1.1
Barium	17 / 17	Yes	101	95% Student's-t UCL	104	95% Student's-t UCL	1.0
Cadmium	17 / 17	Yes	8.7	95% Student's-t UCL	9.1	95% Student's-t UCL	1.0
Chromium VI (Hexavalent)	0 / 2	Yes	--	--	--	--	--
Cobalt	17 / 17	Yes	169	95% Adjusted Gamma UCL	176	95% Adjusted Gamma UCL	1.0
Copper	17 / 17	Yes	58000	95% Student's-t UCL	60745	95% Student's-t UCL	1.0
Iron	17 / 17	Yes	48900	95% Student's-t UCL	50479	95% Student's-t UCL	1.0
Lead	17 / 17	Yes	138	Mean	144	Mean	1.0
Manganese	17 / 17	Yes	878	95% Adjusted Gamma UCL	932	95% H UCL	1.1
Mercury	17 / 17	Yes	0.19	95% Student's-t UCL	0.19	95% Student's-t UCL	1.0
Molybdenum	17 / 17	Yes	1130	95% Chebyshev (Mean, Sd) UCL	627	95% H UCL	0.6
Nickel	17 / 17	Yes	114	95% Adjusted Gamma UCL	118	95% Adjusted Gamma UCL	1.0
Selenium	17 / 17	Yes	16	95% Student's-t UCL	16	95% Student's-t UCL	1.0
Silver	16 / 17	Yes	10	95% KM (Chebyshev) UCL	9.0	95% H UCL	0.9
Thallium	11 / 17	Yes	1.7	95% KM (BCA) UCL	1.8	KM H UCL	1.0
Vanadium	17 / 17	Yes	63	95% Student's-t UCL	65	95% Student's-t UCL	1.0
Zinc	17 / 17	Yes	886	95% Adjusted Gamma UCL	915	95% Adjusted Gamma UCL	1.0

ABBREVIATIONS AND NOTES:

-- = Chemical not detected above laboratory reporting limits
COPC = Chemical of potential concern
EPC = Exposure point concentration
mg/kg: milligram per kilogram
UCL = Upper confidence limit

(1) In accordance with USEPA guidance for evaluating lead exposure, the arithmetic mean concentration is used as the EPC.
(2) In accordance with USEPA guidance for analytes that are detected in four or fewer samples, the EPCs are based on the median of the full data set.

TABLE 5.17
EXPOSURE POINT CONCENTRATIONS - EXPOSURE AREA G UNCERTAINTY ANALYSIS
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

Chemical Name	Frequency of Detection	COPC? (Yes/No)	EPC	Statistic	EPC - No Duplicates	Statistic - No Duplicates	Difference
Inorganics (mg/kg)							
Aluminum	7 / 7	Yes	22500	95% Student's-t UCL	22861	95% Student's-t UCL	1.0
Antimony	3 / 7	Yes	4.6	Median	3.1	Median	0.7
Arsenic	7 / 7	Yes	115	95% Student's-t UCL	121	95% Student's-t UCL	1.1
Barium	7 / 7	Yes	182	95% Student's-t UCL	192	95% Student's-t UCL	1.1
Cadmium	7 / 7	Yes	14	95% Student's-t UCL	15	95% Student's-t UCL	1.0
Chromium VI (Hexavalent)	0 / 1	Yes	--	--	--	--	--
Cobalt	7 / 7	Yes	52	95% Student's-t UCL	56	95% Student's-t UCL	1.1
Copper	7 / 7	Yes	18500	95% Student's-t UCL	19316	95% Student's-t UCL	1.0
Iron	7 / 7	Yes	59000	95% Student's-t UCL	61564	95% Student's-t UCL	1.0
Lead	7 / 7	Yes	315	Mean	314	Mean	1.0
Manganese	7 / 7	Yes	674	95% Student's-t UCL	679	95% Student's-t UCL	1.0
Mercury	7 / 7	Yes	0.33	95% Student's-t UCL	0.35	95% Student's-t UCL	1.1
Molybdenum	7 / 7	Yes	778	95% Chebyshev(Mean, Sd) UCL	885	95% Chebyshev(Mean, Sd) UCL	1.1
Nickel	7 / 7	Yes	50	95% Student's-t UCL	51	95% Student's-t UCL	1.0
Selenium	6 / 7	Yes	12	95% KM (t) UCL	13	95% KM (t) UCL	1.1
Silver	7 / 7	Yes	15	95% Student's-t UCL	15	95% Student's-t UCL	1.1
Zinc	7 / 7	Yes	1120	95% Student's-t UCL	1202	95% Student's-t UCL	1.1

ABBREVIATIONS AND NOTES:
-- = Chemical not detected above laboratory reporting limits
COPC = Chemical of potential concern
EPC = Exposure point concentration
mg/kg: milligram per kilogram
UCL = Upper confidence limit

(1) In accordance with USEPA guidance for evaluating lead exposure, the arithmetic mean concentration is used as the EPC.
(2) In accordance with USEPA guidance for analytes that are detected in four or fewer samples, the EPCs are based on the median of the full data set.

