Health Consultation

Future Public Health Implications of
Exposure to Mining Related
Contamination in Surface and Mixed Soil

Ute-Ulay Millsite Tailings and Waste Rock,
An EPA Targeted Brownfield Assessment Site

LAKE CITY, HINSDALE COUNTY, COLORADO

Prepared by
Colorado Department of Public Health and Environment

JULY 27, 2015

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Foreword

The Colorado Department of Public Health and Environment's (CDPHE) Colorado Cooperative Program for Environmental Health Assessments has prepared this health consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the United States Department of Health and Human Services and is the principal federal public health agency responsible for the health issues related to hazardous waste. This health consultation was prepared in accordance with the methodologies and guidelines developed by ATSDR.

The purpose of this health consultation is to identify and prevent harmful health effects resulting from exposure to hazardous substances in the environment. Health consultations focus on health issues associated with specific exposures so that the state or local public health departments can respond quickly to requests from concerned citizens or agencies regarding health information on hazardous substances. The Colorado Cooperative Program for Environmental Health Assessments (CCPEHA) evaluates sampling data collected from a hazardous waste site, determines whether exposures have occurred or could occur in the future, reports any potential harmful effects, and then recommends actions to protect public health.

The findings in this report are relevant to conditions at the site during the time this health consultation was conducted and should not necessarily be relied upon if site conditions or land use changes in the future. For additional information or questions regarding the contents of this health consultation, please contact the author of this document or the Principal Investigator/Program Manager of the CCPEHA:

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Statement and Summary of Issues

Introduction

The Colorado Cooperative Program for Environmental Health Assessments' (CCPEHA) and the Agency for Toxic Substances and Disease Registry's (ATSDR) top priority is to ensure that all stakeholders have the best health information possible to protect the public from potential health hazards associated with environmental contamination at the Ute-Ulay Mine and Millsite in Hinsdale County, Colorado.

The Ute-Ulay Mine and Mill complex is a historic mining camp located near Lake City in the San Juan Mountains in southwestern Colorado. Mining at the Ute-Ulay began around 1874 and continued intermittently through 1900. During the 20th century, the complex changed hands a number of times and was primarily used for milling material from surrounding mines. In 1983, LKA International Incorporated purchased the Ute-Ulay to conduct milling operations. Following a period of inactivity at the site, LKA International and Hinsdale County began discussing the potential renovation and restoration of the Ute-Ulay for heritage tourism and economic development. In turn, Hinsdale County requested environmental and technical assistance from CDPHE through an application for a Targeted Brownfields Assessment (TBA).

The Lake City Downtown Improvement and Revitalization Team and Colorado Art Ranch collaborated to establish a future vision for the Ute-Ulay. "The Hardrock Revision: A Transdisciplinary Collaboration Envisioning Uses for an Inactive Hard Rock Mine in Hinsdale County, CO", was published in April 2011 documenting the work of a group that consists of artists, poets, scientists, community members, landscape architects, and historians. Some of the proposed plans include transforming the historic miners' boardinghouse and cabins into a hostel, interpretive tours that focus on historic mine features, geology, native plants and animals; and converting the original redwood water tank into a camera obscura amongst a number of other ideas.

As part of the TBA process, CDPHE's Hazardous Materials and Waste Management Division (HMWMD) began collecting environmental data from the site in the summer of 2012 to characterize site-related contamination associated with the two parcels of the total 285-acre Ute-Ulay Mine and Mill Complex: the Ute-Ulay "Townsite" and the Ute-Ulay "Millsite". Due to the imminent reuse plans for the site and the increased potential for exposure after redevelopment, the HMWMD requested the assistance of the CCPEHA to evaluate the public health implications of future exposures to site-related contamination found in surface and mixed (surface and subsurface) soil.

The "Mill Tailings and Waste Rock" area is the focus of this evaluation and it is located on the southeastern portion of the "Millsite" parcel. This area contains tailings and waste rock piles as well as multiple tailings impoundments. CCPEHA previously conducted two health consultations on the Ute Ulay Mine and Mill Complex. The first health consultation focused on outdoor exposures at the "Townsite" portion of the Ute-Ulay. The second focused on indoor exposures at the "Millsite" portion.

The purpose of this health consultation is to identify any potential public health hazards associated with future exposures to site-related contamination found in surface and mixed soil based on what is currently known about the proposed future land-use at the site. In addition, recommendations will be made to protect public health and inform stakeholders. In this evaluation, child and adult short-term recreational users and adult hostel workers were used as the representative future exposure scenarios that are likely to occur. Based on the results of this evaluation, lead in surface soil was identified as the primary contaminant of potential concern.

Conclusions

CCPEHA and ATSDR have reached four conclusions regarding future exposure to contaminants in surface and mixed soil at the Ute-Ulay Millsite.

Conclusion 1

Recreational exposure to lead in surface and mixed soil at the Ute-Ulay Millsite could harm the health of children (age 0-7 years) and the fetus(es) of pregnant women.

Basis for Decision

This conclusion was reached because the results of the Integrated Exposure Uptake and Biokinetic (IEUBK) and the Adult Lead Model (ALM) models predicted blood lead levels in young children and pregnant women that are above CDC's reference blood lead level. For surface soil, the predicted geometric mean blood lead level during recreational use by children is 3.7 µg/dL with an estimated 26.7% of all children having blood lead levels greater than 5 µg/dL. In addition, the ALM estimated that 7.1% of fetal blood lead levels of pregnant women using the site for recreational purposes would have blood lead levels greater than CDC's reference level of 5 μg/dL with an estimated geometric mean fetal blood lead level of 2.1 μg/dL. For mixed soil, the predicted geometric mean blood lead level during recreational use by children is 3.8 μg/dL with an estimated 28.1% of all children having blood lead levels greater than 5 μg/dL. In addition, the ALM estimated that 7.5% of fetal blood lead levels of pregnant women using the site for recreational purposes would have blood lead levels greater than CDC's reference level of 5 μg/dL with an estimated geometric mean fetal blood lead level of 2.1 μg/dL. The outputs for surface and mixed (surface and subsurface) soils are above CDC's target for lead.

Conclusion 2 *Exposure to lead in surface and mixed soil at the Ute-Ulay Millsite could harm the health of the fetus(es) of pregnant hostel workers.*

Basis for Decision This conclusion was reached because the ALM predicted >5% probability of fetal blood lead levels of pregnant hostel workers that are well above CDC's reference blood lead level of 5 μg/dL. For surface soil, the ALM predicted a geometric mean blood lead concentration in fetuses of 6.6 μg/dL and that 52.8% of all pregnant female hostel workers would have fetal blood lead concentrations greater than 5 μg/dL. For mixed soil, the ALM predicted >5% probability of fetal blood lead levels of pregnant hostel workers that are well above CDC's reference blood lead level. Specifically, the ALM predicted a geometric mean blood lead concentration in fetuses of 7.0μg/dL and that 56.6% of all pregnant female hostel workers would have fetal blood lead concentrations greater than 5 μg/dL.

Conclusion 3 *Acute exposure to copper and arsenic in surface and mixed soil could harm the health of young children who exhibit pica behavior at the site.*

Basis for Decision This conclusion was reached because the estimated acute dose for pica ingestion of copper in surface soil exceeds known harmful health effect levels published in the scientific literature. For surface soil, the estimated acute dose of copper for children exhibiting pica behavior is nearly three times higher than the levels at which the human exposure group in the critical study reported a significant increase in gastrointestinal symptoms. For arsenic, the estimated acute dose for young children is over six times higher than the acute health-based guideline for arsenic. In addition, the estimated acute dose of arsenic approaches the level at which mild to moderate health effects were observed in humans in the scientific literature (i.e., Lowest Observed Adverse Effect Level). The human exposure group in the critical study for arsenic reported a significant increase in facial edema and gastrointestinal symptoms.

For mixed soil, the findings are similar to the above noted findings for surface soil. The estimated acute dose of copper for children exhibiting pica behavior is just over two times the levels at which the human exposure group in the critical study reported a significant increase in gastrointestinal symptoms. For arsenic, the estimated acute dose for young children is nearly five times higher than the acute health-based guideline for arsenic.

These results indicate that acute exposures to copper and arsenic in either surface soil or mixed soil could result in mild to moderate gastrointestinal symptoms such as nausea, abdominal pain, and/or vomiting in children that exhibit pica behavior. However, it should be noted that pica behavior appears unlikely to occur because children are not expected to be unsupervised due to the remote and mountainous nature of this site.

Conclusion 4

Chronic exposure to metal contaminants other than lead in surface and mixed soil at the Ute-Ulay Millsite is not expected to harm the health of young children and adults during recreational activities or the health of hostel workers.

Basis for Decision

This conclusion was reached because the estimated non-cancer health hazards and estimated cancer risks for both receptor populations considered in this evaluation are associated with a low increased risk of developing cancer and non-cancer health effects from exposure to non-lead metal contaminants in surface soil as well as mixed soil. However, it is recommended that exposure to arsenic be reduced to lower the estimated cancer risks for hostel workers to achieve background levels or CDPHE's risk management goal.

Next Steps

Based on the results of this evaluation, the following recommendations have been made in regard to potential exposure pathways associated with future redevelopment at the Ute-Ulay Mine and Millsite. To be protective of public health, CCPEHA recommends that the Hazardous Materials and Waste Management Division of CDPHE address the following:

- Reduce exposure to lead to protect the health of the young children (0-7 years or 0-84 months) using the site for recreational purposes.

- Reduce exposure to lead to protect the health of fetuses of pregnant women using the site for recreational purposes, and to protect the fetuses of pregnant hostel workers.

- To achieve CDPHE's long-term cancer risk target level, reduce exposure to arsenic in accordance with CDPHE risk management guidance for arsenic in soil.

- Reduce or eliminate children's acute exposure (1-day) to arsenic and copper contaminated surface soils by using appropriate reduction methods: restricting access to highly contaminated areas; reducing or eliminating soil intrusive activities; washing hands and face prior to eating or drinking; cleaning shoes to reduce the amount of soil being tracked into the car and house; and supervising children to prevent pica behavior.

- Ensure that the future drinking water supply that is necessary for the site post-redevelopment has not been impacted by the mine site in a way that would threaten public health.

- Ensure that hostel workers are non-residential (i.e., not using the hostel as their primary residence); especially, ensure that children are not staying onsite with their worker parents. Upon reclamation and remediation of the exposure units in the near future, metals concentrations can/will be re-evaluated to potentially include year –round hostel workers or commercial workers and be reevaluated from a public health perspective.

- Grade and stabilize mill tailings and waste rock piles to reduce the potential for a catastrophic failure of the mill tailings and waste rock piles.

- Upon reclamation and remediation of the exposure units in the future, re-evaluate metals concentrations for potential health hazards, to include year–round hostel workers and/or commercial workers.

For More Information

If you have concerns about your health, you should contact your health care provider. For questions or concerns regarding this evaluation, please contact Thomas Simmons at 303-692-2961 or Raj Goyal at 303-692-2634.

Purpose

The purpose of this health consultation is to evaluate the future public health implications of exposure to mining-related heavy metal contamination in surface and mixed (surface and subsurface) soil at the Millsite portion of the Ute-Ulay Mine and Millsite in southwestern Colorado. It is highly likely that surface and subsurface soil will be mixed during the future redevelopment; however, future exposure to surface soil is also evaluated in case the future land use or redevelopment does not result in mixing of surface and subsurface soils. This evaluation is based on what is currently known about the proposed future land-use at the site. Recommendations will be made to protect public health and inform stakeholders.

Site Background

The Ute-Ulay Mine and Mill Complex is an inactive mining camp located approximately 4 miles west of Lake City, Hinsdale County, Colorado (Figure A1). The Ute and Ulay mines were located and claimed in the early 1870's following the Brunot Treaty, which ceded the San Juan Mountains from the Ute Indians to the United States (CAW 2011). The first notable influx of eastern investment occurred in 1876 when the Crooke Brothers purchased the Ute-Ulay complex. The mill, mining structures, and housing quarters were constructed around 1880 and the Ute-Ulay prospered for some time. Gold, silver, lead, and zinc were the primary minerals extracted from the mine and the ore was concentrated in the onsite mill. The concentrated ore from the mill contained approximately 60% lead, 13-15 ounces of silver and 0.05 to 0.06 ounces of gold per ton (CDPHE 2012a). At one time, the Ute-Ulay was one of the highest producing mines of the Galena Mining District, which begins in Lake City and extends west to the Ouray and San Juan county lines (CDPHE 2012b).

As with a number of early mining operations, a drop in metal prices inevitably ceased production at the Ute-Ulay in the early 1900's. Claims to the property changed hands a number of times over the years and very little mining took place at the site throughout the 20th century. In 1983, LKA International Incorporated purchased the property with the primary intention of milling materials from area mines. Following years of inactivity at the site, LKA International, Incorporated (the current owners of the complex) and Hinsdale County recently began discussing the future uses of the Ute-Ulay Mine and Mill complex. A large portion of the complex is intact including the original boarding house, cabins, storage buildings, mine headframe, and redwood water tank, which people often visit to view and photograph. A land donation proposal was eventually established between LKA International and Hinsdale County for restoration and historical preservation of the site.

The Lake City Downtown Improvement and Revitalization Team and Colorado Art Ranch collaborated to establish a future vision for the Ute-Ulay. "The Hardrock Revision: A Transdisciplinary Collaboration Envisioning Uses for an Inactive Hard Rock Mine in Hinsdale County, CO", was published in April 2011 documenting the work of a group that consists of community members, artists, poets, scientists, landscape architects, and historians (CAW 2011). The group proposed a number of ideas for the future use of the site, some of which include transforming the historic miners' boardinghouse and cabins into a hostel and conducting interpretive tours that focus on historic mine features, geology, native plants and animals.

However, remnants of historic mining and milling operations remain at the site including unlined tailings impoundments, spent ore, mill tailings and waste rock. The leftover material contains high levels of heavy metals, which could pose a risk to public health. As such, Hinsdale County submitted an application to the Colorado Department of Public Health and Environment's Hazardous Waste and Waste Management Division for their consideration of a Targeted Brownfields Assessment (TBA). As part of the TBA process, CDPHE's Hazardous Materials and Waste Management Division (HMWMD) began collecting environmental data from the site in the summer of 2012 to characterize site-related contamination associated with the private portion of the total 285-acre Ute-Ulay Mine and Mill Complex. The privately owned section of the Ute-Ulay is the focus of the TBA and consists of the "Townsite" area, located on the north side of County Road 20, and the "Millsite" area, located across the road to the south. The Millsite consists of the historic mill and support buildings, waste rock piles, and several tailings impoundments containing mixed tailings. Due to the imminent reuse plans for the site and the increased potential for exposure after redevelopment, the HMWMD requested the assistance of the CCPEHA to evaluate the public health implications of future exposures to site-related metal contamination.

It should be noted that CCPEHA has previously conducted two health consultations related to the Ute-Ulay Mine and Mill Complex. The Townsite portion of the complex was the focus of the first health consultation and the indoor exposures in the buildings associated with the Millsite were the focus of the second health consultation. Both documents are available at: http://www.atsdr.cdc.gov/HAC/PHA/HCPHA.asp?State=CO. The focus of this evaluation is outdoor exposures to the mill tailings and waste rock located in the Millsite portion of the Ute-Ulay complex.

Site Description

The Ute-Ulay Mine and Mill Complex is located in the San Juan Mountains of southwestern Colorado at approximate coordinates of 38.0209º North, 107.3774º West (CDPHE 2012a). The general area surrounding the site is best described as unaltered wooded and mountainous terrain at an elevation of approximately 9,200 to 9,800 feet above mean sea level. The site is located on the "Alpine Loop", a 65 mile backcountry loop that connects Lake City, Silverton, and Ouray. Site access is relatively easy via passenger vehicle traveling west on Hinsdale County Road 20 (CR20) out of Lake City for approximately four miles towards Engineer Pass. Approaching from the west would require a high clearance 4-wheel drive vehicle.

Technically, the entire Ute-Ulay Mine and Mill Complex consists of the Ute-Ulay Private Mine and Mill Area, the Bureau of Land Management Mine/Mill Area, and the Upper Tailings Impoundments Area (Figure A2). The Private Mine and Mill Area (PMMA) of the complex is the area under consideration for redevelopment and restoration following the TBA. The PMMA has been subdivided into the Townsite and the Millsite, which are separated by CR-20. The Townsite is a 4-acre parcel that contains the original boarding house, cabins, storage buildings, mine headframe and portal; and a redwood water tank. The Millsite is also a 4-acre parcel that contains the mill, a power generation building, an assay lab, mine portal, and mill tailings and waste rock.

The major surface water body adjacent to the site is Henson Creek, a tributary of the Lake Fork of the Gunnison River. Henson Creek flows in an easterly direction for approximately four miles towards Lake City and joins with the Lake Fork of the Gunnison River, which then flows in a northerly direction for approximately 30 miles before connecting with Blue Mesa Reservoir and the Gunnison River. Tailings and waste rock have eroded over time and are currently in contact with Henson Creek. The preliminary stability analyses conducted by the Bureau of Land Management suggest a potential for slope failure of the mine waste into Henson Creek (CDPHE 2012b). Access to the Site is uncontrolled and open but is posted with 'No Trespassing' signs. Trespassing is a common occurrence due to the historic nature of this site and the buildings associated with it (CDPHE 2012a).

Groundwater is present in the alluvium associated with Henson Creek at a depth of 12-70 feet based on groundwater wells drilled in the area. Based on topography and geologic formations, the ground water flow direction in the vicinity of the site is inferred to be east/south east in the direction of Henson Creek. Groundwater may also be present onsite in limited quantity in joints and faults associated with volcanic intrusion. The extent of the alluvial aquifer in this area is thought to be extremely limited due to the extensive presence of bedrock outcrops (CDPHE 2011). The Lake City municipal water supply draws water from two groundwater wells. One of the wells is located at the mouth of Henson Creek to Lake City and is 75 feet deep. The other well is located at Memorial Park in Lake City and is approximately 80 feet deep. The remainder of the water supply for rural residents of Hinsdale County comes from private groundwater wells drilled at varying depths and formations. The closest private groundwater well to the site is approximately 2.4 miles downgradient of the site (CDPHE 2011). The potential for the site to impact groundwater is minimal because groundwater is thought to occur only in limited quantities onsite based on the hydrology and geologic features of the area. Due to the limited potential impact of site wastes on groundwater and the distance to the nearest groundwater well, CDPHE does not feel groundwater investigations are warranted at this site (CDPHE 2011).

