

TABLE OF CONTENTS

Section 1	Introduction.....	1-1
1.1	Purpose.....	1-1
1.2	Property History.....	1-1
1.3	Proposed Future Land Uses	1-2
Section 2	Data Collection and Assessment	2-3
2.1	Sampling Areas.....	2-3
2.1.1	Vegetated Preliminary Area.....	2-3
2.1.2	Smelter Preliminary Area	2-3
2.1.3	Floodplain Preliminary Area.....	2-3
Section 3	Exposure Assessment	3-3
3.1	Current Land Use.....	3-3
3.1.1	On-Site.....	3-3
3.1.2	Off-site.....	3-3
3.2	Future Land Use.....	3-3
3.2.1	On-Site.....	3-3
3.2.2	Off-Site	3-3
3.3	Conceptual Site Model.....	3-3
3.3.1	Potential Sources.....	3-3
3.3.2	Potential Release Mechanisms.....	3-3
3.3.3	Potential Exposure Media	3-3
3.3.4	People Potentially Exposed.....	3-3
3.3.5	Potential Exposure Pathways.....	3-3
3.4	Selection of Chemicals of Concern.....	3-3
3.5	Exposure Areas	3-3
3.6	Calculation of Chronic Preliminary Remediation Goals	3-3
3.6.1	Arsenic	3-3
3.6.2	Lead.....	3-3
3.6.3	Summary of PRGs	3-3
Section 4	Calculation of 95% UCLs and RALs.....	4-3
4.1	Introduction.....	4-3
4.2	Surface Material Data Sets Used to Calculate 95% UCLs and RALs.....	4-3
4.2.1	Data Set for Exposure Area 1	4-3
4.2.2	Data Set for Exposure Area 2	4-3
4.2.3	Data Set for Exposure Area 3	4-3
4.2.4	Laboratory Sampling Results.....	4-3
4.2.5	Non-Detect Sampling Results.....	4-3
4.2.6	XRF Data Adjustments	4-3
4.3	Methodology for Calculation of 95% UCLs.....	4-3
4.4	Methodology for Calculating RALs	4-3

TABLE OF CONTENTS

4.5	Results and Discussion of Remedial Alternatives	4-3
4.5.1	Exposure Area 1.....	4-3
4.5.2	Exposure Area 2.....	4-3
4.5.3	Exposure Area 3.....	4-3
4.6	Refinement of RAL Approach.....	4-3
4.6.1	Exposure Area 1.....	4-3
4.6.2	Exposure Area 3.....	4-3
Section 5	Uncertainties in the Risk Evaluation.....	5-3
5.1	Sampling, Data Evaluation, and Data Usability	5-3
5.2	Future Land Use.....	5-3
5.3	Pathways Not Evaluated	5-3
5.4	Identification of COCs.....	5-3
5.5	Estimation of EPCs.....	5-3
5.6	Exposure Factor Assumptions	5-3
5.7	Toxicity Assessment	5-3
5.8	Uncertainty Conclusions.....	5-3
Section 6	Overall Conclusions in the Risk Evaluation.....	6-3
Section 7	References	7-3

List of Tables

Table 1	Surface and Subsurface Sample XRF Data
Table 2	COC Selection – Site-wide Surface Material
Table 3	COC Selection – Site-wide Subsurface Soil
Table 4	Summary of Chemicals of Concern
Table 5	Summary of Preliminary Remediation Goals
Table 6	Exposure Factors for Arsenic, Construction Workers
Table 7	Exposure Factors for Arsenic, Commercial/Industrial Workers
Table 8	Exposure Factors for Arsenic, Residents
Table 9	Exposure Factors for Arsenic, Recreational Path Users
Table 10	Arsenic Relative Bioavailability Estimates
Table 11	Lead Relative Bioavailability Estimates
Table 12	Exposure Factors for the Adult Lead Exposure Model, Future Adult Commercial/Industrial Workers
Table 13	Exposure Factors for the Adult Lead Exposure Model, Future Adult Resident

TABLE OF CONTENTS

Table 14	Exposure Factors for the Adult Lead Exposure Model, Future Construction Workers
Table 15	Exposure Factors for the Adult Lead Exposure Model, Future Adult Recreational Path Users
Table 16	Summary Statistics for Calculating the Pre-remediation 95% UCLs for Arsenic and Lead by Area
Table 17	Pre- and Post-remediation Summary Statistics for Arsenic and Lead by Area
Table 18	XRF and Laboratory Data
Table 19	Exposure Area 1 – Arsenic and Lead Data
Table 20	Exposure Area 2 – Arsenic and Lead Data
Table 21	Exposure Area 3 – Arsenic and Lead Data
Table 22	Exposure Area 1 Arsenic and Lead Potential Cleanup - Samples for Removal
Table 23	Exposure Area 3 Arsenic and Lead Potential Cleanup - Samples for Removal

List of Figures

Figure 1	Current Site Conditions Planned Use Map
Figure 2	Conceptual Site Model
Figure 3	Soil XRF Analytical Results in Exposure Areas 1, 2, and 3
Figure 4	Arsenic XRF-Laboratory Data Correlation
Figure 5	Lead XRF-Laboratory Data Correlation

TABLE OF CONTENTS

Acronyms

cm ²	square centimetre
COC	Chemical of Concern
CSM	Conceptual Site Model
CT	Central Tendency
EDA	Exploratory Data Analysis
EPA	U.S. Environmental Protection Agency
EPC	Exposure Point Concentration
ESA	Environmental Site Assessment
FSP	Field Sampling Plan
IEUBK	Integrated Exposure Uptake Biokinetic
m ³	cubic meter
mg/kg	milligrams per kilogram
MS/MSD	Matrix Spike/Matrix Spike Duplicate
MVUE	minimum variance unbiased estimator
NHANES	National Health and Nutrition Examination Survey
ppm	parts per million
PRG	Preliminary Remediation Goal
QA/QC	Quality Assurance/Quality Control
R ²	correlation coefficient
RAL	Remedial Action Level
RBC	Risk-Based Concentration
RBF	relative bioavailability factor
RME	Reasonable Maximum Exposure
START#	Superfund Technical Assessment and Response Team
TAL	Target Analyte List
TBA	Targeted Brownfields Assessment
TCLP	Toxicity Characteristic Leachate Procedure
TCR	target cancer risk
TDD	Technical Direction Document
Tech Memo	Technical Memorandum
THQ	target hazard quotient

TABLE OF CONTENTS

TRW	Technical Review Workgroup
UCL	Upper confidence limit of the mean
UOS	URS Operating Services
XRF	X-Ray Fluorescence
µg/dL	micrograms per deciliter

This human health risk evaluation Technical Memorandum (Tech Memo) for the Rose and Walsh Smelter site near Silverton in San Juan County, Colorado, has been prepared to satisfy the requirements of Technical Direction Document (TDD) 0506-42 issued to URS Operating Services, Inc. (UOS) on October 3, 2005, under the U.S. Environmental Protection Agency (EPA) Region 8 Superfund Technical Assessment and Response Team 3 (START 3) Contract No. EP-W-05-050. This work is a continuation of requirements of TDD No. 0506-0009 issued to UOS START2 under Contract No. 68-W-00-118 on June 16, 2005. The purpose of these TDDs is to perform a Targeted Brownfields Assessment (TBA) at the site. The scope of work is to perform a Phase II assessment of site soil, perform a human health risk evaluation, and develop remedial action alternatives.

1.1 PURPOSE

The purpose of the site investigation is to gather information for the evaluation of the site with regard to the intended use of the property. The specific objectives of this TBA are:

- Assess and evaluate the recognized environmental conditions identified in the Phase I and II processes by collecting soil samples and analyzing the samples for concentrations of hazardous metals including arsenic, barium, and lead.
- Gather sufficient data to perform an evaluation of risk to the health of potential future residents, future recreational users, future construction workers, and future commercial/industrial workers with respect to the recognized environmental conditions.
- Develop remedial action alternatives that may include soil extraction and disposal, a soil cover, or *in situ* treatment options, that will reduce the risk to levels acceptable for the intended use.

The human health risk evaluation presented in this Tech Memo addresses the second objective and parts of the third objective presented above.

1.2 PROPERTY HISTORY

The property is located adjacent to the town limits of Silverton, Colorado, in the Mineral Creek watershed and on the east corner of U.S. Highway 550 and San Juan County Road 6, known as the Shrine Road. The portion of the property that was investigated included the approximate 15.9 acres shown in Figure 1. The property is described as Parcel Number 4829-0.00-0.1-032 by San Juan County and is known as Tract B of the Ophir Placer (San Juan County 2005a). To the north of the site is a residential lot and the Miner's Shrine. Directly west of the property is undeveloped mountainside and some unnamed old mine adits. To the northeast of the site is the town of Silverton and east of the site is undeveloped land. The southwest portion of the site on the south side of U.S. Highway 550 is in the floodplain of Mineral Creek (Plateau 2003, 2004).

The property was owned by Seth R. Beckwith and Thomas Francis Walsh from the late 1800s. The property was owned by Duane Eggett from 1979 to 1990 and by the Lancaster Trust from 1990 until 2004 when San Juan County acquired the property (San Juan County 2005a).

A smelter was constructed on the property in 1882 and operated as an ore crushing facility and a coal-fired blast furnace producing silver, lead, and some gold. The smelter was comprised of a roaster building containing four roasting units, a smelting room with a pair of rectangular

wrought iron furnaces, an ore house, an engine and boiling house, a sampling and assaying laboratory, and an office building (Nossaman 1998)(Figure 1). Operations also included a railroad siding from the Denver and Rio Grande Railroad and a waste slag pile (San Juan County 2005a).

The smelter operated for only 3 days in October 1882 producing 11 tons of bullion before bankruptcy was declared. In 1890, Thomas Walsh purchased the smelter and restarted operations. The smelter operated for approximately 3 years before it was closed and dismantled. Coarse/heavy slag from smelter operations is visible in the area south of the escarpment (San Juan County 2005a).

The property was never redeveloped and a small portion of the western part of the property may have been mined for gravel. The fine slag that is visible only on the part of the property north of U.S. Highway 550 and south of the railroad grade may have been deposited on site and may not be related to smelter operations (San Juan County 2005b). Much of the fine slag observed in historic photographs of the property has been removed (San Juan County 2005a). Finally, a brown fibrous plaster suspected asbestos-containing material appears to have been dumped on site in one small area. Remains of the former smelting operation include the former railroad grade, several small piles of scrap iron and wood, and slag (Figure 1)(San Juan County 2005a).

Phase I and Limited Phase II Environmental Site Assessments (ESAs) of the site have been completed for Colorado Housing, Inc. and Housing Solutions for the Southeast, Inc. (Plateau 2003, 2004). These ESAs were conducted as due diligence activities regarding the potential purchase and development of the property for residential and industrial use (San Juan County 2005a). The Phase I ESA identified the presence of slag on the property as a recognized environmental condition. Potential soil and groundwater metals contamination related to past smelting operations were also identified (Plateau 2003). The Phase II ESA identified arsenic, barium, and lead as contaminants of concern. During that investigation, slag thickness was found to be no more than 2 feet in any area (Plateau 2004).

1.3 PROPOSED FUTURE LAND USES

Available and affordable housing has become a pressing issue in San Juan County and is one of the barriers to economic development identified by the county. About 85% of San Juan County is publicly owned. In addition, the County Assessor estimates that up to 50% of housing stock are used as seasonal homes. All current building permit applications are for seasonal homes (UOS 2005a). The demand for affordable housing has also eliminated homes from the pool of rentals used as housing for seasonal workers and created a shortage in the labor pool.

Redevelopment of this property as affordable housing would be a significant step in the economic development of the county (EDDSC 2004). The San Juan County master redevelopment plan calls for the redevelopment of the Rose and Walsh smelter property as affordable housing including approximately 48 apartment units and 12 single family homes, either detached individual homes or attached townhomes. The county has selected two non-profit housing entities for the property development. Housing Solutions for the Southwest will develop the apartment units and Colorado Housing, Inc. will develop the single family residential units (San Juan County 2005a, UOS 2005b).

A geotechnical engineering study was conducted in 2004 for Housing Solutions for the Southwest by Lambert and Associates (2004). Nine of the 12 test bores provided data regarding

the depth of the slag. No groundwater was detected to a depth of 10 feet in November when the study was conducted. Seasonal variations in groundwater elevations are anticipated (Lambert and Associates 2004).

In addition, the county is considering building a town and county maintenance facility in the floodplain on the south side of U.S. Highway 550 since this would not be a suitable location for housing. Finally, the county is considering the sale of the wooded area at the north end of the site for use as private residences to raise funds for the affordable housing development (San Juan County 2005a,b).

San Juan County intends to develop the site to include affordable housing, recreational paths, a historic preservation and interpretive area, a town and county equipment maintenance facility, and private residential housing (Figure 1).

The *Phase II Field Sampling Plan (FSP) for Targeted Brownfields Assessment, Rose and Walsh Smelter* (UOS 2005a) describes the field investigation that was conducted to assess property conditions based on the findings of the previous Phase I and II assessments (Plateau 2003, 2004). Field activities specifically included collecting soil and slag samples to be analyzed for total metals, Toxicity Characteristic Leachate Procedure (TCLP) metals, bioaccessability, metals speciation, uranium, pH, and acid/base accounting. Quality Assurance/Quality Control (QA/QC) samples included X-Ray Fluorescence (XRF) replicates, XRF duplicates, collaborative fixed laboratory analysis, and laboratory matrix spike and matrix spike duplicate (MS/MSD) samples. The results of the field investigation are presented in the *Analytical Results Report* (UOS 2005c).

Property characterization samples included 253 soil samples for XRF, 42 soil samples for collaborative laboratory analysis of metals, 23 source samples, and 20 samples for relative bioavailability analysis. Source slag and soil samples were analyzed with a Niton Xlt 7080 XRF in the field laboratory. Collaborative soil samples were analyzed for Target Analyte List (TAL) metals and additional soil samples were analyzed for uranium.

2.1 SAMPLING AREAS

The property was divided into three “preliminary areas” for sampling purposes, based on geography (floodplain), vegetative cover, and former use. The portion of the property investigated included approximately 15.9 acres as shown in Figure 1. The three preliminary areas used for sampling were: the floodplain area, the vegetated area, and the smelter area (UOS 2005a).

In all preliminary areas, surface soil samples were collected at a depth of 0 to 2 inches below ground surface (in areas with no slag) or at a depth of 0 to 2 inches immediately beneath slag (in areas with less than 1 foot of slag); subsurface soil samples were collected at a depth of 6 to 8 inches. In the smelter area, samples also were collected from cores at depth intervals of 0 to 2 inches and at 1-foot intervals to 8 feet, and several source samples of slag were collected at a depth of 0 to 2 inches.

2.1.1 Vegetated Preliminary Area

The vegetated preliminary area consists of two vegetated areas that border the northwestern side of the site north of U.S. Highway 550 (Figure 1). Forty surface soil samples were collected in the vegetated preliminary area. Twenty-six surface soil samples were collected from locations evenly distributed in the northern part of the vegetated preliminary area, and 14 samples from locations evenly distributed in the southern part. In addition, two replicates and one duplicate surface soil samples from the northern part of the vegetated preliminary area and one replicate from the southern part of the vegetated preliminary area were analyzed. Subsurface soil samples were collected at 15 of the 40 surface soil sampling locations (10 in the northern part and five in the southern part). In addition, two duplicate subsurface soil samples were analyzed in the northern part of the vegetated preliminary area.

2.1.2 Smelter Preliminary Area

The smelter preliminary area consists of the eastern portion north of U.S. Highway 550 (Figure 1). The smelter preliminary area includes the vegetated ridge, historic features, and areas

covered with slag. Sixty-four surface material samples were collected from locations in the smelter preliminary area. In addition, five duplicate and three replicate surface material samples were analyzed in the smelter preliminary area. An additional 15 surface material samples were collected for evaluating bioavailability of arsenic and lead. Subsurface soil samples were collected at 14 of the 64 surface soil sampling locations. Cores were obtained and samples were collected from the cores at 10 biased locations in the smelter preliminary area. At each location, samples were collected from cores at depth intervals of 0 to 2 inches and at 1-foot intervals to 8 feet. Surface source (slag) samples were obtained at 13 biased locations in the smelter preliminary area, including four composite source samples obtained for evaluating bioavailability of arsenic and lead.

2.1.3 Floodplain Preliminary Area

The floodplain preliminary area is the area of the site south of U.S. Highway 550, bordering Mineral Creek. Eighteen surface soil samples were collected from locations evenly distributed in the floodplain preliminary area. In addition, one duplicate and one replicate surface soil sample were analyzed. Subsurface soil samples were collected at six of the 18 surface soil sampling locations. One duplicate subsurface soil sample was analyzed.

3.1 CURRENT LAND USE

3.1.1 On-Site

The property is located adjacent to the town limits of Silverton, Colorado, in the Mineral Creek watershed and on the east corner of U.S. Highway 550 and San Juan County Road 6, known as the Shrine Road (Figure 1).

3.1.2 Off-site

To the north of the site is a residential lot and the Miners' Shrine. Directly west of the property is undeveloped mountainside and some unnamed old mine adits. To the northeast of the site is the town of Silverton and east of the site is undeveloped land. The southwest portion of the site on the south side of U.S. Highway 550 is in the floodplain of Mineral Creek (Plateau 2003, 2004).

3.2 FUTURE LAND USE

3.2.1 On-Site

Figure 1 shows planned future use of the Rose and Walsh smelter property. The San Juan County master redevelopment plan calls for the redevelopment of the Rose and Walsh smelter property as private residences, affordable housing, and a town and county maintenance facility (San Juan County 2005a,b).

Three preliminary areas were initially designated on the site for sampling purposes – vegetated, smelter, and floodplain areas. The county is considering the sale of the vegetated area at the north end of the site for use as private residences to raise funds for the affordable housing development. The northern portion of the vegetated area would contain private residential homes, while the southern portion would be a landscaped area.

The smelter area would be redeveloped as affordable housing including approximately 48 apartment units and 12 single-family homes, either detached individual homes or attached townhomes. The northern portion of the smelter area would contain affordable houses and townhouses, the center portion would contain a historic preservation and interpretive area and a landscaped area, and the southern portion would contain affordable apartments. Two recreational paths are planned for the smelter area.

In addition, the county is considering building a town and county maintenance facility in the floodplain on the south side of U.S. Highway 550 since this would not be a suitable location for housing.

Therefore, land on the Rose and Walsh smelter property will be primarily used for residential purposes, with recreational use of non-residential areas and commercial/industrial use of floodplain area. All of the property except for the floodplain area will be evaluated for potential residential use, since housing will be in close proximity to all non-residential parts of property (recreational paths, historic preservation, and interpretive area) which will be attractive for children at play.

3.2.2 Off-Site

It is assumed that off-site land use will remain as it is currently. Evaluation of on-site areas for residential use serves as a protective measure for off-site land uses as well.

3.3 CONCEPTUAL SITE MODEL

A Conceptual Site Model (CSM) has been developed for the Rose and Walsh smelter site and is presented in Figure 2. A CSM is a schematic representation of source areas, release mechanisms, environmental transport media, and potential exposure routes for chemicals that may lead to exposure of the receptors to chemicals in the site area.

Potentially complete and significant exposure pathways are evaluated. A complete exposure pathway includes the following elements:

- A source and mechanism of contaminant release
- A transport or contact medium (e.g., soil)
- An exposure point where humans can contact the contaminated medium
- An exposure (intake) route (such as ingestion or inhalation).

The absence of one of these elements results in an incomplete exposure pathway. Where there is no potential exposure, there is no potential risk. EPA's risk assessment and risk characterization guidance (EPA 1989, 1992) does not require that all plausible exposure scenarios and exposure pathways be assessed. Pathways that are incomplete or potentially complete, but negligible, are not evaluated in the risk assessment. A pathway may be potentially complete, but negligible, if the transport process is considered to be insignificant resulting in negligible concentrations of chemicals in the exposure medium, or if the amount of exposure to the medium is considered to be negligible. Potentially complete, but negligible, pathways were not evaluated quantitatively because these pathways would be unlikely to measurably impact risk estimates or cleanup decisions. Potentially complete pathways that were not evaluated quantitatively in the risk characterization are discussed qualitatively in the uncertainty section of the risk evaluation.

3.3.1 Potential Sources

Sources of metals at the site are slag and other deposits from smelter activities and fine slag dust that may have been deposited on site and may not be related to smelter operations.

3.3.2 Potential Release Mechanisms

Weathering of slag could release metals into soil. Metals in surface soil or fine slag dust could enter ambient air as windblown dust which could be transported to and deposited in surface soil in adjacent areas. Metals in surface material can leach to subsurface soil, and from there to groundwater beneath the site. Groundwater beneath the site could flow to groundwater in adjacent areas and to Mineral Creek. Subsurface soil and groundwater could be exposed during future excavation.

3.3.3 Potential Exposure Media

Potential exposure media could include surface material, subsurface soil, ambient air, groundwater, surface water, and sediments.

3.3.4 People Potentially Exposed

Current exposure is limited to recreational use. The primary future use of the vegetated and smelter preliminary areas will be residential and recreational. Since young children and adults could be exposed under each scenario, all of the property except for the floodplain, will be evaluated for residential use. Construction workers could be exposed to surface material and subsurface soil during excavation of foundations for buildings, construction of recreational areas, and installation of utility lines in the vegetated and smelter preliminary areas. The primary future use of the floodplain area will be commercial/industrial. Therefore, commercial/industrial workers will be evaluated in this area. Construction workers could be exposed to surface and subsurface soil during excavation of foundations for buildings and installation of utility lines in the floodplain preliminary area.

3.3.5 Potential Exposure Pathways

3.3.5.1 Potentially Complete and Significant Exposure Pathways

The following potentially complete and significant pathways were evaluated quantitatively in the risk evaluation:

- Future child and adult residents – ingestion, dermal, and inhalation exposure to surface material (includes soil and slag)
- Future child and adult recreational users – ingestion, dermal, and inhalation exposure to surface material (includes soil and slag)
- Future commercial/worker workers – ingestion, dermal, and inhalation exposure to surface material (includes soil and slag)
- Future construction workers – ingestion, dermal, and inhalation exposure to surface material and subsurface soil.

3.3.5.2 Potentially Complete, But Negligible Pathways

The following potentially complete, but negligible pathways were not evaluated quantitatively, but are discussed qualitatively in the uncertainty section of the risk evaluation:

- Current trespasser – ingestion, dermal, and inhalation exposure to surface material
- Future resident – ingestion of plants
- All receptors – dermal exposure to arsenic

These pathways are expected to be potentially complete, but not significant. For example, edible plants have not been identified as a significant resource on the site, and climate, altitude, and terrain will limit the growing season for garden vegetables. Also, the space available for private

gardens will be limited. The property has not yet been developed to be attractive for recreation, so the current trespasser is expected to visit very infrequently and for a brief duration.

Although information is limited on the rate and extent of dermal absorption of metals in soil across the skin, most scientists consider that this pathway is likely to be minor in comparison to the amount of exposure that occurs by soil and dust ingestion. This view is based on the following concepts: (1) most people do not have extensive and frequent direct contact with soil; (2) most metals tend to bind to soils, reducing the likelihood that they would dissociate from the soil and cross the skin; and (3) ionic species such as metals have a relatively low tendency to cross the skin even when the contact does occur. Based on this, and recognizing that current methods and data are very limited for attempting to quantify dermal absorption of chemicals from soil, dermal contact with arsenic in soil is not quantified in this risk assessment.

