Health Consultation

Public Health Implications of Indoor
Exposure to Mixed Soil and Mine Waste
Material at the Ute-Ulay Mine and Mill Site

Ute-Ulay Mine and Mill Site, An EPA Targeted Brownfield Assessment Site

Lake City, Hinsdale County, Colorado

Prepared by the
Colorado Department of Public Health and Environment

NOVEMBER 18, 2013

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 current and future health hazards associated with exposure to environmental contamination at the Ute-Ulay Mine and Mill site in Hinsdale County, Colorado.

The Ute-Ulay Mine and Millsite is part of a historic mining camp located near Lake City in the San Juan Mountains of 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 the site parcel was primarily used for milling material from the surrounding mines. Following a period of inactivity at the site, the current owner and Hinsdale County began discussing the potential renovation and restoration of the Ute-Ulay for recreational use and historic preservation.

In 2011, a collaboration of community members, artists, poets, scientists, landscape architects, and historians has proposed a number of ideas for the future use of the site. Some of the proposed plans include transforming the historic miners' boardinghouse and cabins at the Townsite 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 that need to be evaluated for potential public health implications. Currently, only a limited number of people visit the site for short periods of time to view the historic mine structures. Following redevelopment, it is likely that people will visit the site more frequently for longer periods of time.

In the summer of 2012, the Colorado Department of Public Health and Environment (CDPHE) began a Phase II Environmental Site Assessment (CDPHE 2012) in support of the Targeted Brownfields Assessment application submitted by Hinsdale County. Due to the imminent reuse plans for the site and the increased potential for exposure after redevelopment, the Hazardous Materials and Waste Management Division of the CDPHE requested the assistance of the CCPEHA to evaluate the public health implications of future exposures to site-related metal contamination inside the mill buildings.

The “millsite” is one of three Targeted Brownfields Assessment (TBA) sites of the total 285-acre Ute-Ulay Mine and Mill complex, which also consists of the Ute-Ulay Townsite and the Ute-Ulay Mill Tailings and Waste Rock site. Additional site assessment and health consultation activities have also taken place across the street from the millsite at the “Townsite” portion of the Ute-Ulay under a separate TBA (ATSDR 2013). Site assessment activities have also been conducted at the Mill Tailings and Waste Rock portion of the site, which will be the focus of a future health consultation.

The millsite is currently developed with a mill building, a power generation building, and the Assayer Office. The mill was a 100 ton per day concentration mill consisting of a number of crushers, rollers, sizers, and settling tanks. A mixture of soil and waste material from mining and milling operations is scattered throughout the millsite buildings. For the purpose of this health consultation, this mixed soil and waste material is considered soil.

The purpose of this health consultation is to identify any potential public health hazards associated with future exposure to site-related metal contamination found in mixed soil and waste material inside the millsite buildings. The evaluation is based on what is currently known about the proposed future land-use of the site. In addition, recommendations will be made to protect public health and inform stakeholders. In this evaluation, child and adult tourists/visitors (short-term recreational users) and adult hostel workers were used as the representative future exposure scenarios that are likely to occur. Estimated exposure to lead in surface soil, waste rock, and graded ore was identified as the primary contaminant of potential concern.

Overview

CCPEHA and ATSDR have reached four conclusions regarding exposure to site-related contamination at the Ute-Ulay Mine and Mill site.

Conclusion 1

Exposure to lead in soil at the Ute-Ulay Mine and Mill site could harm the health of child (age 0-7 years) and pregnant women visiting the site for tourism/recreational purposes.

Basis for Decision

This conclusion was reached because the results of the Integrated Exposure Uptake Biokinetic (IEUBK) model and the EPA Adult

Lead Model (ALM) predicted elevated blood lead levels in young children and pregnant women following exposure to lead while visiting the Ute-Ulay millsite. The results of the IEUBK model predicted blood lead levels in young children that are well above CDC's reference blood lead level. CDC's new reference blood lead level is 5µg/dL for children and the fetus of pregnant women. The EPA has currently 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 level. Thus, if the lead models predict that more than 5% of exposed children and the fetus of pregnant women have estimated blood levels greater than 5 µg/dL, it is expected to harm the health of young children. The predicted geometric mean blood lead level for children is 4.1µg/dL with an estimated 33% of all children having blood lead levels greater than or equal to 5 µg/dL. For pregnant woman visiting the site, the ALM predicted that exposure to lead in soil could result in a geometric mean fetal blood lead concentration of 2.3 µg/dL and that 9.0% of these women would have fetal blood lead concentrations greater than 5 µg/dL.