TABLE 5.18
SENSITIVITY ANALYSIS SCENARIO
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

In-Town Trespasser	**Soil Ingestion Rate**		**Fraction of Day**		**Exposure Frequency**	
(Exposure Areas D and H)	**Current Value**	**Change to:**	**Current Value**	**Change to:**	**Current Value**	**Change to:**
Child (6 - >11)	200	NC	0.5	1	150	250
Adolescent (11 - <16)	200	NC	0.5	1	250	NC
Adult	50	100	0.5	1	100	NC
	Scenario 1		Scenario 2		Scenario 3	
	Scenario 4					
	Scenario 5					

Isolated Area Trespasser	**Soil Ingestion Rate**	
Exposure Area J	**Current Value**	**Change to:**
Child (6 - >11)	200	NC
Adolescent (11 - <16)	200	NC
Adult	50	100
	Scenario 1	

Remote Area Trespasser	**Soil Ingestion Rate**	
Exposure Area K	**Current Value**	**Change to:**
Child (6 - >11)	200	NC
Adolescent (11 - <16)	200	NC
Adult	50	100
	Scenario 1	

Restricted Area Trespasser	**Soil Ingestion Rate**	
Exposure Area F	**Current Value**	**Change to:**
Adolescent (11 - <16)	200	NC
Adult	50	100
	Scenario 1	

In-Town Trespasser	Water Ingestion Rate		Exposure Time		Exposure Frequency	
(Stormwater)	Current Value	Change to:	Current Value	Change to:	Current Value	Change to:
Child (6 - >11)	5	10	1	2	10	20
Adolescent (11 - <16)	5	10	1	2	10	20
Adult	2	4	1	2	5	10
	Scenario 1				Scenario 2	
	Scenario 3					