3.3.5.3 Incomplete Pathways

Groundwater, surface water, and sediments at the site will not be evaluated. Each medium probably has been impacted by many non-site-related sources within this drainage which holds many historical mining operations. Therefore, the Brownfields team, including the San Juan County Administrator, decided not to include groundwater and surface water/sediment pathways in this Phase II site investigation. Groundwater at the site is not currently used, nor is future use anticipated. Surface water in Mineral Creek will also not be used as a source of drinking water. Instead, water used by future residents and commercial/industrial workers will come from the Silverton municipal water source.

Exposure (ingestion, dermal, and inhalation) to subsurface soil is considered an incomplete pathway for receptors other than construction workers.

Ingestion of plants is considered incomplete for all receptors except the future resident. As indicated above, edible plants are not noted as a significant natural resource on the site.

3.4 SELECTION OF CHEMICALS OF CONCERN

Site-wide chemicals of concern (COCs) were selected by comparing maximum detected concentrations of chemicals in surface material and subsurface soil in each exposure area to Region 3 Risk-Based Concentrations (RBCs) for residential soil (EPA 2005a). Table 1 shows the data set that was used to select COCs. The surface material data set consisted of surface soil samples, surface soil bioavailability samples, and surface samples collected from cores: (1) at the surface at locations with no slag, or (2) immediately under slag at locations where slag is 1 foot or less in depth.¹ The surface material data set does not include samples collected under slag at locations where slag is greater than 1 foot in depth.² Surface soil samples RWSMSU17 and RWSMSU18 were excluded from the surface material data set because those samples were determined not to be surface soil samples.

¹ Soil under slag less than 1 foot deep was included because it is anticipated that slag will be removed and the soil will then be at the surface.

² Soil under slag greater than 1 foot in depth was not evaluated because it is anticipated slag will be removed, and that soil will be covered during contouring of the site.

The subsurface material data set consisted of subsurface soil samples collected: (1) at 6 to 8 inches below the surface at locations with no slag, or (2) 6 to 8 inches under slag at locations where slag is 1 foot or less in depth.¹ In addition, the subsurface material data set included subsurface samples collected from cores at 1-foot intervals to 8 feet. The subsurface material data set did not include samples collected under slag at locations where slag is greater than 1 foot in depth.² Subsurface soil sample RWSMSS17 was not included in the subsurface material data set because that sample was determined not to be a subsurface soil sample.

The XRF data set used to select COCs is shown in Table 1. Maximum detected concentrations for surface material and subsurface soil are shown in Tables 2 and 3. Chemicals that were not selected as COCs were not evaluated further because those chemicals would not be expected to pose a threat to residents exposed 350 days/year for 30 years. Arsenic, chromium, copper, iron, lead, manganese, and mercury in surface material were selected as COCs because maximum detected concentrations exceeded Region 3 RBCs (Table 4). In addition, rubidium and zirconium were selected as COCs to be discussed in the uncertainty section because Region 3 RBCs were not available for those chemicals. COCs in subsurface soil were the same as COCs in surface material (Table 4). Arsenic and lead had the largest exceedances of Region 3 RBCs and, therefore, were selected as the primary risk drivers for derivation of cleanup levels.

3.5 EXPOSURE AREAS

Exposure areas, as distinct from the preliminary areas used for sampling, were identified primarily based on concentrations of arsenic and lead in surface material (Table 1). Exposure Area 1, located in the center of the smelter preliminary area, is the most contaminated portion of the site (Figure 3). Exposure Area 1 contains all surface material locations where concentrations of arsenic were greater than 500 milligrams per kilogram (mg/kg) or concentrations of lead were greater than 2,500 mg/kg. Exposure Area 1 also contains a few sample locations with lower concentrations that were located within the larger area defined by arsenic greater than 500 mg/kg or lead greater than 2,500 mg/kg. Child and adult residents could be exposed to surface material at their homes or in recreational areas in Exposure Area 1. Construction workers could be exposed to surface material and subsurface soil in Exposure Area 1 during excavation activities to construct homes and recreational areas and to install utility lines.

Exposure Area 2 is the floodplain preliminary area located on the south side of U.S. Highway 550 (Figure 3). Exposure Area 2 has the lowest levels of arsenic and lead. Adult commercial/industrial workers could be exposed to surface soil. Construction workers could be exposed to surface and subsurface soil during excavation activities.

Exposure Area 3 consists of the vegetated preliminary area and portions of the smelter preliminary area where concentrations of arsenic were less than 500 mg/kg and concentrations of lead were less than 2,500 mg/kg (Figure 3). Child and adult residents could be exposed to surface material at their homes or in recreational areas in Exposure Area 3. Construction

¹ Soil under slag less than 1 foot deep was included because it is anticipated that slag will be removed and the soil will then be at the surface.

² Soil under slag greater than 1 foot in depth was not evaluated because it is anticipated slag will be removed, and that soil will be covered during contouring of the site.

workers could be exposed to surface material and subsurface soil in Exposure Area 3 during excavation activities to construct homes and recreational areas and to install utility lines.

3.6 CALCULATION OF CHRONIC PRELIMINARY REMEDIATION GOALS

During the COC selection step of the human health risk evaluation, it was observed that both arsenic and lead exceed their risk-based screening levels by very large margins. For example, site-wide arsenic in surface material exceeds its screening level by 4 orders of magnitude (a factor of 10,000), and site-wide lead exceeds its screening level by 2 orders of magnitude (a factor of 100). Other COCs (with screening levels) had maximum concentrations that exceeded their screening levels by about one order of magnitude (a factor of 10) or less. This observation led to two decisions:

1. It was not necessary to conduct a baseline (or forward) risk assessment to estimate cancer and noncancer risk, because the magnitude of exceedence for arsenic and lead indicates that risk would likely be unacceptable for sensitive human receptors. Current concentrations of arsenic and lead alone (not including the other COCs) at the site would probably present a significant risk under anticipated future land use conditions.
2. Further evaluation in this Tech Memo, intended to support the purpose of developing remedial alternatives, would focus on arsenic and lead. This is a reasonable and protective approach because:
 - a. Arsenic and lead are the clear risk drivers at the site
 - b. All site-related chemicals are assumed to have the same original sources
 - c. COCs are not expected to have fate and transport characteristics that differ dramatically from those of arsenic and lead
 - d. Other COCs are generally co-located with arsenic and lead
 - e. Remedial alternatives that address arsenic and lead are expected also to adequately address the other, co-located, COCs.

Therefore, the remainder of this Tech Memo focuses on arsenic and lead in surface material. Exposure assumptions and toxicity values were used to calculate Preliminary Remediation Goals (PRGs) for child and adult residents, child and adult recreational users, adult commercial/industrial workers, and adult construction workers exposed to arsenic and lead in surface material. The PRGs are summarized in Table 5.

3.6.1 Arsenic

Chronic PRGs for arsenic were calculated for target cancer risk (TCR) levels of 1E-06, 1E-05, and 1E-04 and a target hazard quotient (THQ) of 1.0.

Tables 6 through 9 show exposure factors used to calculate PRGs for arsenic. Justifications for the exposure factor values are shown in footnotes in the tables. Additional information on derivation of exposure factor values for arsenic is provided in the following sections.

3.6.1.1 Meteorological Factor

Recreational users would not be expected to be present at the site every day of the year. Therefore, a meteorological factor of 0.75 was used to account for the fraction of the year during which exposure to chemicals in soil may occur for recreational path users. It is reasonable to assume that direct contact with soil will not occur for recreational visitors when the ground is frozen or covered with snow. Thus the frequency of contact with potentially impacted soil was adjusted for these site-specific meteorological conditions.

There are several metrics that can be used to describe the fraction of the year when meteorological conditions are likely to limit outdoor exposure. These include temperature and the amount of precipitation per day, which includes rain and snow. Weather information for the site was obtained from the on-line Western Regional Climate Center, Station 057656 in Silverton, Colorado (Western Regional Climate Center 2005). In Silverton, snowfall occurs primarily during the months of December, January, February, and March when average snow depth is approximately 12 inches or greater. Average temperatures are in the 10s and 20s (degrees Fahrenheit) in Silverton during those 4 months.

The fraction of the year during which exposure to chemicals in soil could occur was assumed to be the 8 months of the year where there is typically less than 12 inches of snow on the ground and average daily temperatures are higher than 25 degrees Fahrenheit. Exposure to soil would be decreased during the four colder months, because soil may be frozen and/or covered with snow. Rainfall was not considered in deriving the meteorological factor, due to the uncertainty regarding the effect of rainfall on recreational use of the path. The fraction of the year during which exposure to chemicals in soils could occur (the meteorological factor) was equal to 8 months/12 months or approximately 0.75.

There is some uncertainty in the use of a meteorological factor of 0.75. For example, there will be days during the warmer 8 months of the year when exposure to soils may not occur due to heavy rain (e.g., on the average, there are 41 days in the months of April through October when daily rainfall in Silverton is greater than 0.1 inches). With these considerations in mind, a meteorological factor of 0.75 is reasonably conservative for the area near the site.

The meteorological factor of 0.75 was applied to the estimated exposure frequency during good weather, to yield the exposure frequency in days/year. Because of the close proximity to residences, the recreational path will be easily accessible. Therefore, for the recreational path user scenario, it was assumed recreators would use the path for 5 days each week for the reasonable maximum exposure (RME) condition. The RME exposure frequency for the recreational scenario was estimated as 5 days/week x 50 weeks/year x 0.75 = 188 days/year.

3.6.1.2 Relative Bioavailability Factor

At this site, samples were collected specifically for evaluation of the bioavailability of metals. Results are shown on Tables 10 and 11. Based on these site-specific data, a relative bioavailability factor (RBF) of 0.4 was used for arsenic. The site-specific RBF was derived as follows. At the Rose and Walsh site, slag was the mineral form which occurred with the greatest frequency, followed by iron oxyhydroxide. However, slag contained very little of the arsenic, barium, and lead present at the site. The majority of the arsenic mass was consistently found in iron oxyhydroxide. It is believed that the mineral forms which are associated with the greatest

arsenic mass will influence the bioaccessability of arsenic in a physiological system. Even though slag was the predominant mineral form present it does not influence bioaccessability to the extent that the forms containing the largest arsenic mass will. The iron oxyhydroxide minerals which contain the majority of the arsenic mass, and the barium sulfate which contains the majority of the barium mass, would also be expected to be moderately soluble and bioavailable. The site-specific *in vitro* bioaccessability results for arsenic are more varied, but they (and the barium results) provide support for an assumption of moderate bioavailability.

The site-specific RBF derived for arsenic (0.4) was used to calculate arsenic PRGs. The RBF calculated was the 95% upper confidence limit of the mean (UCL) of the lognormal distribution of 14 site-specific estimates of relative bioavailability (Table 10). A 95% UCL RBF value of 0.37 was derived assuming a normal distribution. To be conservative, the 95% UCL of 0.40 for the lognormal distribution was used in the PRG calculations.

3.6.1.3 PRG Equations

The following equations were used to calculate PRGs for arsenic in surface material.

$$PRG_{ca} = (AT \times BW \times TCR) / (EF \times ED) \times [(IngR \times CF \times SFo \times RBF) + (InhR \times SFi / PEF)]$$

or

$$PRG_{nc} = (AT \times BW \times THI) / (EF \times ED) \times [(IngR \times CF \times RBF / RfDo) + (InhR / (PEF \times RfDi))]$$

where:

PRG_{ca} = PRG for cancer endpoint (mg COC/kg soil or mg/kg)

PRG_{nc} = PRG for noncancer endpoint (mg COC/kg soil or mg/kg)

AT = averaging time (days)

BW = body weight (kg)

TCR = target cancer risk (unitless)

THI = target hazard index (unitless)

EF = exposure frequency (days/year)

ED = exposure duration (years)

IngR = soil ingestion rate (mg/day)

CF = conversion factor = 1×10^{-6}

SFo = oral slope factor (mg/kg-day)⁻¹

RfDo = oral reference dose (mg/kg-day)

RBF = relative bioavailability factor (unitless)

InhR = inhalation rate (cubic meters [m³]/day)

SFi = inhalation slope factor (mg/kg-day)⁻¹

RfDi = inhalation reference dose (mg/kg-day)

PEF = particulate emission factor (m^3/kg)

Toxicity values used to calculate arsenic PRGs were an oral reference dose of $3\text{E-}04$ mg/kg-day, an oral slope factor of 1.5 ($\text{mg}/\text{kg}\text{-day}$)⁻¹ and an inhalation slope factor of 15.1 ($\text{mg}/\text{kg}\text{-day}$)⁻¹. No inhalation reference dose is available for arsenic.

3.6.2 Lead

Chronic PRGs for lead were calculated based on acceptable blood lead levels. Specific information on derivation of exposure factor values for lead is provided in the following sections.

3.6.2.1 Relative Bioavailability Factor

The mineral forms which lead was associated with at the site were more varied than those for arsenic. The lead mass was found in iron oxyhydroxide, iron sulfate, lead silicate, and phosphates. It is believed that the mineral forms which are associated with the greatest lead mass will influence the bioaccessability of lead in a physiological system. Although slag was the predominant mineral form present, it does not influence bioaccessability to the extent that the forms containing the largest lead mass will. For example, lead associated with iron oxyhydroxide, phosphates, silicates, etc. is expected to be moderately bioavailable. The site-specific *in vitro* bioaccessability results for lead, which average about 60% relative (and 30% absolute) bioavailability, would support this expectation. For lead, the average RBF was 64% (Table 11), which is similar to the EPA default value of 60% used in EPA's Adult Lead Exposure Model (EPA 2003) and Integrated Exposure Uptake Biokinetic (IEUBK) model (EPA 2005b). Therefore, a site-specific RBF for lead was not used (the default value was used).

3.6.2.2 Adult Lead Exposure Model

The Adult Lead Exposure Model (EPA 2003) was used to calculate PRGs for adults exposed to lead in surface material. Tables 12 to 15 show exposure factors used to calculate PRGs for lead using the Adult Lead Exposure Model. Additional information on derivation of exposure factors is discussed next.

EPA's Technical Review Workgroup (TRW) reviewed blood lead concentrations of U.S. adult females in the West region from the Third National Health and Nutrition Examination Survey (NHANES III)(EPA 2002a). The geometric mean blood lead levels were 1.3 micrograms per deciliter (mg/dL) for non-Hispanic whites, 1.4 mg/dL for all ethnicities, 1.59 mg/dL for Mexican-Americans, and 1.87 mg/dL for non-Hispanic blacks (EPA 2002a). Because the population in San Juan County and the town of Silverton is 92 to 93% white, and 7 to 8% Hispanic of any race (Census 2000 a,b), the 1.4 mg/dL level for all ethnicities will be used as the geometric mean background blood lead concentrations (PbBadult,0) value.

The individual geometric mean (GSDi) value is based on analysis by AGEISS (1996) of blood lead data originally obtained by Bornschein in 1994 at the Bingham Creek site, a mining site near Salt Lake City, Utah. In this study, blood lead data were obtained for 127 pregnant or

nursing women. The GSDi value of 1.5 was derived from these data using the sliding box model approach recommended by EPA (1994b).

3.6.2.3 Child Residents

The EPA residential soil screening level of 400 mg/kg (EPA 1994) was used as the lead PRG for child residents.

3.6.2.4 Child Recreational Users

The residential soil screening level for lead of 400 parts per million (ppm) is overly conservative for child recreation users due to the lower exposure frequency for recreational users compared to residential land use. Therefore, a site-specific PRG was derived for lead in surface material based on a child recreational user.

The risk-based PRG for a child recreational user was derived based on a recreational scenario where children visit the site 94 days/year and only ingest one-fourth of their daily intake of soil while at the site. Ninety-four days/year is one-half the RME exposure frequency of 188 days/year calculated in Section 3.6.1.1, and is assumed to represent the central tendency (CT) exposure frequency value for lead exposures. The CT is used in the lead model because EPA's lead models are explicitly designed to use CT values as inputs (rather than RMEs). Child visitors to the site would be exposed to one exposure point concentration (EPC) of lead in soil/dust during their visits to the site and another (background) level of lead in soil/dust on the 271 days when they do not visit the site. Blood lead levels in the child visitor would be expected to correspond to average long-term daily exposure to lead in soil/dust, because steady-state blood lead levels in children reflect overall long-term exposure to lead, rather than day-to-day changes in exposure (Van Leeuwen, personal communications 1996).

Therefore, the following equation was used to calculate a time-weighted average daily EPC for lead in soil/dust for child visitors exposed both at the site and to background levels of lead in soil/dust offsite:

$$C_s = ((C_a \times E_{Ft}) - [(C_{so} \times E_{Fs} \times FS1) + (C_{do} \times E_{Fs} \times FD1) + (C_{so} \times E_{Fo} \times FS2) + (C_{do} \times E_{Fo} \times FD2)]) / (E_{Fs} \times FSs)$$

where:

C_s = Concentration of lead in soil/dust on site = 5,648 mg/kg

C_a = time-weighted average EPC of lead in soil/dust = 400 mg/kg

E_{Ft} = Total exposure frequency = 365 days/year

C_{so} = EPC of lead in soil offsite = 40 mg/kg (Griffin, personal communication 2006a)

E_{Fs} = Exposure frequency for visiting the path = 94 days/year

$FS1$ = Fraction of daily soil intake from offsite on days visiting the path = 0.34

C_{do} = EPC of lead in dust offsite = 38 mg/kg (EPA 2005b)

$FD1$ = Fraction of daily dust intake from offsite on days visiting the path = 0.41

E_{Fo} = Exposure frequency offsite = 271 days/year

FS2= Fraction of daily soil intake from offsite on days not visiting the path = 0.45

FD2= Fraction of daily dust intake from offsite on days not visiting the path = 0.55

FSs = Fraction of daily soil intake from the site on days visiting the path = 0.25

Based on exposure to (1) the site concentration of lead in soil of 5,648 mg/kg (ingesting one-fourth of the total daily soil intake) and to 40 mg/kg lead in offsite soil and 38 mg/kg in offsite indoor dust (ingesting three-fourths of the total daily soil/dust intake) for the 94 days/year of visiting the path, and (2) to 40 mg/kg lead in offsite soil and 38 mg/kg in offsite indoor dust only for the other 271 days each year, the average time-weighted EPC of lead in soil/dust for child recreators is 400 mg/kg. So, the PRG for lead for child recreational users is 5,648 mg/kg.

3.6.3 Summary of PRGs

The following Tables summarizes the PRGs that were calculated for the Rose and Walsh site.

SCENARIO-BASED PRGs

Scenario	Arsenic PRG (mg/kg) (1E-06)	Arsenic PRG (mg/kg) (1E-05)	Arsenic PRG (mg/kg) (1E-04)	Arsenic PRG (mg/kg) (HQ = 1)	Lead PRG (mg/kg)
Child/Adult Resident	1.06	10.6	106	58.7	-
Child/Adult Recreational User	7.90	79.0	790	109	-
Adult Commercial/Industrial Worker	9.47	94.7	947	1533	2988
Construction Worker	14.3	143	1430	232	1494
Adult Resident	-	-	-	-	2797
Child Resident	-	-	-	-	400
Adult Recreational User	-	-	-	-	27846
Child Recreational User	-	-	-	-	5648

4.1 INTRODUCTION

The objective of the following statistical analysis was to determine the remedial action levels (RALs) for arsenic and lead in surface material for different exposure scenarios in Exposure Areas 1, 2, and 3. The iterative truncation method, as described in EPA's draft guidance document, *Guidance on Surface Soil Cleanup at Hazardous Waste Sites: Implementing Cleanup Levels* (EPA 2004a), was used in this analysis. Calculation of RALs required the following steps:

- 1) Surface material sampling data were segregated into exposure areas and further refined for calculating 95% UCLs and RALs.
- 2) Pre-remediation 95% UCLs were calculated for arsenic and lead in surface material in each exposure area.
- 3) Pre-remediation 95% UCLs were compared to PRGs for arsenic and lead for each exposure scenario to determine whether additional evaluation (calculation of RALs) was necessary.
- 4) RALs were calculated for arsenic and lead for each exposure scenario where the 95% UCL exceeded the PRG.

The process of calculating RALs required identification of surface material sampling locations potentially requiring cleanup. Following calculation of RALs, post-remediation 95% UCLs were calculated assuming that surface material was removed from those specific sampling locations and replaced with clean fill.

The summary statistics and assessed pre-remediation 95% UCLs are shown in Table 16. In addition, PRGs, RALs, and predicted post-remediation 95% UCLs are shown in Table 17.

4.2 SURFACE MATERIAL DATA SETS USED TO CALCULATE 95% UCLs AND RALS

Prior to use in the calculation of 95% UCLs and RALs, (1) XRF sampling results for arsenic and lead in surface material from Table 1 were segregated into Exposure Areas 1, 2, and 3; (2) data sets were further refined on a case-by-case basis; (3) XRF sampling results for arsenic and lead were replaced with laboratory results (when available); (4) values for non-detect samples were set at one-half of the detection limit; and (5) XRF sampling results were numerically adjusted to account for predicted differences between XRF and laboratory data. The data sets used to calculate 95% UCLs and RALs are summarized in Tables 19 through 21.

4.2.1 Data Set for Exposure Area 1

Table 19 shows the data set for calculating 95% UCLs and RALs for arsenic and lead in Exposure Area 1. There are 18 surface material results (not including duplicates or replicates) in the Exposure Area 1 data set: 11 surface soil samples, three surface samples collected from cores, three surface slag samples for TCLP, and 1 surface soil sample collected for determining bioavailability.

4.2.2 Data Set for Exposure Area 2

Table 20 shows the data set for calculating 95% UCLs and RALs for arsenic and lead in Exposure Area 2. There are 18 surface soil sample results (not including duplicates or replicates) in the Exposure Area 2 data set.

4.2.3 Data Set for Exposure Area 3

Table 21 shows the data set for calculating 95% UCLs and RALs for arsenic and lead in Exposure Area 3. Four surface slag samples (RWSMSR71, RWSMSR72, RWSMSR73, and RWSMSR74) were removed from the data set because they were composite samples. Therefore, there are 86 surface material samples (not including duplicates or replicates) in the data sets for Exposure Area 3: 65 surface soil samples, five surface samples collected from cores, six surface slag samples, and 10 surface soil samples collected for determining bioavailability.

4.2.4 Laboratory Sampling Results

For samples where both laboratory and XRF results were available, laboratory results were used in the data sets for calculation of 95% UCLs and RALs.

4.2.5 Non-Detect Sampling Results

Values for non-detect samples analyzed in the laboratory were set at 0.5-times the detection limit for use in calculating 95% UCLs and RALs (Tables 19 through 21). Values for non-detect XRF sampling results were set at 0.5-times the detection limit, and then were adjusted using linear regression equations (discussed in the following section).

4.2.6 XRF Data Adjustments

XRF data provide a basis for screening materials; however, laboratory data provide a more accurate indication of concentrations. XRF was used at the Rose and Walsh site to maximize the amount of data that could be collected, because XRF is a less expensive and less labor- and time-intensive method. Thus, a greater density of data was obtained across the site. To ensure the quality and usefulness of the XRF data, paired data (both XRF and laboratory analyses) were collected at 42 sample locations (Table 18). The relationship between the laboratory and XRF data was evaluated for these locations, and linear regression equations were used to adjust the XRF data at other sample locations, to better estimate actual site concentrations.

4.2.6.1 Arsenic

There were 29 pairs of detected XRF and laboratory results for arsenic. The 29 arsenic XRF and laboratory pairs are plotted in Figure 4. The linear regression equation selected for adjusting XRF data for arsenic was: $\ln(y)=0.9447\ln(x) + 0.1132$. The correlation coefficient (R^2) for this linear regression equation was 0.9863. Adjusted XRF values for arsenic used to calculate 95% UCLs and RALs are shown in the “As (value)” columns in Tables 19 through 21.