Conclusion 2

Exposure to lead in soil at the Ute-Ulay Mill site could harm the fetus of pregnant hostel workers.

Basis for Decision

This conclusion was reached because the ALM predicted elevated blood lead levels in the fetus of pregnant hostel workers following exposure to lead in soil. Specifically, the ALM predicted a geometric mean blood lead concentration in the fetus of 8.8 µg/dL with 68.5% of all pregnant hostel workers having fetal blood lead concentrations greater than 5µg/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 the information gathered from the CDPHE Project Manager. The levels of lead found at this site could be harmful to young children that are exposed on a regular basis while living there. Please see the recommendations section for more information on this issue.

Conclusion 3

Acute (1-day) and long- term chronic exposures to copper in soil at the Ute-Ulay Mine and Mill site could harm the health of children visiting the site and hostel workers.

Basis for Decision

This conclusion was reached because the estimated doses for children visiting the site and hostel workers exceed the LOAELs for copper identified in the critical studies used by ATSDR to establish the acute and intermediate non-cancer health-based guidelines for copper. Specifically, the estimated dose of copper for children is 0.12 mg/kg-day and 0.15 mg/kg-day for hostel workers, which is well above the human intermediate and acute LOAELs of 0.091 and 0.0731 mg/kg-day, respectively. Exposure at these levels could cause less serious gastrointestinal health effects in humans (e.g., nausea and vomiting). It is, however, important to note that these conclusions regarding exposure to copper at the site are associated with some uncertainty because the exposure point concentration is biased high due to the concentration of copper in one location (sample #3), which is not technically considered a true soil sample because the sample contains a mixture of waste material and soil. This composite sample was collected from a drum and bag of material labeled copper sulfate as well as the soil surrounding the drum and bag. It should be noted regarding the evaluation for copper, that the conclusions are based on intermediate and acute LOAEL due to the unavailability of the chronic NOAEL and LOAEL for copper. This indicates that short-term exposures could occur above the acute and intermediate LOAELs.

Conclusion 4

Acute exposure (1-day) to arsenic in mixed soil and waste material at the Ute-Ulay Mine and Mill site could harm the health of child visitors (recreational users).

Basis for Decision

This conclusion was reached because the estimated dose of 0.04 mg/kg-day (even using the relative soil bioavailability of 60%) is just below the LOAEL of 0.05mg/kg-day for less serious health effects, but is well above the acute Minimal Risk Level of 0.005 mg/kg-day. This indicates that young children (2-3 years of age) who are most likely to exhibit pica behavior have the possibility of experiencing less serious acute health effects (e.g., gastrointestinal symptoms including nausea, diarrhea, and vomiting) from acute exposure (1-day) to arsenic in soil. It should, however, be noted that the millsite is located in mountainous terrain. It is also unlikely that young children would be allowed to roam freely in the millsite building because of the physical hazards present. Therefore, a pica scenario may not be very likely to actually occur.

Next Steps

Based on the results of this evaluation, the following recommendations have been made in regard to future redevelopment at the Ute-Ulay Mine and Mill Site. To be protective of public health, the Hazardous Materials and Waste Management Division of CDPHE should address the following:

- Exposure to lead should be reduced to protect the health of tourists, visitors, pregnant hostel workers, and hostel workers that could become pregnant.
- Exposure to copper should be reduced to protect the health of child visitors and hostel workers.
- Ensure that the future drinking water supply 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. If the proposed land-use were to change in the future to include year-round hostel workers or commercial workers, the site should be reevaluated from a public health perspective.

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 Dr. Raj Goyal at 303-692-2634.