Demographics

The nearest population center to the site is the town of Lake City, Colorado, which is located approximately 4 miles to the east. Lake City is the county seat and only town in Hinsdale County with a population of approximately 408 full-time residents according to the 2010 U.S. Census. In the summer months, the population nearly doubles with the seasonal influx of temporary residents and recreational users (CDPHE 2011). The median age of the Lake City population is 46 years with 8.8% of the population ages less than 5 years and 17.9% of the population over the age of 65 years (Census 2010). There are slightly more males (54.4%) than females (45.6%) in Lake City. Women of child-bearing age (defined as 15-49 years due to Census age brackets) constitute approximately 38% (71/186) percent of the female population. The racial make-up is White (94.6%), Hispanic or Latino (2.7%), American Indian and Alaska Native (1.0%), Black or African American (0.2%), Asian (0.2%), and 1.5% of people reported "some other race".

Everyone that participated in the latest Census reported that they spoke English very well or better, which indicates that health education materials in different languages may not be necessary, but can be provided upon request. In addition, the population appears to be educated with 92% of individuals reporting they earned a high school diploma or higher and 40.9% of people stated they earned a Bachelor's degree or higher. Both of these educational statistics are higher than state and national values. The median household income is $73,295, which is also well above the median household income in Colorado and the United States.

Discussion

The overall goal of this health consultation is to determine if future exposure to mining-related soil contamination in tailings and waste rock at the Ute-Ulay Millsite pose a public health hazard and, if so, make recommendations to protect public health. The first steps of the health consultation process include an examination of the currently available environmental data and how individuals could be exposed to site-related contaminants of potential concern (COPCs). If people can come into contact with COPCs, exposure doses are estimated and compared to health-based guidelines established by the ATSDR, EPA, or other state agencies. This is followed by a more in-depth evaluation if the estimated exposure doses exceed health-based guidelines.

Exposure Assessment

Environmental Data

Soil is the primary environmental medium evaluated in this health consultation because no contaminants of concern have been identified in surface water at this time (CDPHE 2012a). If any contamination is identified by CDPHE in the future, a separate health consultation will be conducted for surface water. As mentioned previously, CDPHE does not feel groundwater investigations are warranted at this site and no groundwater data have been collected from the site (CDPHE 2012a). Therefore, groundwater and surface water were not considered completed exposure scenarios in this evaluation.

Soil Data

The soil samples utilized in this evaluation were collected from tailings and waste rock located in the southeastern section of Millsite area. In this evaluation, soil is defined as a mixture of native soil, tailings, and waste rock. Soil samples were collected in conjunction with a stability assessment performed by the Colorado Division of Reclamation, Mining, and Safety that began in the fall of 2011 (CDRMS 2011). Six boreholes were completed in the area as shown in Figure A3. The boreholes were oriented to determine the thickness of the mining-related wastes and the depth to bedrock. All of the boreholes were drilled below bedrock contact, which ranged from 15-46 feet deep. The composition of mining-related wastes encountered during drilling varied in color, grain size, waste rock, alluvium, and bed rock.

At least one soil sample was collected from each borehole, totaling sixteen surface and subsurface samples. Composite samples were collected from varying intervals as shown in Table A1 with an overall sampling depth range of 0-204 inches (0-17 feet) below ground surface (bgs.). Only one sample (UU-4A) was collected from the surface (0-4 in. bgs.).

The samples were collected using standardized soil sampling methods and were then sent to Pace Analytical Laboratory for chemical analysis of aluminum, arsenic, cadmium, chromium, copper, iron, magnesium, manganese, nickel, selenium, silver, zinc, mercury, and cyanide. The chemical results of this analysis are shown in Table A1 and summary statistics of the data are shown in Table A2.

Selection of Contaminants of Potential Concern

To identify contaminants of potential concern (COPCs) in soil, the data were screened against comparison values established by ATSDR and EPA. The screening values from both agencies were reviewed and the most conservative value was selected as the Comparison Value (CV) (Table A3). The screening values used to identify COPCs in soil were derived for residential soil exposures. ATSDR's soil comparison values for chronic exposures are based on daily exposure to soil over a period longer than 1 year. EPA's residential soil screening values are based on 350 days of exposure per year over a period of 30 years (assumes 15 days away from the home per year).

Using these screening values is considered conservative and protective of individuals that might come into contact with surface soil contaminants at the Ute-Ulay Millsite based on what is currently known about the future land-uses at the site. Therefore, if the maximum concentration of a particular contaminant is below the screening value, it is dropped from further evaluation. If the maximum concentration of the contaminant is above the screening value; it is generally retained for further analysis as a COPC. However, exceeding the CV does not indicate that a health hazard exists; only that additional evaluation is warranted.

It should be noted that the Centers for Disease Control and Prevention has recently revised their reference blood lead level based on information showing the blood lead levels less than 10 micrograms per deciliter (μg/dL) have been associated with adverse health effects. As more information becomes available on the health effects of lower blood lead levels, it seems possible that there is no safe level of lead in blood. For more information, please refer to CDC (2012a) and CDC (2012b). However, the concentration of lead in site soils is substantially higher than the current EPA screening value for lead of 400 mg/kg. In addition, running the IEUBK model using CDC recommended blood lead level of 5 μg/dL indicates soil screening level about 150-200 mg/kg for lead.

For screening purposes, the entire area was evaluated as single exposure unit and if a contaminant exceeded the screening value in one location, it was selected as a COPC for the entire unit. The results of the COPC selection are shown in Table A3. Arsenic, cadmium, chromium, copper, lead, and manganese had maximum detected concentrations greater than the residential CVs used in this evaluation and were selected as COPCs. It should be noted that naturally elevated levels of heavy metals in soil are likely to occur due to the mining rich location of the site. Due to the heterogeneous nature of the mining-related waste encountered during drilling, the concentration of soil contaminants varied a considerable degree in regards to depth and distance and the contamination did not appear to follow any discernible pattern. For instance, at some locations the concentration of a particular contaminant was higher in the shallow sample rather than the deeper sample from the same boring. In other locations, the opposite was true. At times, the metal concentrations also varied widely between borings.

Summary statistics of the selected contaminants of concern are shown below in Table 1. The concentration of arsenic ranged from 31.7 milligram per kilogram (mg/kg) to 94.5 mg/kg with a mean concentration of 56.4 mg/kg. Cadmium concentrations ranged from 3.9 mg/kg to 73.4 mg/kg with a mean concentration of 22.7 mg/kg. The concentration of chromium ranged from not detected to 10.7 mg/kg with a mean concentration of 4.4 mg/kg. It should be noted that the species of chromium has not been determined at this site. The common, and conservative, approach is to assume that all chromium is in the hexavalent form even though the majority of chromium at this site is most likely in a lower valence state and thus a less toxic form of chromium. Chromium would not have been selected as a COPC if the screening values for trivalent chromium were used for screening. Copper concentrations ranged from 92.1 mg/kg to 970 mg/kg with an average concentration of 464 mg/kg. The concentration of lead ranged from 1,490 mg/kg to 9,830 mg/kg with a mean concentration of 5,197 mg/kg. Manganese concentrations in soil ranged from 79.2 mg/kg to 6,490 mg/kg with a mean concentration of 3,399 mg/kg.

Table 1. Summary Statistics Mill Tailings and Waste Rock Data (all depths)

Analyte	Minimum (in mg/kg)	Mean (in mg/kg)	Median (in mg/kg)	Maximum (in mg/kg)	Detection Frequency
Arsenic	31.7	60.2	56.4	94.5	16/16
Cadmium	3.9	22.7	16.8	73.4	16/16
Chromium	ND	4.4	3.0	10.7	6/16
Copper	92.1	464	433	970	16/16
Lead	1,490	5,197	4,425	9,830	16/16
Manganese	79.2	3,399	3,750	6,490	16/16

NOTE: mg/kg = milligram per kilogram, ND = Not Detected above reporting limit, NA = Not applicable

Only one sample was collected from the 0-4 inch bgs. range, which is technically considered a surface soil sample (UU-4A). However, the concentration of contaminants found in the surface soil sample do not appear to differ notably from the samples collected at depth from borehole #4 nor the subsurface samples collected from the other boreholes. For instance in borehole #4, the concentration of the relevant COPCs (arsenic, cadmium, copper, lead and manganese) varies only slightly from the samples collected at depth (Table A1 cont.). The concentration of arsenic was higher in the surface sample than the samples collected at depth (95 mg/kg vs. 39 mg/kg). The concentration of lead was also higher in the surface sample than the sample collected at depth (4,730 mg/kg vs.4,070 mg/kg). The concentration of all other COPCs found in the surface soil sample is lower than the concentrations found at depth from borehole #4.

In comparison to the remaining boreholes that were sampled, the concentration of COPCs in the surface soil sample collected from borehole #4 is below the average concentration from all samples collected with the exception of arsenic and manganese. The concentration of arsenic in the surface soil sample is 95 mg/kg, which is the maximum detected concentration of arsenic out of all samples collected. However, the concentration of arsenic in samples UU-5B (52-82" deep), UU-1C (48-90" deep) and UU-3C (180-204" deep) are nearly equivalent to the surface soil sample. The overall mean concentration of arsenic is 60.2 mg/kg. The concentration of manganese found in the surface soil sample of 4,910 mg/kg is also greater than the overall mean of 3,399 mg/kg. However, the concentration of manganese from 5 other depth samples (UU-1A, UU-1B, UU-1C, UU-2C, and UU-4C) is higher than that found at the surface.

Conceptual Site Model

A conceptual site model helps to visualize how contaminants of potential concern move in the environment and how people might come into contact with these contaminants. Soil (including waste rock and tailings) is the primary environmental medium under consideration in this health consultation and three routes of exposure to soil contaminants are likely to occur under any given scenario: 1) incidental ingestion of surface soil, 2) dermal contact with surface soil, and 3) inhalation of soil particles suspended in air (fugitive dust). However, dermal contact with metals is considered a relatively minor exposure pathway due to the limited ability of metal contaminants to cross the skin barrier and enter the bloodstream. Therefore, dermal contact with metals in surface soil was not quantitatively addressed in this evaluation. Inhalation of resuspended soil particulates (dust) is typically not considered an important pathway in terms of public health unless there is evidence to suggest a significant mechanical disturbance of the soil (e.g. ATV riding and/or high, sustained winds). At this site, no such evidence exists and this pathway was also not quantitatively evaluated in this health consultation. The exclusion of the dermal and inhalation pathways could result in a slight underestimation of risk. However, the primary pathway is incidental ingestion of surface soil and any underestimation of risk is expected to be minimal.

Exposure Scenarios/Receptors

Based on the proposed future use of the site, two exposure scenarios were developed to evaluate the potential public health implications of exposure to surface soil contaminants at the site: hostel workers and recreational users. Each exposure scenario is discussed in more detail in the following subsections including the primary exposure assumptions used for each scenario. Additional information of the exposure scenarios used in this evaluation can be found in Appendix B. The exposure assumptions could be a major source of uncertainty in this evaluation because there is no site-specific information available on the frequency, duration, or specific activities conducted at the Ute-Ulay site. However, based on the site-specific information that is available, the exposure assumptions used in the evaluation were deemed appropriate for describing infrequent recreational users and seasonal hostel workers.

Recreational Users (Future Potential Exposures)

Currently, tourists visit the Ute-Ulay site to view or take pictures of the historic features of the mining camp. Access to the site is uncontrolled and open, but ‘No Trespassing’ signs are posted. However, trespassing occurs on a regular basis due to the historic nature of the site and the buildings associated with it. Although there are no concrete site-specific data available on the frequency any particular user visits the site, it is reasonable to assume that these people would only visit for a brief period of time, perhaps an hour or two per year. Unless they are accidentally swallowing substantial amounts of dirt during their stay, which is unlikely, the extremely short-term exposure is not expected to be a health concern. Therefore, current exposures are not evaluated in this health consultation. Once the site is redeveloped, it is likely that people will visit more often; however, it is still reasonable to assume that stays would be for relatively short periods of time. For the purpose of this evaluation, it was assumed that children (ages 0-6 years) and adults would visit the site for 12 days per year for recreational use once the site has been redeveloped. The exposure duration for children using the site for recreational purposes is 6 years and the assumed exposure duration for adults using the site for recreational purposes is 30 years. However, it should be noted that the model used to evaluate lead exposures for young children is based on children ages 0-7 years old (or 0-84 months). All other exposure factors, which are typically default values for recreational exposures, are presented in Appendix Table B1.

Hostel Workers (Future Potential Exposure)

If the proposed plan developed by Colorado Art Ranch and Hinsdale County becomes reality, one or more individuals will be necessary to operate the hostel and cabins. It should be noted that the future plans for a hostel were not final at the time this evaluation was conducted. Therefore, hostel workers are considered a future, potential exposure scenario at this time. It was assumed that a non-residential hostel worker(s) would be present onsite throughout the year. However, during the winter months (November through March), snowpack would eliminate their contact with surface soil. In addition, it is reasonable to assume that the hostel workers would be away from the site for short periods of time during the year for travel, vacations, etc. Thus, it was assumed that adult hostel workers could be exposed to surface soil for a period of 140 days per year over the course of 25 years. The remaining exposure assumptions that are shown in Appendix Table B1 are typically default values for residential exposures. Based on what is currently known about the future land use, children of hostel workers were not evaluated because young children would not be staying at the hostel or going to work with their parents. Information provided through personal contact with CDPHE Project Manager for the site, supports this assumption (CDPHE 2013). However, if the proposed land-use were to change in the future to include year-round hostel workers or commercial workers, it is recommended that the site be reevaluated from a public health perspective. The exposure scenarios discussed above and the likely routes of exposure used in this evaluation are summarized below in Table 2, the Conceptual Site Model (CSM).

Table 2. Conceptual Site Model

Source	Area of Exposure	Affected Environmental Medium	Timeframe of Exposure	Potentially Exposed Population	Route of Exposure	Pathway Designation
Mining related waste	Ute-Ulay Mine and Millsite (**Mill Tailings and Waste Rock**)	Surface Soil Mixed Soil (surface and subsurface)	Future	Adult Hostel Workers and Child and Adult Recreational Users	Incidental Soil Ingestion	Potential
					Inhalation of Fugitive Dust*	Potential
					Dermal Exposure to Soil Contaminants **	Potential

NOTE:
* Inhalation of fugitive dusts is not considered an important exposure scenario in this evaluation because there is no evidence to suggest any substantial mechanical disturbance of soil at the site. Therefore, the concentration of soil contaminants in dust is likely to be low.
** Dermal exposure to surface soil contaminants is a potential exposure pathway. However, since metals have a limited ability to cross the skin barrier and enter the blood stream, this pathway is considered very minor and is not quantitatively evaluated in this health consultation.

Exposure Units

As described previously, surface and subsurface soil samples were collected from six boreholes drilled through mining-related wastes in the southeastern portion of the Millsite. The concentration of soil contaminants varied to some degree in regards to depth and distance and the contamination did not appear to follow any discernible pattern.. Additionally, there is some uncertainty regarding the future exposures to different soil horizons after redevelopment (i.e., to surface soil and/or mixed soil (surface and subsurface soil). To address the potential for exposure to both surface and mixed soil, future exposures were evaluated in three different ways in this health consultation:

1) The entire outdoor area of the Millsite was considered the exposure unit with exposure to current surface soil, based on the known future land use.

2) The entire outdoor area of the Millsite was considered the exposure unit with exposure to mixed surface and subsurface soil after redevelopment, based on the known future land use (Appendix E). The current site plans call for stabilization and removal of tailings and waste rock, which will require substantial dirt movement and grading. Thus, surface and subsurface soil will be mixed up during this process. It is possible that exposure to this mixed soil most likely represents the levels of contaminants that people will be exposed to in the future.

3) Each sampling location was also evaluated as an individual exposure unit to facilitate risk management decision-making for reducing future exposures (Appendix F)

Exposure Point Concentrations

The exposure point concentration (EPC) describes the concentration of soil contaminants that people are likely to come into contact with in the exposure unit. For the surface soil evaluation, the EPC that was used is the detected concentration in the one available surface soil sample (0-4 inches). Once again, no other surface soil samples were collected and the concentration of contaminants of concern found in the one surface soil sample must be used as the surface soil EPC. Surface soil and mixed soil EPCs are summarized below in Table 3. More information on the EPC used for surface soil in this evaluation is shown in Appendix Table B2.

For the mixed surface and subsurface soil evaluation (Appendix E), a total of 16 surface and subsurface soil samples were collected from the area where exposure is likely to occur. Although the dataset is somewhat limited from a statistical perspective, EPA's ProUCL 5.0 software can be used to estimate the EPC for this site (EPA 2011a). For a normally distributed dataset, ProUCL will calculate the 95th percentile Upper Confidence Limit (95% UCL) on the mean concentration of the data intended to be used for the EPC estimation. In other cases, ProUCL uses rigorous statistical methods to determine the appropriate estimate that can be used as the EPC. The soil EPCs used in the evaluation of mixed soil are shown in Table 3. Additional information on the EPC used for the mixed soil evaluation in available in Appendix Table E1. It should be noted that all surface and subsurface data were combined in the EPC estimate. This assumption reflects contaminant concentrations that are likely to be present after stabilization and re-grading of the tailings and waste rock piles for the future land-use. During the stabilization and grading work, surface and subsurface soils will be mixed and the concentrations of contaminants found in surface and subsurface samples will be present at the surface where people will be exposed.