4.2.6.2 Lead

There were 42 pairs of detected XRF and laboratory results for lead. The 42 lead XRF and laboratory pairs are plotted in Figure 5. The linear regression equation for lead was: $\ln(y)=0.9395\ln(x) + 0.3629$. The R^2 for this linear regression equation was 0.9942. Adjusted XRF values for lead used to calculate 95% UCLs and RALs are shown in the “Pb (value)” columns in Tables 19 through 21.

4.3 METHODOLOGY FOR CALCULATION OF 95% UCLS

The data sets for arsenic and lead used to calculate pre-remediation 95% UCLs are shown in Tables 19 through 21. Post-remediation 95% UCLs were calculated after replacing sampling results for specific sampling locations with assumed background concentrations for arsenic and lead.

The 95% UCL is recommended by EPA (2002b) as a reasonable estimate of true average concentration at a site, given the uncertainty associated with limited sampling. The ProUCL software version 3.0 (Singh et al. 2004) was used to determine the appropriate 95% UCL to be used, based on the parametric or non-parametric assumption. The main steps of calculating 95% UCL are as follows:

1. Perform exploratory data analysis (EDA).
2. Test for data distribution assumption.
3. Calculate the 95% UCL.

A brief description of each step follows.

1. Perform EDA.

The objective of EDA is to discover trends and patterns in the data so that appropriate approaches and limitations in using the data sets can be identified. Both numerical and graphical methods of EDA may be used. Non-detects were replaced with one-half of the corresponding detection limit in this analysis. In addition, the average concentration among the duplicates/replicates was used as a single data point to ensure the data were reasonably independent. For calculation of post-remediation 95% UCLs, the assumed background concentrations (15 mg/kg for arsenic and 25 mg/kg for lead)⁴ were used to replace the current sample values for sample locations that were assumed (during the truncation process described in Section 4.3.1) to be replaced by clean fill materials.

The numerical methods included development of a table of basic summary statistics, such as mean, standard deviation, minimum, and maximum, for both raw values and natural log-transformed values. These statistics can be used to make inferences concerning the population from which the sample data were drawn. Graphical methods may include histograms, box-and-whisker plots, and normal probability plots. These plots were used to assess the shape and skewness of the data distribution, as well as to inspect any potential outliers (extreme values).

⁴ Regional background concentrations suggested by EPA Region 8 are 10 to 20 mg/kg for arsenic and 10 to 40 mg/kg for lead (Griffin, personal communication 2006b). The mid-points of these ranges were used in this analysis.

2. Test for data distribution assumption.

The purpose of this step is to check whether the data (raw or log-transformed) could be assumed to be normally distributed and/or the data (raw only) could be assumed to follow a gamma distribution. Based on the results of this evaluation, an appropriate probability distribution can be assumed for the data for use in the calculation of a 95% UCL in the next step.

The Shapiro-Wilk W test was used to test the normality of the data set at a 5% significance level, as described in EPA (2004b). The test was first applied to raw data. If the raw data set passed the normality test, the raw data were assumed to be normally distributed. If the raw data did not pass the normality test, a gamma distribution goodness-of-fit test (at 5% significance level) would then be applied to the data, and if the data set passed the gamma distribution goodness-of-fit test, the data were assumed to follow a gamma distribution. Otherwise, the Shapiro-Wilk W test (at 5% significance level) would be applied to the log-transformed data. If the log-transformed data passed the normality test, the data were assumed to be lognormally distributed. If the data failed all three tests, the data were assumed to be non-parametric. In all cases, visual inspection of the shape of histograms was performed to confirm the distributional assumption.

3. Calculate the 95% UCL.

If the data were determined to be normally distributed, the 95% UCL was calculated as follows (EPA 2002b):

$$UCL = \bar{x} + t_{1-\alpha, n-1} \frac{s}{\sqrt{n}}$$

where \bar{x} = sample mean

t = the Student t value at α significance level, with $n-1$ degree of freedom

α = 0.05 (one-tailed)

n = sample size

s = sample standard deviation

Otherwise, if the data were determined to follow a gamma or lognormal distribution, or if non-parametric assumption was used, the 95% UCL was determined based on the recommendation of the ProUCL software, which takes into account sample size and data skewness and ensuring adequate coverage of 95% UCL (Singh et al. 2004). Depending on the sample statistics, the ProUCL software generally recommended one of the following methods:

- For gamma distribution, Approximate Gamma UCL or Adjusted Gamma UCL.
- For lognormal distribution, Chebyshev Theorem using the minimum variance unbiased estimator (MVUE) of the parameters of a lognormal distribution or Land's H-statistic.
- For non-parametric assumption, Chebyshev Theorem using the sample arithmetic mean and standard deviation or Hall's bootstrap.

The details of statistical steps for the various methods described above are documented in the ProUCL software user guide (Singh et al. 2004).

4.4 METHODOLOGY FOR CALCULATING RALS

The primary concept introduced in EPA's draft guidance document on calculating RALs (EPA 2004a) is that a cleanup level can be implemented as an area average approach, rather than the traditional not-to-exceed level approach. The area average approach allows remediation of those locations with the highest concentrations, such that the average concentration remaining at the site after remediation is at or below the PRG.

Of the three methods suggested in EPA's guidance document, the iterative truncation method was selected for this analysis. This method is simple to apply, and for this study, because the sampling data are not biased (i.e., not over-sampled in higher concentration area and the sample locations are roughly spread out across the entire site), this method is appropriate to use. The steps involved in iterative truncation method are as follows (excerpt from EPA 2004a):

- Order the sampling data from lowest to highest concentration.
- Starting with the highest concentration, remove a sample and replace it with the post-remediation concentration (e.g., concentration found in clean fill).
- Recalculate the post-remediation EPC for the new data set and compare the resulting EPC to the cleanup level.
- If the EPC is higher than the cleanup level, repeat the process iteratively until the EPC is less than or equal to the cleanup level.
- When the calculated post-remediation EPC in the data set is less than or equal to the cleanup level, the highest sample concentration remaining in the data set is designated the RAL.

The cleanup level, or the PRG, is determined by the risk assessor based on the exposure and risk scenarios. If a sample location is to be replaced with clean fill during remediation, it is assumed that soils are removed around that location until the concentration is below the PRG.

RALs were based on PRGs. The PRGs were developed to protect humans from adverse effects of long-term exposure to arsenic and lead in soil. However, by its nature the RAL approach may result in soil remaining in place at one or more locations with concentrations that exceed the PRGs. And the refinement of the RAL approach that results in fewer locations being remediated leaves samples in place that exceed the RAL.

It is important in this situation to ensure that humans are also protected against potential adverse effects associated with acute (short-term or even one-time) exposure to arsenic and lead remaining in place after remediation. Therefore, maximum concentrations of arsenic and lead likely to remain in place at the site were compared with acute PRGs, protective of children, that had been derived at another site in EPA Region 8 (Syracuse Research Corporation 2003). These values were 4,545 mg/kg for arsenic and 14,850 mg/kg for lead. All concentrations likely to remain in place on site were significantly lower than these acute screening levels, generally by greater than an order of magnitude. Therefore, soils that would remain in place on site do not present a risk of acute effects.

4.5 RESULTS AND DISCUSSION OF REMEDIAL ALTERNATIVES

The summary statistics and pre-remediation 95% UCLs are shown in Table 16. The following table summarizes the pre-remediation 95% UCLs for arsenic and lead in the three exposure areas.

EXPOSURE AREA 95% UCLS

Exposure Area	Arsenic (mg/kg)	Lead (mg/kg)
1	1097	6,270
2	57	587
3	103	737

Table 17 compares calculated 95% UCLs to PRGs for each exposure scenario in each exposure area, to determine if further evaluation is required. The RALs determined for different exposure scenarios in Exposure Areas 1, 2, and 3 and the associated post-remediation 95% UCLs are also shown in Table 17. Following is a discussion of cleanup alternatives in each exposure area based on protection of receptors from potential noncancer effects of lead and potential noncancer and cancer effects of arsenic.

4.5.1 Exposure Area 1

Based on comparisons of pre-remediation 95% UCLs and PRGs for Exposure Area 1:

1. Lead in surface material in Exposure Area 1 would pose an unacceptable threat of noncancer effects to child and adult residents, child recreational users, and adult construction workers.
2. Arsenic in surface material in Exposure Area 1 would pose an unacceptable threat of cancer and noncancer effects to child/adult residents, child/adult recreational users, and adult construction workers.

Therefore, RALs were derived for arsenic and lead in Exposure Area 1. The table below summarizes the effects of potential surface material cleanup decisions on hazard/risk for exposure scenarios in Exposure Area 1. It was assumed that, if a surface material sample location is to be replaced with clean fill during remediation, soils are removed around that location until the concentration is below the PRG.

EXPOSURE AREA 1 – POTENTIAL CLEANUP DECISIONS

Exposure Scenario	Number of Surface Soil Sampling Locations Replaced					
	0	2	13	14	16	18 (All)
Adult recreational user exposed to lead	X	X	X	X	X	X
Construction worker exposed to arsenic (TCR = 1E-04)	X	X	X	X	X	X
Child recreational user exposed to lead		X	X	X	X	X

Exposure Scenario	Number of Surface Soil Sampling Locations Replaced					
	0	2	13	14	16	18 (All)
Child/adult recreational user exposed to arsenic (TCR =1E-04)		X	X	X	X	X
Adult Resident exposed to lead			X	X	X	X
Construction worker exposed to arsenic (THQ = 1)			X	X	X	X
Construction worker exposed to arsenic (TCR = 1E-05)			X	X	X	X
Child/Adult Resident exposed to arsenic (TCR = 1E-04)			X	X	X	X
Child/adult recreational user exposed to arsenic (THQ =1)			X	X	X	X
Construction worker exposed to lead				X	X	X
Child/adult recreational user exposed to arsenic (TCR =1E-05)				X	X	X
Child Resident exposed to lead					X	X
Child/Adult Resident exposed to arsenic (THQ=1)					X	X
Maximum achievable protection (see text below for explanation)						X
Child/Adult Resident exposed to arsenic (TCR = 1E-05)						
Child/adult recreational user exposed to arsenic (TCR =1E-06)						
Construction worker exposed to arsenic (TCR = 1E-06)						
Child/Adult Resident exposed to arsenic (TCR = 1E-06)						

Two potential future land use scenarios were evaluated for Exposure Area 1: (1) recreational land use, which assumes exposure for child/adult recreational users and construction workers during construction of the recreational area; and (2) residential land use, which assumes exposure for child/adult residents and construction workers during construction of the residential area. It is assumed that, at a minimum, cleanup must be protective for noncancer effects for lead, for noncancer effects of arsenic (THQ =1), and for cancer risk from arsenic (TCR = 1E-04). In addition, the amount of cleanup required to achieve additional protection for cancer risk from arsenic (TCR = 1E-05 or 1E-06) is discussed.

4.5.1.1 Recreational Land Use

For the recreational area land use scenario for Exposure Area 1, surface material at a minimum of 14 of 18 sampling locations would need to be replaced with clean fill to address health effects from lead and surface material at a minimum of 14 of 18 sampling locations (not necessarily the same sample locations as for lead) would need to be replaced with clean fill to address health

effects from arsenic. In the first case, the post-remediation 95% UCL for lead in surface material of 1,488 mg/kg is less than PRGs for construction workers, child recreational users, and adult recreational users. In the second case, the post-remediation 95% UCL for arsenic in surface material of 76 mg/kg is less than PRGs for construction workers and child/adult recreational users (THQ = 1; TCR = 1E-04, 1E-05). Protection from exposure to arsenic to a TCR of 1E-06 is not achievable for construction workers and child/adult recreational users even if all surface material locations in Area 1 are replaced with clean fill because the assumed concentration of arsenic in clean fill of 15 mg/kg is higher than the PRGs (TCR of 1E-06). However, maximum achievable protection for construction workers and child/adult recreational users would be attained by replacing all surface material locations in Exposure Area 1 with clean fill.

4.5.1.2 Residential Land Use

For the residential land use scenario for Exposure Area 1, surface material at a minimum of 16 of 18 sampling locations would need to be replaced with clean fill to address health effects from lead and surface material at a minimum of 15 of 18 sampling locations (not necessarily the same sample locations as for lead) would need to be replaced with clean fill to address health effects from arsenic. In the first case, the post-remediation 95% UCL for lead in surface material of 121 mg/kg is less than PRGs for construction workers, child residents, and adult residents. In the second case, the post-remediation 95% UCL for arsenic in surface material of 22 mg/kg is less than PRGs for construction workers and child/adult residents (THQ = 1; TCR = 1E-04). Protection from exposure to arsenic to 1E-05 is not achievable for child/adult residents in Area 1 even if all locations are replaced with clean fill because the assumed concentration of arsenic in clean fill of 15 mg/kg is higher than the PRGs (TCR of 1E-05). Similarly, replacing all locations with clean fill cannot achieve a TCR level of 1E-06 for construction workers, child residents, and adult residents. However, maximum achievable protection for construction workers and child/adult residents would be attained by replacing all surface material locations in Exposure Area 1 with clean fill.

4.5.2 Exposure Area 2

Based on comparisons of pre-remediation 95% UCLs and PRGs for Exposure Area 2:

1. Lead in surface soil in Area 2 would not pose an unacceptable threat of noncancer effects to adult commercial/industrial and construction workers.
2. Arsenic in surface soil in Area 2 would not pose an unacceptable threat of noncancer effects to adult commercial/industrial and construction workers. Depending on the TCR selected, arsenic could pose an unacceptable threat of cancer effects .

Therefore, RALs were derived for arsenic in Area 2. The following table summarizes the effects of potential surface soil cleanup decisions on exposure scenarios in Exposure Area 2. It was assumed that, if a surface material sample location is to be replaced with clean fill during remediation, soils are removed around that location until the concentration is below the PRG.

EXPOSURE AREA 2 – POTENTIAL CLEANUP DECISIONS

Exposure Scenario	Number of Surface Soil Sampling Locations Replaced	
	0	18 (All)
Construction worker exposed to lead	X	X
Adult Commercial/Industrial worker exposed to lead	X	X
Construction worker exposed to arsenic (THQ = 1)	X	X
Adult Commercial/Industrial worker exposed to arsenic (THQ =1)	X	X
Construction worker exposed to arsenic (TCR = 1E-04)	X	X
Adult Commercial/Industrial worker exposed to arsenic (TCR =1E-04)	X	X
Construction worker exposed to arsenic (TCR = 1E-05)	X	X
Adult Commercial/Industrial worker exposed to arsenic (TCR =1E-05)	X	X
Maximum achievable protection (see discussion below for explanation)		X
Construction worker exposed to arsenic (TCR = 1E-06)		
Adult Commercial/Industrial worker exposed to arsenic (TCR =1E-06)		

One potential future land use scenario was evaluated for Exposure Area 2: commercial/industrial land use, which assumed exposure for adult commercial/industrial workers and construction workers during construction of the buildings. It is assumed that, at a minimum, cleanup must be protective for noncancer effects for lead, for noncancer effects of arsenic (THQ =1), and for cancer risk from arsenic (TCR = 1E-04). In addition, the amount of cleanup required to achieve additional protection for cancer risk from arsenic (TCR = 1E-05 or 1E-06) is discussed.

It would not be necessary to replace any surface soil in Exposure Area 2 to achieve minimum cleanup requirements. Based on current concentrations in Exposure Area 2, the 95% UCL for lead in surface soil of 587 mg/kg is less than PRGs for lead for construction and commercial/industrial workers and the 95% UCL for arsenic in surface soil of 57 mg/kg is less than PRGs for construction and commercial/industrial workers (THQ = 1; TCR = 1E-04, 1E-05). Protection from exposure to arsenic to a TCR of 1E-06 is not achievable for construction and commercial/industrial workers in Exposure Area 2, even if all surface soil locations were replaced with clean fill. However, a maximum achievable protection for construction and commercial/industrial workers would be attained by replacing all surface soil locations in Exposure Area 2 with clean fill.

4.5.3 Exposure Area 3

Based on comparisons of pre-remediation 95% UCLs and PRGs for Exposure Area 3:

1. Lead in surface material in Exposure Area 3 would pose an unacceptable threat of noncancer effects only to child residents.
2. Arsenic in surface material in Exposure Area 3 would pose an unacceptable threat of noncancer effects to child/adult residents. Depending on the TCR selected, arsenic could also pose an unacceptable threat of cancer effects for child/adult residents, child/adult recreational users and construction workers.

The following table summarizes the effects of potential surface material cleanup decisions on exposure scenarios in Exposure Area 3. It was assumed that, if a surface material sample location is to be replaced with clean fill during remediation, soils are removed around that location until the concentration is below the PRG.

EXPOSURE AREA 3 – POTENTIAL CLEANUP DECISIONS

Exposure Scenario	Number of Surface Soil Sampling Locations Replaced			
	0	8	29	86 (All)
Adult recreational user exposed to lead	X	X	X	X
Construction worker exposed to arsenic (TCR = 1E-04)	X	X	X	X
Child recreational user exposed to lead	X	X	X	X
Child/adult recreational user exposed to arsenic (TCR =1E-04)	X	X	X	X
Adult Resident exposed to lead	X	X	X	X
Construction worker exposed to arsenic (THQ = 1)	X	X	X	X
Construction worker exposed to arsenic (TCR = 1E-05)	X	X	X	X
Construction worker exposed to lead	X	X	X	X
Child/adult recreational user exposed to arsenic (THQ =1)	X	X	X	X
Child/Adult Resident exposed to arsenic (TCR = 1E-04)	X	X	X	X
Child/adult recreational user exposed to arsenic (TCR =1E-05)		X	X	X
Child Resident exposed to lead			X	X
Child/Adult Resident exposed to arsenic (THQ=1)			X	X
Maximum achievable protection (see text below for explanation)				X
Child/Adult Resident exposed to arsenic (TCR = 1E-05)				

Exposure Scenario	Number of Surface Soil Sampling Locations Replaced			
	0	8	29	86 (All)
Child/adult recreational user exposed to arsenic (TCR =1E-06)				
Construction worker exposed to arsenic (TCR = 1E-06)				
Child/Adult Resident exposed to arsenic (TCR = 1E-06)				

Two potential future land use scenarios were evaluated for Exposure Area 3: (1) recreational land use, which assumes exposure for child/adult recreational user and for construction workers during construction of the recreational area; and (2) residential land use, which assumes exposure for a child/adult resident and for construction workers during construction of the residences. It is assumed that at a minimum, cleanup must be protective for noncancer effects for lead, for noncancer effects of arsenic (THQ =1), and for cancer risk from arsenic (TCR = 1E-04). In addition, the amount of cleanup required to achieve additional protection for cancer risk from arsenic (TCR = 1E-05 or 1E-06) is discussed.

4.5.3.1 Recreational Land Use

For the recreational land use scenario for Exposure Area 3, it would not be necessary to replace any surface soil in Exposure Area 3 to achieve minimum cleanup requirements. Based on current concentrations in Exposure Area 3, the pre-remediation 95% UCL for arsenic in surface material of 103 mg/kg is less than PRGs for construction workers and child/adult recreational users (THQ = 1; TCR = 1E-04). In addition, the pre-remediation 95% UCL for lead in surface material of 737 mg/kg is less than PRGs for lead for construction workers, child recreational users, and adult recreational users. Eight surface material locations would need to be replaced with clean fill to increase the protection from exposure to arsenic in surface material by construction workers, child recreational users, and adult recreational users to a TCR of 1E-05. Protection from exposure to arsenic in surface material to a TCR of 1E-06 is not achievable for construction workers, child recreational users, and adult recreational users even if all locations are replaced with clean fill. However, maximum achievable protection of construction workers and child/adult recreational users would be attained by replacing all surface material locations in Exposure Area 3 with clean fill.

4.5.3.2 Residential Land Use

For the residential land use scenario for Exposure Area 3, surface material at a minimum of 28 of 86 sampling locations would need to be replaced with clean fill to address health effects from lead and surface material at a minimum of 29 of 86 sampling locations (not necessarily the same sample locations as for lead) would need to be replaced with clean fill to address health effects from arsenic. In the first case, the post-remediation 95% UCL for lead in surface material of 393 mg/kg is less than PRGs for lead for construction workers and child/adult residents. In the second case, the post-remediation 95% UCL for arsenic in surface material of 52 mg/kg is less than PRGs for construction workers and child/adult residents (THQ = 1; TCR = 1E-04). Protection from exposure to arsenic to a TCR of 1E-05 is not achievable for child/adult residents

in Exposure Area 3 even if all locations are replaced with clean fill because the assumed concentration of arsenic in clean fill of 15 mg/kg is higher than the PRG (TCR of 1E-05). Similarly, replacing all surface material locations with clean fill cannot achieve a TCR level of 1E-06 for construction workers, child residents, or adult residents in Exposure Area 3. However, maximum achievable protection for construction workers and child/adult residents would be attained by replacing all surface material locations in Exposure Area 3 with clean fill.

4.6 REFINEMENT OF RAL APPROACH

For Exposure Areas 1 and 3, the RAL approach was refined with the intent of protecting public health while simplifying the remediation scheme by reducing the number of sample locations to be replaced. (This was not done for Exposure Area 2 because the information presented in section 4.5.2 and the binomial character of the in-text table in that section, indicated that additional refinement was not likely to prove helpful.)

4.6.1 Exposure Area 1

The first step in the process of refinement of the RALs was to evaluate, for each scenario in each area, whether the original RALs were based on removal of the same set of samples for both arsenic and lead. This information is presented in Table 22 for Area 1, as locations marked with an x (removed initially to reduce concentrations of this chemical) or o (removed for the other chemical incidentally and secondarily impacting this chemical).

As a result of this step, it became evident that in Exposure Area 1 there was nearly total overlap between the samples that had been removed to achieve the RAL for arsenic and those that had been removed to achieve the RAL for soil (that is, x's on Table 22 coincide almost exactly for both chemicals). In order to meet both requirements of the post-remediation 95% UCL for arsenic being below 109 mg/kg and the post-remediation 95% UCL for lead being below 1,494 mg/kg, surface soil at a total of 15 sampling locations would need to be removed for the recreational/construction worker scenario in Area 1 (Table 22). If this removal action is done, one more surface soil sampling location than necessary will incidentally be removed for lead and one more surface soil sampling location than necessary will be incidentally removed for arsenic. However, removal of surface soil at both of these sampling locations is necessary for the post-remediation 95% UCLs for both arsenic and lead to be below their respective PRGs for the recreational/construction worker scenarios in Area 1. Table 22 provides the post-remediation 95% UCLs for arsenic and lead for the recreational/construction worker scenario in Area 1.

In order to meet the requirements of the post-remediation 95% UCL for lead being below 400 mg/kg, surface soil at a total of 16 sampling locations would need to be removed for the residential scenario in Area 1 (Table 22). If this removal is done, one more surface soil sampling location than necessary for the post-remediation 95% UCLs for arsenic to be below the PRG for the residential scenario in Area 1 will be incidentally removed. Table 22 provides the post-remediation 95% UCLs for arsenic and lead for the residential scenario in Area 1.

4.6.2 Exposure Area 3

Table 23 shows locations marked with an x (removed initially to reduce concentrations of this chemical) or o (removed for the other chemical incidentally and secondarily impacting this chemical) for Area 3.

In order to increase the protection from exposure to arsenic in surface material by construction workers, child recreational users, and adult recreational users to a TCR of 1E-05, surface soil at a total of eight sampling locations would need to be removed in Area 3 (Table 23). If this removal is done, eight more surface soil sampling locations than necessary for the post-remediation 95% UCLs for lead to be below the PRG for the construction and recreational scenarios in Area 3 will be incidentally removed. Table 23 provides the post-remediation 95% UCLs for arsenic and lead for the recreational scenario in Area 3.