Purpose

The purpose of this health consultation is to evaluate the potential public health implications of exposure to mining related metal contaminated mixture of soil and waste material inside the Ute-Ulay Mine and Millsite ("millsite") in southwestern Colorado based on what is currently known about the future land-use at the site, and to make recommendations 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 1). The Ute and Ulay mines were claimed in 1871 following the Brunot Treaty, which ceded the San Juan Mountains from the Ute Indians to the United States (CAW 2011). The first significant 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 contained approximately 60% lead, 13-15 ounces of silver and 0.05 to 0.06 ounces of gold per ton. 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.

A drop in metal prices ceased production at the Ute-Ulay in the early 1900's. Claims to the property changed hands numerous 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 primarily for milling purposes. 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 Ute-Ulay Mine and Mill 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 (DIRT) 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. 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. 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). In support of the TBA, a Phase II Environmental Site Assessment (ESA) was conducted at the millsite by the CDPHE Hazardous Materials and Waste Management Division (HMWMD) in the summer of 2012 to characterize site-related contamination inside the buildings at the millsite. The millsite occupies approximately 2-acres of the total 285-acre complex.

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 found in mining and milling waste that remains inside the buildings at the millsite.

Site Description

The Ute-Ulay Mine and Mill Complex consists of the Ute-Ulay Private Mine and Mill Area, the BLM Mine/Mill Area, and the Upper Tailings Impoundments Area. The area under consideration in this evaluation ("millsite") is a portion of a Private Mine and Mill Area. The site is located in the San Juan Mountains of southwestern Colorado at approximate coordinates of 38.0209° North, 107.3774° West (CDPHE 2012). 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 toward Engineer Pass. Approaching from the west would require a high clearance 4-wheel drive vehicle.

The millsite is currently developed with a mill building, a power generation building, and the Assayer Office. The mill was a 100 ton per day concentration mill consisting of a number of crushers, rollers, sizers, and settling tanks. The equipment and processes at the mill were mechanical or hydraulic in nature and there is no evidence to suggest that chemicals were used as part of the milling operations at this site. Salable material was transported from the mill in railcars while the tails were transported from the mill in slurry form to the unlined settling impoundments in the Upper Tailings Impoundment Area. The major environmental features in the millsite include the inactive mill, sub-economic ore stockpiles, small overflow pond, approximately 70% of the lower tailings impoundment; underground mine workings, and a portal.

The major surface water body adjacent to the site is Henson Creek, a tributary of the Lake Fork of the Gunnison River. A small seasonal creek (Ute Creek) intersects in a roughly north-south trajectory. To the north of the millsite, across CR-20, Ute Creek disappears into what appears to be fill and waste rock material and then discharges at the down gradient portion of this waste rock pile. Ute Creek also discharges along CR20 in the form of numerous seeps at the toe of the waste rock pile. These seeps and creek pass under CR20 in a culvert and down to Henson Creek (CDPHE 2011). Henson Creek flows in an easterly direction for approximately four miles to Lake City and joins with the Lake Fork of the Gunnison River and flows in a northerly direction for approximately 30 miles before connecting with Blue Mesa Reservoir and the Gunnison River. As part of the Phase II ESA conducted by CDPHE, 2 samples were collected to assess the impact of the millsite on Henson Creek.

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 (CDPHE 2012). Based on topography and geologic formations, the ground water flow 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 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. 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 exposure to mining-related metal contamination in soil/waste inside the millsite buildings poses a public health hazard to future users of the site and, if so, to 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 Analysis

Environmental Data

Soil and surface water data were collected during the CDPHE’s Phase II ESA, conducted in July 2012 (CDPHE 2012). 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 2012). If any contamination is identified by CDPHE in the future, a separate health consultation will be conducted for surface water. In addition, CDPHE does not feel groundwater investigations are warranted at this site and no groundwater data has been collected from the site (CDPHE 2012). Therefore, groundwater and surface water exposures were not considered in this evaluation. However, the source of water for the proposed future land-use at the site has not been determined. For this reason, CDPHE should ensure that the future water supply has not been impacted by site-related activities to a degree that would make it unfit for consumption. If any contamination is identified by CDPHE in the future, a separate health consultation will be conducted for surface water.