Table 3. Exposure Point Concentrations for Surface and Mixed Soil

Contaminant of Potential Concern	Surface Soil EPC (in mg/kg)	Mixed Soil EPC* (in mg/kg)
Arsenic	94.5	69
Cadmium	8.7	33.7
Chromium	2.4U	4
Copper	482	593
Manganese	4,910	4,379

NOTE: EPC: Exposure Point Concentration, *EPCs were calculated with EPA ProUCL Version 4.1.00
Mixed Soil: a mixture of native soil, tailings, and waste rock collected from an overall sampling depth range of 0-17 feet below ground surface.

When each sampling location was evaluated as an individual exposure unit (Appendix F), the maximum detected concentration from each borehole was used as EPC. This is because of the fact that there are not enough soil samples collected from each borehole to produce a ProUCL estimate. Therefore, as a conservative approach, the maximum detected concentration from soil samples collected from each borehole was used as the EPC (Appendix F).

Public Health Implications

The public health implications of exposure to metal contaminants in surface soil and mixed soil at the site were determined using a combination of exposure dose estimations and biokinetic modeling. For metal contaminants of potential concern other than lead (arsenic, cadmium, chromium, and manganese), the estimated doses for non-cancer health effects were divided by the appropriate health-based guidelines to calculate the Hazard Quotient (HQ). The cumulative non-cancer hazard (or hazard index; HI) of multiple contaminants is estimated by adding all HQs together. A HQ greater than one indicates the estimated exposure exceeds the non-cancer health-based guideline and requires further evaluation by comparison of estimated exposure doses or concentrations with health effects levels known to be associated with harmful effects in animal and/or human studies (see Appendix D for more details). The in-depth analysis serves as a means of gaining a better perspective on how strongly the available toxicological information in the scientific literature suggests potential for harmful exposures (i.e., could harm people's health). However, it should be noted that because of the uncertainties regarding exposure conditions and adverse health effects associated with environmental levels of exposure, definitive answers on whether health effects actually will or will not occur are not possible.

The estimated doses for cancer health effects are calculated in a similar manner to non-cancer health effects; however, the cancer doses are averaged over a lifetime and are multiplied by oral slope factors developed by the EPA and other agencies. The resulting risks are compared to the EPA target cancer risk level of 1×10^{-6} to 1×10^{-4}, or 1 excess cancer case per million exposed individuals to 100 excess cancer cases per million exposed individuals. If the estimated lifetime excess cancer risks are greater than 100 excess cancer cases per million exposed individuals, exposure to the carcinogen is evaluated in greater detail. Please refer to Appendix B for additional information on the exposure doses calculated for this evaluation. Appendix D contains additional information on the toxicological evaluation and toxicity values used in this evaluation.

To assess the public health implications of lead exposures during recreational use, the EPA's Integrated Exposure Uptake Biokinetic (IEUBK) lead model for children and the EPA Adult Lead Model (ALM) was used to estimate the blood lead level in pregnant women working at the site and/or using the site for recreational purposes. Essentially the lead models are designed to predict the blood lead levels of fetuses or children exposed to lead in the environment.

Until recently, the U.S. Centers for Disease Control and Prevention (CDC) had established a level of concern for case management of 10 micrograms lead per deciliter of blood (µg/dL) (CDC 2005). Recent scientific evidence, however, has suggested that blood lead levels below 10 µg/dL can cause serious and irreversible health effects in children. Blood lead levels below 10 µg/dL have been associated with neurological, behavioral, immunological, and developmental effects in young children. Specifically, lead causes or is associated with decreases in intelligent quotient (IQ); attention deficit hyperactivity disorder (ADHD); deficits in reaction time; problems with visual-motor integration and fine motor skills; withdrawn behavior; lack of concentration; issues with sociability; decreased height; and delays in puberty, such as breast and pubic hair development, and delays in menarche (CDC 2011; CDC 2012a; CDC 2012b).

On January 4, 2012, CDC's Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP) recommended that CDC adopt the 97.5 percentile blood lead level of children in the United States (ages 1 to 5 years old) as the reference value for designating elevated blood lead levels in children. Based on the latest National Health and Nutrition Examination Survey (NHANES) data, the 97.5% currently is 5 µg/dL (CDC 2012a).

On June 7, 2012, CDC released a statement indicating concurrence with the recommendations of the ACCLPP (CDC 2012b). CDC intends for health professionals to use the reference value as defined to identify high-risk childhood populations and geographic areas most in need of primary prevention. Yet, still, there may be an underestimation of risk for lead because there is no proven "safe" level of lead in the blood. Appendix C contains additional information on the health risk evaluation of exposures to lead using the IEUBK and ALM models at the site. Chronic exposures to lead and other metal contaminants of concern are described below.

Please note that the public health implications of exposure to metal contaminants in waste rock and tailings at the site were determined in the following three ways in order to address the uncertainty associated with future exposures to different soil horizons after redevelopment and to facilitate risk management decision-making:

1) The entire outdoor area of the Millsite was considered the exposure unit with future exposure to *current surface soils*, based on the known future land use (noted below).

2) The entire outdoor area of the Millsite was considered the exposure unit with future exposure to *mixed surface and sub surface soil after redevelopment,* based on the known future land use (Noted below; for details see Appendix E).

3) Each sampling location was also evaluated as an individual exposure unit to facilitate risk management decision-making for reducing future exposures (Appendix F)

Public Health Implications of Recreational Use of the Site

Non-cancer Hazards from Exposure to Surface Soil during Recreational Use

Arsenic, cadmium, chromium, copper, and manganese were identified as contaminants of potential concern because the maximum detected site concentrations exceeded the residential soil screening value for these contaminants. All other metals (except for lead) that were analyzed were dropped from further evaluation because the maximum detected concentration did not exceed the residential screening values. The non-cancer exposure dose estimates for recreational use of the site are shown in Table B3 and the associated HQs are shown in Table A4. As shown in Table A4, the non-cancer HQs are below 1 for both child and adult recreational users for each COPC identified in this evaluation. Thus, all of the estimated exposure doses for recreational users are below the respective health-based guidelines. The highest HQ was estimated for child recreational users from exposure to arsenic in surface soil (HQ = 0.14). This indicates that the estimated dose for child recreational users is approximately 7 times lower than the health-based guideline for arsenic. In addition, the combined non-cancer HI for multiple contaminants of potential concern is also below 1 for both child and adult recreational users (HI = 0.03 for adults and 0.3 for children). This indicates that non-cancer adverse health effects are not likely to occur from recreational exposure to non-lead metal contaminants based on the assumption of additivity for multiple chemical exposures.

Non-cancer Hazards from Exposure to Mixed (Surface and Subsurface) Soil during Recreational Use

Overall, the estimated non-cancer doses and hazards of the mixed soil approach are consistent with the surface soil approach. For mixed soil, the non-cancer exposure dose estimates for recreational users are shown in Table E2 and the associated HQs are shown in Table E3. As shown in Table E3, the non-cancer HQs are below 1 for both child and adult recreational users for each COPC identified in this evaluation. Thus, all of the estimated exposure doses for recreational users are below the respective health-based guidelines. In mixed soil, the highest HQ was estimated for children exposed to cadmium during recreational use (HQ = 0.15), which indicates that the estimated dose is approximately 7 times lower than the health-based guideline for cadmium. In addition, the combined non-cancer HI for multiple contaminants of potential concern is also below 1 for child and adult recreational users (HI = 0.03 for adults and 0.3 for children). This also indicates that non-cancer adverse health effects are not likely to occur during recreational exposure to metal contaminants (aside from lead) in mixed soil.

Cancer Risks from Exposure to Surface Soil during Recreational Use

Arsenic and chromium VI are the only known carcinogens identified as contaminants of potential concern at this site. Once again, it should be noted that the form of chromium has not been determined at this site. Due to this uncertainty, the most common approach is to assume that all chromium is in the hexavalent state even though the majority of chromium found in the environment is in a lower oxidative state such as trivalent chromium. Trivalent chromium is a less toxic form of chromium that is also non-carcinogenic. To be prudent, exposure doses for chromium and arsenic were calculated for carcinogenic health effects and the results are shown in Appendix Tables B4 and the associated theoretical cancer risks are shown in Table A5.

Cancer risks were estimated for child and adult recreational users and were also combined to evaluate cancer risks from exposures occurring as a child into adulthood up to the age of 30 years. The lifetime estimated cancer risks are the most conservative values, followed by exposure during childhood, and then by exposure occurring as an adult. As shown in Table A5, the maximum cumulative (child and adult) estimated cancer risk from exposure to arsenic and chromium is 7.7×10^{-6}. The estimated lifetime excess cancer risk for recreational users is largely attributable to exposure to arsenic, which constitutes approximately 99% of the total cumulative risk. Exposure to chromium contributes very little to the overall combined cancer risk. Rounded to the nearest whole number, the estimated combined cancer risk translates to 8 excess cancer cases per million people exposed. Relative to EPA's target cancer risk range of $1 \times 10^{-6} – 1 \times 10^{-4}$, or one excess cancer case per million exposed individuals to 100 excess cancer cases per million exposed individuals, the estimated 8 excess cases per million people exposed during recreational use of the Ute-Ulay Millsite represents a low increased risk of developing cancer.

Cancer Risks from Exposure to Mixed Soil during Recreational Use

Overall, the estimated cancer doses and risks of the mixed soil approach are consistent with the surface soil approach. For mixed soil, the cancer exposure dose estimates for recreational users are shown in Table E4 and the associated HQs are shown in Table E5. As shown in Table E5, the maximum cumulative (child and adult) estimated cancer risk from exposure to arsenic and chromium is 5.7×10^{-6}. This level of excess risk is largely attributable to the estimated exposure to arsenic, which constitutes approximately 98% of the cumulative risk. The estimated combined cancer risk translates to roughly 6 excess cancer cases per million people exposed. Relative to EPA's target cancer risk range of $1 \times 10^{-6} – 1 \times 10^{-4}$, or one excess cancer case per million exposed individuals to 100 excess cancer cases per million exposed individuals, the estimated 6 excess cases per million people exposed during recreational use of the Ute-Ulay Millsite represents a low increased risk of developing cancer.

Evaluation of Surface Soil Exposures to Lead during Recreational Use

As mentioned previously, potential lead exposures to children and adults during recreational use of the site were evaluated using EPA models, the IEUBK and the ALM, respectively. The results of the IEUBK model for children recreating at the site are shown below in Table 4. The IEUBK model results for surface soil exposures to lead indicate a potential concern for children that use the site for recreational purposes. The predicted geometric mean blood lead level for children is 3.7 μg/dL with an estimated 26.7% of all children having blood lead levels greater than or equal to 5 μg/dL. The results show more than 5% of children would have predicted blood lead levels above CDC's reference value of 5 μg/dL for designating elevated blood lead levels in young children.

Table 4. IEUBK Model Results for Recreational Use by Children

Approach	**Time Weighted Site Soil Lead Concentration (in mg/kg)**	**Age Group (Months)**	**Geometric Mean Blood Lead Concentration of Recreational Children (μg/dL)**	**Percent of Recreational Child Population with a Predicted Blood Lead Level Greater than 5 μg/dL**
Surface Soil	349	0-84	3.7	26.7
Mixed Soil	365	0-84	3.8	28.1

NOTE: mg/kg = milligram lead per kilogram soil, μg/dL = micrograms lead per deciliter of blood, bolded values exceed the current CDC threshold.

The ALM results for recreational use of the site by adults are shown in Table 5. The results of the ALM also indicate elevated fetal blood lead levels for pregnant women during recreational use. Specifically, the ALM estimated that 7.1% of pregnant women would have fetal blood lead levels greater than or equal to 5 μg/dL with a geometric mean fetal blood level of 2.1 μg/dL following exposure to lead in soil during recreational use of the site. While the probability is relatively low, the model results still indicate greater than a 5% probability of blood lead levels above CDC's reference value of 5 μg/dL.

Based on the results of the IEUBK and ALM models, exposure to lead during recreational use of the site has the potential to harm the health of young children and the developing fetuses of pregnant women. Overall, to protect the health of young children and the fetuses of pregnant women, it is recommended that exposures to lead in soil during recreational use at the site be reduced.

Table 5. Adult Lead Model Results for Recreational Adults

Approach	Soil lead Concentration (in mg/kg)	Geometric Mean Fetal Blood Lead Concentration (µg/dL)	Probability of fetal Blood Lead Exceeding 5 (µg/dL)
Surface Soil	4,730	2.1	7.1%
Mixed Soil	5,197	2.1	7.5%

NOTE: mg/kg = milligram lead per kilogram soil, µg/dL = micrograms lead per deciliter of blood, bolded values exceed the current CDC threshold

Evaluation of Mixed Soil Exposures to Lead during Recreational Use

Overall, the modeling results of exposure to lead in mixed soil are consistent with surface soil exposures. The lead modeling results for exposure to mixed soil during recreational use of the site are shown in Tables 4 and 5. The predicted geometric mean blood lead level for children using the site for recreational purposes is 3.8 µg/dL with an estimated 28.1% of all children having blood lead levels greater than or equal to 5 µg/dL. The ALM estimated that 7.5% of pregnant women would have fetal blood lead levels greater than or equal to 5 µg/dL with a geometric mean fetal blood level of 2.1 µg/dL following exposure to lead in soil during recreational use of the site. These results also indicate that exposure to lead in mixed soil during recreational use of the site are a concern for children and adults.

Public Health Implications of Hostel Worker Exposures

Non-cancer Hazards for Hostel Workers from Exposure to Surface Soil

The non-cancer exposure doses that were estimated for adult hostel workers are shown in Appendix Table B3 and the resulting HQs are shown in Appendix Table A4. As shown in Table A4, the estimated exposure doses for non-cancer health effects are below the health-based guideline for all contaminants of potential concern that were identified in this evaluation (all HQs < 1). The highest HQ occurs from exposure to arsenic in surface soil while working at the hostel (HQ = 0.17), which indicates the estimated exposure dose is approximately 6 times lower than the health based guideline for arsenic. In addition, the combined HI from exposure to all contaminants of concern is below 1 (HI = 0.4). This information indicates that adverse non-cancer health effects are not likely to occur from exposure to surface soil while working at the onsite hostel based on the assumption of additivity for multiple chemicals.

Non-cancer Hazards for Hostel Workers from Exposure to Mixed Soil

Overall, the estimated non-cancer doses and hazards of the mixed soil approach are consistent with the surface soil approach. The non-cancer exposure doses for adult hostel workers from exposure to metals in mixed soil are shown in Appendix Table E2 and the resulting HQs are shown in Table E3. As shown in Table E3, the estimated exposure doses for non-cancer health effects are below the health-based guideline for all contaminants of potential concern that were identified in this evaluation (all HQs < 1). The highest HQ occurs from exposure to cadmium while working at the hostel (HQ = 0.18), which indicates the estimated exposure dose is approximately 6 times lower than the health based guideline for cadmium. In addition, the combined HI from exposure to all contaminants of concern is below 1 (HI = 0.3). This information also indicates that adverse non-cancer health effects are not likely to occur from hostel workers coming into contact with non-lead metals in mixed soil.

Estimated Cancer Risks for Hostel Workers from Exposure to Surface Soil

As shown in Table A5, the estimated cancer risks for hostel workers are within the EPA target cancer risk range in this evaluation. The maximum estimated excess cancer risk from exposure to arsenic and chromium while working at the hostel is 2.7×10^{-5}. This level of risk is largely attributable to exposure to arsenic in surface soil, which constitutes approximately 99% of the cumulative risk. Exposure to chromium contributes very little to the overall combined cancer risk. The estimated combined cancer risk translates to 27 excess cancer cases per million people exposed. Relative to the EPA's target cancer risk range of $1 \times 10^{-6} – 1 \times 10^{-4}$, or one excess cancer case per million exposed individuals to 100 excess cancer cases per million exposed individuals, the estimated 27 excess cancer cases per one million exposed individuals represents a low increased risk of developing cancer.

Estimated Cancer Risks for Hostel Workers from Exposure to Mixed Soil

Overall, the estimated cancer doses and risks of the mixed soil approach are consistent with the surface soil approach. The estimated cancer risks for hostel workers exposed to mixed soil are also within the EPA target cancer risk range. The maximum estimated excess cancer risk from exposure to arsenic and chromium while working at the hostel is 2.1×10^{-5} (Table E5). The estimated combined cancer risk translates to 21 excess cancer cases per million people exposed. The estimated 21 excess cancer cases per one million exposed individuals represents a low increased risk of developing cancer from contacting mixed soil while working at the hostel.

Evaluation of Hostel Workers Exposure to Lead in Surface Soil

As noted above, details on lead risk evaluation using the ALM are provided in Appendix C and the results of the ALM model performed for hostel workers are shown below in Table 6. The ALM model was performed for pregnant female hostel workers, which is thought to be protective of non-pregnant females and male adult workers as well. The results of the ALM indicate a potential for hazardous lead exposures for pregnant females while working at the onsite hostel. The ALM predicted a geometric mean blood lead concentration in the fetus of 6.6 μg/dL and predicted that 52.8% of all pregnant female hostel workers would have fetal blood lead concentrations greater than 5 μg/dL. This output is above CDC's reference level of 5 μg/dL for designating elevated blood lead levels in young children. Therefore, exposure to lead in surface soil while working at the hostel has the potential to harm the health of the developing fetuses of pregnant women.

Table 6. Adult Lead Model Results for the Pregnant Hostel Workers (Fetal blood lead levels)

Approach	Soil lead Concentration (in mg/kg)	Geometric Mean Fetal Blood Lead Concentration (µg/dL)	Probability of fetal Blood Lead Exceeding 5 µg/dL
Surface Soil	4,730	6.6	52.8%
Mixed Soil	5,197	7.0	56.6%

NOTE: mg/kg = milligram lead per kilogram soil, µg/dL = micrograms lead per deciliter of blood, bolded values exceed the current CDC threshold.

Evaluation of Hostel Worker Exposure to Lead in Mixed Soil

Overall, the modeling results of exposure to lead in mixed soil are consistent with surface soil exposures. The results of the ALM conducted for mixed soil also indicate a potential for hazardous lead exposures for pregnant females while working at the onsite hostel. The ALM predicted a geometric mean blood lead concentration in the fetus of 7.0 µg/dL and predicted that 56.6% of all pregnant female hostel workers would have fetal blood lead concentrations greater than 5 µg/dL (Table 6). Therefore, exposure to lead in mixed soil while working at the hostel also has the potential to harm the health of the developing fetuses of pregnant women.