Further refinement of the RAL for residential receptors in Exposure Area 3 required a more sophisticated iterative approach in which samples were removed one by one, and both the arsenic and the lead value for each sample replaced with the assumed background values. Thus, removal of a location for the purpose of remediating arsenic would also result in a lower concentration of lead (and removal for the purpose of remediating lead would also result in a lower arsenic concentration). The assessed 95% UCL for both arsenic and lead was recalculated each time a sample location was removed from the data set. Additional sample locations were removed and 95% UCLs recalculated until the 95% UCLs equaled or were approximately below the residential PRGs of 58.7 mg/kg for arsenic and 400 mg/kg for lead. To achieve the PRGs by this refined RAL method, only 28 sample locations were required to be replaced for both arsenic and lead (Table 23). Table 23 also provides the post-remediation 95% UCLs for arsenic and lead for the residential scenario in Area 3.

Because data for both analytes are removed at the same time, this RAL refinement process did not necessarily proceed linearly from removal of the highest concentration and then next highest, etc. In addition, this approach can achieve a 95% UCL lower than the PRG while leaving in place sample locations that exceed not only the PRG, but also the original RAL. Therefore, maximum concentrations that could be left in place were compared to the acute screening levels identified in Section 4.4. Remaining concentrations are protective of human health because (1) 95% UCLs are below PRGs, and (2) the maximum residual concentrations are significantly below the acute screening levels.

Uncertainties are inherent in the risk evaluation process because of the numerous assumptions that are made in estimating exposure, toxicity, and potential risk. An evaluation of uncertainties in the risk evaluation is important in order to place the site risk estimates in perspective and to support risk managers in risk-based decision making.

This uncertainty analysis identifies the key factors and assumptions that contribute to uncertainty and assesses their potential impacts on the results and conclusions of the risk evaluation.

Uncertainties in the following areas were discussed: sampling, data evaluation, and data usability; future land use; pathways not evaluated; identification of COCs; estimation of EPCs; exposure factor assumptions; toxicity assessment; RALs; and risk characterization.

Uncertainties in the risk evaluation process could result in an overestimation or underestimation of risk. However, it is standard in risk assessment (per EPA guidance) to require conservative (health protective) assumptions when uncertainty about a particular factor in quantifying risk exists, so as not to underestimate potential risk. Therefore, the risk assessment process is generally skewed toward protectiveness.

5.1 SAMPLING, DATA EVALUATION, AND DATA USABILITY

During the sampling and data evaluation phases, variations in the sample collection methods and in analytical methods may introduce some uncertainty in the sampling results. This type of uncertainty was reduced by a well-designed and representative sampling plan, collection of duplicate samples, and by the QA/QC programs that are a standard part of laboratory and project protocols. Collection of paired XRF and laboratory data at a number of locations minimizes uncertainty related to XRF data results. Validation of the analytical data by an outside validator further improved the quality of the data. Uncertainties in these phases may contribute to an overestimation or underestimation of risk depending on the representativeness of the sample collection program.

5.2 FUTURE LAND USE

There is uncertainty regarding future land use at any site. However, planning related to redevelopment of this site has already progressed through several steps and assumptions regarding future land use are reasonable estimates of potential future land use.

5.3 PATHWAYS NOT EVALUATED

Potentially complete, but negligible pathways that were not evaluated quantitatively are:

- Current trespasser – ingestion, dermal, and inhalation exposure to surface soil
- Future resident – ingestion of plants.

These pathways are not expected to contribute significantly to risk from the site. Edible plants have not been identified as a significant resource on the site, and climate, altitude, and terrain will limit the growing season for garden vegetables. Also, the space available for private gardens will be limited. The property has not yet been developed to be attractive for recreation, so the current trespasser is expected to visit very infrequently and for a brief duration.

- All receptors – dermal exposure to arsenic

Although information is limited on the rate and extent of dermal absorption of metals in soil across the skin, most scientists consider that this pathway is likely to be minor in comparison to the amount of exposure that occurs by soil and dust ingestion. This view is based on the following concepts: (1) most people do not have extensive and frequent direct contact with soil; (2) most metals tend to bind to soils, reducing the likelihood that they would dissociate from the soil and cross the skin; and (3) ionic species such as metals have a relatively low tendency to cross the skin even when the contact does occur. Based on this, and recognizing that current methods and data are very limited for attempting to quantify dermal absorption of chemicals from soil, dermal contact with arsenic in soil is not quantified in this risk assessment.

Incomplete pathways do not pose a risk and were not evaluated further in the risk evaluation. Groundwater at the site is not currently used nor is future use anticipated. Surface water in Mineral Creek will also not be used as a source of drinking water. Instead, water used by residents and commercial/industrial workers will come from the Silverton municipal water source. Therefore, it was not necessary to evaluate these pathways.

5.4 IDENTIFICATION OF COCS

A conservative (health protective) approach was used to identify COCs (comparison of maximum concentrations to Region 3 RBCs for residential soil). Chemicals that did not exceed RBCs based on a hazard quotient of 1 or cancer risk of 1E-06 and that would not be expected to contribute significantly to cumulative hazard index or cancer risk were not evaluated further in the risk evaluation because those contaminants would not pose an unacceptable risk even to child and adult residents assumed to be exposed only to the maximum concentrations of the contaminants at the site. Further, those chemicals would not drive remediation. Therefore, removing contaminants that did not exceed RBCs from further evaluation did not significantly impact the results and conclusions of the risk evaluation.

After COCs were identified, it was determined that only arsenic and lead would be carried forward in the risk evaluation. Maximum concentrations of arsenic and lead in each exposure area were sufficient to conclude that arsenic and lead alone would likely pose an unacceptable threat to future human receptors and that soil cleanup may be required. Therefore, cleanup levels were derived for arsenic and lead in surface soil. Chromium, copper, iron, manganese, mercury, rubidium, and zirconium were not evaluated further in the risk evaluation. This is a protective assumption because:

- All site-related chemicals are assumed to be present as a result of the same original sources.
- All of the COCs were distributed similarly in the environment, so that remediation of arsenic and lead to acceptable levels would also be expected to eliminate any risks associated with the other COCs.

5.5 ESTIMATION OF EPCS

EPCs for surface material and subsurface soil used in the risk evaluation were 95% UCLs because, as outlined in EPA guidance (e.g., EPA 1989, 2002b), the true mean concentrations cannot be calculated with certainty from a limited set of measurements. These concentrations may overestimate actual average exposure to COCs at the site.

XRF data were adjusted prior to calculation of EPCs, resulting in a better approximation of actual site concentrations. High correlation coefficients (greater than 0.98) were associated with the linear regression relationship between XRF and laboratory data. Although some uncertainty is inherent in the adjustment of XRF data, overall the uncertainty associated with these data is decreased through the process of comparison to laboratory data and data adjustment.

5.6 EXPOSURE FACTOR ASSUMPTIONS

EPA recommends the use of site-specific values for exposure parameters when available. When site-specific information is not available, EPA standard default values are recommended. In general, there is higher uncertainty and conservatism (protectiveness) involved in using default values instead of site-specific values. Therefore, default values tend to contribute to an overestimation of risk. Site-specific values are intended to be more realistic than default values and are less likely to contribute to an overestimation of risk. However, high-end site-specific exposure factors were usually combined with conservative EPA default exposure factors to estimate conservative intake factors.

Most of the site-specific and EPA default exposure factor values are upper-bound values for the RME condition, which tend to contribute to an overestimation of risk. For estimating the RME, 95% UCL values or upperbound estimates of national averages are generally used for exposure assumptions. The intent of RME, as discussed by the EPA Deputy Administrator and the Risk Assessment Council (EPA 1992), is to present high-end risk (“above the 90th percentile of the population distribution”). This descriptor is intended to estimate the risks that are expected to occur in small but definable “high end” segments of the subject population (EPA 1992). The use of RME values for exposure factors contributed to an overestimation of average exposure and risk at the site.

The meteorologic factor that was used to derive exposure frequency to soil is considered protective because at such a high elevation and extreme winter weather, it would not be reasonable to expect year round exposure to soil. Adjusting the exposure frequency using a site-specific meteorologic factor that accounts for snow cover and frozen conditions for 4 months/year may reduce uncertainty in the risk evaluation. Other site-specific exposure values were adopted to better represent site-specific demographics related to blood lead levels and are also likely to reduce uncertainty in the risk evaluation.

The exception to use of RMEs at this site is exposure parameters used in the IEUBK model (EPA 2005b) and Adult Lead Exposure Model (EPA 2003). Both models were designed to use average or mean exposure parameter values. Therefore, the meteorologic factor was adjusted from the RME value of 188 to a CT value of 94 days/year to comply with design of the model.

5.7 TOXICITY ASSESSMENT

In this Tech Memo, toxicity values were inherent in the EPA Region 3 RBCs that were used to select COCs. Toxicity values were also used in developing site-specific PRGs for arsenic. Quantification of the toxicity of lead is inherent in the IEUBK (EPA 2005b) and Adult Lead Exposure Models (EPA 2003).

There is inherent uncertainty in assessing the toxicity of chemicals in humans. However, EPA’s methodology for toxicity assessment was specifically designed to ensure that estimates of

toxicity are protective of human health. Because uncertainties exist in the toxicity assessment process, numerous conservative (health-protective) approaches are used, so as not to underestimate toxicity. Thus, the toxicity assessment process is skewed towards overestimating toxicity. Conservative approaches used to derive toxicity factors include:

- Assuming humans are more sensitive than the most sensitive laboratory species
- Assuming carcinogens do not have a threshold
- Assuming that animal carcinogens also cause cancer in humans.

Depending on the chemical, humans can be more or less sensitive than animal species. Additionally, there is growing evidence that some carcinogens have threshold doses, below which cancer does not occur. In this Tech Memo, the conservative assumptions listed for toxicity values likely contributed to an overestimation of toxicity and hazard/risk. Therefore, PRGs, RALs, and potential cleanup decisions will be protective of potential future receptors at the site.

5.8 UNCERTAINTY CONCLUSIONS

Every aspect of the risk evaluation contains multiple sources of uncertainty which introduced uncertainty into the risk characterization results. Although some aspects of the risk evaluation may contribute to an underestimation of risk (e.g., not including several COCs in the quantitative evaluation), many more conservative assumptions were made at every step of the process so as not to underestimate potential risk. The use of (1) 95% UCLs for EPCs, (2) EPA lead models and conservative adaptations of those models to represent site receptors and conditions, (3) EPA default exposure factor values, and (4) RME exposure factor values each contribute to a net overestimation of hazard index and cancer risk at the site. Therefore, the PRGs and RALs developed in this Tech Memo are expected to guide protective and conservative redevelopment of the property.

Several inorganics at the Rose & Walsh site were elevated above conservative risk-based screening levels and could potentially pose an unacceptable health risk to humans who come into contact with the soil. Arsenic and lead in surface material had the largest exceedances of residential RBCs and, therefore, were selected as the primary risk drivers for derivation of cleanup levels. Pre-remediation 95% UCLs were derived for arsenic and lead in three exposure areas. The pre-remediation 95% UCLs were compared to site-specific PRGs for child/adult residents, child/adult recreational users, adult construction workers, and adult commercial/industrial workers. The following conclusions were drawn based on those comparisons:

1. Lead in surface material in Exposure Area 1 could pose an unacceptable threat of noncancer effects to child and adult residents, child recreational users, and adult construction workers.
2. Arsenic in surface material in Exposure Area 1 could pose an unacceptable threat of noncancer and cancer effects to child/adult residents, child/adult recreational users, and adult construction workers (THQ = 1, TCR = 1E-04).
3. Lead in surface soil in Exposure Area 2 would not pose an unacceptable threat of noncancer effects to adult commercial/industrial and construction workers.
4. Arsenic in surface soil in Exposure Area 2 would not pose an unacceptable threat of noncancer effects to adult commercial/industrial and construction workers (THQ = 1). Depending on the TCR selected, arsenic could pose an unacceptable risk of cancer.
5. Lead in surface material in Exposure Area 3 could pose an unacceptable threat of noncancer effects for child residents only.
6. Arsenic in surface material in Exposure Area 3 could pose an unacceptable threat of noncancer effects to child/adult residents and child/adult recreational users and of cancer to child/adult residents (THQ = 1, TCR = 1E-04). Depending on the TCR selected, arsenic could also pose an unacceptable risk of cancer to child/adult recreational users and construction workers.

RALs were derived for exposure scenarios in exposure areas where pre-remediation 95% UCLs for arsenic and lead exceeded PRGs. In deriving the RALs, specific sampling locations were identified as potentially requiring removal and replacement with clean fill. This information was used to discuss remedial alternatives for each exposure area based on various future land use scenarios.

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Tables

TABLE 1
Surface and Subsurface Sample XRF Data

ID	Analysis Date	Sample Type	As	AsQ	Cr	CrQ	Co	CoQ	Cu	CuQ	Fe	FeQ	Pb	PbQ	Mn	MnQ	Hg	HgQ	Mo	MoQ	Ni	NiQ	Rb	RbQ	Se	SeQ	Sr	SrQ	Zn	ZnQ	Zr	ZrQ	Confirmation
RWFPSU10	27-Jul-05	Surface Soil	73		230	U	330	U	69	U	61000		360		1400		8.4	U	7.1	U	54	U	98		5.6	U	340		750		410		
RWFPSU11	27-Jul-05	Surface Soil	72	U	230	U	330	U	190	J	51000		720		1600		8.4	U	7.1	U	54	U	96		5.6	U	380		610		410		
RWFPSU11D	27-Jul-05	Surface Soil	75	U	230	U	330	U	79	J	51000		750		1600		8.4	U	7.1	U	54	U	100		5.6	U	360		600		410		
RWFPSU12	27-Jul-05	Surface Soil	69		230	U	330	U	120	J	56000		510		1400		8.4	U	7.1	U	54	U	98		5.6	U	340		700		460		
RWFPSU16	27-Jul-05	Surface Soil	54		230	U	330	U	210	J	51000		290		1400		8.4	U	7.1	U	54	U	82		7.8	J	340		430		360		
RWFPSU17	27-Jul-05	Surface Soil	72		260	J	330	U	97	J	54000		670		1700		8.4	U	7.1	U	54	U	95		5.6	U	370		830		330		
RWFPSU18	27-Jul-05	Surface Soil	63		230	U	330	U	190	J	54000		440		1400		8.4	U	7.1	U	54	U	89		5.6	U	300		710		500		YES
RWFPSU19	27-Jul-05	Surface Soil	49		230	U	330	U	150	J	50000		430		1600		8.4	U	7.1	U	54	U	87		5.6	U	320		870		420		
RWFPSU20	27-Jul-05	Surface Soil	56		230	U	330	U	69	U	52000		520		1700		8.4	U	7.1	U	54	U	96		5.6	U	370		550		420		
RWFPSU21	27-Jul-05	Surface Soil	96	U	230	U	330	U	130	J	54000		960		1400		8.4	U	7.1	U	54	U	94		5.6	U	350		510		380		YES
RWFPSU22	27-Jul-05	Surface Soil	53	U	230	U	330	U	77	J	54000		530		1300		8.4	U	7.1	U	54	U	91		5.6	U	310		580		390		
RWFPSU22R	27-Jul-05	Surface Soil	52	U	230	U	330	U	93	J	55000		520		1300		8.4	U	7.1	U	54	U	91		5.6	U	310		630		460		
RWFPSU23	27-Jul-05	Surface Soil	58		230	U	330	U	210	J	52000		500		1400		8.4	U	7.1	U	54	U	79		5.6	U	290		980		330		
RWFPSU24	27-Jul-05	Surface Soil	47	U	230	U	330	U	180	J	53000		470		1400		8.4	U	7.1	U	54	U	94		5.6	U	350		800		300		
RWFPSU25	27-Jul-05	Surface Soil	45	U	230	U	330	U	170	J	46000		450		960		8.4	U	7.1	U	54	U	79		6.4	J	410		760		430		
RWFPSU26	27-Jul-05	Surface Soil	52		230	U	410	J	150	J	50000		390		1100		8.4	U	7.1	U	54	U	85		5.6	U	390		390		410		
RWFPSU27	27-Jul-05	Surface Soil	100	U	230	U	330	U	420		55000		1000		2200		8.4	U	7.1	U	54	U	87		5.6	U	310		680		350		YES
RWFPSU28	27-Jul-05	Surface Soil	42		230	U	330	U	69	U	57000		330		1600		8.4	U	7.1	U	54	U	98		5.6	U	330		350		310		
RWFPSU29	27-Jul-05	Surface Soil	16	J	230	U	330	U	69	U	25000		98		290	U	8.4	U	7.1	U	54	U	71		9.3	J	770		32	U	350		
RWFPSU30	27-Jul-05	Surface Soil	52		230	U	330	U	95	J	48000		280		1200		8.4	U	7.1	U	67	J	84		5.6	U	350		310		410		
RWSMSU01	27-Jul-05	Surface Soil	11	U	230	U	330	U	99	J	4100		110		290	U	8.4	U	25		54	U	18	J	5.6	U	110		270		54	J	
RWSMSU02	27-Jul-05	Surface Soil	11	U	230	U	330	U	89	J	7800		110		290	U	8.4	U	25		54	U	25	J	5.6	U	120		270		87	J	
RWSMSU03	27-Jul-05	Surface Soil	120		230	U	330	U	1600		130000		1100		2000		15	J	7.2	J	54	U	73		6.7	J	390		4400		390		
RWSMSU04	27-Jul-05	Surface Soil	380		230	U	330	U	1900		79000		1600		1700		8.4	U	7.1	U	54	U	95		7.6	J	400		670		420		
RWSMSU06	27-Jul-05	Surface Soil	170	U	230	U	330	U	750		67000		1700		3300		8.4	U	10	J	54	U	92		5.6	U	430		2800		270		
RWSMSU07	27-Jul-05	Surface Soil	55	U	230	U	330	U	360		71000		550		1000		8.4	U	7.1	U	54	U	78		5.6	U	310		810		310		YES
RWSMSU07D	27-Jul-05	Surface Soil	55	U	190	U	290	U	350		69000		550		990		8	U	6	U	84	U	74		7	U	290		810		300		
RWSMSU08	27-Jul-05	Surface Soil	32	U	230	U	330	U	320		62000		320		660	J	8.4	U	9.4	J	54	U	73		5.6	U	410		770		340		
RWSMSU10	27-Jul-05	Surface Soil	310		230	U	330	U	1500		140000		1700		980		8.8	J	9.3	J	69	J	75		16	J	390		1900		360		
RWSMSU11	27-Jul-05	Surface Soil	430		230	U	330	U	1700		100000		2400		940	J	8.4	U	7.1	U	54	U	70		5.6	U	330		1100		350		
RWSMSU12	27-Jul-05	Surface Soil	70		230	U	330	U	770		50000		560		970		8.4	U	7.1	U	54	U	90		5.6	U	340		500		350		YES
RWSMSU13	27-Jul-05	Surface Soil	120		230	U	330	U	480		66000		820		540	J	8.4	U	7.1	U	54	U	78		5.6	U	300		300		330		
RWSMSU14	27-Jul-05	Surface Soil	200		230	U	330	U	590		45000		820		550	J	9.7	J	7.1	U	54	U	87		8.1	J	300		170		560		
RWSMSU15	27-Jul-05	Surface Soil	220		230	U	330	U	1100		51000		1000		810	J	8.4	U	7.1	U	54	U	76		8.4	J	250		560		480		
RWSMSU16	27-Jul-05	Surface Soil	1600		230	J	330	U	12000		230000		8000		3000		8.4	U	15	J	110	J	90		26		450		4000		400		YES
RWSMSU19	27-Jul-05	Surface Soil	250		230	U	330	U	3000		120000		1400		960		8.4	U	11	J	61	J	79		9.4	J	420		650		410		
RWSMSU19R	27-Jul-05	Surface Soil	250		230	U	600	J	2700		120000		1300		480	J	8.4	U	7.1	U	54	U	73		6.6	J	390		550		420		
RWSMSU20	27-Jul-05	Surface Soil	130		230	U	330	U	480		110000		660		620	J	8.4	U	7.1	U	54	U	72		6.6	J	320		590		350		
RWSMSU20D	27-Jul-05	Surface Soil	110		230	U	330	U	490		110000		640		770	J	8.4	U	10	J	54	U	76		7.4	J	340		600		340		
RWSMSU21	27-Jul-05	Surface Soil	49		230	U	610	J	160	J	110000		200		670	J	8.4	U	7.1	U	54	U	73		5.6	U	330		59	J	350		YES
RWSMSU22	27-Jul-05	Surface Soil	37		230	U	620	J	110	J	160000		99		600	J	8.4	U	7.1	U	54	U	74		5.6	U	290		32	U	310		
RWSMSU23	27-Jul-05	Surface Soil	740		230	U	410	J	2700		79000		3100		490	J	8.4	U	7.1	U	54	U	67		15	J	290		540		490		
RWSMSU24	27-Jul-05	Surface Soil	83		230	U	330	U	100	J	110000		290		400	J	8.4	U	7.1	U	54	U	77		5.6	U	320		120		430		
RWSMSU25	27-Jul-05	Surface Soil	4400		230	U	330	U	4700		200000		20000		870	J	10	J	20	J	54	U	100		41		430		1400		330		
RWSMSU26	27-Jul-05	Surface Soil	1100		230	U	330	U	3000		120000		4800		880	J	8.4	U	8	J	54	U	94		11	J	350		590		410		
RWSMSU27	27-Jul-05	Surface Soil	1100		230	U	330	U	6900		95000		6300		1400		11	J	7.1	U	54	U	130		8.3	J	360		2100		490		
RWSMSU28	27-Jul-05	Surface Soil	36		230	U	330	U	69	U	31000		160		320	J	8.4	U	7.1	U	54	U	77		5.6	U	430		120		520		
RWSMSU29	27-Jul-05	Surface Soil	120		230	U	330	U	690		29000		950		390	J	8.4	U	7.1	U	54	U	79		5.6	U	270		220		390		
RWSMSU30	27-Jul-05	Surface Soil	65		230	U	330	U	300		25000		390		500	J	8.4	U	7.1	U	54	U	80		5.6	U	300		410		350		
RWSMSU31	27-Jul-05	Surface Soil	110		230	U	330	U	370		43000		560		290	U	8.4	U	7.1	U	54	U	74		5.6	U	370		120		370		YES
RWSMSU32	27-Jul-05	Surface Soil	1600		230	U	330	U	1000		91000		5300		300	J	9.7	J	14	J	54	U	91		23		540		890		470		
RWSMSU33	27-Jul-05	Surface Soil	1400		230	U	330	U	2000		100000		5500		620	J	8.4	U	8.6	J	54	U	82		26		350		1500		390		
RWSMSU34	27-Jul-05	Surface Soil	1000	U																													