Soil Data

Soil of potential concern at the millsite consists of residual mining and milling spoils inside the mine/mill building, residual coal and oil in the generator room, and potential assay contaminants in the Assay Office. The term soil was used in this assessment to describe a mixture of soil and fine grained tailings to coarse waste rock or spent ore from historic operations (CDPHE 2012). The material is scattered throughout the inside of the millsite buildings and can also be found in heaps, bins, and barrels. For the purpose of this health consultation, the mixed soil and waste material is defined as soil.

A total of 12 composite soil samples were collected during the Phase II ESA from various areas in the Mine and Mill Building (9 samples), the Power Generation Building (2 samples) and the Assay Building (1 sample). Soil samples were collected from 0-4 inches below the surface in a five-point composite pattern. The sampling locations were selected based on the composition of the waste materials and environmental indicators found at the site. Sampling locations and rationale for sample collection are described in the Appendix Table A1.

The composited soil samples were sent to Pace Analytical Laboratory in Lenexa, Kansas for analysis. All of the samples were analyzed for total metals including aluminum, arsenic, cadmium, chromium, copper, iron, lead, manganese, magnesium, nickel, mercury, selenium, silver, and zinc. Based on the soil results shown in Appendix Table A2, lead was the predominant site-wide contaminant of potential concern. The site-wide concentration of lead ranged from 224 mg/kg to 47,800 mg/kg with an average concentration of 7,095 (milligram lead per kilogram soil).

In the Mine and Mill Building, which consists of four levels, the concentration of lead ranged from 224 mg/kg to 47,800 mg/kg. The highest concentration of lead was found on the second level of the building. However, this sample could represent a hot spot of lead contamination since the results from two other samples collected from the second level of the building indicate concentrations of lead at 224 mg/kg and 247 mg/kg. At the top of the ore bin located on level 2, the material had a concentration of lead of 3,400 mg/kg. To a lesser degree, the concentration of lead appears to vary in other areas of the Mine and Mill Building as well. For example, on the third level, lead was detected at concentrations of 582 mg/kg and 5,480 mg/kg. The soil located on subfloor of level 3 had lead concentrations of 5,430 mg/kg and 1,720 mg/kg. On the fourth floor (or lowest level), lead was found at a concentration of 887 mg/kg. In the Power Generation Building (also known as the Buckeye Building), lead was found at concentrations of 8,770 mg/kg and 9,720 mg/kg in the soil samples. Lead was also found in the Assay Building at a concentration of 881 mg/kg.

Other notable metals contaminants include arsenic and copper. Arsenic is a known human carcinogen. The concentration of arsenic ranges from Not Detected (ND in one location) to 378 mg/kg with an average concentration of 130.5 mg/kg. Copper was detected at all locations, but the concentration in one sampling location is extremely high (Sample 3). This sample was collected from the Mine and Mill Building on the second level and had a copper concentration of 294,000 mg/kg. The presence of copper in this sample is due to the historic use of copper sulfate. This sample is not technically considered a true soil sample because the sample contains a mixture of waste material and soil. This composite sample was collected from a drum and bag of material labeled copper sulfate as well as the soil surrounding the drum and bag (CDPHE 2012).

Selection of Contaminants of Potential Concern

To identify soil contaminants of potential concern (COPCs), the soil data was screened against comparison values established by the ATSDR and EPA. The screening values from both agencies were reviewed and the most conservative value was selected for screening purposes in this evaluation (Table A3). The screening values used to identify COPCs in soil were derived for residential soil exposures. In this case, using residential screening values is considered conservative and protective of individuals that might come into contact with soil contaminants at the millsite. 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 screening value does not indicate that a health hazard exists; only that additional evaluation is warranted. It should be noted that the EPA screening value for lead has not yet been revised to reflect recent changes in CDC's reference blood lead level. Therefore, the previous screening value used for lead of 400 mg/kg may no longer be protective of young children and the developing fetus of pregnant women exposed to lead in a residential setting. In lieu of the revised value, CDPHE is currently retaining all detected concentrations of lead found in soil.

The soil COPC selection is shown in Table A3. Arsenic, cadmium, chromium, copper, and lead had maximum detected concentrations greater than the residential CVs used in this evaluation and were selected as COPCs. It should be noted that the valence state of chromium in site soil is unknown at this time. Therefore, all chromium was treated as the more toxic, hexavalent form. This could result in an overestimation of potential health risks.