TABLE 5.19
RISK SUMMARY - SENSITIVITY ANALYSIS SCENARIOS
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

			In-Town Trespasser					**In-Town Trespasser**				
			Area D - All Scenario 1	**Area D - All Scenario 2**	**Area D - All Scenario 3**	**Area D - All Scenario 4**	**Area D - All Scenario 5**	**Area H - All Scenario 1**	**Area H - All Scenario 2**	**Area H - All Scenario 3**	**Area H - All Scenario 4**	**Area H - All Scenario 5**
		ELCR	**7E-06**	**1E-05**	**7E-06**	**1E-05**	**2E-05**	**2E-05**	**4E-05**	**2E-05**	**4E-05**	**5E-05**
COPC	**Critical Effect**	**Target Organ**	**HQ**	**HQ**	**HQ**	**HQ**	**HQ**	**HQ**	**HQ**	**HQ**	**HQ**	**HQ**
Aluminum	Neuorotoxicity	Nervous system	2.1E-02	4.1E-02	3.4E-02	4.1E-02	6.9E-02	2.1E-02	4.3E-02	3.6E-02	4.3E-02	7.2E-02
Manganese	CNS; Impairment of neurobehavioral function	Nervous system	1.0E-02	2.1E-02	1.7E-02	2.1E-02	3.4E-02	2.2E-02	4.3E-02	3.6E-02	4.3E-02	7.2E-02
		HI - Nervous system	**0.03**	**0.06**	**0.05**	**0.06**	**0.1**	**0.04**	**0.09**	**0.07**	**0.09**	**0.1**
Barium	Kidney; nephropathy	Kidney	7.8E-04	1.6E-03	1.3E-03	1.6E-03	2.6E-03	1.2E-03	2.3E-03	1.9E-03	2.3E-03	3.9E-03
Cadmium	Kidney; proteinuria	Kidney	6.7E-03	1.3E-02	1.1E-02	1.3E-02	2.2E-02	2.4E-02	4.9E-02	4.1E-02	4.9E-02	8.1E-02
Molybdenum	Kidney; increased uric acid levels	Kidney	2.4E-02	4.9E-02	4.1E-02	4.9E-02	8.1E-02	4.7E-02	9.4E-02	7.8E-02	9.4E-02	1.6E-01
		HI - Kidney	**0.03**	**0.06**	**0.05**	**0.06**	**0.1**	**0.07**	**0.1**	**0.1**	**0.1**	**0.2**
Vanadium	Decreased hair cysteine	Liver	1.7E-02	3.5E-02	2.9E-02	3.5E-02	5.8E-02	2.0E-02	4.1E-02	3.4E-02	4.1E-02	6.8E-02
Zinc	Liver; decreased erythrocyte superoxide dismutase activity	Liver	1.9E-03	3.9E-03	3.2E-03	3.9E-03	6.5E-03	8.7E-03	1.7E-02	1.5E-02	1.7E-02	2.9E-02
Selenium	Skin and liver; clinical selenosis	Skin / Liver	2.1E-03	4.2E-03	3.5E-03	4.2E-03	7.0E-03	4.7E-03	9.3E-03	7.8E-03	9.3E-03	1.6E-02
		HI - Liver	**0.02**	**0.04**	**0.04**	**0.04**	**0.07**	**0.03**	**0.07**	**0.06**	**0.07**	**0.1**
Arsenic	Skin; keratosis and hyperpigmentation	Skin	1.0E-01	2.1E-01	1.7E-01	2.1E-01	3.5E-01	2.9E-01	5.9E-01	4.9E-01	5.9E-01	9.8E-01
Selenium	Skin and liver; clinical selenosis	Skin / Liver	2.1E-03	4.2E-03	3.5E-03	4.2E-03	7.0E-03	4.7E-03	9.3E-03	7.8E-03	9.3E-03	1.6E-02
Silver	Skin, eye, and respiratory tract; argyria	Skin / Eye / Respiratory	6.7E-04	1.3E-03	1.1E-03	1.3E-03	2.2E-03	1.5E-02	3.0E-02	2.5E-02	3.0E-02	4.9E-02
		HI - Skin	**0.1**	**0.2**	**0.2**	**0.2**	**0.4**	**0.3**	**0.6**	**0.5**	**0.6**	**1.0**
Beryllium	Small intestine; small intestinal lesions	GI system	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper	GI system; irritation	GI system	3.7E-01	7.4E-01	6.1E-01	7.4E-01	1.2E+00	4.0E-01	7.9E-01	6.6E-01	7.9E-01	1.3E+00
Iron	GI system; gastrointestinal effects	GI system	7.3E-02	1.5E-01	1.2E-01	1.5E-01	2.4E-01	6.9E-02	1.4E-01	1.2E-01	1.4E-01	2.3E-01
		HI - GI system	**0.4**	**0.9**	**0.7**	**0.9**	**1.4**	**0.5**	**0.9**	**0.8**	**0.9**	**1.5**
Cobalt	Thyroid; decreased iodine updake	Endocrine	1.4E-01	2.8E-01	2.3E-01	2.8E-01	4.6E-01	1.3E-01	2.6E-01	2.2E-01	2.6E-01	4.3E-01
		HI - Endocrine	**0.1**	**0.3**	**0.2**	**0.3**	**0.5**	**0.1**	**0.3**	**0.2**	**0.3**	**0.4**
Mercury (as mercuric chloride)	Immune system; autoimmune effects	Immune system	9.6E-04	1.9E-03	1.6E-03	1.9E-03	3.2E-03	1.5E-03	3.0E-03	2.5E-03	3.0E-03	5.1E-03
		HI - Immune system	**0.001**	**0.002**	**0.002**	**0.002**	**0.003**	**0.002**	**0.003**	**0.003**	**0.003**	**0.005**
Antimony	Reduced lifespan; hematological; blood glucose and cholesterol	General Toxicity / Hematological	8.2E-03	1.6E-02	1.4E-02	1.6E-02	2.7E-02	6.5E-02	1.3E-01	1.1E-01	1.3E-01	2.2E-01
Nickel	Decreased body and organ weights	General Toxicity	1.9E-03	3.8E-03	3.2E-03	3.8E-03	6.4E-03	3.4E-03	6.8E-03	5.6E-03	6.8E-03	1.1E-02
		HI - General Toxicity	**0.01**	**0.02**	**0.02**	**0.02**	**0.03**	**0.07**	**0.1**	**0.1**	**0.1**	**0.2**
Boron	Developmental; reduced fetal weight	Developmental	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		HI - Developmental	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Chromium VI	No effects observed	NOAEL	2.5E-04	4.9E-04	4.1E-04	4.9E-04	8.2E-04	2.2E-04	4.5E-04	3.7E-04	4.5E-04	7.5E-04
		HI - NOAEL	**0.0003**	**0.0005**	**0.0004**	**0.0005**	**0.0008**	**0.0002**	**0.0005**	**0.0004**	**0.0005**	**0.0008**

ABBREVIATIONS AND NOTES:
COPC = Chemical of potential concern
ELCR = Excess lifetime cancer risk
GI = Gastrointestinal
HQ = Hazard quotient
HI = Hazard index
NA = Not applicable
NOAEL = No observed adverse effects level
Risk calcuations are documented in Appendix G.
Target organs are documented in Table 4-2.