Acute Health Risk Evaluation

Short-term or acute exposures, occurring over a period of one day, were also evaluated in this health consultation. Child recreational users are the focus of the acute evaluation since young children are the most likely to ingest large amounts of soil during a short amount of time. Soil pica ingestion is the recurrent ingestion of unusually high amounts of soil by either intentionally eating dirt or unintentionally ingesting soil from excessive mouthing behavior or eating dropped food. While the typical child might ingest 1/8 teaspoon soil daily (or about 100 to 200 milligrams), children with soil-pica behavior ingest about a teaspoon or more of soil daily (or about 1,000-5,000 mg or more per day).

To evaluate short-term pica exposures, ATSDR recommends ingestion rates of 5,000 mg/day be used instead of the standard default ingestion rate for children of 200 mg/day. It should be noted that the pica exposure scenario at the millsite does not appear very likely since the site is remote and the terrain is steep. It seems unlikely that people would let their children roam unsupervised at the site and remain there long enough to ingest the assumed amount of soil for pica ingestion. Nonetheless, the pica scenario was included to inform stakeholders of the potential hazards of acute pica exposures. Arsenic and copper are the primary contaminants of concern for acute risks because it has been shown that short-term exposures to both contaminants can present a health risk. In addition, amongst the contaminants of potential concern selected in this evaluation, acute health-based guidelines are only available for arsenic and copper.

Acute Health Risk Evaluation from Exposure to Surface Soil

The estimated exposure doses for acute exposure to surface soil at the millsite are shown in Table 7. The estimated exposure dose for 1-day, acute exposure to arsenic in surface soil by children exhibiting pica behavior is 0.032 mg/kg-day and the ATSDR acute health-based guideline is 0.005 mg/kg/day. Thus, the estimated acute dose is more than 6 times higher than the acute health-based guideline for arsenic. Therefore, the estimated dose was compared to known health effect levels in the scientific literature. In the derivation of the acute MRL, ATSDR identified a Lowest Observed Adverse Effect Level (LOAEL) of 0.05mg/kg-day. A No Observed Adverse Effect Level (NOAEL) was not established for acute exposure to arsenic.

The LOAEL for arsenic was initially identified in a study of people who ingested soy sauce that had inadvertently been contaminated with arsenic. The study involved 220 people that had consumed the soy sauce and the dose was reconstructed. The duration of exposure was 2-3 weeks in most cases. At the LOAEL, individuals experienced facial edema and gastrointestinal symptoms including nausea, diarrhea, and vomiting. This was considered the critical effect in the derivation of the LOAEL. The estimated acute dose of 0.03 mg/kg-day is approaching the LOAEL value of 0.05 mg/kg-day. Based on the assumption of 60% Relative Bioavailability for arsenic in soil (EPA 2012), the estimated dose from pica behavior is 0.02 mg/kg/day, which is about 2.5 times lower than the LOAEL. The adjusted estimated dose approaches the level at which a significant increase in facial edema and gastrointestinal symptoms was observed in humans in the scientific literature (i.e., Lowest Observed Adverse Effect Level). This indicates that acute exposures to arsenic could result in mild to moderate health effects (e.g., gastrointestinal symptoms such as nausea, abdominal pain, and/or vomiting) in young children if they exhibit pica behavior at the site. However, as noted, previously, the probability of pica exposure to tailings and waste rock appears low at this site.

The estimated acute pica exposure dose to copper in surface soil is 0.2 mg/kg-day and the ATSDR acute health-based guideline is 0.01 mg/kg-day. Therefore, the estimated dose is approximately 20 times higher than the acute MRL for copper. The basis of the MRL derivation is a 1999 study conducted by Pizarro et al. in which a group of 60 healthy women were split into 4 groups that were exposed to graded levels of copper sulfate in drinking water over a two-week period (Pizarro et al., 1999). Twenty-one of the women reported gastrointestinal symptoms, predominantly nausea and abdominal pain. There was a significant difference in the incidence of gastrointestinal symptoms at doses of 0.0272 mg/kg-day versus 0.0731 mg/kg-day. In the derivation of the acute MRL, ATSDR used 0.0272 mg/kg-day as the NOAEL value and 0.0731 mg/kg-day as the LOAEL. In comparison to the estimated acute doses in this evaluation, the estimated dose for pica ingestion exceeds both the NOAEL and LOAEL values. This indicates that acute exposures to copper in the tailings and waste rock piles at the millsite could result in mild to moderate health effects (e.g., gastrointestinal symptoms such as nausea and abdominal pain) in young children if they exhibit pica behavior at the site. However, as noted, previously, the probability of pica exposure to surface and mixed soils appears low at this site. Additionally, there is some uncertainty associated with the bioavailability of copper from soil (vs. copper in drinking water in the critical study).

Table 7. Acute Health Hazards for Children Exhibiting Pica Behavior

Approach	Contaminant of Concern	Estimated Acute Exposure Dose (in mg/kg-day)	Acute Minimal Risk Level (in mg/kg-day)	No Observed Adverse Effect Level (in mg/kg-day)	Lowest Observed Adverse Effect Level (in mg/kg-day)
Surface Soil	Arsenic	0.03	0.005	NA	0.05
	Copper	0.2	0.01	0.027	0.073
Mixed Soil	Arsenic	0.023	0.005	NA	0.05
	Copper	0.2	0.01	0.027	0.073

NOTE: mg/kg-day = milligrams per kilogram per day. Based on the assumption of 60% Relative Bioavailability for arsenic in soil (EPA 2012), the estimated dose from pica behavior is 0.02 mg/kg/day

Acute Health Risk Evaluation from Exposures to Mixed Soil

Overall, the potential for health risks from acute exposure to mixed soil are consistent with the health risks from acute exposure to surface soil. The results of acute health risk evaluation from exposure to mixed soil are shown in Table 7. The estimated exposure dose for 1-day, acute exposure to arsenic in mixed soil is 0.023 mg/kg-day. Thus, the estimated acute dose is approximately 5 times higher than the acute health-based guideline for arsenic. Based on the assumption of 60% Relative Bioavailability for arsenic in soil (EPA 2012), the estimated acute dose of arsenic in mixed soil is 0.014 mg/kg/day, which is about 4 times lower than the LOAEL. However, the adjusted estimated dose of arsenic is still approaching the level at which a significant increase in facial edema and gastrointestinal symptoms was observed in humans in the scientific literature (i.e., Lowest Observed Adverse Effect Level). This indicates that acute exposures to arsenic in mixed soil could result in mild to moderate health effects (e.g., gastrointestinal symptoms such as nausea, abdominal pain, and/or vomiting) in young children if they exhibit pica behavior at the site.

The estimated acute pica exposure dose to copper is 0.2 mg/kg-day and the ATSDR acute health-based guideline is 0.01 mg/kg-day. Therefore, the estimated dose is approximately 20 times higher than the acute MRL for copper. In comparison to the estimated acute dose of copper in mixed soil, the dose exceeds both the NOAEL and LOAEL values. This indicates that acute exposures to copper in mixed soil at the Millsite could result in mild to moderate health effects (e.g., gastrointestinal symptoms such as nausea and abdominal pain) in young children if they exhibit pica behavior at the site.

Uncertainty/Limitations

In general, the uncertainties associated with any risk-based health consultation are likely to over- or underestimate environmental exposures and the associated health hazards because all aspects of the exposure are typically unknown. This section of the discussion is not intended to be an in-depth description of all the uncertainties associated with this evaluation. Rather, the focus is to highlight the major assumptions and limitations that are specific to this evaluation and result in uncertainty.

- The mill tailings and waste rock at the Millsite have eroded into Henson Creek over the years. A stability assessment of the mill tailings and waste rock piles was conducted by the Colorado Division of Reclamation, Mining, and Safety in the fall of 2011 (CDRMS 2011). The results of the stability analyses demonstrate that slope failure is likely under extreme loading events such as an earthquake or rapid drawdown of contained water, and that the slopes are only marginally stable in their existing, static conditions. A catastrophic failure of the tailings or waste rock would severely impact the water quality in Henson Creek, which is a cold water fishery. However, the potential health effects associated with a catastrophic failure of the mill tailings and waste rock cannot be determined at this time due to the limited amount of information that can be ascertained regarding future natural events such as avalanches, flooding, and earthquakes.

- There is some uncertainty associated with human error introduced by sampling because the spatial distribution of the sampling points may not be representative of where most people will visit the site. In addition, there is only one surface soil sample and a limited, but adequate, number of mixed soil samples that have been collected from this area. The health risk estimates based on the surface soil sample are consistent with the estimated risk based on the mixed surface and subsurface soil. Either approach results in potential for health hazards. However, it is still possible that the estimated health risks found in this evaluation could be higher or lower than actual exposures if the soil sampling data are not representative of the soil concentration that people are exposed to.

- There are no land-use data to support the exposure frequency and/or exposure duration assumptions used in this assessment meaning that the assumptions used in this evaluation may over- or under-estimate health risks. This is a major source of uncertainty because these assumptions are vital components of the exposure dose calculations and the resulting public health implications of exposure to site-related contamination. However, based on the current knowledge of future land-use, health protective and conservative assumptions were made to evaluate the future potential health risks.

- Site-specific chromium speciation has not been conducted at the Ute-Ulay Millsite. Therefore, the species of chromium was conservatively assumed to be all Cr (VI). This assumption is likely to overestimate cancer risk for chromium because it is unlikely that all chromium at the site is Cr (VI).

- The assumption of additive risk in the estimation of cumulative cancer and non-cancer risks could over- or under-estimate risk due to possible synergistic and antagonistic chemical interactions.

- Without site-specific data, there is some uncertainty about how well the risk estimates predicted by lead modeling using default parameters reflect the true conditions at a site. For example, lead risks may be over- or underestimated based on the unavailable site-specific relative bioavailability of lead from soil. However, there is an underestimation of risk for lead based on the use of 5 μg /dL of blood lead level as a reference value in light of the recent evidence that there is no "safe" level of lead in the body.

- The overall cancer and non-cancer risks from ingestion pathway are likely overestimated because of the assumption of 100% metal bioavailability. Based on what is known of the reduced bioavailability of metals in soils, 100% is a conservative assumption (biased high). For example, EPA has recently recommended a default value of 60% Relative Bioavailability for arsenic in soil (EPA 2012).

Child Health Considerations

In communities faced with air, water, or food contamination, the many physical differences between children and adults demand special emphasis. Children could be at greater risk than are adults from certain kinds of exposure to hazardous substances. Children play outdoors and sometimes engage in hand-to-mouth behaviors that increase their exposure potential. Children are shorter than are adults; this means they breathe dust, soil, and vapors close to the ground. A child's lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Finally, children are dependent on adults for access to housing, for access to medical care, and for risk identification. Thus adults need as much information as possible to make informed decisions regarding their children's health.

Child recreational users were included in this evaluation because they are most representative of the young children that are likely to be at the Ute-Ulay Millsite tailings and waste rock site. Lead was the primary contaminant of concern for children using the site for recreational purposes. The IEUBK modeling indicates that exposure to lead could harm the health of young children (0-84 months) during recreational use of the site. In addition, the evaluation found that exposure to lead could harm the fetuses of pregnant women using the site for recreational and occupational purposes. Exposure to all other surface soil contaminants of potential concern (other than lead) that were identified in this evaluation is not expected to harm the health of young children. Thus, it is recommended that exposure to lead in the mill tailings and waste rock be reduced to protect children and the fetuses of pregnant women using the site for recreational and occupational purposes.

It should be noted that it was assumed in this evaluation that young children (0-7 yrs.) will not be living at the hostel based on personal communication gathered from the CDPHE Project Manager. Based on the lead modeling results for other receptors in this evaluation, the levels of lead found at this site could be harmful to young children if they were living at the site. If children are living at the hostel in the future, it is recommended that CCPEHA be contacted to evaluate this exposure scenario.

In addition, the results of the acute (1-day) exposure evaluation also indicate a potential health concern from exposure to arsenic and copper for children exhibiting pica behavior at the site. For arsenic, the estimated acute dose from pica ingestion approaches the level at which a significant increase in facial edema and gastrointestinal symptoms were observed in humans in the scientific literature (i.e., Lowest Observed Adverse Effect Level). For copper, the estimated acute dose is greater than the NOAEL and the LOAEL values cited in the critical study in which a significant increase was reported in the incidence of gastrointestinal symptoms in women at the LOAEL. This indicates that acute exposures to arsenic and copper in soil at the millsite could result in mild to moderate health effects (e.g., gastrointestinal symptoms such as nausea, abdominal pain and/or vomiting) in young children if they exhibit pica behavior at the site. However, as noted, previously, the probability of pica exposure to tailings and waste rock appears low at this site. Additionally, there is some uncertainty associated with the bioavailability of copper from soil (vs. copper in drinking water in the critical study).

Conclusions

CCPEHA and ATSDR have reached four conclusions regarding future exposures to current surface soil and mixed (surface and subsurface) soil after redevelopment at the Ute-Ulay Millsite:

Exposure to lead in surface soil and mixed soil at the Ute-Ulay Millsite during recreational use could harm the health of children (age 0-7 years) and the fetuses of pregnant women. This conclusion was reached because the results of the Integrated Exposure Uptake and Biokinetic (IEUBK) and the Adult Lead Model (ALM) models predicted blood lead levels above CDC’s reference blood lead level for more than 5% of young children and pregnant women. For surface soil, the predicted geometric mean blood lead level during recreational use by children is 3.7 μg/dL with an estimated 26.7% of all children having blood lead levels greater than 5 μg/dL. In addition, the ALM estimated that 7.1% of fetal blood lead levels of pregnant women using the site for recreational purposes would have blood lead levels greater than CDC’s reference level of 5 μg/dL with an estimated geometric mean fetal blood lead level of 2.1 μg/dL.

For mixed soil, the predicted geometric mean blood lead level during recreational use by children is 3.8 μg/dL with an estimated 28.1% of all children having blood lead levels greater than 5 μg/dL. In addition, the ALM estimated that 7.5% of fetal blood lead levels of pregnant women using the site for recreational purposes would have blood lead levels greater than CDC's reference level of 5 μg/dL with an estimated geometric mean fetal blood lead level of 2.1 μg/dL. The outputs for surface and mixed (surface and subsurface) soils are above CDC's target for lead.

Exposure to lead in surface soil and mixed soil at the Ute-Ulay Millsite could harm the health of the fetuses of pregnant hostel workers. This conclusion was reached because the ALM predicted >5% probability of fetal blood lead levels of pregnant hostel workers that are well above CDC's reference blood lead level of 5 μg/dL. For surface soil, the ALM predicted a geometric mean blood lead concentration in fetuses of 6.6 μg/dL and that 52.8% of all pregnant female hostel workers would have fetal blood lead concentrations greater than 5 μg/dL. For mixed soil, the ALM predicted >5% probability of fetal blood lead levels of pregnant hostel workers that are well above CDC's reference blood lead level. Specifically, the ALM predicted a geometric mean blood lead concentration in fetuses of 7.0μg/dL and that 56.6% of all pregnant female hostel workers would have fetal blood lead concentrations greater than 5 μg/dL.

It should be noted that it was assumed in this evaluation that young children (0-7 yrs.) will not be living at the hostel based on personal communication gathered from the CDPHE Project Manager (Personal Communication, Mark Rudolph, CDPHE, HMWMD). If there were young children living at the site, the levels of lead found in soil site could be harmful to them if exposed on a regular basis. Please see the recommendations section for more information on this issue.

Acute exposure to copper and arsenic in surface soil and mixed soil could harm the health of young children who exhibit pica behavior at the site. This conclusion was reached because the estimated acute dose for pica ingestion of copper in surface soil exceeds known harmful health effect levels published in the scientific literature. For surface soil, the estimated acute dose of copper for children exhibiting pica behavior is nearly three times higher than the levels at which the human exposure group in the critical study reported a significant increase in gastrointestinal symptoms. For arsenic, the estimated acute dose for young children is over six times higher than the acute health-based guideline for arsenic. In addition, the estimated acute dose of arsenic approaches the level at which mild to moderate health effects were observed in humans in the scientific literature (i.e., Lowest Observed Adverse Effect Level). The human exposure group in the critical study for arsenic reported a significant increase in facial edema and gastrointestinal symptoms.

For mixed soil, the estimated acute dose of copper for children exhibiting pica behavior is just over two times the levels at which the human exposure group in the critical study reported a significant increase in gastrointestinal symptoms. For arsenic, the estimated acute dose for young children is nearly five times higher than the acute health-based guideline for arsenic. This estimated dose also approaches the level at which mild to moderate health effects were observed in humans in the scientific literature (i.e., Lowest Observed Adverse Effect Level).

These results indicate that acute exposures to copper and arsenic in either surface soil or mixed soil could result in mild to moderate health effects (e.g., gastrointestinal symptoms such as nausea, abdominal pain, and/or vomiting) in children that exhibit pica behavior. However, it should be noted that pica behavior appears unlikely to occur because children are not expected to be unsupervised due to the remote and mountainous nature of this site. Additionally, there is some uncertainty associated with the bioavailability of copper from soil (vs. copper in drinking water in the critical study).

Chronic exposure to metal contaminants other than lead in surface soil and mixed soil at the Ute-Ulay Millsite is not expected to harm the health of young children and adults during recreational activities or hostels workers. This conclusion was reached because the estimated non-cancer health hazards and estimated cancer risks for both receptor populations considered in this evaluation are associated with a low increased risk of developing cancer and non-cancer health effects from exposure to non-lead metal contaminants in surface soil as well as mixed soil.

Recommendations

The following recommendations have been made to the Hazardous Material and Waste Management Division of CDPHE in order to protect the health of recreational users and hostel workers at the Ute-Ulay Millsite:

- Reduce exposure to lead to protect the health of the young children (0-7 years or 0-84 months) using the site for recreational purposes.