Conceptual Site Model

A conceptual site model describes how people could come into contact with contaminants of potential concern at a site. Soil is the primary environmental medium under consideration in this health consultation and three routes of exposure to soil contaminants could occur under any given scenario: 1) incidental ingestion of soil, 2) dermal contact with soil, and 3) inhalation of soil particles suspended in air (dust). However, dermal contact with metals is considered a relatively insignificant 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 soil was not quantitatively addressed in this evaluation. Inhalation of 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, especially for outdoor exposures (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. While there may be some additional exposure that is unaccounted for from dermal exposure and inhalation of dust, these pathways are not likely to significantly alter the body burden of doses received from incidental ingestion. Thus, incidental ingestion of soil is considered the primary pathway of exposure to soil contaminants at the Ute-Ulay site.

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 soil contaminants at the site: hostel workers and tourists/visitors. 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 tourists, visitors, and seasonal hostel workers.

It is currently unknown what these buildings would be used for in the future or how often people would be visiting the areas where soil samples were collected. In lieu of land-use data to support site-related exposure factors, conservative estimates of future potential exposures were used to be prudent of public health. This variability between the exposure assumptions used in this evaluation and actual exposures that might occur in the future could lead to an over- or under-estimation of health risks. The uncertainty associated with the exposure assumptions used in this evaluation is addressed in more detail in the uncertainty analysis section.

Tourists/visitors (Recreational Users for Future Potential Exposures)

Currently, tourists visit the Ute-Ulay site to view or take pictures of the historic features of the mining camp. Although there is no definitive site-specific data available on the frequency any particular user visits the site, it is reasonable to assume that people would only visit for a brief period of time perhaps an hour or two per year. Unless they are accidentally swallowing significant amounts of dirt during their stay, 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 the stays would still 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 tourism or recreational use once the site has been redeveloped. The exposure duration for children visiting the site is 6 years and the assumed exposure duration for adults 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. 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. Thus, hostel workers are considered a future potential exposure scenario. 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), it is unlikely that people would be visiting or staying onsite due to the remoteness of the area and difficulty accessing the site in the snow. 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 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. Children of hostel workers were not considered in this evaluation because it is unlikely that young children would be staying at the hostel or going to work with their parents. Information provided through personal communication with CDPHE Project Manager for the site, supports this assumption (Personal Communication with Mark Rudolph August 27, 2013). If children are going to be present onsite for the same time period as their worker parents, this evaluation should be amended to include that exposure scenario before it actually occurs.

The exposure scenarios discussed above and the likely routes of exposure used in this evaluation are summarized below in Table 1, the Conceptual Site Model (CSM).

Table 1. 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	Soil	Future	Adult Hostel Workers and Child and Adult Tourists/Visitors (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 significant mechanical disturbance of soil at the site. Therefore, the concentration of soil contaminants in dust is likely to be low.

** Dermal exposure to soil contaminants is a potential exposure pathway. Since metals have a limited ability to cross the skin barrier and enter the blood stream, this pathway is considered insignificant and is not quantitatively evaluated in this health consultation.

Exposure Unit

All of the available soil data collected in the ESA conducted by CDPHE, was utilized in this evaluation. As described previously, soil samples were collected from three buildings on the property. It was assumed that exposure to soil contaminants in all three buildings would be equivalent. Therefore, the exposure unit consists of all three buildings sampled and the average concentration of contaminants from all buildings is assumed to represent the potential exposure point concentration. It is however, important to note that to facilitate risk management decision-making for reducing future exposures, each sampling location was also evaluated as an individual exposure unit in Appendix E.

Exposure Point Concentrations

The exposure point concentration (EPC) describes the concentration of soil contaminants that people are likely to come into contact within the exposure unit. A total of 12 soil samples were collected from the three buildings where exposure is likely to occur. Although the data set is somewhat limited from a statistical perspective, EPA's ProUCL 4.1 software can be used to estimate the EPC for this site (EPA 2011a). On a normally distributed data set, ProUCL will calculate the 95th percentile Upper Confidence Limit (95% UCL) on the mean concentration of the data set to be used as the EPC. In other cases, ProUCL uses rigorous statistical methods to determine the appropriate EPC. The soil EPCs used in this evaluation are shown in Appendix Table B2. When each sampling location was evaluated as an individual exposure unit, the detected concentration was used as the EPC (Appendix E).