TABLE 5.19
RISK SUMMARY - SENSITIVITY ANALYSIS SCENARIOS
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

			Isolated Area Trespasser	Remote Area Trespasser	Restricted Area Trespasser	Stormwater Area Trespasser		
			Area J Scenario 1	**Area K Scenario 1**	**Area F Scenario 1**	**Stormwater Scenario 1**	**Stormwater Scenario 2**	**Stormwater Scenario 3**
		ELCR	**1E-05**	**7E-06**	**2E-05**	**3E-06**	**3E-06**	**7E-06**
COPC	**Critical Effect**	**Target Organ**	**HQ**	**HQ**	**HQ**	**HQ**	**HQ**	**HQ**
Aluminum	Neuorotoxicity	Nervous system	3.7E-03	8.4E-03	6.8E-04	6.5E-03	6.5E-03	1.3E-02
Manganese	CNS; Impairment of neurobehavioral function	Nervous system	1.6E-03	4.0E-03	3.7E-04	3.6E-03	3.6E-03	7.2E-03
		HI - Nervous system	**0.005**	**0.01**	**0.001**	**0.01**	**0.01**	**0.02**
Barium	Kidney; nephropathy	Kidney	6.7E-04	2.5E-04	1.2E-04	1.7E-04	1.7E-04	3.3E-04
Cadmium	Kidney; proteinuria	Kidney	6.9E-03	6.9E-03	1.1E-02	1.9E-02	1.9E-02	3.8E-02
Molybdenum	Kidney; increased uric acid levels	Kidney	1.5E-02	2.3E-02	6.6E-02	2.4E-02	2.4E-02	4.9E-02
		HI - Kidney	**0.02**	**0.03**	**0.08**	**0.04**	**0.04**	**0.09**
Vanadium	Decreased hair cysteine	Liver	2.7E-03	6.7E-03	7.8E-04	7.9E-03	7.9E-03	1.6E-02
Zinc	Liver; decreased erythrocyte superoxide dismutase activity	Liver	1.0E-03	1.3E-03	8.1E-04	2.0E-03	2.0E-03	4.0E-03
Selenium	Skin and liver; clinical selenosis	Skin / Liver	1.7E-03	8.5E-04	1.3E-03	2.6E-04	2.6E-04	5.1E-04
		HI - Liver	**0.005**	**0.009**	**0.003**	**0.01**	**0.01**	**0.02**
Arsenic	Skin; keratosis and hyperpigmentation	Skin	1.3E-01	8.8E-02	2.4E-01	5.9E-02	5.9E-02	1.2E-01
Selenium	Skin and liver; clinical selenosis	Skin / Liver	1.7E-03	8.5E-04	1.3E-03	2.6E-04	2.6E-04	5.1E-04
Silver	Skin, eye, and respiratory tract; argyria	Skin / Eye / Respiratory	2.0E-03	5.4E-04	1.2E-03	4.4E-03	4.4E-03	8.9E-03
		HI - Skin	**0.1**	**0.09**	**0.2**	**0.06**	**0.06**	**0.1**
Beryllium	Small intestine; small intestinal lesions	GI system	NA	NA	NA	6.9E-05	6.9E-05	1.4E-04
Copper	GI system; irritation	GI system	2.2E-01	1.9E-01	1.2E-01	5.5E-01	5.5E-01	1.1E+00
Iron	GI system; gastrointestinal effects	GI system	2.0E-02	3.3E-02	7.3E-03	2.1E-02	2.1E-02	4.2E-02
		HI - GI system	**0.2**	**0.2**	**0.1**	**0.6**	**0.6**	**1.1**
Cobalt	Thyroid; decreased iodine updake	Endocrine	3.0E-02	3.9E-02	9.6E-03	5.9E-02	5.9E-02	1.2E-01
		HI - Endocrine	**0.03**	**0.04**	**0.010**	**0.06**	**0.06**	**0.1**
Mercury (as mercuric chloride)	Immune system; autoimmune effects	Immune system	1.1E-02	4.5E-03	4.5E-03	2.0E-03	2.0E-03	4.0E-03
		HI - Immune system	**0.01**	**0.005**	**0.005**	**0.002**	**0.002**	**0.004**
Antimony	Reduced lifespan; hematological; blood glucose and cholesterol	General Toxicity / Hematological	1.9E-02	2.1E-02	1.9E-02	2.2E-03	2.2E-03	4.3E-03
Nickel	Decreased body and organ weights	General Toxicity	5.2E-04	8.1E-04	2.5E-04	1.7E-03	1.7E-03	3.3E-03
		HI - General Toxicity	**0.02**	**0.02**	**0.02**	**0.004**	**0.004**	**0.008**
Boron	Developmental; reduced fetal weight	Developmental	NA	NA	NA	3.52E-05	3.52E-05	7.04E-05
		HI - Developmental	**NA**	**NA**	**NA**	**0.00004**	**0.00004**	**0.00007**
Chromium VI	No effects observed	NOAEL	2.2E-04	9.3E-04	8.2E-05			
		HI - NOAEL	**0.0002**	**0.0009**	**0.00008**	**0.00002**	**0.00002**	**0.00003**