- Reduce exposure to lead to protect the health of fetuses of pregnant women using the site for recreational purposes, and to protect the fetuses of pregnant hostel workers.

- To achieve CDPHE’s long-term cancer risk target level, reduce exposure to arsenic in accordance with CDPHE risk management guidance for arsenic in soil.

- Ensure that the future drinking water supply that is necessary for the site post-redevelopment has not been impacted by the mine site in a way that would threaten public health.

- Reduce or eliminate children’s acute exposure (1-day) to arsenic- and copper-contaminated surface soils by using appropriate reduction methods: restricting access to highly contaminated areas; reducing or eliminating soil intrusive activities; washing hands and face prior to eating or drinking; cleaning shoes to reduce the amount of soil being tracked into the car and house; and supervising children to prevent pica behavior

- Ensure that hostel workers are non-residential (i.e., not using the hostel as their primary residence); especially, ensure that children are not staying onsite with their worker parents. Upon reclamation and remediation of the exposure units in the near future, metals concentrations can/will be re-evaluated to potentially include year –round hostel workers or commercial workers and be reevaluated from a public health perspective.

- Grade and stabilize mill tailings and waste rock piles to reduce the potential for a catastrophic failure of the mill tailings and waste rock piles.

- Upon reclamation and remediation of the exposure units in the future, re-evaluate metals concentrations for potential health hazards, to include year–round hostel workers or commercial workers.

The following recommendations have been made for recreational users and hostel workers at the Ute-Ulay Mill site to reduce their risk of elevated blood lead levels:

- While onsite, refrain from hand-to-mouth activities such as eating, smoking, drinking, etc. Particularly, keep young children from eating soil onsite.

- Wash hands, and remove and wash potentially contaminated clothing (boots, pants, etc.).

- Examine other potential sources of lead in the home, particularly those homes built prior to 1978.

Public Health Action Plan

The public health action plan for the site contains a description of actions that have been or will be taken by CCPEHA and other governmental agencies at the site. The purpose of the public health action plan is to ensure that this public health consultation both identifies public health hazards and provides a plan of action designed to mitigate and prevent harmful human health effects resulting from breathing, drinking, eating, or touching hazardous substances in the environment. Included is a commitment on the part of CCPEHA to follow up on this plan to be sure that it is implemented.

Public health actions that will be implemented include:

- Providing a copy of health consultation to stakeholders;

- Providing additional health education by distributing health education material such as fact sheets and responding to any questions via phone, meetings, or emails, etc. as requested or necessary; and

- Reviewing any additional soil data collected and updating the health consultation report on the Ute-Ulay Millsite as requested. This action item is particularly relevant for recreational use and hostel worker exposures to lead.

Report Preparation

This Health Consultation for the Ute-Ulay Millsite (Mill Tailings and Waste Rock) was prepared by the Colorado Department of Public Health and Environment under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry. It is in accordance with approved agency methodology and the procedures existing at the time the health consultation was initiated. Editorial review was completed by the cooperative agreement partner. The Agency for Toxic Substances and Disease Registry has reviewed this health consultation and concurs with its findings based on the information presented in this report. ATSDR's approval of this document has been captured in an electronic database, and the approving reviewers are listed below.

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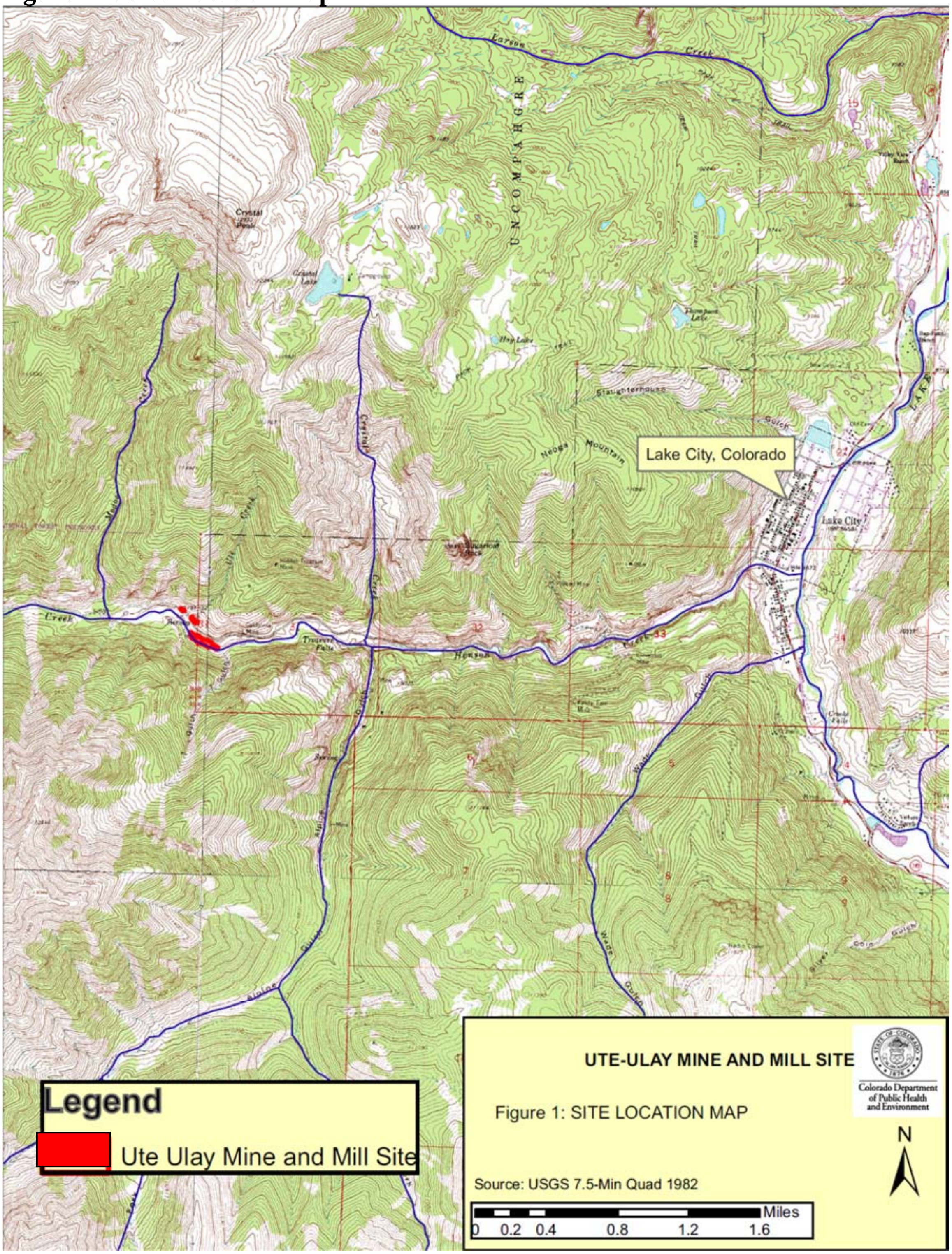
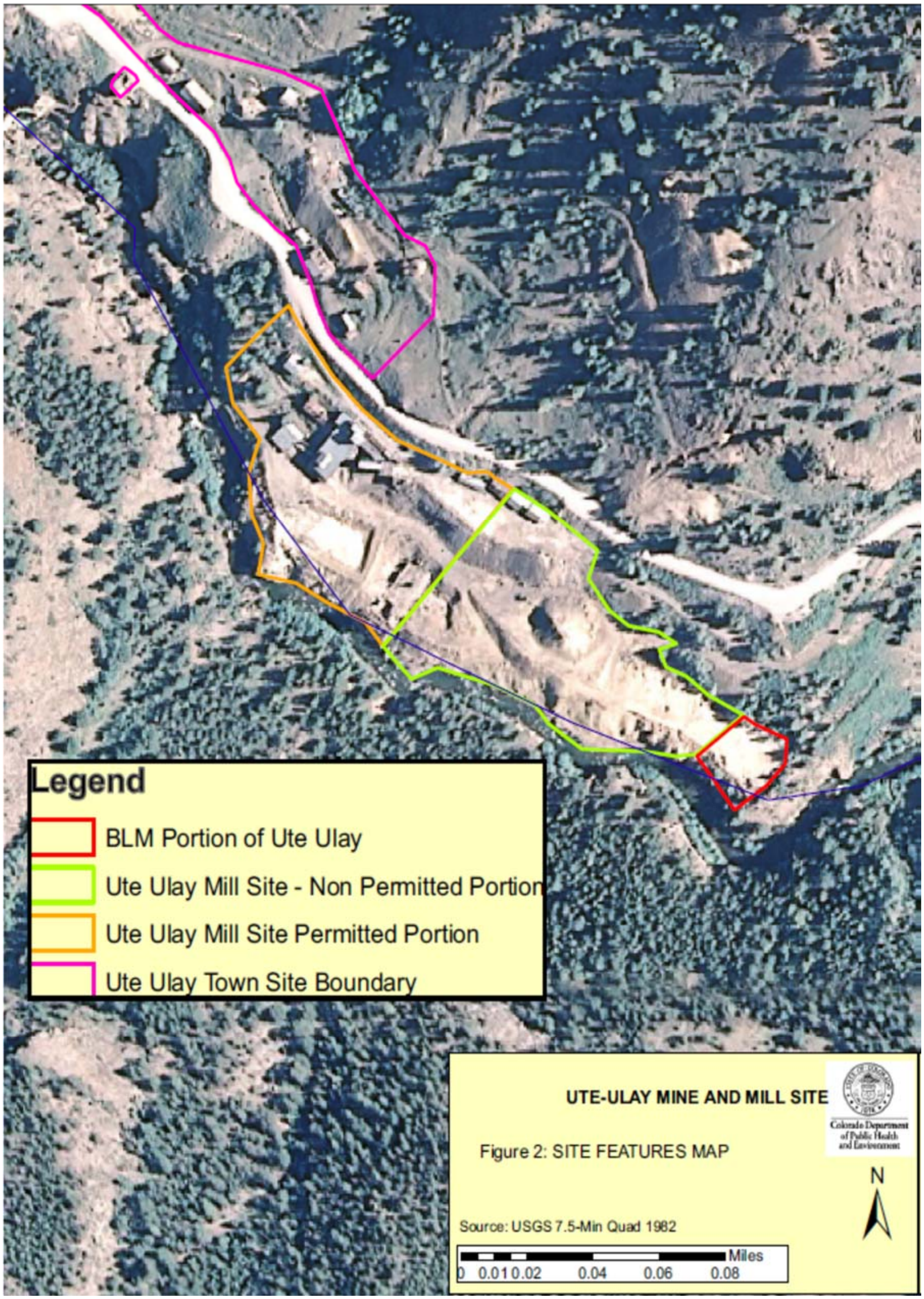
APPENDIX A. Figures and Additional Tables

Figure A1. Site Location Map



SOURCE: CDPHE 2012b

Figure A2. Site Features of the Ute-Ulay Mine and Mill Complex



SOURCE: CDPHE 2012b

Figure A3. Soil Sampling Locations

SOURCE: CDPHE 2012b

Table A1. Analytical Results of Soil Samples Collected from Mill Tailings and Waste Rock

Metals		Soil Sample Results (in mg/kg)								
		UU-1			UU-2				UU-3	
	Average Concentration of All Samples at All Depths	UU-1A	UU-1B	UU-1C	UU-2A	UU-2B	UU-2C	UU-2D	UU-3A	UU-3C
Compound		1"-24"	24"-48"	48"-90"	0"-24"	24"-72"	72"-96"	100"-108"	60"-80"	180"-204"
Aluminum	4,319	4,780	5,160	1,630	1,400	4,240	8,430	5,270	6,630	--
Arsenic *	60.2	55.2	57.6	92.2	65.6	34.1	39.6	52.8	52.1	91.1
Cadmium	22.7	9.5	10.2	8.0	4.5	13.4	28.8	3.9	73.4	2.8
Chromium	NA	2.4 U	2.7 U	2.5 U	2.4 U	2.2 U	2.4 U	2.4 U	3.1	--
Copper	464	614	601	93.1	92.1	712	283	318	827	310
Iron	13,443	12,100	12,500	12,400	14,600	6,870	14,800	19,200	17,500	--
Lead	5,197	9,020	6,350	2,200	1,760	2,220	1,490	4,100	4,120	3,530
Magnesium	NA	392	408	96.1	120	435	1,790	3,990	1,560	--
Manganese	3,390	5,460	6,490	5,760	1,080	1,440	5,290	4,470	4,340	1,570
Nickel	NA	2.4 U	2.7 U	2.5 U	2.4 U	2.2 U	4.40	2.4 U	5.60	--
Selenium	NA	7.1 U	8.1 U	7.5 U	7.1 U	6.7 U	7.3 U	7.3 U	6.1 U	--
Silver	15.8	16.4	5.9	11.4	17.4	6.0	5.0	14.5	23.2	--
Zinc	3,267	2,510	2,940	1,560	850	951	2,510	942	906	553
Mercury	0.219	0.054	0.110	0.049 U	0.047 U	0.045	0.051 U	0.200	0.890	--
Cyanide	10.5	--	--	0.4	--	--	--	--	--	--

Table A1 (Continued). Analytical Results of Soil Samples Collected from Mill Tailings and Waste Rock

Metals		Soil Samples (in mg/kg)							
Compound	Average Concentration of All Samples at All Depths	UU-4			UU-5			UU-6	
		UU-4A	UU-4B	UU-4C	UU-5A	UU-5B	UU-5C	UU-6A	UU-6B
		0"-4"	4"-58"	58"-80"	0"-52"	52"-82"	82"-99"	0"-49"	49"-112"
Aluminum	4,319	5,000	6,390	660	4,710	2,660	3,530	3,740	4,880
Arsenic *	60.2	94.5	31.7	38.8	69.1	87.4	47.9	66.6	77.3
Cadmium	22.7	8.7	7.9	20.4	20.3	42.4	21.8	42.1	47.8
Chromium	NA	2.4 U	2.9	2.1 U	10.7	5.2	2.1 U	2.1	2.7
Copper	464	482	224	151	964	970	212	384	494
Iron	13,443	17,600	13,000	6,220	13,200	18,200	10,900	12,000	14,000
Lead	5,197	4,730	3,010	4,070	5,550	9,830	7,330	7,700	9,670
Magnesium	NA	2,740	2,050	111	448	442	588	523	517
Manganese	3,390	4,910	3,160	6,100	79.2	579	329	1,760	3,140
Nickel	NA	2.4 U	2.30	2.1 U	2.1 U	2.3 U	2.1 U	2.40	2.90
Selenium	NA	7.1 U	6.3 U	6.4 U	6.3 U	7.0 U	6.4 U	6.1 U	1.5 U
Silver	15.8	25.8	6.8	14.6	15.5	31.9	12.2	21.4	24.6
Zinc	3,267	1,630	1,270	3,710	2,650	7,380	3,970	8,100	10,400
Mercury	0.219	0.260	0.240	0.056	0.110	0.270	0.250	0.300	0.570
Cyanide	10.5	--	--	--	--	--	--	--	20.5

TABLE A1 NOTES:
mg/kg = milligram per kilogram
"--" - Not Tested or Not Applicable
U - Not detected at the reported value.

Table A2. Mill Tailings and Waste Rock Data Summary Statistics (all depths)

Analyte	Minimum (in mg/kg)	Mean (in mg/kg)	Median (in mg/kg)	Maximum (in mg/kg)	Detection Frequency
Aluminum	660	4,319	4,745	8,430	16/16
Arsenic	31.7	60.2	56.4	94.5	16/16
Cadmium	3.9	22.7	16.8	73.4	16/16
Chromium	ND	4.4	3.0	10.7	6/16
Copper	92.1	464	433	970	16/16
Cyanide	0.4	NA	NA	20.2	2/2
Iron	6,220	13,443	13,100	19,200	16/16
Lead	1,490	5,197	4,425	9,830	16/16
Magnesium	96.1	1,013	482	3,990	16/16
Manganese	79.2	3,399	3750	6,490	16/16
Mercury	ND	0.258	0.240	0.890	13/16
Nickel	ND	3.5	2.9	5.6	5/16
Selenium	ND	ND	ND	ND	0/16
Silver	5.0	15.8	15.0	31.9	16/16
Zinc	850	3,267	2,510	10,400	16/16

NOTE: mg/kg = milligram per kilogram, ND = Not Detected above reporting limit, NA = Not applicable

Table A3. Screening and Selection of Contaminants of Potential Concern

Analyte	Maximum Detected Concentration (in mg/kg)	ATSDR Comparison Value (in mg/kg)	Source of ATSDR CV	EPA Regional Screening Level (in mg/kg)	Basis of RSL	Selected as COPC	Samples that Exceed the Screening Value
Aluminum	8,430	**50,000**	cEMEG	77,000	non-cancer		
Arsenic	94.5	0.47	CREG	**0.39**	cancer	X	All
Cadmium	73.4	**5**	cEMEG	70	non-cancer	X	All
Chromium	10.7	50 (as Cr VI)	cEMEG	**0.29** (as Cr VI)	cancer	X	All
Copper	970	**500**	iEMEG	3,100	non-cancer	X	1,2,3,5
Cyanide	20.5	**30**	RMEG	47	non-cancer		
Iron	19,200	NA	--	**55,000**	non-cancer		
Lead	9,830	NA	--	**400**	non-cancer	X	All
Manganese	3,990	2,500	RMEG	**1,800**	non-cancer	X	1,2,3,4,6
Magnesium	6,490	NA	--	NA			
Mercury	0.890	NA	--	**10**	non-cancer		
Nickel	58.6	**1,000**	RMEG	1,500	non-cancer		
Selenium	ND	**250**	cEMEG	390	non-cancer		
Silver	31.9	**250**	RMEG	390	non-cancer		
Zinc	10,400	**15,000**	cEMEG	23,000	non-cancer		

NOTE: mg/kg = milligram per kilogram, COPC = Contaminant of Potential Concern, ND = Not Detected above reporting limit, NA = Not available, cEMEG = Chronic Environmental Media Evaluation Guide (child), CREG = Cancer Risk Evaluation Guide, iEMEG = Intermediate Environmental Media Evaluation Guide (child), RMEG = Reference Dose Media Evaluation Guide

Table A4. Estimated Surface Soil (UU-4A) Non-Cancer Hazard Quotients for Hostel Workers and for Recreational Use by Children and Adults

COPC	Estimated Non-Cancer Hazard Quotient for Children during Recreational Use	Estimated Non-Cancer Hazard Quotient for Adults during Recreational Use	Estimated Non-Cancer Hazard Quotient for Adult Hostel Workers
Arsenic	1.4E-01	1.5E-02	1.7E-01
Cadmium	3.8E-02	4.1E-03	4.8E-02
Chromium	1.1E-03	1.1E-04	1.3E-03
Copper	2.1E-02	2.3E-03	2.6E-02
Manganese	9.2E-02	9.6E-03	1.1E-01
Hazard Index	2.9E-01	3.1E-02	3.6E-01

NOTE: Hazard Quotients are equal to the estimated non-cancer exposure dose (shown in Table B3) divided by the Health-based guideline (shown in Appendix D). Values bolded in red indicate that the estimated doses exceed the health-based guideline. Hazard Index is equal to the sum of all hazard quotients.