TABLE 1
Surface and Subsurface Sample XRF Data

ID	Analysis Date	Sample Type	As	AsQ	Cr	CrQ	Co	CoQ	Cu	CuQ	Fe	FeQ	Pb	PbQ	Mn	MnQ	Hg	HgQ	Mo	MoQ	Ni	NiQ	Rb	RbQ	Se	SeQ	Sr	SrQ	Zn	ZnQ	Zr	ZrQ	Confirmation
RWSMSU62	03-Aug-05	Soil/Bioavailability	210		210	U	430	U	1200		94000		1100		1400		6.6	U	13	J	62	U	80		4.8	U	400		2300		320		
RWSMSU64	03-Aug-05	Soil/Bioavailability	38	J	210	U	430	U	390		32000		340		270	J	6.6	U	4.5	U	62	U	81		4.8	U	300		280		470		
RWVGUSU01	27-Jul-05	Surface Soil	100		230	U	330	U	270		31000		310		290	U	8.4	U	7.1	U	54	U	70		7.4	J	690		150		440		YES
RWVGUSU02	27-Jul-05	Surface Soil	40		230	U	330	U	170	J	16000		260		460	J	8.4	U	7.1	U	54	U	59		5.6	U	270		150		480		
RWVGUSU03	27-Jul-05	Surface Soil	67		230	U	330	U	170	J	18000		370		430	J	8.4	U	7.1	U	54	U	56		5.6	U	260		240		440		
RWVGUSU03R	27-Jul-05	Surface Soil	64		230	U	330	U	230		18000		380		460	J	8.4	U	7.1	U	54	U	48		5.6	U	280		260		380		YES
RWVGUSU04	27-Jul-05	Surface Soil	55		230	U	330	U	290		16000		470		290	U	8.4	U	7.1	U	54	U	48		5.6	U	280		510		270		
RWVGUSU05	27-Jul-05	Surface Soil	99		230	U	330	U	400		26000		490		500	J	8.4	U	7.1	U	54	U	73		5.6	U	350		190		470		
RWVGUSU06	27-Jul-05	Surface Soil	130		190	U	290	U	360		27000		650		360	J	8	U	7.4	J	84	U	63		7	U	360		440		280		
RWVGUSU07	27-Jul-05	Surface Soil	150		230	U	330	U	340		33000		590		520	J	8.4	U	7.1	U	54	U	68		5.6	U	430		300		350		
RWVGUSU08	27-Jul-05	Surface Soil	120		230	U	330	U	450		31000		500		450	J	8.4	U	7.1	U	54	U	70		5.6	U	250		250		560		
RWVGUSU09	27-Jul-05	Surface Soil	57		230	U	330	U	250		22000		330		590	J	8.4	U	7.1	U	54	U	59		5.6	U	270		240		510		
RWVGUSU10	27-Jul-05	Surface Soil	38		230	U	330	U	150	J	19000		220		320	J	8.4	U	7.1	U	54	U	59		5.6	U	340		160		540		
RWVGUSU11	27-Jul-05	Surface Soil	60		230	U	330	U	230	J	28000		290		340	J	8.4	U	7.1	U	54	U	64		5.6	U	400		160		350		
RWVGUSU12	27-Jul-05	Surface Soil	65		230	U	330	U	220	J	26000		480		410	J	8.4	U	7.1	U	54	U	62		5.6	U	310		320		290		YES
RWVGUSU13	27-Jul-05	Surface Soil	250		230	U	330	U	900		35000		1300		570	J	8.4	U	7.1	U	54	U	77		9.2	J	260		340		430		YES
RWVGUSU14	27-Jul-05	Surface Soil	61		230	U	330	U	280		25000		350		450	J	8.4	U	7.1	U	54	U	62		5.6	U	330		210		400		YES
RWVGUSU15	27-Jul-05	Surface Soil	150		230	U	330	U	390		33000		680		420	J	8.4	U	7.1	U	54	U	71		5.6	U	370		240		480		
RWVGUSU16	27-Jul-05	Surface Soil	120		230	U	330	U	420		23000		670		290	U	8.4	U	8.2	J	54	U	57		5.6	U	220		540		200		
RWVGUSU16R	27-Jul-05	Surface Soil	96		230	U	330	U	400		21000		630		380	J	8.4	U	7.1	U	54	U	47		5.6	U	220		530		180		
RWVGUSU17	27-Jul-05	Surface Soil	19	J	230	U	330	U	69	U	53000		99		500	J	8.4	U	7.1	U	54	U	80		5.6	U	370		170		350		
RWVGUSU18	27-Jul-05	Surface Soil	53		230	U	330	U	230		35000		370		470	J	8.4	U	7.1	U	54	U	80		7.2	J	320		220		450		
RWVGUSU19	27-Jul-05	Surface Soil	14	U	230	U	330	U	69	U	29000		140		310	J	8.4	U	7.1	U	54	U	72		5.6	U	390		93	J	340		
RWVGUSU20	27-Jul-05	Surface Soil	15	J	230	U	330	U	69	U	31000		84		320	J	8.4	U	7.1	U	54	U	64		5.6	U	500		65	J	400		
RWVGUSU21	27-Jul-05	Surface Soil	24	J	230	U	330	U	89	J	32000		150		410	J	8.4	U	7.1	U	54	U	67		5.6	U	480		130		440		
RWVGUSU22	27-Jul-05	Surface Soil	39		230	U	330	U	120	J	38000		220		490	J	8.4	U	7.1	U	54	U	81		5.6	U	220		160		390		YES
RWVGUSU23	27-Jul-05	Surface Soil	80		230	U	330	U	160	J	76000		250		600	J	8.4	U	7.1	U	54	U	65		7.8	J	290		320		290		
RWVGUSU24	27-Jul-05	Surface Soil	45		230	U	330	U	180	J	65000		190		600	J	8.4	U	7.1	U	54	U	69		5.6	U	310		190		350		
RWVGUSU25	27-Jul-05	Surface Soil	95		230	U	330	U	310		92000		370		560	J	8.4	U	7.1	U	54	U	74		5.6	U	320		220		360		
RWVGUSU26	27-Jul-05	Surface Soil	38		230	U	330	U	69	U	150000		56		540	J	8.4	U	9.9	J	55	J	75		5.6	U	340		32	U	350		
RWVGUSU27	27-Jul-05	Surface Soil	120		230	U	330	U	450		49000		750		520	J	8.4	U	7.1	U	54	U	67		5.6	U	270		620		350		
RWVGUSU28	27-Jul-05	Surface Soil	230		230	U	330	U	1200		47000		1900		740	J	8.4	U	7.1	U	54	U	69		5.6	U	260		1100		330		YES
RWVGUSU29	27-Jul-05	Surface Soil	53	U	230	U	330	U	260		43000		530		340	J	8.4	U	9.7	J	54	U	69		5.6	U	350		520		350		
RWVGUSU30	27-Jul-05	Surface Soil	33	J	230	U	330	U	73	J	43000		130		510	J	8.4	U	7.1	U	54	U	72		5.6	U	440		150		390		
RWVGUSU30R	27-Jul-05	Surface Soil	24	J	230	U	330	U	69	U	38000		120		410	J	8.4	U	7.1	U	54	U	73		5.6	U	430		120		360		
RWVGUSU31	27-Jul-05	Surface Soil	59		190	U	290	U	220	J	24000		330		630	J	8	U	6	U	84	U	72		7	U	250		200		390		
RWVGUSU32	27-Jul-05	Surface Soil	490		190	U	290	U	1300		43000		1900		740	J	8	U	6	U	84	U	70		15	J	420		310		490		
RWVGUSU33	27-Jul-05	Surface Soil	53		190	U	290	U	240	J	22000		290		320	J	8	U	6	U	84	U	63		7	U	400		140		460		
RWVGUSU34	27-Jul-05	Surface Soil	120		190	U	290	U	470		22000		610		570	J	8	U	6	U	84	U	65		7	U	280		300		570		
RWVGUSU35	27-Jul-05	Surface Soil	100		190	U	290	U	280		21000		460		460	J	8	U	6	U	84	U	57		7	U	320		290		340		YES
RWVGUSU36	27-Jul-05	Surface Soil	100		190	U	290	U	500		23000		550		480	J	8	U	6	U	84	U	71		7	U	300		280		560		
RWVGUSU36D	27-Jul-05	Surface Soil	120		190	U	290	U	460		23000		580		530	J	8	U	6	U	84	U	75		7	U	310		280		560		
RWVGUSU37	27-Jul-05	Surface Soil	63		190	U	290	U	210	J	21000		280		470	J	8	U	6	U	84	U	56		7	U	420		170		550		
RWVGUSU38	27-Jul-05	Surface Soil	27	J	190	U	290	U	83	U	20000		110		460	J	8	U	6	U	84	U	70		7	U	230		150		450		
RWVGUSU39	27-Jul-05	Surface Soil	100		190	U	290	U	430		25000		540		440	J	8	U	6	U	84	U	63		7	U	380		150		570		
RWVGUSU40	27-Jul-05	Surface Soil	70		190	U	290	U	150	J	18000		290		380	J	8	U	6	U	84	U	56		7	U	350		450		320		
RWSMSR50	03-Aug-05	Surface Slag	130	U	210	U	430	U	3400		260000		1300		2600		6.6	U	23		87	J	61		4.8	U	750		13000		440		
RWSMSR52L	03-Aug-05	Surface Slag	460	U	1000		430	U	4100		440000		4600		5600		6.6	U	65		140	J	26		14	J	560		19000		420		
RWSMSR53	03-Aug-05	Surface Slag	150	U	210	U	430	U	4500		230000		1500		5000		6.6	U	18		62	U	67		8.3	J	510		10000		390		
RWSMSR54	03-Aug-05	Surface Slag	230	U	440	J	430	U	5700		340000		2300		5600		28	U	53		120	J	46		18	J	620		14000		410		
RWSMSR57	03-Aug-05	Surface Slag	140	U	550	J	430	U	5300		320000		1400		2500		12	J	32		96	J	47		4.8	U	720		15000		420		
RWSMSR61	03-Aug-05	Surface Slag	250		230	J	500	J	7400		260000		2000		3300		15	J	37		62	U	46		22	J	790		14000		340		
RWSMSR65	03-Aug-05	Surface Slag	990		210																												

TABLE 1
Surface and Subsurface Sample XRF Data

ID	Analysis Date	Sample Type	As	AsQ	Cr	CrQ	Co	CoQ	Cu	CuQ	Fe	FeQ	Pb	PbQ	Mn	MnQ	Hg	HgQ	Mo	MoQ	Ni	NiQ	Rb	RbQ	Se	SeQ	Sr	SrQ	Zn	ZnQ	Zr	ZrQ	Confirmation
RWSMCO070	27-Jul-05	Surface Core	110		230	U	330	J	450		130000		530		730	J	8.4	U	7.1	U	54	U	77		7.1	J	300		330		360		YES
RWSMCO080	27-Jul-05	Surface Core	150		230	U	330	U	1300		140000		1000		1100		8.4	U	9.1	J	54	U	75		8.8	J	410		2000		360		YES
RWSMCO090	27-Jul-05	Surface Core	34	J	230	U	330	U	120	J	49000		150		670	J	8.4	U	7.1	U	54	U	80		5.6	U	430		180		370		
RWSMCO100	27-Jul-05	Surface Core	58		230	U	330	U	1600		64000		320		1500		8.4	U	7.1	U	54	U	86		11	J	350		360		380		YES
RWFPSS05	27-Jul-05	Subsurface Soil	88		230	U	330	U	1500		77000		620		1600		8.4	U	7.1	U	54	U	82		5.6	U	430		1900		370		
RWFPSS11	27-Jul-05	Subsurface Soil	85		230	U	330	U	170	J	56000		710		1800		8.4	U	7.1	U	54	U	100		5.6	U	380		510		400		
RWFPSS16	27-Jul-05	Subsurface Soil	24	J	230	U	330	U	69	U	54000		150		1400		8.4	U	7.4	J	54	U	88		6	J	340		170		280		
RWFPSS20	27-Jul-05	Subsurface Soil	66		230	U	330	U	69	U	55000		370		1200		8.4	U	9.4	J	63	J	93		5.6	U	330		460		480		YES
RWFPSS24	27-Jul-05	Subsurface Soil	65		230	U	330	U	210	J	59000		500		1600		8.4	U	7.1	U	64	J	92		5.6	U	330		810		460		YES
RWFPSS26	27-Jul-05	Subsurface Soil	40	U	230	U	330	U	130	J	54000		400		1400		8.4	U	10	J	54	U	93		5.6	U	390		370		400		
RWFPSS28	27-Jul-05	Subsurface Soil	66		230	U	330	U	69	U	54000		340		1800		8.4	U	7.1	U	54	U	89		5.6	U	350		310		390		
RWFPSS28D	27-Jul-05	Subsurface Soil	38	U	230	U	410	J	70	J	53000		380		1700		8.4	U	7.1	U	54	U	93		7	J	350		260		390		
RWSMSS07	27-Jul-05	Subsurface Soil	130		230	U	330	U	690		110000		770		660	J	8.4	U	8.1	J	54	U	79		8.9	J	340		650		300		
RWSMSS11	27-Jul-05	Subsurface Soil	1200		230	U	330	U	3200		120000		4100		1300		8.4	U	18	J	54	U	73		13	J	350		1400		440		
RWSMSS14	27-Jul-05	Subsurface Soil	170		230	U	330	U	660		46000		790		530	J	8.4	U	7.1	U	54	U	92		5.6	U	270		190		450		
RWSMSS23	27-Jul-05	Subsurface Soil	520		230	U	330	U	1500		46000		2500		290	J	8.4	U	7.1	U	54	U	37		5.6	U	270		250		680		
RWSMSS25	27-Jul-05	Subsurface Soil	3600	U	230	U	330	U	4700		230000		36000		930	J	12	J	21	J	54	U	110		23		600		1700		310		YES
RWSMSS28	27-Jul-05	Subsurface Soil	35	J	230	U	330	U	69	U	42000		58		430	J	8.4	U	7.1	U	54	U	85		5.6	U	420		38	J	360		
RWSMSS31	27-Jul-05	Subsurface Soil	120		230	U	330	U	430		43000		690		350	J	8.4	U	7.1	U	54	U	75		6.6	J	360		130		360		
RWSMSS33	27-Jul-05	Subsurface Soil	200		230	U	330	U	310		420000		750		1100		8.4	U	13	J	120	J	55		5.6	U	230		32	U	210		
RWSMSS33R	27-Jul-05	Subsurface Soil	160		230	U	330	U	310		430000		710		1200		8.4	U	7.1	U	54	U	56		5.6	U	220		32	U	240		
RWSMSS34	27-Jul-05	Subsurface Soil	2300	U	250	J	330	U	2400		130000		23000		470	J	8.4	U	12	J	88	J	92		42		410		960		380		YES
RWSMSS34D	27-Jul-05	Subsurface Soil	2300	U	230	U	330	U	2500		140000		23000		530	J	8.4	U	7.1	U	54	U	100		20		420		1000		370		
RWSMSS36	27-Jul-05	Subsurface Soil	80		230	U	330	U	200	J	130000		300		540	J	8.4	U	10	J	54	U	80		7.4	J	340		46	J	340		
RWSMSS39	27-Jul-05	Subsurface Soil	55		230	U	330	U	350		33000		330		640	J	8.4	U	7.1	U	54	U	83		5.6	U	250		230		430		YES
RWVGSS03	27-Jul-05	Subsurface Soil	54		230	U	330	U	180	J	18000		160		290	U	8.4	U	7.1	U	54	U	59		5.6	U	290		100	J	530		
RWVGSS05	27-Jul-05	Subsurface Soil	80		230	U	330	U	260		31000		270		290	U	8.4	U	7.4	J	54	U	74		7.6	J	450		110	J	360		
RWVGSS05D	27-Jul-05	Subsurface Soil	56		230	U	330	U	250		30000		300		290	U	8.4	U	7.1	U	54	U	74		5.6	U	450		110		360		
RWVGSS06	27-Jul-05	Subsurface Soil	130		230	U	330	U	360		27000		650		360	J	8.4	U	7.4	J	54	U	63		5.6	U	360		440		280		
RWVGSS08	27-Jul-05	Subsurface Soil	110		230	U	330	U	660		33000		630		680	J	8.4	U	7.1	U	54	U	85		7	J	290		190		490		
RWVGSS09	27-Jul-05	Subsurface Soil	42		230	U	330	U	210	J	23000		300		490	J	8.4	U	7.1	U	54	U	64		5.6	U	290		160		530		
RWVGSS13	27-Jul-05	Subsurface Soil	250		230	U	330	U	910		35000		1200		470	J	8.4	U	7.1	U	54	U	79		5.6	U	250		230		440		YES
RWVGSS15	27-Jul-05	Subsurface Soil	110		230	U	330	U	380		35000		520		330	J	8.4	U	7.1	U	54	U	71		5.9	J	480		160		470		YES
RWVGSS15D	27-Jul-05	Subsurface Soil	81		230	U	330	U	330		34000		510		430	J	8.4	U	8.2	J	54	U	70		5.6	U	470		120		450		
RWVGSS17	27-Jul-05	Subsurface Soil	21	J	230	U	330	U	87	J	47000		120		440	J	8.4	U	7.1	U	54	U	83		5.6	U	460		97	J	350		
RWVGSS19	27-Jul-05	Subsurface Soil	27	J	230	U	330	U	69	U	38000		110		450	J	8.4	U	7.1	U	54	U	78		6	J	290		85	J	380		
RWVGSS22	27-Jul-05	Subsurface Soil	52		230	U	330	U	190	J	36000		250		510	J	8.4	U	7.1	U	54	U	80		5.6	U	250		250		400		
RWVGSS24	27-Jul-05	Subsurface Soil	45		230	U	330	U	170	J	62000		200		440	J	8.4	U	7.1	U	54	U	77		5.6	U	310		160		440		
RWVGSS26	27-Jul-05	Subsurface Soil	29	J	230	U	330	U	69	U	100000		55		460	J	8.4	U	7.1	U	54	U	75		5.6	U	370		32	U	300		
RWVGSS31	27-Jul-05	Subsurface Soil	58		190	U	290	U	320		27000		360		670	J	8	U	6	U	84	U	76		7	U	250		140		500		
RWVGSS32	27-Jul-05	Subsurface Soil	250		190	U	290	U	920		32000		1300		450	J	8.8	J	6	U	84	U	64		7	U	490		190		510		
RWVGSS34	27-Jul-05	Subsurface Soil	80		190	U	290	U	400		30000		380		440	J	8	U	7.4	J	84	U	68		7	U	560		230		480		
RWSMCO011	27-Jul-05	Subsurface Core	300		230	U	330	U	1800		28000		2100		410	J	8.4	U	7.1	U	54	U	88		5.6	U	260		360		460		
RWSMCO012	27-Jul-05	Subsurface Core	500		230	U	370	J	950		91000		3100		640	J	8.4	U	8.1	J	54	U	84		17	J	310		160		350		YES
RWSMCO013	27-Jul-05	Subsurface Core	68		230	U	410	J	470		47000		370		490	J	8.4	U	7.1	U	54	U	65		7	J	280		32	U	460		
RWSMCO014	27-Jul-05	Subsurface Core	68		230	U	330	U	330		100000		260		950	J	8.4	U	36	U	54	U	60		5.6	U	480		85	J	250		
RWSMCO021	27-Jul-05	Subsurface Core	3200		520	J	330	U	2700		190000		9900		1600		33		7.1	U	170	J	96		50		650		930		410		
RWSMCO022	27-Jul-05	Subsurface Core	130		680	J	500	J	86	J	220000		130		1800		8.4	U	7.1	U	110	J	89		5.6	U	310		32	U	220		YES
RWSMCO023	27-Jul-05	Subsurface Core	63		450	J	1000	J	130	J	170000		38	J	1500		8.4	U	7.1	U	54	U	110		5.6	U	380		32	U	420		
RWSMCO024	27-Jul-05	Subsurface Core	37		650	J	330	U	190	J	240000		43	J	2100		8.4	U	7.1	U	54	U	55		5.6	U	200		32	U	210		
RWSMCO025	27-Jul-05	Subsurface Core	26	J	250	J	580	J	180	J	210000		15	U	1800		8.4	U	7.1	U	54	U	75		5.6	U	310		32	U	300		
RWSMCO026	27-Jul-05	Subsurface Core	24	J	230	U	330	U	140	J	170000		38	J	1200		8.4	U	7.1	U	54	U	63		5.6	U	360		32	U	270		

TABLE 1
Surface and Subsurface Sample XRF Data

ID	Analysis Date	Sample Type	As	AsQ	Cr	CrQ	Co	CoQ	Cu	CuQ	Fe	FeQ	Pb	PbQ	Mn	MnQ	Hg	HgQ	Mo	MoQ	Ni	NiQ	Rb	RbQ	Se	SeQ	Sr	SrQ	Zn	ZnQ	Zr	ZrQ	Confirmation
RWSMCO045	27-Jul-05	Subsurface Core	63		230	U	330	U	430		58000		370		1900		8.4	U	7.1	U	54	U	85		5.6	U	310		190		320		
RWSMCO046	27-Jul-05	Subsurface Core	18	J	230	U	330	U	870		57000		95		1800		8.4	U	7.1	U	54	U	82		5.6	U	270		300		300		
RWSMCO047	27-Jul-05	Subsurface Core	14	J	230	U	440	J	69	U	97000		83		1500		8.4	U	7.7	J	54	U	94		5.6	U	290		730		330		
RWSMCO048	27-Jul-05	Subsurface Core	21	J	230	U	1000	J	140	J	220000		44	J	1700		8.4	U	7.1	U	54	U	76		5.6	U	320		210		290		
RWSMCO071	27-Jul-05	Subsurface Core	47		230	U	380	J	200	J	140000		290		570	J	8.4	U	11	J	54	U	86		5.6	U	320		50	J	290		
RWSMCO072	27-Jul-05	Subsurface Core	58		230	U	700	J	410		160000		380		600	J	8.4	U	8.6	J	54	U	84		5.6	U	310		52	J	290		
RWSMCO073	27-Jul-05	Subsurface Core	37		230	U	330	U	230	J	190000		230		420	J	11	J	7.1	U	110	J	71		9	J	340		77	J	290		
RWSMCO074	27-Jul-05	Subsurface Core	82		230	U	330	U	290		140000		400		700	J	8.4	U	7.1	U	54	U	76		7.8	J	320		150		300		
RWSMCO075	27-Jul-05	Subsurface Core	34	J	230	U	330	U	160	J	180000		170		540	J	8.4	U	7.1	U	54	U	82		5.6	U	300		32	U	320		YES
RWSMCO076	27-Jul-05	Subsurface Core	190	U	470	J	560	J	6300		330000		1900		2800		8.4	U	50		54	U	59		16	J	1300		11000		450		YES
RWSMCO077	27-Jul-05	Subsurface Core	240	U	1500		330	U	8100		340000		2400		2800		8.4	U	43		54	U	65		15	J	1300		13000		510		
RWSMCO078	27-Jul-05	Subsurface Core	270		610	J	330	U	11000		240000		2300		2300		8.4	U	17	J	54	U	84		9	J	1100		10000		450		
RWSMCO081	27-Jul-05	Subsurface Core	22	J	230	U	330	U	69	U	150000		58		580	J	9.5	J	7.1	U	54	U	85		8.7	J	320		32	U	340		
RWSMCO081R	27-Jul-05	Subsurface Core	20	J	230	U	330	U	69	U	150000		55		520	J	8.4	U	8.6	J	54	U	84		5.6	U	320		32	U	310		
RWSMCO082	27-Jul-05	Subsurface Core	19	J	230	U	330	J	69	U	140000		47	J	530	J	8.4	U	7.1	U	54	U	74		11	J	310		32	U	350		
RWSMCO083	27-Jul-05	Subsurface Core	30	J	230	U	330	U	84	J	160000		44	J	510	J	8.4	U	7.1	U	54	U	75		5.6	U	330		32	U	320		
RWSMCO084	27-Jul-05	Subsurface Core	21	J	230	U	330	U	81	J	130000		47	J	440	J	8.4	U	8.2	J	54	U	88		5.6	U	300		32	U	340		
RWSMCO085	27-Jul-05	Subsurface Core	23	J	230	U	330	U	69	U	160000		33	J	570	J	8.4	U	7.1	U	54	U	75		5.6	U	330		32	U	330		
RWSMCO086	27-Jul-05	Subsurface Core	12	J	230	U	330	U	69	U	150000		45	J	530	J	8.4	U	7.1	U	54	U	76		5.6	U	300		32	U	310		
RWSMCO087	27-Jul-05	Subsurface Core	15	J	230	U	330	U	69	U	120000		51		600	J	8.4	U	7.1	U	54	U	78		5.6	U	290		120		340		
RWSMCO088	27-Jul-05	Subsurface Core	41	U	230	U	330	U	86	J	43000		410		600	J	8.4	U	7.1	U	54	U	89		5.7	J	350		340		440		
RWSMCO091	27-Jul-05	Subsurface Core	33	J	230	U	330	U	78	J	49000		100		530	J	8.4	U	7.1	U	54	U	75		5.6	U	470		140		390		
RWSMCO091D	27-Jul-05	Subsurface Core	32	J	230	U	330	U	100	J	50000		130		600	J	8.4	U	7.4	J	54	U	76		5.6	U	470		150		400		
RWSMCO092	27-Jul-05	Subsurface Core	140	U	230	U	620	J	5800		220000		1400		2900		8.4	U	30		77	J	79		7.6	J	820		5900		380		
RWSMCO093	27-Jul-05	Subsurface Core	410	U	250	J	330	U	4500		480000		4100		4000		17	J	48		140	J	56		5.6	U	580		20000		330		
RWSMCO094	27-Jul-05	Subsurface Core	130		230	U	380	J	1700		72000		1100		1600		8.4	U	11	J	54	U	82		5.6	U	440		960		410		
RWSMCO101	27-Jul-05	Subsurface Core	17	J	230	U	330	U	270		62000		110		1700		8.4	U	7.1	U	54	U	87		5.6	U	330		460		330		
RWSMCO101D	27-Jul-05	Subsurface Core	35	J	230	U	330	U	320		61000		100		1700		8.4	U	7.1	U	54	U	89		5.6	U	330		460		330		
RWSMCO102	27-Jul-05	Subsurface Core	38		230	U	330	U	93	J	50000		110		1300		8.4	U	7.1	U	54	U	87		5.6	U	320		580		390		
RWSMCO103	27-Jul-05	Subsurface Core	14	J	230	U	330	U	130	J	35000		93		980		9.1	J	13	J	54	U	89		5.6	U	440		330		280		
RWSMCO104	27-Jul-05	Subsurface Core	18	J	230	U	330	U	69	U	44000		70		1500		8.4	U	7.1	U	54	U	94		5.6	U	450		140		300		
RWSMCO105	27-Jul-05	Subsurface Core	27	J	230	U	330	U	69	U	37000		47	J	1100		8.4	U	7.1	U	54	U	94		5.6	U	500		110		260		
RWSMCO106	27-Jul-05	Subsurface Core	11	U	230	U	330	U	110	J	44000		71		1500		8.4	U	7.1	U	54	U	88		5.6	U	530		160		280		

ID = identification. Sample IDs ending in "R" are replicate samples and those ending in "D" are duplicate samples.