ABBREVIATIONS AND NOTES:
COPC = Chemical of potential concern
ELCR = Excess lifetime cancer risk
GI = Gastrointestinal
HQ = Hazard quotient
HI = Hazard index
NA = Not applicable
NOAEL = No observed adverse effects level
Risk calcuations are documented in Appendix G.
Target organs are documented in Table 4-2.

TABLE 5.20

RISK SUMMARY - SENSITIVITY ANALYSIS OF ARSENIC BIOAVAILABILITY IN SOIL

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

Area H - RME							
Bioavailibity	78%	60%	49%	31%	26%	14%	4.1%
Bioavailibility-adjusted ELCR - Arsenic	2.3E-05	1.8E-05	1.5E-05	9.2E-06	7.7E-06	4.2E-06	1.2E-06
Bioavailibility-adjusted HQ - Arsenic	0.38	0.29	0.24	0.15	0.13	0.07	0.02
HQ Selenium	0.0047	0.0047	0.0047	0.0047	0.0047	0.0047	0.0047
HQ Silver	0.015	0.015	0.015	0.015	0.015	0.015	0.015
Target Organ HI	0.40	0.31	0.26	0.17	0.15	0.09	0.04

Area H - Sensitivity Analysis Scenario 5							
Bioavailibity	78%	60%	49%	31%	26%	14%	4.1%
Bioavailibility-adjusted ELCR - Arsenic	6.1E-05	4.7E-05	3.8E-05	2.4E-05	2.0E-05	1.1E-05	3.2E-06
Bioavailibility-adjusted HQ - Arsenic	1.3	0.98	0.80	0.51	0.43	0.23	0.07
HQ Selenium	0.016	0.016	0.016	0.016	0.016	0.016	0.016
HQ Silver	0.049	0.049	0.049	0.049	0.049	0.049	0.049
Target Organ HI	1.3	1.0	0.87	0.57	0.49	0.29	0.13

ABBREVIATIONS AND NOTES:

% = percent

ELCR = Excess lifetime cancer risk

HI = Hazard index

HQ = Hazard quotient

RME = Reasonable maximum exposure

TABLE 5.21
UPPER-BOUND UNCERTAINTY ANALYSIS RESIDENTIAL EXPOSURE SCENARIOS - AMBIENT AIR
HUMAN HEALTH RISK ASSESSMENT
ASARCO HAYDEN PLANT SITE

Resident	**Outdoor Exposure Time**		**PM10 Statistic Used as Basis of EPCs**	
(Exposure Area D)	**Current Value**	**Change to [a]:**	**Current Value [b]**	**Change to [c]:**
Child (0 - <6)	2.3	7.1	KP Mean by Station	95 UCL of 4 Stations
Child (6 - >11)	2.6	6.1	KP Mean by Station	95 UCL of 4 Stations
Adolescent (11 - <16)	1.9	5	KP Mean by Station	95 UCL of 4 Stations
Adult	2.3	6	KP Mean by Station	95 UCL of 4 Stations
Value used as basis for scenario	2.3	7.1	KP Mean by Station	95 UCL of 4 Stations
Scenario 1				
Scenario 2				
Scenario 3				

ABBREVIATIONS AND NOTES:

[a] - Values are the 90th percentile values from Table 6-20, category "cumulative outdoors", EPA, 2011. The scenarios evaluate cumulative ambient air exposures for an indoor exposure time of 16.7 hours per day (Table 3.2) and an outdoor exposure time of 7.1 hours per day.

[b] - Each of the four stations in EA D (ST-01, ST-16, ST-23, ST-26) are evaluated as separate exposure points.

[c] - The four stations in EA D (ST-01, ST-16, ST-23, ST-26) are evaluated collectively as a single exposure point.