Table A5. Estimated Surface Soil Cancer Risks for Hostel Workers and for Recreational use by Children and Adults

COPC	Estimated Cancer Risk for Children during Recreational Use	Estimated Cancer Risk for Adults during Recreational Use	Lifetime Estimated Cancer Risk for Recreational Users	Estimated Cancer Risk for Adult Hostel Workers
Arsenic	5.40E-06	2.25E-06	7.65E-06	2.70E-05
Chromium	4.50E-08	1.95E-08	6.50E-08	2.35E-07
Total Cancer Risk	5.45E-06	2.27E-06	7.72E-06	2.72E-05

NOTE: Cancer risks are equal to the estimated cancer exposure dose (shown in Table B4) multiplied by the Oral Cancer Slope Factor (shown in Appendix D). Total cancer risk is equal to the sum of all cancer risks. Lifetime cancer risks include exposure as a child and as an adult.

APPENDIX B. Additional Exposure Assessment Information

This section provides additional information on the exposure assumptions and exposure doses that were used to evaluate the public health implications of surface soil exposures at the Ute-Ulay Millsite.

The two primary exposure pathways that are likely to occur in the future and were evaluated in this health consultation:

- Short term Recreational Users, and
- Hostel Workers

The recreational use exposure scenario evaluated in this health consultation is evaluated for future timeframes of exposure. The Hostel Worker exposure scenario is likely to occur in the future after the restoration and redevelopment of the Ute-Ulay Townsite. The primary exposure parameters that were used to evaluate each scenario are shown in detail below.

Exposure Parameters

The following exposure parameters were used to describe recreational users and hostel workers.

Table B1. Site-Specific and Default Exposure Factors

Receptor	Recreational User	Source of Exposure Factor	Hostel Worker	Source of Exposure Factor
Exposure Frequency (days/year)	12 days	Site-specific Professional Judgment	140 days	Site-specific Professional Judgment
Exposure Duration (years)	Child: 6 yrs. Adult: 24 yrs.	RME Default Value (EPA 1997)	25 yr.	Site-specific Professional Judgment
Soil Ingestion Rate (mg/day)	Child: 200 mg/day Adult: 100 mg/day	Default Value (EPA 2002)	100 mg/day	Default Value (EPA 2002)
Body Weight (kg)	Child: 15 kg. Adult: 70 kg.	Default Value (PHAGM 2005)	70 kg.	Default Value (PHAGM 2005)
Non-Cancer Averaging Time (days)	Child: 2,190 days Adult: 10,950 days	Default Value (PHAGM 2005)	9125 days	Default Value (PHAGM 2005)
Cancer Averaging Time (days)	25,550 days	Default Value (EPA 1997)	25,550 days	Default Value (EPA 1997)

kg. = kilogram, mg. = milligram, RME: Reasonable Maximum Exposure
EPA (1997) = Environmental Protection Agency, Exposure Factors Handbook

EPA (2002) = Environmental Protection Agency, Supplemental Guidance for Developing Soil Screening Levels at Superfund Sites
EPA (2004) = Environmental Protection Agency, Risk Assessment Guidance for Superfund, Part E. Supplemental Guidance for Dermal Exposure, PHAGM (2005) = Agency for Toxic Substances and Disease Registry, Public Health Assessment Guidance Manual

Exposure Point Concentrations

The exposure concentrations used in this evaluation for surface soil are presented below in Table B2.

Table B2. Exposure Point Concentrations for Surface Soil

Contaminant of Potential Concern	Detected Concentration in Sample UU-4A (in mg/kg)
Arsenic	94.5
Cadmium	8.7
Chromium	2.4U
Copper	482
Lead	4,730
Manganese	4,910

NOTE: mg/kg = milligram per kilogram, U = Undetected

Exposure Dose Equations and Results

Ingestion Pathway

Using Equation 1, the non-cancer exposure doses for soil ingestion were calculated for all non-lead surface soil contaminants of concern. Equation 1 applies to soil ingestion for recreational users and hostel workers. The estimated exposure doses for incidental ingestion of surface soil during recreational use are shown below in Table B3 and the estimated exposure doses for incidental ingestion of surface soil while working at the hostel are shown in Table B3.

Equation 1. Non-Cancer Soil Ingestion Dose

Non-Cancer Dose = (C_s * IRS * CF * EF * ED) / (BW * AT_{NC})

Where:
C_s = Chemical Concentration in Soil (in mg/kg or milligrams contaminant per kilogram of soil) Soil exposure point concentrations are found in Table A6
IRS = Ingestion Rate of Soil (in milligrams of soil per day)
FI = Fraction of soil ingested from contaminated source
CF = Conversion Factor (in kilograms per milligram)
EF = Exposure Frequency (in days per year)
ED = Exposure Duration (in years)
BW = Body Weight (in kilograms)
AT_{NC} = Non-Cancer Averaging Time (in days)

Example: Non-cancer Adult Recreational User ingestion dose of Arsenic (Table B3) =>
(94.5 mg/kg * 100 mg/day * 10^{-6} kg/mg * 12 days per year * 30 years) / (70 kg. * 10,950 days)
= **4.4 * 10^{-6} (4.4E-06) mg/kg-day**

Table B3. Estimated Surface Soil (UU-4A) Dose Results for Non-Carcinogenic Health Effects

COPC	Estimated Non-Cancer Dose for Recreational Children (in mg/kg-day)	Estimated Non-Cancer Dose for Recreational Adults (in mg/kg-day)	Estimated Non-Cancer Dose for Adult Hostel Workers (in mg/kg-day)
Arsenic	4.1E-05	4.4E-06	5.2E-05
Cadmium	3.8E-06	4.1E-07	4.8E-06
Chromium	1.1E-06	1.1E-07	1.3E-06
Copper	2.1E-04	2.3E-05	2.6E-04
Manganese	2.2E-03	2.3E-04	2.7E-03

NOTE: mg/kg-day = milligram per kilogram a day**,** COPC: Contaminant of Potential Concern, 3.0E-05 is equivalent to 3.0* 10^{-5}or 0.00003mg/kg-day

The equation used to calculate the exposure dose for cancer risks is similar to the non-cancer exposure dose equation shown above. The primary difference between the two is that non-cancer exposure doses are averaged over the time period of exposure and cancer exposures are averaged over a lifetime (70 years). As mentioned previously, it was assumed that the chromium detected in surface soil is hexavalent chromium because site-specific speciation of the chromium valence state has not been performed. Therefore, the conservative assumption that chromium in site soils is hexavalent was made to be prudent of public health. In reality, it is more likely that the majority of chromium found onsite is trivalent chromium, which is not classified as a human carcinogen. Equation 2 was used to calculate surface soil ingestion doses for all receptors in this evaluation.

Equation 2. Cancer Soil Ingestion Dose

Cancer Dose = (C_s * CF * IRS * FI * EF * ED) / (BW * AT_C)

Where:
C_s = Chemical Concentration in Soil (in mg/kg or milligrams contaminant per kilogram of soil)
CF = Conversion Factor (in kilograms per milligram)
IRS = Soil Ingestion Rate (in milligrams of soil-year per kilogram body weight)
EF = Exposure Frequency (in days per year)
FI = Fraction ingested from contaminated source
ED = Exposure Duration (in years)
AT_C = Cancer Averaging Time (in days)

Example: Theoretical Cancer Dose of Chromium for the Child Recreational User (Table B4) =>
(2.4 mg/kg * 10^{-6} kg/mg * 200 mg/day * 12 days/year * 6 years) / (15kg. * 25,550 days)
= 9.0 * 10^{-8} mg/kg/day

The resulting carcinogenic exposure doses from incidental ingestion of soil are shown below in Tables B4.

Table B4. Estimated Surface Soil (UU-4A) Dose Results for Carcinogenic Health Risks

COPC	Estimated Cancer Dose for Recreational Children (in mg/kg-day)	Estimated Cancer Dose for Recreational Adults (in mg/kg-day)	Estimated Lifetime Cancer Dose for Recreational Users (in mg/kg-day)	Estimated Non-Cancer Dose for Adult Hostel Workers (in mg/kg-day)
Arsenic	3.6E-06	1.5E-06	5.1E-06	1.8E-05
Chromium	9.0E-08	3.9E-08	1.3E-07	4.7E-07

NOTE: Lifetime Cancer Doses include exposure as a child (6 years) and as an adult (24 years) over a period of 30 years.

Acute Health Risk Evaluation of Surface Soil Exposure

Acute health risks from exposure to arsenic were also evaluated for children experiencing pica-behavior. Pica is an eating condition that includes an abnormal craving to eat nonfood items, such as dirt, paint chips, and clay. Children that exhibit pica behavior consume large amounts of soil in a given period. For this evaluation, it was assumed that children would consume 5,000 mg of soil per day. This is in comparison to the default assumption of 200 mg. of soil per day. Acute health risks are evaluated in same general fashion as chronic risks, with slight adjustments including only one day of exposure and the comparison with health-based guidelines derived for acute exposure. The exposure parameters used in the acute dose calculation are shown below in Table B5. Equation 3, shown below is the method used to calculate acute exposures over a period of one day.

Table B5. Acute Exposure Factors

Receptor	**Tourists/Visitors**	**Source of Exposure Factor**
Exposure Frequency (days/year)	1 day	Site-specific Professional Judgment
Pica Soil Ingestion Rate (mg/day)	Child: 5,000 mg/day	Default Value (ATSDR 2001)
Body Weight (kg)	Child: 15 kg.	Default Value (PHAGM 2005)

kg. = kilogram, mg. = milligram, EPA (1997) = Environmental Protection Agency, Exposure Factors Handbook; PHAGM (2005) = Agency for Toxic Substances and Disease Registry, Public Health Assessment Guidance Manual; ATSDR (2001) = Agency for Toxic Substances and Disease Registry, Summary report for the ATSDR soil-pica workshop

Equation 3. Acute Non-cancer Soil Ingestion Dose

Non-Cancer Dose = (C_s * IR * CF * EF * ED) / (BW * AT_{NC})

Where:
C_s = Chemical Concentration in Soil (in mg/kg or milligrams contaminant per kilogram of soil) Soil exposure point concentrations are found in Table A6
IRP = Ingestion Rate of Soil (in milligrams of soil per day)
CF = Conversion Factor (in kilograms per milligram)
EF = Exposure Frequency (in days per year)
BW = Body Weight (in kilograms)

Example: Acute Pica Non-cancer ingestion dose of Arsenic, Table 6 in main text =>
(94.5 mg/kg * 5,000 mg/day * 10^{-6} kg/mg * 1 day per year) / (15 kg.) = **0.03 mg/kg-day**

APPENDIX C. Evaluation of Non-cancer Health Hazards Associated with Lead Exposure

Lead is naturally occurring element found at low levels in soils. At mining sites, lead is typically released either directly by targeting and removing lead from the mine, or indirectly through acid mine drainage, which has a low pH capable of releasing metals from their naturally bound state. Thus, lead is a common contaminant found at mining sites throughout the state.

Exposure Assessment

Lead exposure can occur via multiple pathways (air inhalation and ingestion of water, food, soil, and dust). Therefore, exposure to lead is assessed based on total exposure through all pathways rather than site-specific exposures. However, a primary human exposure pathway to lead is through ingestion of soil and dust. Current knowledge of lead pharmacokinetics indicates that risk values derived by standard procedures would not truly indicate the potential risk, because of the difficulty in accounting for pre-existing body burdens of lead. Lead bioaccumulates in the body, primarily in the skeleton. Lead body burdens vary markedly with age, health status, nutritional state, maternal body burden during gestation and lactation, etc. For this reason, and because of the continued apparent lack of threshold, it is still inappropriate to develop reference values for lead (CDC, 2004: http://www.cdc.gov/nceh/lead/spotLights/changeBLL.htm, EPA IRIS 2004). Therefore, estimation of exposure and risk from lead in soil also requires assumptions about the level of lead in other media, and also requires use of pharmacokinetic parameters and assumptions that are not needed traditionally. Thus, EPA has adopted a method that entails modeling total lead exposure (uptake/biokinetic) by incorporating input data on the levels of lead in soil, dust, water, air, and diet from multiple sources in addition to site soils. These models are discussed in later sections.

Lead has particularly profound effects in children, well before the usual term of chronic exposure can take place (EPA 2004). Children under 7 years old have a high risk of exposure because of their more frequent hand-to-mouth behavior and they absorb more lead than adults (CDC 1991). Pregnant women and women of child bearing age should also be aware of lead in their environment because lead ingested by a mother can affect the fetus. Thus, the population of most concern is young children for residential and recreational use, and pregnant women for nonresidential use (e.g., occupational and recreational).

Health Effects /Blood Lead Levels of Concern

Health effects of lead are well known from studies of children. It is important to note that estimated risks of lead exposure in this document are not based on theoretical calculations and are not extrapolated from data on lab animals or high-dose occupational exposures. Rather, health risks of exposure to lead are determined using predictive biokinetic modeling. Lead affects virtually every organ and system in the body and exhibits a broad range of health effects. The most sensitive among these are the central nervous system, hematological, and cardiovascular systems, and the kidney. However, it is particularly harmful to the developing brain and nervous system of fetuses and young children (CDC, 1991, ATSDR, 2007). It should be noted that many health effects of lead may occur without overt signs of toxicity, i.e. most poisoned children have no symptoms. Extremely high levels of lead in children (BLL of 380 μg/dL) can cause coma, convulsions, and even death. Lower levels of blood lead cause effects on the central nervous system, kidney, and hematopoietic system. Blood lead levels which do not cause distinct symptoms, are associated with decreased intelligence and impaired neurobehavioral development (CDC, 1991). A growing body of research has shown that there are measurable adverse neurological effects in children at blood lead concentrations as low as 1 μg/dL (EPA, 2003a). EPA believes that effects may occur at blood levels so low that there is essentially no threshold or "safe" level of lead (EPA IRIS, 2004). Although the concentration of lead in blood is an important indicator of risk, it reflects only current exposures. Lead is also accumulated in bone. Recent research suggests that lead concentrations in bone may be related to adverse health effects in children.

Recently, EPA developed candidate lead dust hazard standards (i.e. the amount of lead dust present on floors and window sills) aimed at providing various levels of protection for sensitive populations using blood lead concentration as a marker of adverse health effects (EPA 2011b). Blood lead concentrations of 1.0, 2.5, and 5.0 micrograms per deciliter were selected to protect children against IQ deficits in both residences and public and commercial buildings. It is however, important to note that in order to protect children against IQ deficits in both residences and public and commercial buildings, EPA's Science Advisory Board (SAB) Lead Review Panel recently recommended target blood lead concentrations of 1.0 and 2.5 micrograms per deciliter for dust lead hazard standard rulemaking (EPA, 2011b). The SAB does not support the high target blood lead concentration of 5 micrograms per deciliter due to recent studies indicating adverse health effects in children with blood lead concentrations well below 10 micrograms per deciliter (EPA 2011b).

Lead is classified as a probable human carcinogen by the EPA based on sufficient evidence of carcinogenicity in animals and inadequate evidence in humans. However, no toxicity value has been derived for cancer effects and EPA has determined that non-cancer effects discussed above provide a more sensitive endpoint than cancer effects to assess health risks from exposure to lead.

CDC New 2012 Reference Value for Lead

Until recently, the U.S. Centers for Disease Control and Prevention (CDC) had established a level of concern for case management of 10 micrograms lead per deciliter of lead blood (μg/dL) (CDC 2005). Recent scientific research, however, has clearly shown that blood lead levels below 10 μg/dL can cause serious harmful effects in children. Blood lead levels below 10 μg/dL have been shown to cause neurological, behavioral, immunological, and developmental effects in young children. Specifically, lead causes or is associated with decreases in intelligent quotient (IQ); attention deficit hyperactivity disorder (ADHD); deficits in reaction time; problems with visual-motor integration and fine motor skills; withdrawn behavior; lack of concentration; issues with sociability; decreased height; and delays in puberty, such as breast and pubic hair development, and delays in menarche (CDC 2011; CDC 2012a; CDC 2012b). On January 4, 2012, CDC's Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP) recommended that CDC adopt the 97.5 percentile for children 1 to 5 years old as the reference value for designating elevated blood lead levels in children. The 97.5% currently is 5 µg/dL (CDC 2012a). On June 7, 2012, the CDC released a statement indicating concurrence with the recommendations of the ACCLPP (CDC 2012b).

Health Risk Assessment

Health risks of exposure to lead are determined using predictive modeling. EPA uses two predictive lead models for risk assessment purposes: the Integrated Exposure Uptake Biokinetic (IEUBK) model for children up to the age of 7 years or 0- 84 months (EPA, 2002), and the adult lead model (ALM) (EPA 2003b) for adolescents and adults for assessing nonresidential exposures. The ALM model is designed for nonresidential exposures to lead such as female workers and recreationalists. The model is thought to be protective of the fetus, which the EPA considers the most sensitive health endpoint for adults. Whether lead risk is deemed acceptable or unacceptable is determined by comparing the predicted BLLs with target BLLs of 10 µg/dL (for fetuses and young children), established by the CDC (1991). The EPA has set a goal that there should be no more than a 5% chance that a typical (or hypothetical) child or group of similarly exposed children will exceed a blood lead value of 10 µg/dL. This approach focuses on the risk to a child at the upper bound of the distribution (i.e., 95^{th} percentile).