Chemical symbols include: As = Arsenic, Cr = Chromium, Co = Cobalt, Cu = Copper, Fe = Iron, Pb = Lead, Mn = Manganese, Hg = Mercury, Mo = Molybdenum, Ni = Nickel, Rb = Rubidium, Se = Selenium, Sr = Strontium, Zn = Zinc, and Zr = Zirconium.

Q = Qualifier. Chemical- and sample-specific data qualifiers include: J = estimate and U = the analyte was not detected at or above the instrument detection limit (IDL).

Confirmation - Noted as "Yes" for confirmatory samples sent to lab.

XRF = X-Ray Fluorescence

TABLE 2
COC Selection - Site-wide Surface Material
Rose and Walsh Smelter

Metal	Maximum Detected Surface Material Concentration (mg/kg) (1)	Region 3 Residential Soil RBC (mg/kg)	Maximum Detected Surface Concentration Exceeds RBC?	COC?
Arsenic	4.4E+03	4.3E-01	Yes	Yes
Chromium	1.1E+03	2.4E+00 (2)	Yes	Yes
Cobalt	6.2E+02	1.6E+03	No	No
Copper	1.8E+04	3.1E+03	Yes	Yes
Iron	4.4E+05	2.3E+04	Yes	Yes
Lead	2.0E+04	4.0E+02	Yes	Yes
Manganese	5.6E+03	1.6E+03	Yes	Yes
Mercury	2.8E+01	2.3E+01	Yes	Yes
Molybdenum	6.5E+01	3.9E+02	No	No
Nickel	1.4E+02	1.6E+03	No	No
Rubidium	1.3E+02	-	No	Yes (3)
Selenium	4.1E+01	3.9E+02	No	No
Strontium	8.4E+02	4.7E+04	No	No
Zinc	1.9E+04	2.3E+04	No	No
Zirconium	5.7E+02	-	No	Yes (3)

(1) Includes surface soil, surface soil bioavailability, and surface core samples collected at the surface at locations with no slag or immediately under slag at locations where slag is 1 foot or less in depth. Also includes surface slag samples.

(2) The maximum detected concentrations of chromium at the site do not exceed the Region 3 RBC for chromium III of 117,321 mg/kg.

(3) Selected as COC because no RBC was available.

Bold text highlights those chemicals selected as COCs.

- = not applicable

mg/kg = milligram per kilogram

RBC = Risk-Based Concentration

COC = Chemical of Concern

TABLE 3
COC Selection - Site-wide Subsurface Soil
Rose and Walsh Smelter

Metal	Maximum Detected Subsurface Soil Concentration (mg/kg) (1)	Region 3 Residential Soil RBC (mg/kg)	Maximum Subsurface Soil Concentration Exceeds RBC?	COC?
Arsenic	3.2E+03	4.3E-01	Yes	Yes
Chromium	1.5E+03	2.4E+02 (2)	Yes	Yes
Cobalt	1.0E+03	1.6E+03	No	No
Copper	1.1E+04	3.1E+03	Yes	Yes
Iron	4.8E+05	2.3E+04	Yes	Yes
Lead	3.6E+04	4.0E+02	Yes	Yes
Manganese	4.0E+03	1.6E+03	Yes	Yes
Mercury	3.3E+01	2.3E+01	Yes	Yes
Molybdenum	5.0E+01	3.9E+02	No	No
Nickel	1.7E+02	1.6E+03	No	No
Rubidium	1.1E+02	-	-	Yes (3)
Selenium	5.0E+01	3.9E+02	No	No
Strontium	1.3E+03	4.7E+04	No	No
Zinc	2.0E+03	2.3E+04	No	No
Zirconium	6.8E+02	-	-	Yes (3)

(1) Subsurface soil soil samples collected 6-8 inches bgs at location with no slag or 6-8 inches below slag at locations where slag is less than 1 foot in depth. Also, includes subsurface core samples collected at 1 foot intervals down to a maximum depth of 8 feet.

(2) The maximum detected concentrations of chromium at the site do not exceed the Region 3 RBC for chromium III of 117,321 mg/kg.

(3) Selected as COC because no RBC was available.

Bold text highlights those chemicals selected as COCs.

- = not applicable

mg/kg = milligram per kilogram

RBC = Risk-Based Concentration

COC = Chemical of Concern

TABLE 4
Summary of Chemicals of Concern
Rose and Walsh Smelter

Metal	COCs	
	Surface (1)	Subsurface (2)
Arsenic	X	X
Cobalt		
Chromium	X	X
Copper	X	X
Iron	X	X
Mercury	X	X
Manganese	X	X
Molybdenum		
Nickel		
Lead	X	X
Rubidium	X	X
Selenium		
Strontium		
Zinc		
Zirconium	X	X

(1) Includes surface soil, surface soil bioavailability, and surface core samples collected at the surface at locations with no slag or immediately under slag at locations where slag is 1 foot or less in depth. Also includes surface slag samples.

(2) Subsurface soil soil samples collected 6-8 inches below ground surface at location with no slag or 6- inches below slag at locations where slag is less than 1 foot in depth. Also, includes subsurface core samples collected at 1 foot intervals down to a maximum depth of 8 feet.
Bold text highlights those chemicals selected as COCs.

COC = Chemical of Concern

TABLE 5
Summary of Preliminary Remediation Goals
Rose and Walsh Smelter

Scenario	Arsenic PRG (mg/kg) (1E-06)	Arsenic PRG (mg/kg) (1E-05)	Arsenic PRG (mg/kg) (1E-04)	Arsenic PRG (mg/kg) (HQ = 1)	Lead PRG (mg/kg)
Child/Adult Resident	1.06	10.6	106	58.7 (5)	-
Child/Adult Recreational User	7.90	79.0	790	109 (5)	-
Office Worker	9.47	94.7	947	1533	2988
Construction Worker (1)	14.3	143	1430	232	1494
Construction Worker (2)	14.3	143	1430	232	1494
Adult Resident	-	-	-	-	2797
Child Resident	-	-	-	-	400 (3)
Adult Recreational User	-	-	-	-	27846
Child Recreational User (4)	-	-	-	-	5648

- (1) PRG for comparison to EPCs for surface plus subsurface soil.
- (2) PRGs for comparison to separate EPCs for surface soil and subsurface soil (assumes half of total exposure is to surface soil and half is to subsurface soil).
- (3) EPA default soil screening level for lead (EPA 1994).
- (4) Assumes EPA Region 8 default background value for lead in soil of 40 mg/kg. Per the IEUBK model, corresponding lead in indoor dust is assumed to be 38 mg/kg (EPA 2005).
- (5) PRG for children only.

U. S. Environmental Protection Agency (EPA). 1994. Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities. Washington, DC: Office of Emergency and Remedial Response. OSWER Directive #9355.4-12. July.

EPA. 2005. Uptake/Biokinetic Model for Lead. IEUBKwin v1.0 build 263. Software program developed by EPA. November. Available for download from:
<http://www.epa.gov/superfund/programs/lead/products.htm>

- = not applicable

EPA = Environmental Protection Agency

EPC = Exposure Point Concentration

HQ = Hazard quotient

IEUBK = Integrated Exposure Uptake Biokinetic

mg/kg = milligrams per kilogram

PRG = Preliminary Remediation Goal

TABLE 6
Exposure Factors for Arsenic
Construction Workers
Rose and Walsh Smelter

Intake Parameter		RME	Source
IRs:	Ingestion, soil (mg/day)	330	EPA 2002
IN:	Inhalation, air (m ³ /day)	20	EPA 2002
PEF:	Particulate Emission Factor (m ³ /kg) (1)	1.00E+06	Site-Specific
CF:	Conversion Factor (kg/mg)	1.00E-06	--
EF:	Exposure Frequency (days/year)	250	EPA 2002
ED:	Exposure Duration (years)	1	EPA 2002
BW:	Body Weight (kg)	70	EPA 1989
AT:	Averaging Time (days)		
	Carcinogenic	25,550	EPA 1989
	Noncarcinogenic	365	EPA 1989

(1) Particulate Emission Factor: Visible dust levels.

U. S. Environmental Protection Agency (EPA). 1989. Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual, Part A. Interim Final. Office of Emergency and Remedial Response, Washington, D.C. December.

EPA. 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites.

hr = hour

kg = kilogram

m = meter

mg = milligram

RME = Reasonable Maximum Exposure

TABLE 7
Exposure Factors for Arsenic
Office Workers
Rose and Walsh Smelter

Intake Parameter		RME	Source
IRs:	Ingestion, soil (mg/day)	50	EPA 1991
IN:	Inhalation, air (m ³ /hr)	2.5	EPA 1991
ET:	Exposure Time, air (hr/day) (1)	8	Site-Specific
PEF:	Particulate Emission Factor (m ³ /kg)	1.32E+09	EPA 1996
CF:	Conversion Factor (kg/mg)	1.00E-06	--
EF:	Exposure Frequency (days/year)	250	EPA 1991
ED:	Exposure Duration (years)	25	EPA 1991
BW:	Body Weight (kg)	70	EPA 1989
AT:	Averaging Time (days)		
	Carcinogenic	25,550	EPA 1989
	Noncarcinogenic	9,125	EPA 1989

(1) Exposure Time: Based upon typical 8-hour workday.

U.S. Environmental Protection Agency (EPA). 1989. Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual, Part A. Interim Final. Office of Emergency and Remedial Response, Washington, D.C. December.

EPA. 1991. Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors. Washington, DC: Office of Emergency and Remedial Response. March.

EPA. 1996. Soil Screening Guidance: User's Guide.

hr = hour

kg = kilogram

m = meter

mg = milligram

RME = Reasonable Maximum Exposure

TABLE 8
Exposure Factors for Arsenic
Residents
Rose and Walsh Smelter

Intake Parameter		RME	Source
IRs:	Ingestion, soil (mg/day)		
	IRSa: Adult	100	EPA 1991
	IRSc: Child	200	EPA 1991
IN:	Inhalation, air (m ³ /day)		
	INa: Adult	20	EPA 1991
	INc: Child	10	EPA 2004b (1)
PEF:	Particulate Emission Factor (m ³ /kg)	1.32E+09	EPA 1996
EF:	Exposure Frequency (days/year)	350	EPA 1989
ED:	Exposure Duration (years)		
	EDa: Adult	24	EPA 1989
	EDc: Child	6	EPA 1989
CFs:	Conversion Factor, soil (kg/mg)	1E-06	
BW:	Body Weight (kg)		
	BWa: Adult	70	EPA 1989
	BWc: Child	15	EPA 1989
AT:	Averaging Time (days)		
	Noncarcinogenic: ATnc		
	ATna: Adult	8,760	EPA 1989
	ATnc: Child	2,190	EPA 1989
	Carcinogenic : ATc		
	ATc: Adult/child	25,550	EPA 1989

(1) Value obtained from Region 9 PRG (2004) tables, which cites EPA (1997).

U.S. Environmental Protection Agency (EPA). 1989. Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual, Part A. Interim Final. Office of Emergency and Remedial Response, Washington, D.C. December.

EPA. 1991. Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors. Washington, DC: Office of Emergency and Remedial Response. March.

EPA. 1996. Soil Screening Guidance: User's Guide.

EPA. 1997. Exposure Factors Handbook. U.S. EPA. Office of Research and Development. Washington, D.C. EPA/600/P-95/002Fa. August.

EPA. 2004. User's guide and Background Technical Document. For USEPA Region 9's Preliminary Remediation Goals (PRGs) Table.

kg = kilogram

m = meter

mg - milligram

PRG = Preliminary Remediation Goal

RME = Reasonable Maximum Exposure

TABLE 9
Exposure Factors for Arsenic
Recreational Path Users
Rose and Walsh Smelter

Intake Parameter		RME	Source
IRs:	Ingestion Rate, soil (mg/day)		
	IRSa: Adult	25	Site-Specific (1)
	IRSc: Child	50	Site-Specific (1)
IN:	Inhalation Rate, air (m ³ /hr)		
	INa: Adult	3.2	EPA 1997 (2)
	INc: Child	1.9	EPA 1997 (2)
PEF	Particulate Emission Factor (m ³ /kg)	1.32E+09	EPA 1996
ET:	Exposure Time (hrs/day)	2.0	Site-Specific (3)
EF:	Exposure Frequency (days/year)	188	Site-Specific (4)
ED:	Exposure Duration (years)		
	EDa: Adult	24	EPA 1989
	EDc: Child	6	EPA 1989
CFs:	Conversion Factor, soil (kg/mg)	1E-06	
BW:	Body Weight (kg)		
	BWa: Adult	70	EPA 1989
	BWc: Child	15	EPA 1989
AT:	Averaging Time (days)		
	Noncarcinogenic: ATnc		
	ATna: Adult	8,760	EPA 1989
	ATnc: Child	2,190	EPA 1989
	Carcinogenic : ATc		
ATc: Adult/child	25,550	EPA 1989	

(1) Child and adult recreational users are assumed to ingest one-fourth of their residential RME daily soil ingestion rates while on the path.

(2) Exposure Factors Handbook recommended values for inhalation rates for heavy activities in children and adults (EPA 1997).

(3) Recreational users are assumed to spend 2 hours/day on the path.

(4) Assumes exposure for 5 days/week, for the 8 warmest months of the year.

U.S. Environmental Protection Agency (EPA). 1989. Risk Assessment Guidance for Superfund: Volume I Human Health Evaluation Manual, Part A. Interim Final. Office of Emergency and Remedial Response, Washington, D.C. December.

EPA. 1996. Soil Screening Guidance: User's Guide. Office of Solid Waste and Emergency Response, Washington, D.C. EPA/540R-96/018.

EPA. 1997. Exposure Factors Handbook. U.S. EPA. Office of Research and Development. Washington, D.C. EPA/600/P-95/002Fa. August.

hr = hour

kg = kilogram

m = meter

mg = milligrams

RME = Reasonable Maximum Exposure

TABLE 10
Arsenic Relative Bioavailability Estimates
Rose and Walsh Smelter

Sample ID	Concentration of Arsenic in less than 250 micron diameter bulk soil (mg/kg)	Soil Mass (g)	Calculated Arsenic #1	ICP Arsenic Concentration (mg/L)	Solution Amount (L)	Percent Relative Bioavailability of Arsenic	Ln (Percent Relative Bioavailability of Arsenic)
RWSM SU 50	29.62	1.00023	0.03	<.003	0.1	NA	-
RWSM SU 51	75.69	1.00032	0.08	0.058	0.1	7.7	2.04
RWSM SU 52	12.15	1.00042	0.01	<.003	0.1	NA	-
RWSM SU 53	54.94	1.00028	0.05	<.003	0.1	NA	-
RWSM SU 54	33.23	1.00026	0.03	0.029	0.1	8.7	2.16
RWSM SU 55	205.70	1.00022	0.21	0.381	0.1	18.5	2.92
RWSM SU 56	52.55	1.00015	0.05	0.065	0.1	12.4	2.51
RWSM SU 57	129.00	1.00016	0.13	0.273	0.1	21.1	3.05
RWSM SU 58	65.24	1.00027	0.07	0.063	0.1	9.7	2.27
RWSM SU 59	21.04	1.00032	0.02	<.003	0.1	NA	-
RWSM SU 60	38.30	1.00025	0.04	<.003	0.1	NA	-
RWSM SU 61	21.10	1.0002	0.02	<.003	0.1	NA	-
RWSM SU 62	103.15	1.00027	0.10	0.184	0.1	17.8	2.88
RWSM SU 63	30.10	1.00003	0.03	0.067	0.1	22.4	3.11
RWSM SU 64	84.75	1.00009	0.08	0.163	0.1	19.3	2.96
RWSM SR 71	1484.68	1.00024	1.49	3.983	0.1	26.8	3.29
RWSM SR 72	1236.82	1.00021	1.24	2.731	0.1	22.1	3.09
RWSM SR 73	91.97	1.00021	0.09	0.716	0.1	77.9	4.36
RWSM SR 74	59.81	1	0.06	0.452	0.1	75.6	4.33
RWSM CO 05	39.51	1.00028	0.04	0.095	0.1	24.0	3.18
mean						26.0	3.0
n						14	14
sqrt(n) or sqrt (n-1)						3.7	3.6
stdev						22.3	0.7
se						6.0	--
t						1.771	--
H						-	2.342
95% UCL						37	40

- = not applicable
g = gram
ICP = Inductively coupled plasma analysis
L = liter
Ln = natural log
mg/kg = milligram per kilogram
mg/L = milligram per liter
n = number of samples
NA = Not applicable because ICP Arsenic concentration is non-detect (shown as <).
se = standard error
sqrt = square root
stdev = standard deviation
UCL = Upper confidence limit of the mean

TABLE 11
Lead Relative Bioavailability Estimates
Rose and Walsh Smelter

Sample ID	Concentration of Lead in less than 250 micron diameter bulk soil (mg/kg)	Soil Mass (g)	Calculated Lead #1	ICP Lead Concentration (mg/L)	Solution Amount (L)	Percent Relative Bioavailability of Lead
RWSM SU 50	257.30	1.00023	0.26	1.266	0.1	49
RWSM SU 51	567.88	1.00032	0.57	1.914	0.1	34
RWSM SU 52	229.84	1.00042	0.23	1.471	0.1	64
RWSM SU 53	435.67	1.00028	0.44	3.155	0.1	72
RWSM SU 54	333.72	1.00026	0.33	2.140	0.1	64
RWSM SU 55	1169.88	1.00022	1.17	11.765	0.1	101
RWSM SU 56	513.02	1.00015	0.51	3.411	0.1	66
RWSM SU 57	963.15	1.00016	0.96	8.859	0.1	92
RWSM SU 58	622.20	1.00027	0.62	2.921	0.1	47
RWSM SU 59	250.57	1.00032	0.25	1.288	0.1	51
RWSM SU 60	461.80	1.00025	0.46	2.936	0.1	64
RWSM SU 61	134.15	1.0002	0.13	0.406	0.1	30
RWSM SU 62	906.06	1.00027	0.91	5.933	0.1	65
RWSM SU 63	500.38	1.00003	0.50	3.740	0.1	75
RWSM SU 64	482.07	1.00009	0.48	2.824	0.1	59
RWSM SR 71	7717.57	1.00024	7.72	41.873	0.1	54
RWSM SR 72	6893.63	1.00021	6.90	38.345	0.1	56
RWSM SR 73	1391.42	1.00021	1.39	11.138	0.1	80
RWSM SR 74	1488.53	1	1.49	12.040	0.1	81
RWSM CO 05	923.89	1.00028	0.92	6.441	0.1	70
Average						64

g = gram
 ICP = Inductively coupled plasma analysis
 L = liter
 mg/kg = milligram per kilogram
 mg/L = milligram per liter

TABLE 12
Exposure Factors for the Adult Lead Exposure Model
Future Adult Office Workers
Rose and Walsh Smelter

Model Parameter	Parameter Description	EPA Default Parameter Values (EPA, 1996a)	Value Used	Units	Basis
GSD _{i,adult}	Individual blood lead geometric standard deviation	1.8 (homogeneous population)	1.5	unitless	The individual geometric mean value is based on analysis by AGEISS (1996) of blood lead data originally collected by Bornschein in 1994 at the Bingham Creek site, a mining site near Salt Lake City. In this study, blood lead data were obtained for 127 pregnant or nursing women. The GSDi value of 1.5 was derived from these data using the sliding box model approach recommended by EPA (1994).
		2.1 (heterogeneous population)			
R _{fetal/maternal}	Fetal/maternal blood lead ratio	0.9	0.9	ug lead/dL fetal blood per ug lead/dL maternal blood	Weight-of-evidence from scientific literature (Goyer 1990, Graziano et al. 1990).
PbB _{fetal,0.95,goal}	95th percentile blood lead concentration in fetus	10	10	ug/dL	Recommended by EPA TRW (EPA 1996).
PbB _{adult,0}	Baseline blood lead concentration	1.7 (whites)	1.4	ug/dL	EPA TRW default values of 1.7, 2.0, and 2.2 ug/dL were based on an analysis of data from Phase I of NHANES III (EPA 1996). A PbBadult,0 value of 1.4 ug/dL was selected based on a recent analysis of data from Phases I and II of NHANES III (EPA 2002) and assuming the residential population of San Juan County and the town of Silverton is predominantly white.
		2.0 (Hispanics)			
		2.2 (blacks)			
BKSF	Biokinetic slope factor	0.4	0.4	ug/dL per mg uptake/day	Based on the EPA TRW analysis of Pocock et al. (1983) and Sherlock et al. (1984) data (EPA 1996).
IR _s	Soil ingestion rate	0.05	0.05	g/day	Recommended by EPA TRW (EPA 1996).
AF _s	Oral absorption of lead in soil	0.12	0.12	unitless	Based on EPA TRW assumptions that (1) absorption fraction for soluble lead in adults is 0.20 and (2) soil matrix factor is 0.6 (EPA 1996).
EF _s	Exposure frequency	219	219	days	Recommended by EPA TRW (EPA 1996).
AT	Averaging time	365	365	days	Recommended by EPA TRW (EPA 1996).