EPC = Exposure point concentration

UCL = Upper confidence limit

TABLE 5.22

UPPER-BOUND UNCERTAINTY ANALYSIS FOR AMBIENT AIR - RISK SUMMARY

HUMAN HEALTH RISK ASSESSMENT

ASARCO HAYDEN PLANT SITE

		Scenario 1				Scenario 2	Scenario 3
		ST-01	ST-16	ST-23	ST-26	4 stations combined	4 stations combined
	ELCR	2E-05	3E-05	3E-05	2E-05	3E-05	3E-05
COPC	Target Organ	HQ	HQ	HQ	HQ	HQ	HQ
Arsenic	Nervous system	6E-01	9E-01	1E+00	7E-01	9E-01	1E+00
	HI - Nervous system	**0.6**	**0.9**	**1**	**0.7**	**0.9**	**1**
Antimony	Lung	1E-02	1E-02	1E-02	1E-02	1E-02	1E-02
Cadmium	Lung/Kidney	1E-01	1E-01	1E-01	1E-01	1E-01	1E-01
Cobalt	Lung	3E-01	4E-01	2E-01	NA	2E-01	3E-01
Nickel	Lung	7E-03	9E-03	9E-03	8E-03	7E-03	9E-03
Vanadium	Lung	3E-02	4E-02	3E-02	2E-02	2E-02	3E-02
	HI - Lung	**0.5**	**0.5**	**0.4**	**0.1**	**0.4**	**0.5**
Barium	Liver	2E-02	2E-02	2E-02	2E-02	2E-02	2E-02
	HI - Developmental	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**
Cadmium	Lung/Kidney	1E-01	1E-01	1E-01	1E-01	1E-01	1E-01
	HI - Kidney	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
HI Associated with Background Conditions							
Aluminum	*Nervous system*	*2E-01*	*2E-01*	*2E-01*	*1E-01*	*1E-01*	*2E-01*
Manganese	*Nervous system*	*3E-01*	*5E-01*	*3E-01*	*2E-01*	*3E-01*	*3E-01*
	HI - Nervous System	***0.4***	***0.7***	***0.4***	***0.3***	***0.4***	***0.5***

ABBREVIATIONS AND NOTES:

COPC = Chemical of potential concern

ELCR = Excess lifetime cancer risk

HI = Hazard index

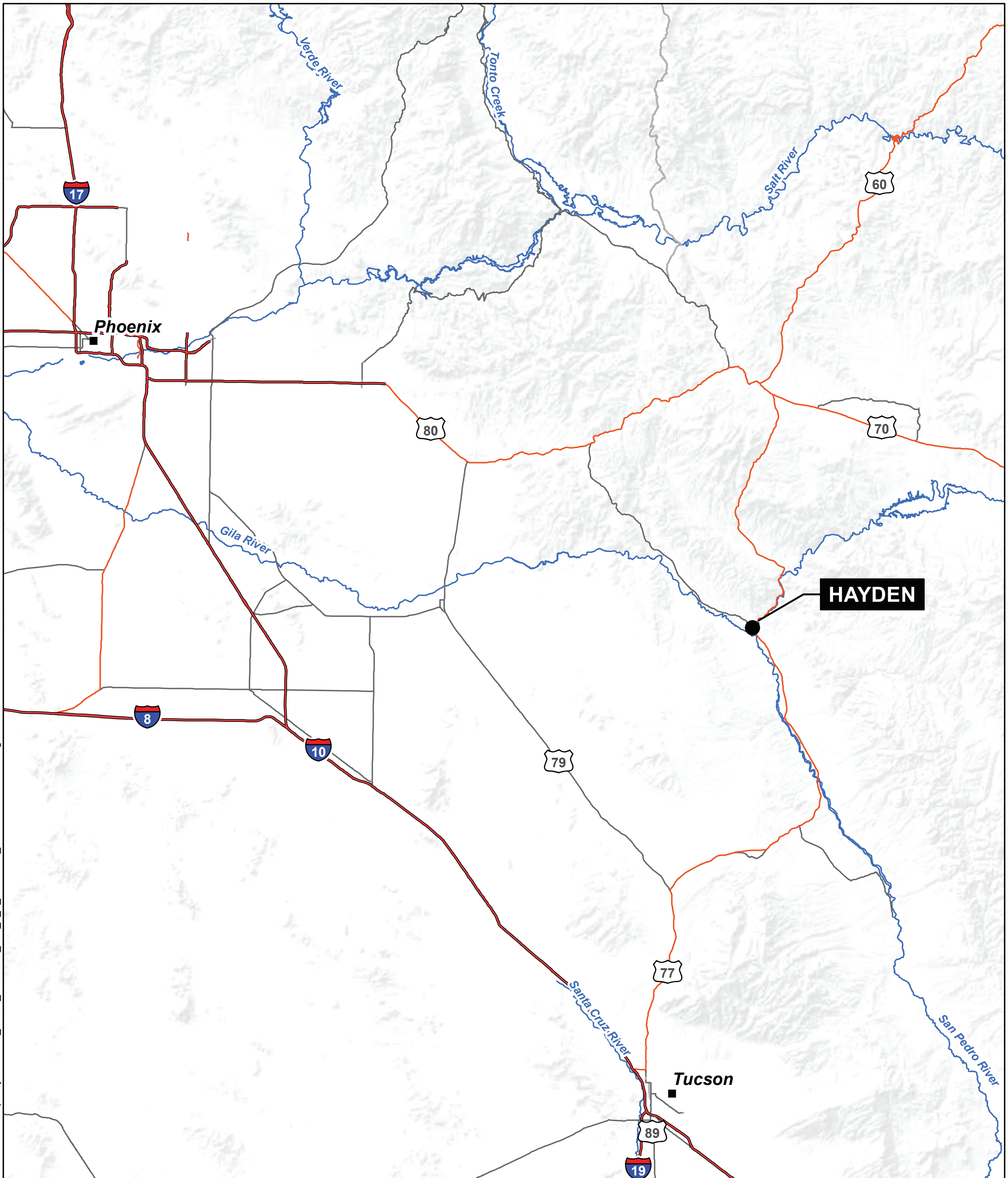
HQ = Hazard quotient

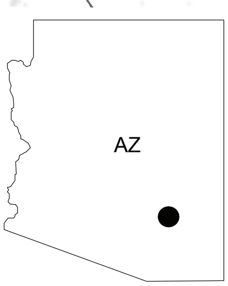
Risk calculations are documented in Appendix G.

Target organs are documented in Table 4.2.

FIGURES

GIS FILE PATH: G:\38712_ASARCO_Hayden\Global\GIS\MapProjects\2016_02\Air_RI\38712_303_1_1_VICINITY_MAP.mxd — USER: gcarson — LAST SAVED: 2/17/2016 7:49:37 AM





MAP SOURCE: ESRI

HALEY ALDRICH

ASARCO, LLC.
HAYDEN, ARIZONA

ASARCO

VICINITY MAP

DECEMBER 2020

FIGURE 1.1

LEGEND

THALWEG (APPROXIMATE)

HIGHWAY

RAILROAD

NOTES:
1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.

N W E S

0 750 1,500 3,000
Feet

HALEY ALDRICH

ASARCO LLC.
HAYDEN, ARIZONA

ASARCO

KEY FEATURES OF
HAYDEN OPERATIONS
AND VICINITY

DECEMBER 2020

FIGURE 1.2

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LEGEND

- AMBIENT AIR MONITORING STATION
- LIMITED MONITORING
- HIGHWAY
- RAILROAD

Station Number	Station Name
ST-01	Hayden Maintenance Yard
ST-02	Hayden High School
ST-05	Globe Highway
ST-06	Hayden Old Jail
ST-08	West Hayden
ST-09	Reverts Crushing
ST-10	Meteorology Station
ST-14	Smelter Parking Lot
ST-16	Terrace Station
ST-18	North Hayden
ST-23	Hillcrest Avenue
ST-26	Concentrator/Post Office

NOTES:
1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.