The IEUBK Model for Young Children (Age 0-7 years or 0-84 months) as recreational users with Parents

The IEUBK model is designed to estimate the percentage of children that could have elevated blood lead levels as a result of exposure to lead in soil. The model calculates the expected distribution of blood lead and estimates the probability that any random child might have a blood lead value over 10 µg/dL. For example, using a combination of default parameters for the IEUBK model and using EPA's soil lead screening concentration of 400 mg/kg, the model estimates children have a 4.5% risk of exceeding 10 µg/dL. Stated another way, if 100 children lived on properties with an average of 400 mg/kg lead in soil, the IEUBK model will predict that four or fewer children out of 100 will exceed old CDC's 10 µg/dL, a blood lead level that corresponds to the EPA current residential lead screening level in soil. In this evaluation, the blood lead level of 10 µg/dL has been modified to 5 µg/dL in the IEUBK model to be consistent with the new 2012 CDC reference value noted above.

As shown in Table C1, Blood lead levels were estimated for children exposed for 12 days/year to the weighted soil lead concentrations and the background levels of lead at home (default assumption of 200 ppm).

The ALM Model for Outdoor Adults

In accordance with ATSDR guidelines, the EPA's Adult Lead Model (ALM) is used to estimate the blood lead level in fetuses from the predicted blood lead level of the pregnant mother. The evaluation of susceptible subpopulations to lead exposure, such as the fetus, is also considered protective of the general population. Therefore, if the blood lead concentration predicted in the fetus is not a concern at the site, exposures to lead by other recreational users is also not of concern.

It is important to note that the ALM relies on many input parameters to estimate blood lead levels. The EPA developed default values for all parameters to allow the model to be used without performing costly and time-consuming site-specific studies. Several of these parameters can be measured more accurately and precisely on a site-specific basis. In the absence of site-specific data, this evaluation used the default values. These default values could result in an over- or under estimation of the actual blood lead levels in any fetus. When possible, the exposure parameters such as frequency, duration, and incidental ingestion of soil are the same values used in the non-lead evaluation. The Technical Review Workgroup (TRW) for lead recommends that 12 days (weekly exposure over a period of three months) should be the minimum exposure frequency used in the ALM (EPA OSWER #9285.7-76). All exposure parameters used for this model and risk evaluation are shown below in Tables C1 to C3. Please note that the blood lead level of 10 μg/dL has been modified to 5 μg/dL in the ALM model in this evaluation to be consistent with the new CDC reference value noted above.

Uncertainty in Risks Predicted by the IEUBK and ALM Lead Model

Reliable estimates of exposure and risk using the IEUBK and ALM models depend on site-specific information for a number of key parameters, including lead concentration in outdoor soil (fine fraction) and indoor dust, soil ingestion rate, individual variability in child blood lead concentrations Geometric Standard Deviation (GSD) and the rate and extent of lead absorption from soil. Therefore, uncertainties are discussed qualitatively here. For example, lead risks may be over- or underestimated based on the unavailable site-specific relative bioavailability of lead from soil. In assessing risks from lead exposure, EPA assumes 60% relative bioavailability of lead in soils, which is a measure of the difference in absorption between different forms of chemical or between different dosing vehicles (e.g., lead in water, or soil). However, in the absence of site-specific data, it is prudent to use the default bioavailability assumption in order to ensure public health protection. In summary, without site-specific data, there will be uncertainty about how well the risk estimates predicted by computer modeling based on the default parameters reflect the true conditions at a site.

In addition, it is important to keep in mind that evidence is growing that there are measurable adverse neurological effects in children at blood lead concentrations as low as 1 μg/dL (EPA, 2003a). This suggests that the target blood lead level of 5 μg/dL in fetuses and young children for the IEUBK model and ALM model may result in underestimation of lead hazards.

Table C1. IEUBK Time Weighted Soil Concentration

Lead Exposure Point Concentration (in mg/kg)	Exposure Frequency (in days)	Averaging Time (in days)	Time Weighted Average Lead Concentration (in mg/kg)
4,730	12	365	349

NOTE: mg/kg = milligram per kilogram
Time Weighted Concentration Calculation:
Frequency of time spent at the site (F_{site}) = 12 days/365 days = 0.033
Frequency of time spent at home (F_{home}) = 1-0.033 = 0.967
Lead site = 0.033 x 4,730 = 156 ppm
Lead home = 0.967 x 200 ppm (default) = 193 ppm
Lead site weighted (PbS_w) = 156 + 193 = 349 ppm

Table C2. Recreational Child IEUBK Input Parameters

Exposure variable	EPA Default Value
Groundwater concentration (C_{gw})	4.0 µg/L
Soil to Dust Ingestion Weighting Factor (percent soil)	45% (0.45)
Geometric standard deviation (GSD) or interindividual variability	1.6
Soil Concentration (ppm)	Site-specific Time-Weighted (Table C1)
Concentration of Lead in Outdoor Air	0.1 µg/m^3
FDA dietary parameters	1.95 – 2.26 µg/day (age dependent)

NOTE: µg/L = micrograms lead per liter of water, ppm = parts per million, µg/m^3 = micrograms lead per cubic meter of air, µg/day = micrograms of lead from dietary ingestion per day

Table C3. Recreational Adult and Hostel Worker Adult Lead Model Inputs

Description of Exposure Variable	Input Value	Units
Soil lead concentration	4,730	mg/kg
Fetal/maternal Blood Lead ratio	0.9	Unitless
Biokinetic Slope Factor	0.4	µg/dL per µg/day
Geometric standard deviation Blood Lead	2.1	--
Baseline Blood Lead	1.5	µg/dL
Soil ingestion rate (including soil-derived indoor dust)	0.050	g/day
Absorption fraction (same for soil and dust)	0.12	Unitless
Exposure frequency (same for soil and dust)	Recreational Adult: 12 Hostel Worker: 140	days/yr
Averaging time (same for soil and dust)	365 (default)	days/yr

NOTE: mg/kg = milligram per kilogram, µg/dL = micrograms per deciliter, µg/day = micrograms per day, g/day = grams per day, yr = year

APPENDIX D. Toxicological Evaluation

The basic objective of a toxicological evaluation is to identify what adverse health effects a chemical causes, and how the appearance of these adverse effects depends on dose. The toxic effects of a chemical also depend on the route of exposure (oral, inhalation, dermal), the duration of exposure (acute, subchronic, chronic or lifetime), the health condition of the person, the nutritional status of the person, and the life style and family traits of the person.

The U.S. Environmental Protection Agency (EPA) and the Agency for Toxic Substances and Disease (ATSDR) have established oral reference doses (RfD) and minimal risk levels (MRL) for non-cancer effects. An RfD is the daily dose in humans (with uncertainty spanning perhaps an order of magnitude), including sensitive subpopulations, that is likely to be without an appreciable risk of non-cancer adverse health effects during a lifetime of exposure to a particular contaminated substance. An MRL is the dose of a compound that is an estimate of daily human exposure that is likely to be without an appreciable risk of adverse non-cancer effects of a specified duration of exposure. The acute, intermediate, and chronic MRLs address exposures of 14 days or less, 14 days to 364 days, and 1-year to lifetime, respectively. The health-based guidelines for the contaminants of potential concern for this evaluation are listed below.

The toxicity assessment process is usually divided into two parts: the first characterizes and quantifies the cancer effects of the chemical, while the second addresses the non-cancer effects of the chemical. This two-part approach is employed because there are typically major differences in the risk assessment methods used to assess cancer and non-cancer effects. For example, cancer risks are expressed as a probability of suffering an adverse effect (cancer) during a lifetime and non-cancer hazards are expressed, semi-quantitatively, in terms of the hazard quotient (HQ), defined as the ratio between an individual's estimated exposure and the health guideline (MRL or RfD). HQs are not an estimate of the likelihood that an effect will occur, but rather an indication of whether there is potential cause for concern for adverse health effects.

Please note inhalation health guideline for arsenic was derived California EPA from studies of arsenic in drinking water and decreases in intellectual function in 10 year old children. Performance results from neurobehavioral testing and exposure to arsenic in drinking water were extrapolated to inhalation exposures. Performance results from neurobehavioral testing and exposure to arsenic in drinking water were extrapolated to inhalation exposures.

Methodology for in-depth evaluation of potential for noncancer health Effects

The estimated non-cancer exposure doses are compared with observed effect levels reported in the **critical toxicological and/or epidemiologic study** used to derive the health guideline in ATSDR Toxicological Profile and/or EPA Integrated Risk Information System (IRIS) database. In addition, the larger toxicological/epidemiological database is also evaluated, especially for critical chemicals with high concentrations in all media in order to gain a better understanding of the range of effect levels rather than focusing on a single dose level, which is used to derive the health guideline.

- When the estimated dose is well below a No-Observed-Adverse-Effect- Level (NOAEL) that is based on a human study, the likelihood of adverse health effects is considered low (i.e., *not expected to cause harm to people's health*). However, when a NOAEL is based on an animal study, the estimated doses near the NOAEL could be of concern because of uncertainty in the relative sensitivity of animals as compared to humans. In the absence of contrary information, it is prudent to assume that humans are more sensitive to the chemicals of potential concern than are animals (ATSDR Public Health Assessment Guidance Manual 2005).

- When the estimated dose approaches or exceeds a Lowest-Observed -Adverse-Effect-Level (LOAEL), it is considered that it could *harm people's health* for longer term exposures, but evaluated for "urgent public health hazard for acute exposures based on other factors listed below.

The relevance of the critical study is carefully evaluated in relation to site-specific exposure conditions by taking into consideration the following factors:

- Animal or human study (adults or children)
- Relevance of effects observed in animals to humans
- High bolus dose or low /medium dose levels, dose regimens, and method of dosing
- Bioavailability of metals (arsenic, lead, copper) in the study matrix versus the environmental media evaluated (e.g., soil and water)
- Level of confidence in the critical study and uncertainties/limitations in supporting studies

For cancer effects, the toxicity assessment process has two components. The first is a qualitative evaluation of the weight of evidence that the chemical does or does not cause cancer in humans. Typically, this evaluation is performed by the EPA, using the system summarized in the table below:

Table D1. Cancer Classifications

Category	Meaning	Description
A	Known human carcinogen	Sufficient evidence of cancer in humans.
B1	Probable human carcinogen	Suggestive evidence of cancer incidence in humans.
B2	Probable human carcinogen	Sufficient evidence of cancer in animals, but lack of data or insufficient data from humans.
C	Possible human carcinogen	Suggestive evidence of carcinogenicity in animals.
D	Cannot be evaluated	No evidence or inadequate evidence of cancer in animals or humans.

For chemicals which are classified in Group A, B1, B2, or C, the second part of the toxicity assessment is to describe the carcinogenic potency of the chemical. This is done by quantifying how the number of cancers observed in exposed animals or humans increases as the dose increases. Typically, it is assumed that the dose response curve for cancer has no threshold, arising from the origin and increasing linearly until high doses are reached. Thus, the most convenient descriptor of cancer potency is the slope of the dose-response curve at low dose (where the slope is still linear). This is referred to as the Slope Factor (SF), which has dimensions of risk of cancer per unit dose. Conversely, the inhalation unit risk (IUR) is defined as the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 $\mu g/m^3$ in air.

Estimating the cancer SF and/or IUR is often complicated by the fact that observable increases in cancer incidence usually occur only at relatively high doses, frequently in the part of the dose-response curve that is no longer linear. Thus, it is necessary to use mathematical models to extrapolate from the observed high dose data to the desired (but unmeasurable) slope at low dose. In order to account for the uncertainty in this extrapolation process, EPA typically chooses to employ the upper 95th confidence limit of the slope as the Slope Factor. That is, there is a 95% probability that the true cancer potency is lower than the value chosen for the Slope Factor. This approach ensures that there is a margin of safety in cancer risk estimates.

Table D2. Non-cancer Toxicity Value Table

Analyte	ATSDR Oral MRL (in mg/kg-day)	Source	EPA Oral Reference Dose (in mg/kg-day)	Source
Aluminum	1.0	Chronic	1.0	PPRTV
Arsenic	0.0003	Chronic	0.0003	IRIS
Cadmium	0.0001	Chronic	0.001	IRIS (diet)
Chromium (hexavalent)	0.001	Chronic	0.003	IRIS (VI)
Copper	0.01	Acute & Int.	0.04	HEAST
Iron	NA		0.7	PPRTV
Lead	NA		NA	
Magnesium	NA		NA	
Manganese	NA		0.024	IRIS (modified)
Mercury	NA		0.0003	IRIS (HgCl2)
Nickel	NA		0.02	IRIS (soluble salts)
Selenium	0.005	Chronic	0.005	IRIS
Silver	NA		0.005	IRIS
Zinc	0.3	Chronic	0.3	IRIS

NOTE: Highlighted values were selected for use in this assessment, ATSDR = Agency for Toxic Substances and Disease Registry, MRL = Minimal Risk Level, IRIS = EPA Integrated Risk Information System, PPRTV = EPA Provisional Peer Reviewed Toxicity Value, Cal EPA OEHHA = California Office of Environmental Health Hazard Assessment, HEAST = Health Effects Assessment Summary Tables

Table D3. Cancer Toxicity Guideline Values

Analyte	EPA Oral Slope Factor (in mg/kg-day^{-1})	Source
Arsenic	1.5	IRIS
Chromium (hexavalent)	0.5	New Jersey

NOTE: IRIS = EPA Integrated Risk Information System, PPRTV = EPA Provisional Peer Reviewed Toxicity Value, OEHHA = California Office of Environmental Health Hazard Assessment, New Jersey Department of Health and Senior Services

APPENDIX E. Estimated Health Risks of Exposure to Mixed Surface and Subsurface Soil

This scenario includes the assumption of exposure to site-related contamination in mixed surface and subsurface soil. Currently, the site plans call for the stabilization and removal of tailings and waste rock, which was determined to be unstable. This work will require substantial dirt movement and grading. Thus, surface and subsurface soil will be mixed up during this process. This assumption, quite possibly, best reflects contaminant concentrations that are likely to be present after stabilization and re-grading of the tailings and waste rock piles for the future land-use. During the stabilization and grading work, surface and subsurface soils will be mixed and the concentrations of contaminants found in surface and subsurface samples could be present at the surface where people will be exposed. The exposure point concentrations used for this approach were calculated using EPA's ProUCL statistical software and are shown below in Table E1. All other exposure factors remained the same (Appendix B). The estimated exposure doses to mixed soils and the resulting health hazards are shown in Tables E2-E9.

Table E1. Exposure Point Concentration Results

Contaminant of Potential Concern	ProUCL Recommended EPC (in mg/kg)	Statistical Basis of Calculated EPC
Arsenic	69	95% Student's-t UCL
Cadmium	33.7	95% Approximate Gamma UCL
Chromium	4	95% KM (t) UCL
Copper	593	95% Student's-t UCL
Manganese	4,379	95% Student's-t UCL

NOTE: EPCs were calculated with EPA ProUCL Version 4.1.00, EPC: Exposure Point Concentration, UCL = Upper Confidence Limit
** As per EPA IEUBK and ALM Guidance, the mean value of lead was used as the model inputs (EPA 2007)

Table E2. Estimated Dose Results for Non-Carcinogenic Health Effects

COPC	Estimated Non-Cancer Dose for Recreational Children (in mg/kg-day)	Estimated Non-Cancer Dose for Recreational Adults (in mg/kg-day)	Estimated Non-Cancer Dose for Adult Hostel Workers (in mg/kg-day)
Arsenic	3.0E-05	3.2E-06	3.8E-05
Cadmium	1.5E-05	1.6E-06	1.8E-05
Chromium	1.8E-06	1.9E-07	2.2E-06
Copper	2.6E-04	2.8E-05	3.2E-04
Manganese	1.9E-03	2.1E-04	2.4E-03

NOTE: mg/kg-day = milligram per kilogram a day, COPC: Contaminant of Potential Concern, 3.0E-05 is equivalent to $3.0 * 10^{-5}$or 0.00003mg/kg-day

Table E3. Estimated Non-Cancer Hazard Quotients for Hostel Workers and for Recreational Use by Children and Adults

COPC	Estimated Non-Cancer Hazard Quotient for Children During Recreational Use	Estimated Non-Cancer Hazard Quotient for Adults During Recreational Use	Estimated Non-Cancer Hazard Quotient for Adult Hostel Workers
Arsenic	1.0E-01	1.1E-02	1.3E-01
Cadmium	1.5E-01	1.6E-02	1.8E-01
Chromium	1.8E-03	1.9E-04	2.2E-03
Copper	6.5E-03	7.0E-04	8.1E-03
Manganese	8.0E-02	8.6E-03	1.0E-01
Hazard Index	2.6E-01	2.8E-02	3.2E-01

NOTE: Hazard Quotients are equal to the estimated non-cancer exposure dose (shown in Table B3) divided by the Health-based guideline (shown in D). Values bolded in red indicate that the estimated doses exceed the health-based guideline. Hazard Index is equal to the sum of all hazard quotients.

Table E4. Estimated Dose Results for Carcinogenic Health Risks

COPC	Estimated Cancer Dose for Recreational Children (in mg/kg-day)	Estimated Cancer Dose for Recreational Adults (in mg/kg-day)	Estimated Lifetime Cancer Dose for Recreational Users (in mg/kg-day)	Estimated Non-Cancer Dose for Adult Hostel Workers (in mg/kg-day)
Arsenic	2.59E-06	1.11E-06	3.70E-06	1.35E-05
Chromium	1.50E-07	6.44E-08	2.15E-07	7.83E-07

NOTE: Lifetime Cancer Doses include exposure as a child (6 years) and as an adult (24 years).