TABLE 12
Exposure Factors for the Adult Lead Exposure Model
Future Adult Office Workers
Rose and Walsh Smelter

- AGEISS Environmental, Inc. (AGEISS). 1996. Calculating Blood Lead Variability for Women of Child Bearing Age. Memo from Susan Walker of AGEISS Environmental, Inc. to Susan Griffin of EPA Region 8. July 12.
- Goyer, R.A. 1990. Transplacental Transport of Lead. Environ. Health Perspect. 89: 101-105.
- Graziano, J.H., D. Popovac, P. Factor-Litvak, et al. Determinants of elevated blood lead during pregnancy in a population surrounding a lead smelter in Kosovo, Yugoslavia. Environ. Health Perspect. 89: 95-100.
- Pocock, S.J., A.G. Shaper, M. Walker, et al. 1983. Effects of Tap Water Lead, Water Hardness, Alcohol, and Cigarettes on Blood Lead Concentration. J. Epidem. Comm. Health. 37: 1-7.
- Sherlock, J.C., D. Ashby, H.T. Delves, et al. 1984. Reduction in exposure to lead from drinking water and its effect on blood lead concentrations. Human Toxicol. 3: 383-392.
- U.S. Environmental Protection Agency (EPA). 1994. Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children. EPA, Office of Emergency and Remedial Response. Publication Number 9285.7-15-1. EPA/540/R-93/081.
- EPA. 1996. Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposure to Lead in Soil. Technical Review Workgroup for Lead. December.
- EPA. 2002. Blood lead concentrations of U.S. adult females: Summary statistics from Phases 1 and 2 of the National Health and Nutrition Evaluation Survey (NHANES III). Final. Technical Review Workgroup for Lead. EPA 9285.7-52. March.

mg - milligram

NHANES III - National Health and Nutrition Evaluation Survey III

TRW - Technical Review Workgroup for Lead

ug/dL - microgram per deciliter

TABLE 13
Exposure Factors for the Adult Lead Exposure Model
Future Adult Resident
Rose and Walsh Smelter

Model Parameter	Parameter Description	EPA Default Parameter Values (EPA, 1996a)	Value Used	Units	Basis
GSD _{i,adult}	Individual blood lead geometric standard deviation	1.8 (homogeneous population)	1.5	unitless	The individual geometric mean value is based on analysis by AGEISS (1996) of blood lead data originally collected by Bornschein in 1994 at the Bingham Creek site, a mining site near Salt Lake City. In this study, blood lead data were obtained for 127 pregnant or nursing women. The GSDi value of 1.5 was derived from these data using the sliding box model approach recommended by EPA (1994).
		2.1 (heterogeneous population)			
R _{fetal/maternal}	Fetal/maternal blood lead ratio	0.9	0.9	ug lead/dL fetal blood per ug lead/dL maternal blood	Weight-of-evidence from scientific literature (Goyer 1990, Graziano et al. 1990).
PbB _{fetal,0.95,goal}	95th percentile blood lead concentration in fetus	10	10	ug/dL	Recommended by EPA TRW (EPA 1996).
PbB _{adult,0}	Baseline blood lead concentration	1.7 (whites)	1.4	ug/dL	EPA TRW default values of 1.7, 2.0, and 2.2 ug/dL were based on an analysis of data from Phase I of NHANES III (EPA 1996). A PbBadult,0 value of 1.4 ug/dl was selected based on a recent analysis of data from Phases I and II of NHANES III (EPA 2002) and assuming the residential population of San Juan County and the town of Silverton is predominantly white.
		2.0 (Hispanics)			
		2.2 (blacks)			
BKSF	Biokinetic slope factor	0.4	0.4	ug/dL per mg uptake/day	Based on the EPA TRW analysis of Pocock et al. (1983) and Sherlock et al. (1984) data (EPA 1996).
IR _s	Soil ingestion rate	-	0.05	g/day	EPA default central tendency soil ingestion rate for adult residents.
AF _s	Oral absorption of lead in soil	0.12	0.12	unitless	Based on EPA TRW assumptions that (1) absorption fraction for soluble lead in adults is 0.20 and (2) soil matrix factor is 0.6 (EPA 1996).
EF _s	Exposure frequency	-	234	days	EPA default CT value for adult residents (EPA 1993).
AT	Averaging time	365	365	days	Recommended by EPA TRW (EPA 1996).

TABLE 13
Exposure Factors for the Adult Lead Exposure Model
Future Adult Resident
Rose and Walsh Smelter

- AGEISS Environmental, Inc. (AGEISS). 1996. Calculating Blood Lead Variability for Women of Child Bearing Age. Memo from Susan Walker of AGEISS Environmental, Inc. to Susan Griffin of EPA Region 8. July 12.
- Goyer, R.A. 1990. Transplacental Transport of Lead. Environ. Health Perspect. 89: 101-105.
- Graziano, J.H., D. Popovac, P. Factor-Litvak, et al. 1990. Determinants of elevated blood lead during pregnancy in a population surrounding a lead smelter in Kosovo, Yugoslavia. Environ. Health Perspect. 89: 95-100.
- Pocock, S.J., A.G. Shaper, M. Walker, et al. 1983. Effects of Tap Water Lead, Water Hardness, Alcohol, and Cigarettes on Blood Lead Concentration. J. Epidem. Comm. Health. 37: 1-7.
- Sherlock, J.C., D. Ashby, H.T. Delves, et al. 1984. Reduction in exposure to lead from drinking water and its effect on blood lead concentrations. Human Toxicol. 3: 383-392.
- U.S. Environmental Protection Agency (EPA). 1993. Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure. Unpublished Preliminary Review Draft. November.
- EPA. 1994. Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children. EPA, Office of Emergency and Remedial Response. Publication Number 9285.7-15-1. EPA/540/R-93/081.
- EPA. 1996. Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposure to Lead in Soil. Technical Review Workgroup for Lead. December.
- EPA. 2002. Blood lead concentrations of U.S. adult females: Summary statistics from Phases 1 and 2 of the National Health and Nutrition Evaluation Survey (NHANES III). Final. Technical Review Workgroup for Lead. EPA 9285.7-52. March.

CT = Central Tendency

mg - milligrams

NHANES III - National Health and Nutrition Evaluation Survey III

TRW - Technical Review Workgroup for Lead

ug/dL - micrograms per deciliter

TABLE 14
Exposure Factors for The Adult Lead Exposure Model
Future Construction Workers
Rose and Walsh Smelter

Model Parameter	Parameter Description	Construction Workers	Value Used	Units	Basis
GSD _{i,adult}	Individual blood lead geometric standard deviation	1.8 (homogeneous population)	1.5	unitless	The individual geometric mean value is based on analysis by AGEISS (1996) of blood lead data originally collected by Bornschein in 1994 at the Bingham Creek site, a mining site near Salt Lake City. In this study, blood lead data were obtained for 127 pregnant or nursing women. The GSD _i value of 1.5 was derived from these data using the sliding box model approach recommended by EPA (1994).
		2.1 (heterogeneous population)			
R _{fetal/maternal}	Fetal/maternal blood lead ratio	0.9	0.9	ug lead/dL fetal blood per ug lead/dL maternal blood	Weight-of-evidence from scientific literature (Goyer 1990, Graziano et al. 1990).
PbB _{fetal,0.95,goal}	95th percentile blood lead concentration in fetus	10	10	ug/dL	Recommended by EPA TRW (EPA 1996).
PbB _{adult,0}	Baseline blood lead concentration	1.7 (whites)	1.4	ug/dL	EPA TRW default values of 1.7, 2.0, and 2.2 ug/dL were based on an analysis of data from Phase I of NHANES III (EPA 1996). A PbB _{adult,0} value of 1.4 ug/dl was selected based on a recent analysis of data from Phases I and II of NHANES III (EPA 2002) and assuming the residential population of San Juan County and the town of Silverton is predominantly white.
		2.0 (Hispanics)			
		2.2 (blacks)			
BKSF	Biokinetic slope factor	0.4	0.4	ug/dL per mg uptake/day	Based on the EPA TRW analysis of Pocock et al. (1983) and Sherlock et al. (1984) data (EPA 1996).
IR _s	Soil ingestion rate	--	0.1	g/day	Standard EPA TRW default value for average soil ingestion by construction workers.
AF _s	Oral absorption of lead in soil	0.12	0.12	unitless	Based on EPA TRW assumptions that (1) absorption fraction for soluble lead in adults is 0.20 and (2) soil matrix factor is 0.6 (EPA 1996).
EF _s	Exposure frequency	--	219	days	Recommended by EPA TRW as CT value for office workers (EPA 1996).
AT	Averaging time	--	365	days	Recommended by EPA TRW (EPA 1996).

TABLE 14
Exposure Factors for The Adult Lead Exposure Model
Future Construction Workers
Rose and Walsh Smelter

- AGEISS Environmental, Inc. (AGEISS). 1996. Calculating Blood Lead Variability for Women of Child Bearing Age. Memo from Susan Walker of AGEISS Environmental, Inc. to Susan Griffin of EPA Region 8. July 12.
- Goyer, R.A. 1990. Transplacental Transport of Lead. Environ. Health Perspect. 89: 101-105.
- Graziano, J.H., D. Popovac, P. Factor-Litvak, et al. Determinants of elevated blood lead during pregnancy in a population surrounding a lead smelter in Kosovo, Yugoslavia. Environ. Health Perspect. 89: 95-100.
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- U.S. Environmental Protection Agency (EPA). 1996. Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposure to Lead in Soil. Technical Review Workgroup for Lead. December.
- EPA. 2002. Blood lead concentrations of U.S. adult females: Summary statistics from Phases 1 and 2 of the National Health and Nutrition Evaluation Survey (NHANES III). Final. Technical Review Workgroup for Lead. EPA 9285.7-52. March.

CT - Central Tendency

mg - milligrams

NHANES III - National Health and Nutrition Evaluation Survey III

TRW - Technical Review Workgroup for Lead

ug/dL - micrograms per deciliter

TABLE 15
Exposure Factors for the Adult Lead Exposure Model
Future Adult Recreational Path Users
Rose and Walsh Smelter

Model Parameter	Parameter Description	EPA Default Parameter Values (EPA, 1996a)	Value Used	Units	Basis
GSD _{i,adult}	Individual blood lead geometric standard deviation	1.8 (homogeneous population)	1.5	unitless	The individual geometric mean value is based on analysis by AGEISS (1996) of blood lead data originally collected by Bornschein in 1994 at the Bingham Creek site, a mining site near Salt Lake City. In this study, blood lead data were obtained for 127 pregnant or nursing women. The GSD _i value of 1.5 was derived from these data using the sliding box model approach recommended by EPA
		2.1 (heterogeneous population)			
R _{fetal/maternal}	Fetal/maternal blood lead ratio	0.9	0.9	ug lead/dL fetal blood per ug lead/dL maternal blood	Weight-of-evidence from scientific literature (Goyer 1990, Graziano et al. 1990).
PbB _{fetal,0.95,goal}	95th percentile blood lead concentration in fetus	10	10	ug/dL	Recommended by EPA TRW (EPA 1996).
PbB _{adult,0}	Baseline blood lead concentration	1.7 (whites)	1.4	ug/dL	EPA TRW default values of 1.7, 2.0, and 2.2 ug/dL were based on an analysis of data from Phase I of NHANES III (EPA 1996). A PbB _{adult,0} value of 1.4 ug/dl was selected based on a recent analysis of data from Phases I and II of NHANES III (EPA 2002) and assuming the residential population of San Juan County and the town of Silverton is predominantly white.
		2.0 (Hispanics)			
		2.2 (blacks)			
BKSF	Biokinetic slope factor	0.4	0.4	ug/dL per mg uptake/day	Based on the EPA TRW analysis of Pocock et al. (1983) and Sherlock et al. (1984) data (EPA 1996).
IR _s	Soil ingestion rate	--	0.0125	g/day	This central tendency soil ingestion rate was assumed to be one-half of the RME soil ingestion rate for adult recreational path users.
AF _s	Oral absorption of lead in soil	0.12	0.12	unitless	Based on EPA TRW assumptions that (1) absorption fraction for soluble lead in adults is 0.20 and (2) soil matrix factor is 0.6 (EPA 1996).
EF _s	Exposure frequency	--	94	days	This central tendency exposure frequency was assumed to be one-half of the RME exposure frequency for adult recreational path users.

TABLE 15
Exposure Factors for the Adult Lead Exposure Model
Future Adult Recreational Path Users
Rose and Walsh Smelter

Model Parameter	Parameter Description	EPA Default Parameter Values (EPA, 1996a)	Value Used	Units	Basis
AT	Averaging time	--	365	days	Recommended by EPA TRW (EPA 1996).

AGEISS Environmental, Inc. (AGEISS). 1996. Calculating Blood Lead Variability for Women of Child Bearing Age. Memo from Susan Walker of AGEISS Environmental, Inc. to Susan Griffin of EPA Region 8. July 12.

Goyer, R.A. 1990. Transplacental Transport of Lead. Environ. Health Perspect. 89: 101-105.

Graziano, J.H., D. Popovac, P. Factor-Litvak, et al. Determinants of elevated blood lead during pregnancy in a population surrounding a lead smelter in Kosovo, Yugoslavia. Environ. Health Perspect. 89: 95-100.

Pocock, S.J., A.G. Shaper, M. Walker, et al. 1983. Effects of Tap Water Lead, Water Hardness, Alcohol, and Cigarettes on Blood Lead Concentration. J. Epidem. Comm. Health. 37: 1-7.

Sherlock, J.C., D. Ashby, H.T. Delves, et al. 1984. Reduction in exposure to lead from drinking water and its effect on blood lead concentrations. Human Toxicol. 3: 383-392.

U.S. Environmental Protection Agency (EPA). 1996. Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposure to Lead in Soil. Technical Review Workgroup for Lead. December.

EPA. 2002. Blood lead concentrations of U.S. adult females: Summary statistics from Phases 1 and 2 of the National Health and Nutrition Evaluation Survey (NHANES III). Final. Technical Review Workgroup for Lead. EPA 9285.7-52. March.

mg - milligrams

NHANES III - National Health and Nutrition Evaluation Survey III

RME - Reasonable Maximum Exposure

TRW - Technical Review Workgroup for Lead

ug/dL - micrograms per deciliter

TABLE 16
Summary Statistics for Calculating the Pre-remediation 95% UCLs for Arsenic and Lead by Area
Rose and Walsh Smelter

Exposure Area	Metal	Number of Samples	Detection Rate	Mean	Standard Deviation	Minimum	Maximum	Distribution	Method of UCL Calculation (4)	Assessed 95% UCL
1	Arsenic	18	86%	706.40	709.88	22.54	3098.36	Gamma	Approximate Gamma	1097.35
1	Lead	18	100%	4255.02	3505.26	169.19	15791.49	Gamma	Approximate Gamma	6269.92
2	Arsenic	18	78%	46.94	22.19	15.37	114.00	Gamma	Approximate Gamma	57.32
2	Lead	18	100%	495.07	223.98	106.75	1010.00	Normal	Student's-t	586.91
3	Arsenic	86	85%	89.87	70.33	5.61	389.57	Gamma	Approximate Gamma	103.33
3	Lead	86	100%	641.21	480.83	63.10	2069.90	Gamma	Approximate Gamma	736.67

All results are in mg/kg.

- (1) Non-detects are replaced with half of the detection limit. The average of duplicate results is used as a single data point. If the lab data are available, the lab data are used as they are. Otherwise, the XRF data are used after adjustment based on a linear regression model between lab data and XRF data.
- (2) Shapiro-Wilk W test and Gamma Goodness-of-Fit test at 5% significance level are used to test for distributional assumption.
- (3) The distributional assumption from (2) is used to select the appropriate UCL calculation method. For normal distribution, the UCL is based on the t-statistics. For lognormal distribution, gamma distribution, and non-parametric assumption, the UCL is based on the recommendations from EPA (2002) and Singh (2004).
- (4) References:
 U.S. Environmental Protection Agency (EPA). 2002. Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Report No. OSWER 9285.6-10.
 Singh, A., A.K. Singh, and R. Maichle. 2004. ProUCL Version 3.0 User Guide. Office of Research and Development, U.S. Environmental Protection Agency, Report No. EPA/600/R04/079.

mg/kg = milligram per kilogram
 UCL = Upper Confidence Limit of the mean
 XRF = X-Ray Fluorescence

TABLE 17
Pre- and Post-remediation Summary Statistics for Arsenic and Lead by Area
Rose and Walsh Smelter

Exposure Area	Scenario	Analyte and Risk Level	Unit	PRG	Pre-remediation				Remedial Action Needed?	RAL	Notes	Number of Samples Replaced	Post-remediation ⁽²⁾						
					Number of Samples	Distribution ⁽³⁾	Method of UCL Calculation ⁽⁴⁾	Assessed 95% UCL					Distribution ⁽³⁾	Method of UCL Calculation ⁽⁴⁾	Assessed 95% UCL				
1	Child/Adult Resident	Arsenic (1E-06)	mg/kg	1.06	18	Gamma	Approximate Gamma	1097.35	Yes	1.06	(5)	All Locations	-	-	-				
	Child/Adult Recreational User	Arsenic (1E-06)	mg/kg	7.9					Yes	7.9	(5)	All Locations	-	-	-				
	Construction Worker	Arsenic (1E-06)	mg/kg	14.3					Yes	14.3	(5)	All Locations	-	-	-				
	Child/Adult Resident	Arsenic (1E-05)	mg/kg	10.6					Yes	10.6	(5)	All Locations	-	-	-				
	Child/Adult Recreational User	Arsenic (1E-05)	mg/kg	79					Yes	150		14	Non-parametric	95% Chebyshev (Mean, Sd)	76				
	Construction Worker	Arsenic (1E-05)	mg/kg	143					Yes	191		13	Non-parametric	95% Chebyshev (Mean, Sd)	100				
	Child/Adult Resident	Arsenic (1E-04)	mg/kg	106					Yes	191		13	Non-parametric	95% Chebyshev (Mean, Sd)	100				
	Child/Adult Recreational User	Arsenic (1E-04)	mg/kg	790					Yes	1192		1	Normal	95% Student's-t	701				
	Construction Worker	Arsenic (1E-04)	mg/kg	1430					No	-		-	-	-	-				
	Child/Adult Resident	Arsenic (HQ = 1)	mg/kg	58.7					Yes	135		15	Non-parametric	95% Chebyshev (Mean, Sd)	57				
	Child/Adult Recreational User	Arsenic (HQ = 1)	mg/kg	109					Yes	191		13	Non-parametric	95% Chebyshev (Mean, Sd)	100				
	Construction Worker	Arsenic (HQ = 1)	mg/kg	232					Yes	232	(6)	13	Non-parametric	95% Chebyshev (Mean, Sd)	100				
	Construction Worker	Lead	mg/kg	1494					18	Gamma	Approximate Gamma	6270	Yes	2154		14	Non-parametric	99% Chebyshev (Mean, Sd)	1488
	Adult Resident	Lead	mg/kg	2797									Yes	2797	(6)	13	Non-parametric	99% Chebyshev (Mean, Sd)	2096
Child Resident	Lead	mg/kg	400	Yes	400	(6)	16	Non-parametric					95% Chebyshev (Mean, Sd)	121					
Adult Recreational User	Lead	mg/kg	27846	No	-		-	-					-	-					
Child Recreational User	Lead	mg/kg	5648	Yes	8234		1	Normal					95% Student's-t	4268					
Construction Worker	Lead	mg/kg	1494	No	-		-	-					-	-					
2	Adult Commercial/Industrial Worker	Arsenic (1E-06)	mg/kg	9.47	18	Gamma	Approximate Gamma	57.32	Yes	9.47	(5)	All Locations	-	-	-				
	Construction Worker	Arsenic (1E-06)	mg/kg	14.3					Yes	14.3	(5)	All Locations	-	-	-				
	Adult Commercial/Industrial Worker	Arsenic (1E-05)	mg/kg	94.7					No	-		-	-	-	-				
	Construction Worker	Arsenic (1E-05)	mg/kg	143					No	-		-	-	-	-				
	Adult Commercial/Industrial Worker	Arsenic (1E-04)	mg/kg	947					No	-		-	-	-	-				
	Construction Worker	Arsenic (1E-04)	mg/kg	1430					No	-		-	-	-	-				
	Adult Commercial/Industrial Worker	Arsenic (HQ = 1)	mg/kg	1533					No	-		-	-	-	-				
	Construction Worker	Arsenic (HQ = 1)	mg/kg	232					No	-		-	-	-	-				
Adult Commercial/Industrial Worker	Lead	mg/kg	2988	18	Normal	Student's-t	587	No	-		-	-	-	-					
Construction Worker	Lead	mg/kg	1494					No	-		-	-	-	-					
3	Child/Adult Resident	Arsenic (1E-06)	mg/kg	1.06	86	Gamma	Approximate Gamma	103.33	Yes	1.06	(5)	All Locations	-	-	-				
	Child/Adult Recreational User	Arsenic (1E-06)	mg/kg	7.9					Yes	7.9	(5)	All Locations	-	-	-				
	Construction Worker	Arsenic (1E-06)	mg/kg	14.3					Yes	14.3	(5)	All Locations	-	-	-				
	Child/Adult Resident	Arsenic (1E-05)	mg/kg	10.6					Yes	10.6	(5)	All Locations	-	-	-				
	Child/Adult Recreational User	Arsenic (1E-05)	mg/kg	79					Yes	198		8	Gamma	Approximate Gamma	78				
	Construction Worker	Arsenic (1E-05)	mg/kg	143					No	-		-	-	-	-				
	Child/Adult Resident	Arsenic (1E-04)	mg/kg	106					No	-		-	-	-	-				
	Child/Adult Recreational User	Arsenic (1E-04)	mg/kg	790					No	-		-	-	-	-				
	Construction Worker	Arsenic (1E-04)	mg/kg	1430					No	-		-	-	-	-				
	Child/Adult Resident	Arsenic (HQ = 1)	mg/kg	58.7					Yes	103		29	Non-parametric	95% Chebyshev (Mean, Sd)	52				
	Child/Adult Recreational User	Arsenic (HQ = 1)	mg/kg	109					No	-		-	-	-	-				
	Construction Worker	Arsenic (HQ = 1)	mg/kg	232					No	-		-	-	-	-				
	Construction Worker	Lead	mg/kg	1494					86	Gamma	Approximate Gamma	737	No	-		-	-	-	-
	Adult Resident	Lead	mg/kg	2797									No	-		-	-	-	-
Child Resident	Lead	mg/kg	400	Yes	659		28	Non-parametric					97.5% Chebyshev (Mean, Sd)	393					
Adult Recreational User	Lead	mg/kg	27846	No	-		-	-					-	-					
Child Recreational User	Lead	mg/kg	5648	No	-		-	-					-	-					
Construction Worker	Lead	mg/kg	1494	No	-		-	-					-	-					

Notes:

- (1) Non-detects are replaced with half of the detection limit. The average of duplicate results is used as a single data point. If the lab data are available, the lab data are used as they are. Otherwise, the XRF data are used after adjustment based on a linear regression model between lab data and XRF data.
- (2) The clean fill concentrations are assumed to be 15 mg/kg for arsenic and 25 mg/kg for lead.
- (3) Shapiro-Wilk W test and Gamma Goodness-of-Fit test at 5% significance level are used to test for distributional assumption.
- (4) The distributional assumption from (2) is used to select the appropriate UCL calculation method. For normal distribution, the UCL is based on the t-statistics. For lognormal distribution, gamma distribution, and non-parametric assumption, the UCL is based on the recommendation from EPA (2002) and Singh (2004).
- (5) Because all locations are required to be remediated in order to achieve the PRG, the RAL is set to PRG and the post-remediation 95% UCL is not available (which is assumed to be below PRG).
- (6) The RAL determined by iterative truncation method is below the PRG; hence, the RAL is re-set to PRG.
- (7) References:
Singh, A., A.K. Singh, and R. Maichle. 2004. ProUCL Version 3.0 User Guide. Office of Research and Development, U.S. Environmental Protection Agency, Report No. EPA/600/R04/079.
U.S. Environmental Protection Agency (EPA). 2002. Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Report No. OSWER 9285.6-10.