N E S W

0 500 1,000 2,000
Feet

HALEY ALDRICH

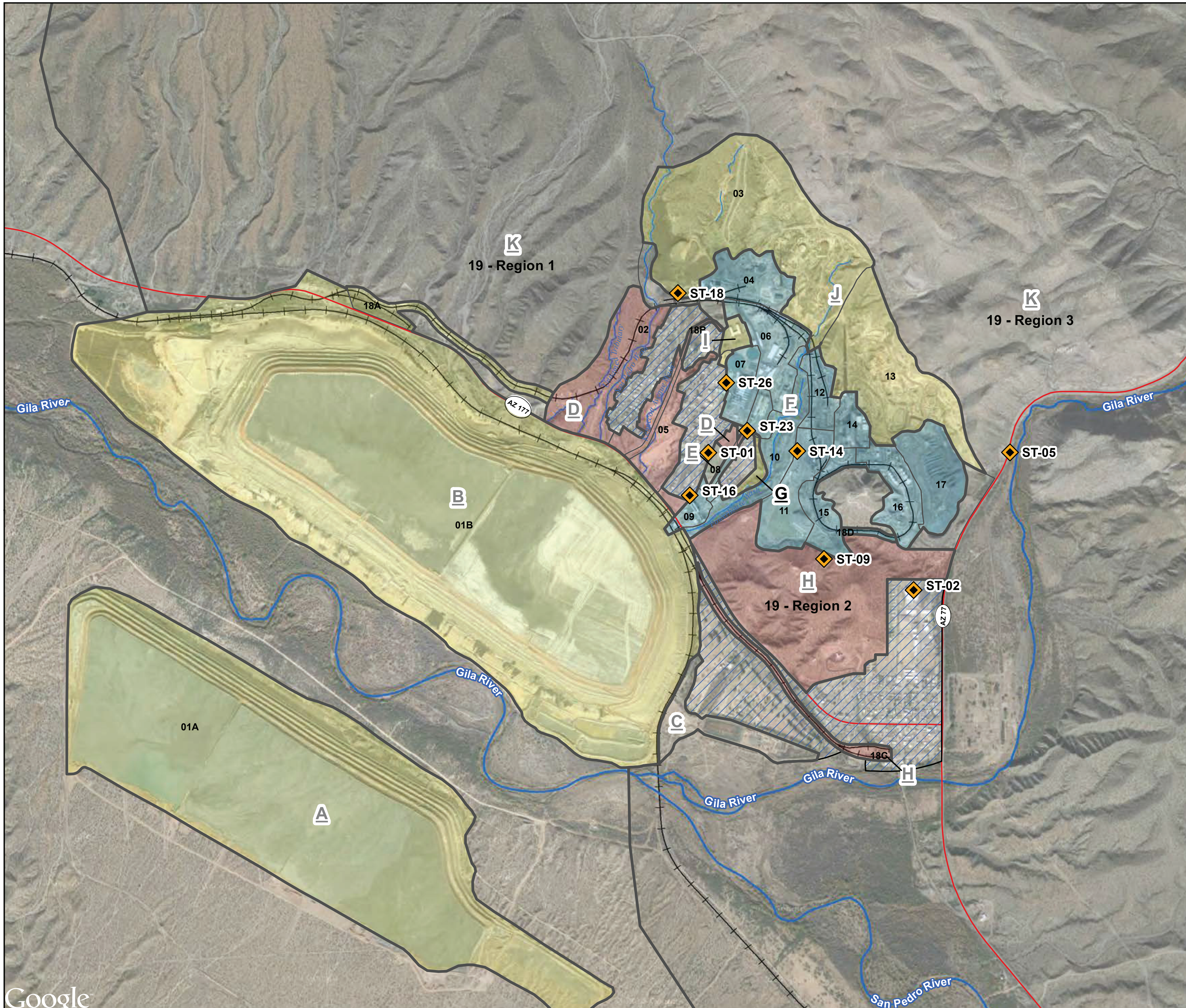
ASARCO LLC.
HAYDEN, ARIZONA

PHASE II RI AMBIENT AIR MONITORING STATIONS

ASARCO

DECEMBER 2020

FIGURE 1.3



LEGEND

EXPOSURE SETTINGS

- IN-TOWN AREA
- ISOLATED FACILITY AREA
- RESTRICTED FACILITY AREA
- REMOTE AREA
- AREAS 1-18
- RESIDENTIAL AND PUBLIC AREAS NOT REQUIRING FURTHER ACTION
- HIGHWAY
- THALWEG (APPROXIMATE)
- RAILROAD
- AMBIENT AIR MONITORING STATION

Exposure Area	RI Areas	Exposure Setting
A	1A	Isolated Facility Area
B	1B (partial), 18A	Isolated Facility Area
C	1B (partial)	Remote Area
D	2, 5, 8 (partial), 9 (partial), 18B	In-Town Area
E	8 (partial)	Remote Area
F	4, 6 (partial), 7 (partial), 8 (partial), 9 (partial), 10 (partial). 11, 12, 14, 15, 16, 17 (partial), 18D	Restricted Facility Area
G	10 (partial)	Isolated Facility Area
H	18C, 19 (Region 2)	In-Town Area
I	6 (partial), 7 (partial)	Isolated Facility Area
J	3 (partial), 13	Isolated Facility Area
K	3 (partial), 6 (partial), 17 (partial), 19 (Regions 1 and 3)	Remote Area

N
W E
S

0 1,000 2,000 4,000 Feet

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ASARCO
HAYDEN, ARIZONA

EXPOSURE STUDY AREAS AND
AMBIENT AIR MONITORING STATIONS

ASARCO

DECEMBER 2020

FIGURE 3.1

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APPENDIX A

Data Sets Used in HHRA
A-1 – Soil and Storm Water
A-2 – Ambient Air

A-1 – Soil and Storm Water

A-2 – Ambient Air

APPENDIX B

EPC Calculations

B-1 – ProUCL Output – 95% UCL Calculations

B-2 – Storm Water Background Threshold Values

B-3 – Ambient Air EPCs

B-4 – Background Air Data ProUCL Output

B-1 – ProUCL Output – 95% UCL Calculations

B-2 – Storm Water Background Threshold Values

B-3 – Ambient Air EPCs

B-4 – Background Air Data ProUCL Output

APPENDIX C

PEF Calculations

APPENDIX D

Toxicity Assessment and Toxicity Profiles

APPENDIX E

Risk Calculations

APPENDIX F

Lead Biokinetic Modeling

APPENDIX G

Sensitivity Analysis

APPENDIX H

Phase II Remedial Investigation Reports
Provided on CD

APPENDIX I

USEPA/ADEQ Comments and Asarco Responses