Table E5. Estimated Cancer Risks for Hostel Workers and for Recreational Use by Children and Adults

COPC	Estimated Cancer Risk for Children During Recreational Use	Estimated Cancer Risk for Adults During Recreational Use	Lifetime Estimated Cancer Risk for Recreational Users	Estimated Cancer Risk for Adult Hostel Workers
Arsenic	3.89E-06	1.67E-06	5.56E-06	2.03E-05
Chromium	7.51E-08	3.22E-08	1.07E-07	3.91E-07
Total Cancer Risk	3.96E-06	1.70E-06	5.66E-06	2.06E-05

NOTE: Cancer risks are equal to the estimated cancer exposure dose (shown in Table B4) multiplied by the Oral Cancer Slope Factor (shown in Appendix D). Total cancer risk is equal to the sum of all cancer risks. Lifetime cancer risks include exposure as a child and as an adult.

Table E6. IEUBK Model Results for Recreational Use by Children

Time Weighted Site Soil Lead Concentration (in mg/kg)	Age Group (Months)	Geometric Mean Blood Lead Concentration of Recreational Children (µg/dL)	Percent of Recreational Child Population with a Predicted Blood Lead Level Greater than 5 µg/dL
365	0-84	3.8	28.1

NOTE: mg/kg = milligram lead per kilogram soil, µg/dL = micrograms lead per deciliter of blood
EPA has set a goal that there should be no more than a 5% chance that a typical (or hypothetical) child or group of similarly exposed children will exceed a reference blood lead value.

Table E7. Adult Lead Model Results for Recreational Use by Pregnant Women

Soil Lead Concentration (in mg/kg)	Geometric Mean Fetal Blood Lead Concentration (µg/dL)	Probability of Fetal Blood Lead Exceeding 5 (µg/dL)
5,197	2.1	7.5%

NOTE: mg/kg = milligram lead per kilogram soil, µg/dL = micrograms lead per deciliter of blood
EPA has set a goal that there should be no more than a 5% chance that the fetal blood levels will exceed a reference blood lead value.

Table E8. Adult Lead Model Results for Hostel Workers

Soil Lead Concentration (in mg/kg)	Geometric Mean Fetal Blood Lead Concentration (µg/dL)	Probability of Fetal Blood Lead Exceeding 5 µg/dL
5,197	7.0	56.6%

NOTE: mg/kg = milligram lead per kilogram soil, µg/dL = micrograms lead per deciliter of blood
EPA has set a goal that there should be no more than a 5% chance that the fetal blood levels will exceed a reference blood lead value.

Table E9. Acute Health Hazards for Children Exhibiting Pica Behavior

Contaminant of Concern	Estimated Acute Exposure Dose (in mg/kg-day)	Acute Minimal Risk Level (in mg/kg-day)	No Observed Adverse Effect Level (in mg/kg-day)	Lowest Observed Adverse Effect Level (in mg/kg-day)
Arsenic	0.023	0.005	NA	0.05
Copper	0.2	0.01	0.027	0.073

NOTE: mg/kg-day = milligrams per kilogram per day

APPENDIX F. Estimated Health Risks of Exposure to Soil at Each Sampling Point (FOR CDPHE RISK MANAGEMENT PURPOSES ONLY!)

To further assist risk managers and inform potential stakeholders, an analysis of the health risk associated with each sampling location was also conducted. The evaluation of health risks by sampling location was conducted using the same methods as the health consultation. This means that the exposure factors, dose calculations, and lead models used for the sample-specific evaluation are the same as those used in the site-wide evaluation. The maximum detected concentration at each sampling location was used as the exposure point concentration. The resulting doses and health risks may not be representative of the exposed population because it is unlikely that future users will spend all of their time in only one of the sampling areas. It is more likely that people will move throughout the Millsite, which is more consistent with the site-wide evaluation. Therefore, the following health risks could be overestimated and are not intended to be used as the sole basis for making conclusions regarding public health.

The estimated sample-specific non-cancer exposure doses are shown in Tables F1 (Recreational) and F3 (Hostel Workers). The resulting hazard quotients are shown in Tables F2 and F4, respectively. Tables F5-F8 show the estimated sample-specific cancer risks. Potential health risks associated with lead exposure are shown in Tables F9-F11. Health risks of potential concern are briefly noted following the tables.

Table F1.Estimated Non-cancer Doses for Recreational Use by Children and Adults

Receptor Population (By Location)	Arsenic Dose (in mg/kg-day)	Cadmium Dose (in mg/kg-day)	Chromium Dose (in mg/kg-day)	Copper Dose (in mg/kg-day)	Manganese Dose (in mg/kg-day)
Sample 1 Child	4.0E-05	4.5E-06	1.2E-06	2.7E-04	2.8E-03
Sample 1 Adult	4.3E-06	4.8E-07	1.3E-07	2.9E-05	3.0E-04
Sample 2 Child	2.9E-05	1.3E-05	1.1E-06	3.1E-04	2.3E-03
Sample 2 Adult	3.1E-06	1.4E-06	1.1E-07	3.3E-05	2.5E-04
Sample 3 Child	2.3E-05	3.2E-05	1.4E-06	3.6E-04	1.9E-03
Sample 3 Adult	2.4E-06	3.4E-06	1.5E-07	3.9E-05	2.0E-04
Sample 4 Child	4.1E-05	8.9E-06	1.3E-06	2.1E-04	2.7E-03
Sample 4 Adult	4.4E-06	9.6E-07	1.4E-07	2.3E-05	2.9E-04
Sample 5 Child	3.8E-05	1.9E-05	4.7E-06	4.3E-04	0.0E+00
Sample 5 Adult	4.1E-06	2.0E-06	5.0E-07	4.6E-05	0.0E+00
Sample 6 Child	3.4E-05	2.1E-05	1.2E-06	2.2E-04	1.4E-03
Sample 6 Adult	3.6E-06	2.2E-06	1.3E-07	2.3E-05	1.5E-04

NOTE: mg/kg-day = milligram per kilogram a day

Table F2. Estimated Non-Cancer Hazard Quotients Recreational Use Children and Adults

Receptor Population (By Location)	Arsenic	Cadmium	Chromium	Copper	Manganese	Hazard Index
Sample 1 Child	1.3E-01	4.5E-02	1.2E-03	6.7E-03	1.2E-01	1.9E-01
Sample 1 Adult	1.4E-02	4.8E-03	1.3E-04	7.2E-04	1.3E-02	2.0E-02
Sample 2 Child	9.6E-02	1.3E-01	1.1E-03	7.8E-03	9.7E-02	2.3E-01
Sample 2 Adult	1.0E-02	1.4E-02	1.1E-04	8.4E-04	1.0E-02	2.5E-02
Sample 3 Child	7.6E-02	3.2E-01	1.4E-03	9.1E-03	7.9E-02	4.1E-01
Sample 3 Adult	8.2E-03	3.4E-02	1.5E-04	9.7E-04	8.5E-03	4.4E-02
Sample 4 Child	1.4E-01	8.9E-02	1.3E-03	5.3E-03	1.1E-01	2.3E-01
Sample 4 Adult	1.5E-02	9.6E-03	1.4E-04	5.7E-04	1.2E-02	2.5E-02
Sample 5 Child	1.3E-01	1.9E-01	4.7E-03	1.1E-02	0.0E+00	3.3E-01
Sample 5 Adult	1.4E-02	2.0E-02	5.0E-04	1.1E-03	0.0E+00	3.5E-02
Sample 6 Child	1.1E-01	2.1E-01	1.2E-03	5.4E-03	5.7E-02	3.3E-01
Sample 6 Adult	1.2E-02	2.2E-02	1.3E-04	5.8E-04	6.1E-03	3.5E-02

The results of the sample-specific evaluation for recreational use does not indicate that estimated exposure doses at any sampling location exceed the health-based guidelines since the hazard quotients (HQ) shown in Table F2 are all lower than 1. The highest HQ (0.3) is from child recreational exposure to cadmium at the sample 3 location. This indicates that the estimated dose for child recreational users is approximately 3 times lower than the health-based guideline, which is below a level of concern. Furthermore, the cumulative non-cancer hazard index at all sampling locations is also below.

The following tables are sample-specific doses and HQs for hostel workers.

Table F3. Estimated Non-cancer Doses for Hostel Workers

Receptor Population (By location)	Arsenic (in mg/kg-day)	Cadmium (in mg/kg-day)	Chromium (in mg/kg-day)	Copper (in mg/kg-day)	Manganese (in mg/kg-day)
Sample 1 Adult	5.1E-05	5.6E-06	1.5E-06	3.4E-04	8.9E-04
Sample 2 Adult	3.6E-05	1.6E-05	1.3E-06	3.9E-04	2.9E-03
Sample 3 Adult	2.9E-05	4.0E-05	1.7E-06	4.5E-04	2.4E-03
Sample 4 Adult	5.2E-05	1.1E-05	1.6E-06	2.6E-04	3.3E-03
Sample 5 Adult	4.8E-05	2.3E-05	5.9E-06	5.3E-04	6.5E-05
Sample 6 Adult	4.2E-05	2.6E-05	1.5E-06	2.7E-04	1.7E-03

NOTE: mg/kg-day = milligram per kilogram a day

Table F4. Non-Cancer Hazard Quotients for Hostel Workers

Receptor	Arsenic	Cadmium	Chromium	Copper	Manganese	Hazard Index
Sample 1 Adult	1.7E-01	5.6E-02	1.5E-03	8.4E-03	3.7E-02	2.3E-01
Sample 2 Adult	1.2E-01	1.6E-01	1.3E-03	9.8E-03	1.2E-01	2.9E-01
Sample 3 Adult	9.5E-02	4.0E-01	1.7E-03	1.1E-02	9.9E-02	5.1E-01
Sample 4 Adult	1.7E-01	1.1E-01	1.6E-03	6.6E-03	1.4E-01	2.9E-01
Sample 5 Adult	1.6E-01	2.3E-01	5.9E-03	1.3E-02	2.7E-03	4.1E-01
Sample 6 Adult	1.4E-01	2.6E-01	1.5E-03	6.8E-03	7.2E-02	4.1E-01

All sample specific dose estimates for hostel workers are below the health-based guidelines. The highest HQ for hostel workers (0.4) is from exposure to cadmium at the sample 3 location. This HQ indicates that the estimated dose from cadmium while working the hostel is just over 2 times lower than the health-based guideline. Moreover, all of the cumulative hazard indices are below 1. The following tables include the results of the cancer risk evaluation for recreational users and hostel workers. The major findings are presented below the cancer risk tables.

Table F5. Estimated Cancer Doses for Recreational Use by Children and Adults

Receptor Population (By Location)	Arsenic (in mg/kg-day)	Chromium (in mg/kg-day)
Sample 1 Child	3.46E-06	1.01E-07
Sample 1 Adult	1.48E-06	4.35E-08
Sample 1 Combined	4.95E-06	1.45E-07
Sample 2 Child	2.46E-06	9.02E-08
Sample 2 Adult	1.06E-06	3.86E-08
Sample 2 Combined	3.52E-06	1.29E-07
Sample 3 Child	1.96E-06	1.16E-07
Sample 3 Adult	4.99E-08	4.99E-08
Sample 3 Combined	2.01E-06	1.66E-07
Sample 4 Child	3.55E-06	1.09E-07
Sample 4 Adult	1.52E-06	4.67E-08
Sample 4 Combined	5.07E-06	1.56E-07
Sample 5 Child	3.28E-06	4.02E-07
Sample 5 Adult	1.41E-06	1.72E-07
Sample 5 Combined	4.69E-06	5.74E-07
Sample 6 Child	2.90E-06	1.01E-07
Sample 6 Adult	1.24E-06	4.35E-08
Sample 6 Combined	4.15E-06	1.45E-07

NOTE: Combined Cancer Risks account for exposure as a child and adult (lifetime cancer risk), mg/kg-day = milligram per kilogram a day

Table F6.Estimated Cancer Risks for Recreational Use by Children and Adults

Receptor Population (By Location)	Arsenic	Chromium	Total Cancer Risks
Sample 1 Child	5.2E-06	5.1E-08	5.2E-06
Sample 1 Adult	2.2E-06	2.2E-08	2.2E-06
Sample 1 Combined	*7.4E-06*	*7.2E-08*	*7.5E-06*
Sample 2 Child	1.6E-06	1.9E-08	1.6E-06
Sample 2 Adult	2.9E-06	5.8E-08	3.0E-06
Sample 2 Combined	*4.5E-06*	*7.8E-08*	*4.6E-06*
Sample 3 Child	5.3E-06	5.4E-08	5.4E-06
Sample 3 Adult	2.3E-06	2.3E-08	2.3E-06
Sample 3 Combined	*7.6E-06*	*7.8E-08*	*7.7E-06*
Sample 4 Child	2.1E-06	8.6E-08	2.2E-06
Sample 4 Adult	4.4E-06	5.1E-08	4.4E-06
Sample 4 Combined	*6.5E-06*	*1.4E-07*	*6.6E-06*
Sample 5 Child	4.93E-06	2.01E-07	5.13E-06
Sample 5 Adult	2.11E-06	8.62E-08	2.20E-06
Sample 5 Combined	*7.04E-06*	*2.87E-07*	*7.32E-06*
Sample 6 Child	4.36E-06	5.07E-08	4.41E-06
Sample 6 Adult	1.87E-06	2.17E-08	1.89E-06
Sample 6 Combined	*6.22E-06*	*7.25E-08*	*6.30E-06*

NOTE: Combined Cancer Risks account for exposure as a child and adult (lifetime cancer risk)

All of the cancer risks estimated for recreational users based on sample-specific concentrations are within EPA's cancer risk range. The primary risk driver for the estimated cancer risks is arsenic. The highest estimated cumulative cancer risks for recreational users occur in sampling area # 3, which is of $8 * 10^{-6}$. This indicates 8 excess cancer cases might occur out of million people exposed.

Table F7. Estimated Cancer Doses for Hostel Workers

Receptor Population (By Location)	Arsenic (in mg/kg-day)	Chromium (in mg/kg-day)
Sample 1 Adult	1.80E-05	5.28E-07
Sample 2 Adult	1.28E-05	4.70E-07
Sample 3 Adult	6.07E-07	6.07E-07
Sample 4 Adult	1.85E-05	5.68E-07
Sample 5 Adult	1.71E-05	2.09E-06
Sample 6 Adult	1.51E-05	5.28E-07

NOTE: mg/kg-day = milligram per kilogram a day

Table F8. Hostel Worker Estimated Cancer Risks

Receptor Population (By Location)	Arsenic	Chromium	Total Cancer Risks
Sample 1 Adult	2.7E-05	2.6E-07	2.7E-05
Sample 2 Adult	1.9E-05	2.3E-07	1.9E-05
Sample 3 Adult	2.8E-05	2.8E-07	2.8E-05
Sample 4 Adult	2.8E-05	2.8E-07	2.8E-05
Sample 5 Adult	2.57E-05	1.05E-06	2.67E-05
Sample 6 Adult	2.27E-05	2.64E-07	2.30E-05

The estimated sample-specific cancer risks for hostel workers are within the EPA target cancer risk range of 1 to 100 in a million. The highest estimated cumulative cancer risk for hostel workers is $2.8 * 10^{-5}$, or 28 excess cancer cases per million people exposed. This value is approaching the mid-point of the target cancer risk range and does not indicates an immediate health concern.

The following tables are the lead model output results based on sampling location for recreational users and hostel workers. In general, the lead model results indicate that the lead concentrations in each sampling location could result in elevated blood lead levels in children and the fetus of pregnant women who might use the site for recreational purposes. In addition, the ALM predicted that the blood lead level in the fetus of pregnant hostel workers would also be elevated based on the latest CDC recommended blood lead level of 5 micrograms per deciliter. For all exposure scenarios the highest estimated blood lead level occurs at the Sample 5 location and the lowest estimated blood lead level occurs at the Sample 2 location. The model results for pregnant female hostile workers indicate the highest risk of elevated blood lead levels of all users followed by children and pregnant female recreational users.

Table F9. IEUBK Model Results for Recreational Use by Children

Sample 1	490	0-84	4.4	38.8
Sample 2	266	0-84	3.3	19.6
Sample 3	329	0-84	3.6	24.9
Sample 4	349	0-84	3.7	26.7
Sample 5	517	0-84	4.5	41.1
Sample 6	511	0-84	4.5	40.6

NOTE: mg/kg = milligram lead per kilogram soil, µg/dL = micrograms lead per deciliter of blood, bolded values exceed the current CDC threshold.

Table F10. Adult Lead Model Results for Recreational Adults

Exposure Unit (EU)	Soil lead Concentration (in mg/kg)	Geometric Mean Fetal Blood Lead Concentration (μg/dL)	Probability of fetal Blood Lead Exceeding 5 (μg/dL)
Sample 1	9,020	2.4	10.7%
Sample 2	2,220	1.9	5.3%
Sample 3	4,120	2.0	6.7%
Sample 4	4,730	2.1	7.1%
Sample 5	9,830	2.6	11.4%
Sample 6	9,670	2.6	11.3%

NOTE: mg/kg = milligram lead per kilogram soil, μg/dL = micrograms lead per deciliter of blood, bolded values exceed the current CDC threshold.

Table F11. Adult Lead Model Results for Hostel Workers

Exposure Unit (EU)	Soil lead Concentration (in mg/kg)	Geometric Mean Fetal Blood Lead Concentration (μg/dL)	Probability of fetal Blood Lead Exceeding 5 μg/dL
Sample 1	9,020	10.9	77.8%
Sample 2	2,220	3.9	27.2%
Sample 3	4,120	5.9	47.4%
Sample 4	4,730	6.6	52.8%
Sample 5	9,830	11.7	80.6%
Sample 6	9,670	11.6	80.1%

NOTE: mg/kg = milligram lead per kilogram soil, μg/dL = micrograms lead per deciliter of blood, bolded values exceed the current CDC threshold.

Summary of Sample-Specific Findings

Overall, the sample-specific evaluation indicates elevated blood lead levels for all exposure scenarios at all sampling locations. Potential health risks from exposure to all contaminants of concern other than lead are below a level of potential concern.