- = not applicable
HQ = Hazard Quotient
mg/kg = milligram per kilogram
PRG = Preliminary Remediation Goal
RAL = Remedial Action Level
Sd = Standard distribution
UCL = Upper confidence limit of the mean
XRF = X-Ray Fluorescence

TABLE 18
XRF and Laboratory Data
parts per million (ppm)

Sample ID	EPA Sample ID	Lead			Arsenic		
		XRF	Laboratory	RPD %	XRF	Laboratory	RPD %
RWFPSS15	MH1FQ7	740	795.0	7.17	74 U	42.5	
RWFPSS20	MH1FQ8	370	378.0	2.14	66	38.4	52.87
RWFPSS24	MH1FQ9	500	519.0	3.73	65	47.5	31.11
RWFPSU13	MH1FR0	430	414.0	3.79	43 U	34.2	
RWFPSU18	MH1FR1	440	439.0	0.23	63	47.4	28.26
RWFPSU21	MH1FT6	960	1010.0	5.08	96 U	50.6	
RWFPSU27	MH1FT7	1000	962.0	3.87	100 U	114.0	
RWSMCO012	MH1FT8	3100	2780.0	10.88	500	419.0	17.63
RWSMCO022	MH1FT9	130	162.0	21.92	130	116.0	11.38
RWSMCO030R	MH1FW0	2600	2580.0	0.77	260 U	193.0	
RWSMCO031	MH1FW1	170	183.0	7.37	17 U	8.6	
RWSMCO05	MH1FW2	760	988.0	26.09	76 U	43.0	
RWSMCO050	MH1FW3	410	454.0	10.19	41 U	24.8	
RWSMCO060	MH1FW4	55	56.0	1.80	16 J	10.2	44.27
RWSMCO070	MH1FW5	530	572.0	7.62	110	82.0	29.17
RWSMCO075	MH1FW6	170	168.0	1.18	34 J	23.2	37.76
RWSMCO076	MH1FW7	1900	1440.0	27.54	190 U	29.1	
RWSMCO080	MH1FW8	1000	962.0	3.87	150	106.0	34.38
RWSMCO100	MH1FW9	320	313.0	2.21	58	55.0	5.31
RWSMSR71	MH1FX0	11000	8190.0	29.29	2700	1550.0	54.12
RWSMSS25	MH1FX1	36000	28000.0	25.00	3600 U	1630.0	
RWSMSS34	MH1FX2	23000	19200.0	18.01	2300 U	700.0	
RWSMSS39	MH1FX3	330	315.0	4.65	55	60.0	8.70
RWSMSU05	MH1FX4	100	87.7	13.11	15 J	19.7	27.09
RWSMSU07	MH1FX5	550	557.0	1.26	55 U	51.7	
RWSMSU09	MH1FX6	35000	24700.0	34.51	3500 U	134.0	
RWSMSU12	MH1FX7	560	561.0	0.18	70	66.8	4.68
RWSMSU16	MH1FX8	8000	5330.0	40.06	1600	1060.0	40.60
RWSMSU21	MH1FX9	200	209.0	4.40	49	40.3	19.48
RWSMSU31	MH1FY0	560	578.0	3.16	110	129.0	15.90
RWSMSU50	MH1FY1	390	405.0	3.77	47	43.6	7.51
RWSMSU53	MH1FY2	510	522.0	2.33	69	67.9	1.61
RWVGSS13	MH1FY3	1200	1230.0	2.47	250	267.0	6.58
RWVGSS15	MH1FY4	520	478.0	8.42	110	100.0	9.52
RWVGUSU01	MH1FY5	310	302.0	2.61	100	83.9	17.51
RWVGUSU03R	MH1FY6	380	409.0	7.35	64	79.0	20.98
RWVGUSU12	MH1FY7	480	450.0	6.45	65	71.3	9.24
RWVGUSU13	MH1FY8	1300	1260.0	3.13	250	241.0	3.67
RWVGUSU14	MH1FY9	350	327.0	6.79	61	57.0	6.78
RWVGUSU22	MH1FZ0	220	177.0	21.66	39	28.4	31.45
RWVGUSU28	MH1FZ1	1900	1620.0	15.91	230	202.0	12.96
RWVGUSU35	MH1FZ2	460	494.0	7.13	100	112.0	11.32

EPA = U.S. Environmental Protection Agency
 RPD = Relative Percent Difference
 XRF = X-Ray Fluorescence

J = Estimated
 U = Not detected

TABLE 19
Exposure Area 1 Arsenic and Lead Data
Rose and Walsh Smelter

ID	Exposure Area	Analysis Date	As (number)	AsQ	As (value)	Pb (Number)	PbQ	Pb (Value)
RWSMCO020	1	27-Jul-05	550		434	3100		2740
RWSMCO030	1	27-Jul-05	250	U	107	2500		2239
RWSMCO030R	1	27-Jul-05	193		193	2580		2580
RWSMCO040	1	27-Jul-05	560		442	3700		3235
RWSMSR52L	1	03-Aug-05	460	U	191	4600		3970
RWSMSR65	1	03-Aug-05	990		757	5300		4535
RWSMSR66	1	03-Aug-05	1500		1121	6200		5255
RWSMSU11	1	27-Jul-05	430		344	2400		2154
RWSMSU16	1	27-Jul-05	1060		1060	5330		5330
RWSMSU23	1	27-Jul-05	740		575	3100		2740
RWSMSU24	1	27-Jul-05	83		73	290		296
RWSMSU25	1	27-Jul-05	4400		3098	20000		15791
RWSMSU26	1	27-Jul-05	1100		836	4800		4132
RWSMSU27	1	27-Jul-05	1100		836	6300		5334
RWSMSU32	1	27-Jul-05	1600		1192	5300		4535
RWSMSU33	1	27-Jul-05	1400		1050	5500		4695
RWSMSU34	1	27-Jul-05	1000	U	397	10000		8234
RWSMSU35	1	27-Jul-05	160		135	1100		1035
RWSMSU51	1	03-Aug-05	24	J	23	160		169

As (number) = XRF or laboratory result for arsenic

AsQ = lab qualifier for arsenic result

As (value) = adjusted XRF or laboratory result for arsenic

Pb (number) = XRF or laboratory result for lead

PbQ = lab qualifier for lead result

Pb (value) = adjusted XRF or laboratory result for lead

ID = identification. Sample IDs ending in "R" are replicate samples.

Q = Qualifier. Chemical- and sample-specific data qualifiers include: J = estimate and U = the analyte was not detected at or above the instrument detection limit (IDL).

Sample RWSMSR52L was a slag sample obtained underneath coarse slag, that was very fine but different than other fine slag at the site

TABLE 20
Exposure Area 2 Arsenic and Lead Data
Rose and Walsh Smelter

ID	Exposure Area	Analysis Date	As (number)	AsQ	As (value)	Pb (Number)	PbQ	Pb (Value)
RWFPSU10	2	27-Jul-05	73		64	360		362
RWFPSU11	2	27-Jul-05	72	U	33	720		695
RWFPSU11D	2	27-Jul-05	75	U	34	750		722
RWFPSU12	2	27-Jul-05	69		61	510		503
RWFPSU16	2	27-Jul-05	54		49	290		296
RWFPSU17	2	27-Jul-05	72		64	670		650
RWFPSU18	2	27-Jul-05	47.4		47.4	439		439
RWFPSU19	2	27-Jul-05	49		44	430		428
RWFPSU20	2	27-Jul-05	56		50	520		512
RWFPSU21	2	27-Jul-05	50.6		50.6	1010		1010
RWFPSU22	2	27-Jul-05	53	U	25	530		521
RWFPSU22R	2	27-Jul-05	52	U	24	520		512
RWFPSU23	2	27-Jul-05	58		52	500		494
RWFPSU24	2	27-Jul-05	47	U	22	470		466
RWFPSU25	2	27-Jul-05	45	U	21	450		447
RWFPSU26	2	27-Jul-05	52		47	390		391
RWFPSU27	2	27-Jul-05	114		114	962		962
RWFPSU28	2	27-Jul-05	42		38	330		334
RWFPSU29	2	27-Jul-05	16	J	15	98		107
RWFPSU30	2	27-Jul-05	52		47	280		286

As (number) = XRF or laboratory result for arsenic

AsQ = lab qualifier for arsenic result

As (value) = adjusted XRF or laboratory result for arsenic

Pb (number) = XRF or laboratory result for lead

PbQ = lab qualifier for lead result

Pb (value) = adjusted XRF or laboratory result for lead

ID = identification. Sample IDs ending in "R" are replicate samples and those ending in "D" are duplicate samples.

Q = Qualifier. Chemical- and sample-specific data qualifiers include: J = estimate and U = the analyte was not detected at or above the instrument detection limit (IDL).

TABLE 21
Exposure Area 3 Arsenic and Lead Data
Rose and Walsh Smelter

ID	Exposure Area	Analysis Date	As (number)	AsQ	As (value)	Pb (Number)	PbQ	Pb (Value)
RWSMCO010	3	27-Jul-05	240		198	1600		1472
RWSMCO070	3	27-Jul-05	82		82	572		572
RWSMCO080	3	27-Jul-05	106		106	962		962
RWSMCO090	3	27-Jul-05	34	J	31	150		159
RWSMCO100	3	27-Jul-05	55		55	313		313
RWSMSR50	3	03-Aug-05	130	U	58	1300		1211
RWSMSR53	3	03-Aug-05	150	U	66	1500		1385
RWSMSR54	3	03-Aug-05	230	U	99	2300		2070
RWSMSR57	3	03-Aug-05	140	U	62	1400		1298
RWSMSR61	3	03-Aug-05	250		206	2000		1815
RWSMSR75	3	03-Aug-05	230		191	1700		1558
RWSMSU01	3	27-Jul-05	11	U	6	110		119
RWSMSU02	3	27-Jul-05	11	U	6	110		119
RWSMSU03	3	27-Jul-05	120		103	1100		1035
RWSMSU04	3	27-Jul-05	380		306	1600		1472
RWSMSU06	3	27-Jul-05	170	U	74	1700		1558
RWSMSU07	3	27-Jul-05	51.7		51.7	557		557
RWSMSU07D	3	27-Jul-05	55	U	26	550		540
RWSMSU08	3	27-Jul-05	32	U	15	320		324
RWSMSU10	3	27-Jul-05	310		253	1700		1558
RWSMSU12	3	27-Jul-05	66.8		66.8	561		561
RWSMSU13	3	27-Jul-05	120		103	820		785
RWSMSU14	3	27-Jul-05	200		167	820		785
RWSMSU15	3	27-Jul-05	220		183	1000		946
RWSMSU19	3	27-Jul-05	250		206	1400		1298
RWSMSU19R	3	27-Jul-05	250		206	1300		1211
RWSMSU20	3	27-Jul-05	130		111	660		641
RWSMSU20D	3	27-Jul-05	110		95	640		622
RWSMSU21	3	27-Jul-05	40.3		40.3	209		209
RWSMSU22	3	27-Jul-05	37		34	99		108
RWSMSU28	3	27-Jul-05	36		33	160		169
RWSMSU29	3	27-Jul-05	120		103	950		902
RWSMSU30	3	27-Jul-05	65		58	390		391
RWSMSU31	3	27-Jul-05	129		129	578		578

TABLE 21
Exposure Area 3 Arsenic and Lead Data
Rose and Walsh Smelter

ID	Exposure Area	Analysis Date	As (number)	AsQ	As (value)	Pb (Number)	PbQ	Pb (Value)
RWSMSU36	3	27-Jul-05	140		119	830		794
RWSMSU37	3	27-Jul-05	140		119	610		595
RWSMSU38	3	27-Jul-05	190		159	870		830
RWSMSU39	3	27-Jul-05	250		206	1100		1035
RWSMSU40	3	27-Jul-05	78		69	430		428
RWSMSU53	3	03-Aug-05	67.9		68	522		522
RWSMSU55	3	03-Aug-05	180		151	1100		1035
RWSMSU56	3	03-Aug-05	65		58	520		512
RWSMSU57	3	03-Aug-05	160	U	70	1600		1472
RWSMSU58	3	03-Aug-05	89		78	830		794
RWSMSU59	3	03-Aug-05	27	J	25	260		267
RWSMSU60	3	03-Aug-05	50	U	23	500		494
RWSMSU61	3	03-Aug-05	45		41	130		139
RWSMSU62	3	03-Aug-05	210		175	1100		1035
RWSMSU64	3	03-Aug-05	38	J	35	340		344
RWVGSU01	3	27-Jul-05	83.9		84	302		302
RWVGSU02	3	27-Jul-05	40		37	260		267
RWVGSU03	3	27-Jul-05	67		59	370		372
RWVGSU03R	3	27-Jul-05	79		79	409		409
RWVGSU04	3	27-Jul-05	55		49	470		466
RWVGSU05	3	27-Jul-05	99		86	490		484
RWVGSU06	3	27-Jul-05	130		111	650		631
RWVGSU07	3	27-Jul-05	150		127	590		577
RWVGSU08	3	27-Jul-05	120		103	500		494
RWVGSU09	3	27-Jul-05	57		51	330		334
RWVGSU10	3	27-Jul-05	38		35	220		228
RWVGSU11	3	27-Jul-05	60		54	290		296
RWVGSU12	3	27-Jul-05	71.3		71	450		450
RWVGSU13	3	27-Jul-05	241		241	1260		1260
RWVGSU14	3	27-Jul-05	57		57	327		327
RWVGSU15	3	27-Jul-05	150		127	680		659
RWVGSU16	3	27-Jul-05	120		103	670		650
RWVGSU16R	3	27-Jul-05	96		84	630		613
RWVGSU17	3	27-Jul-05	19	J	18	99		108

TABLE 21
Exposure Area 3 Arsenic and Lead Data
Rose and Walsh Smelter

ID	Exposure Area	Analysis Date	As (number)	AsQ	As (value)	Pb (Number)	PbQ	Pb (Value)
RWVGUSU18	3	27-Jul-05	53		48	370		372
RWVGUSU19	3	27-Jul-05	14	U	7	140		149
RWVGUSU20	3	27-Jul-05	15	J	14	84		92
RWVGUSU21	3	27-Jul-05	24	J	23	150		159
RWVGUSU22	3	27-Jul-05	28.4		28	177		177
RWVGUSU23	3	27-Jul-05	80		70	250		257
RWVGUSU24	3	27-Jul-05	45		41	190		199
RWVGUSU25	3	27-Jul-05	95		83	370		372
RWVGUSU26	3	27-Jul-05	38		35	56		63
RWVGUSU27	3	27-Jul-05	120		103	750		722
RWVGUSU28	3	27-Jul-05	202		202	1620		1620
RWVGUSU29	3	27-Jul-05	53	U	25	530		521
RWVGUSU30	3	27-Jul-05	33	J	30	130		139
RWVGUSU30R	3	27-Jul-05	24	J	23	120		129
RWVGUSU31	3	27-Jul-05	59		53	330		334
RWVGUSU32	3	27-Jul-05	490		390	1900		1730
RWVGUSU33	3	27-Jul-05	53		48	290		296
RWVGUSU34	3	27-Jul-05	120		103	610		595
RWVGUSU35	3	27-Jul-05	112		112	494		494
RWVGUSU36	3	27-Jul-05	100		87	550		540
RWVGUSU36D	3	27-Jul-05	120		103	580		567
RWVGUSU37	3	27-Jul-05	63		56	280		286
RWVGUSU38	3	27-Jul-05	27	J	25	110		119
RWVGUSU39	3	27-Jul-05	100		87	540		531
RWVGUSU40	3	27-Jul-05	70		62	290		296

As (number) = XRF or laboratory result for arsenic
AsQ = lab qualifier for arsenic result
As (value) = adjusted XRF or laboratory result for arsenic
Pb (number) = XRF or laboratory result for lead
PbQ = lab qualifier for lead result
Pb (value) = adjusted XRF or laboratory result for lead

ID = identification. Sample IDs ending in "R" are replicate samples and those ending in "D" are duplicate samples.

TABLE 21
Exposure Area 3 Arsenic and Lead Data
Rose and Walsh Smelter

ID	Exposure Area	Analysis Date	As (number)	AsQ	As (value)	Pb (Number)	PbQ	Pb (Value)
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Q = Qualifier. Chemical- and sample-specific data qualifiers include: J = estimate and U = the analyte was not detected at or above the instrument detection limit (IDL).

TABLE 22
Exposure Area 1 Arsenic and Lead Potential Cleanup - Samples for Removal
Rose and Walsh Smelter

ID	As (value)	Pb (Value)	15 Samples Removed (1)		16 Samples Removed (2)	
			Arsenic-based	Lead-based	Arsenic-based	Lead-based
RWSMCO020	434	2740	x	x	x	x
RWSMCO030 (3)	150	2409	o	x	x	x
RWSMCO040	442	3235	x	x	x	x
RWSMSR52L	191	3970	x	x	x	x
RWSMSR65	757	4535	x	x	x	x
RWSMSR66	1121	5255	x	x	x	x
RWSMSU11	344	2154	x	o	x	x
RWSMSU16	1060	5330	x	x	x	x
RWSMSU23	575	2740	x	x	x	x
RWSMSU24	73	296				
RWSMSU25	3098	15791	x	x	x	x
RWSMSU26	836	4132	x	x	x	x
RWSMSU27	836	5334	x	x	x	x
RWSMSU32	1192	4535	x	x	x	x
RWSMSU33	1050	4695	x	x	x	x
RWSMSU34	397	8234	x	x	x	x
RWSMSU35	135	1035			o	x
RWSMSU51	23	169				
Post-remediation Statistics:						
Distribution Method of UCL Calculation			Non-parametric 95% Chebyshev (Mean, Sd)	Non-parametric 99% Chebyshev (Mean, Sd)	Non-parametric Student's t	Non-parametric 95% Chebyshev (Mean, Sd)
Assessed 95% UCL			57	673	24	121

(1) For the recreational area land use scenario for Exposure Area 1, surface material at a minimum of 15 of 18 sampling locations would need to be replaced with clean fill.

(2) For the residential land use scenario for Exposure Area 1, surface material at a minimum of 16 of 18 sampling locations would need to be replaced with clean fill.

(3) The average of replicate results is shown as used as a single data point.

As (value) = adjusted XRF or laboratory result for arsenic

Pb (value) = adjusted XRF or laboratory result for lead

ID = identification.

Sd = standard deviation

Sample RWSMSR52L was a slag sample obtained underneath coarse slag, that was very fine but different than other fine slag at the site.

x = Primary effect. Soil at this sample to be removed for remediation.

o = Secondary effect. Soil at this sample location is removed based on remediation requirements for the other chemical.

TABLE 23
Exposure Area 3 Arsenic and Lead Potential Cleanup - Samples for Removal
Rose and Walsh Smelter

ID	As (value)	Pb (Value)	8 Samples Removed (1)		28 Samples Removed (2)	
			Arsenic-based	Lead-based	Arsenic-based	Lead-based
RWSMCO010	198	1472			x	x
RWSMCO070	82	572				
RWSMCO080	106	962			x	x
RWSMCO090	31	159				
RWSMCO100	55	313				
RWSMSR50	58	1211			x	x
RWSMSR53	66	1385			x	x
RWSMSR54	99	2070			x	x
RWSMSR57	62	1298			x	x
RWSMSR61	206	1815	x	o	x	x
RWSMSR75	191	1558			x	x
RWSMSU01	6	119				
RWSMSU02	6	119				
RWSMSU03	103	1035			x	x
RWSMSU04	306	1472	x	o	x	x
RWSMSU06	74	1558			x	x
RWSMSU07 (3)	39	548				
RWSMSU08	15	324				
RWSMSU10	253	1558	x	o	x	x
RWSMSU12	66.8	561				
RWSMSU13	103	785			x	x
RWSMSU14	167	785			x	x
RWSMSU15	183	946			x	x
RWSMSU19 (3)	206	1255	x	o	x	x
RWSMSU20 (3)	103	631				
RWSMSU21	40.3	209				
RWSMSU22	34	108				
RWSMSU28	33	169				
RWSMSU29	103	902			x	x
RWSMSU30	58	391				
RWSMSU31	129	578			x	x
RWSMSU36	119	794			x	x
RWSMSU37	119	595				
RWSMSU38	159	830			x	x
RWSMSU39	206	1035	x	o	x	x
RWSMSU40	69	428				
RWSMSU53	68	522				
RWSMSU55	151	1035			x	x
RWSMSU56	58	512				
RWSMSU57	70	1472			x	x
RWSMSU58	78	794				
RWSMSU59	25	267				
RWSMSU60	23	494				
RWSMSU61	41	139				
RWSMSU62	175	1035			x	x
RWSMSU64	35	344				
RWVGUSU01	84	302				
RWVGUSU02	37	267				
RWVGUSU03 (3)	69	390				
RWVGUSU04	49	466				
RWVGUSU05	86	484				
RWVGUSU06	111	631				
RWVGUSU07	127	577				
RWVGUSU08	103	494				

TABLE 23
Exposure Area 3 Arsenic and Lead Potential Cleanup - Samples for Removal
Rose and Walsh Smelter

ID	As (value)	Pb (Value)	8 Samples Removed (1)		28 Samples Removed (2)	
			Arsenic-based	Lead-based	Arsenic-based	Lead-based
RWVGUSU09	51	334				
RWVGUSU10	35	228				
RWVGUSU11	54	296				
RWVGUSU12	71	450				
RWVGUSU13	241	1260	x	o	x	x
RWVGUSU14	57	327				
RWVGUSU15	127	659				
RWVGUSU16 (3)	93	631				
RWVGUSU17	18	108				
RWVGUSU18	48	372				
RWVGUSU19	7	149				
RWVGUSU20	14	92				
RWVGUSU21	23	159				
RWVGUSU22	28	177				
RWVGUSU23	70	257				
RWVGUSU24	41	199				
RWVGUSU25	83	372				
RWVGUSU26	35	63				
RWVGUSU27	103	722			x	x
RWVGUSU28	202	1620	x	o	x	x
RWVGUSU29	25	521				
RWVGUSU30 (3)	27	134				
RWVGUSU31	53	334				
RWVGUSU32	390	1730	x	o	x	x
RWVGUSU33	48	296				
RWVGUSU34	103	595				
RWVGUSU35	112	494				
RWVGUSU36 (3)	95	554				
RWVGUSU37	56	286				
RWVGUSU38	25	119				
RWVGUSU39	87	531				
RWVGUSU40	62	296				
Post-remediation Statistics:						
	Distribution		Gamma	Gamma	Non-Parametric	Non-Parametric
	Method of UCL Calculation		Approximate	Approximate	95% Chebyshev	97.5% Chebyshev
	Assessed 95% UCL		Gamma	Gamma	(Mean, Sd)	(Mean, Sd)
			78	599	58.7	399

- (1) Eight surface material locations would need to be replaced with clean fill to increase the protection from exposure to arsenic in surface material by construction workers, child recreational users, and adult recreational users to a TCR of 1E-05.
- (2) For the residential land use scenario for Exposure Area 3, surface material at a 28 of 86 sampling locations would need to be replaced with clean fill.
- (3) The average of duplicate/replicate results is shown as used as a single data point.

As (value) = adjusted XRF or laboratory result for arsenic

Pb (value) = adjusted XRF or laboratory result for lead

ID = identification.

Sd = standard deviation

x = Primary effect. Soil at this sample to be removed for remediation.

o = Secondary effect. Soil at this sample location is removed based on remediation requirements for the other chemical.

Figures