Public Health Implications

The public health implications of exposure to soil contaminants at the site were determined using a combination of exposure dose estimations and biokinetic modeling. To assess the public health implications of metal contaminants of potential concern other than lead, the estimated doses for non-cancer health effects were divided by the appropriate health-based guidelines (acute or chronic) 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 or HI 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 non-cancer health effect levels are referred to as the No-Observed-Adverse-Effect Level (NOAEL) and the Lowest-Observed-Adverse-Effect Level (LOAEL). It should, however, be noted that because of the uncertainties regarding exposure conditions and the adverse health effects associated with environmental levels of exposure, definitive answers on whether health effects actually will occur or will not occur are not possible. The in-depth analysis only 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).

The estimated doses for cancer health effects are used in conjunction with the EPA's oral slope factors to calculate the lifetime excess cancer risks from exposure to site-related contamination. The estimated lifetime excess cancer risk is compared to the EPA target cancer risk level of 1 x 10^{-6} to 1 x 10^{-4}, or 1 excess cancer case per million exposed individuals to 100 excess cancer cases per million exposed individuals. Appendix B contains 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 were evaluated using the EPA's Integrated Exposure Uptake Biokinetic (IEUBK) lead model for recreating children and the EPA Adult Lead Model (ALM) to estimate the blood lead level in pregnant women working and/or recreating at the site. 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 research, however, has clearly shown that blood lead levels below 10 µg/dL can cause serious and irreversible effects in children such as neurological, behavioral, immunological, and developmental effects. 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, the CDC released a statement indicating concurrence with the recommendations of the ACCLPP (CDC 2012b). CDC plans to use the reference value as defined to identify high-risk childhood populations and geographic areas most in need of primary prevention. For more information, please visit the CDC's Lead Program webpage at http://www.cdc.gov/nceh/lead/ACCLPP/blood_lead_levels.htm.

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 at the site. Chronic exposures to lead and other metal contaminants of concern are described below.

Evaluation of Contaminants of Concern (Other than Lead)

Non-cancer Hazards

In addition to lead, arsenic, cadmium, chromium, and copper were identified contaminants of concern in soil at this site because the maximum detected site concentrations exceeded the residential screening value for these contaminants. All other non-lead metals 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 results for tourists/visitors are shown in Table B3 and the associated HQs are shown in Table A4. As shown, the non-cancer HQs are below the acceptable level of 1 for both child and adult recreational users, as well as hostel workers for all contaminants of concern with the exception of copper. The non-cancer HQs for copper are 2.9 for child recreational users and 3.7 for hostel workers based on ATSDR's acute Minimal Risk Level (MRL). No chronic MRL or reference dose is available from ATSDR or EPA. Thus, the estimated exposure dose for these receptors is 2.9 and 3.7 times higher than the non-cancer health-based guideline for copper, respectively.

Since the estimated doses exceeded the health-based guidelines, copper exposures were further evaluated by a comparison with known adverse health effect levels such as the NOAEL and LOAEL. For copper, the intermediate NOAEL and LOAEL values are based on a 2-month controlled human exposure study conducted by Arya et al in 2003 (ATSDR 2004). In this study, gastrointestinal symptoms (e.g., nausea and vomiting) were observed in humans orally exposed to 0.091 mg Cu/kg-day (LOAEL) of copper sulfate in drinking water, but not at 0.042 mg Cu/kg-day (NOAEL). In relation to this evaluation, the estimated dose of copper for child recreational users is 0.12 mg/kg-day and 0.15 mg/kg-day for hostel workers. Thus, the estimated doses for child tourists/visitors and hostel workers exceed the LOAEL identified for copper in the critical study. It should be noted that the estimated doses for tourists/visitors and hostel workers also exceed acute LOAEL of 0.0721 mg Cu/kg-day identified in the 1999 acute critical study of a 2-week duration by Pizarro et al (ATSDR 2004).

It must be noted that the elevated dose results are due to concentration of copper in sample #3 of 294,000 mg/kg. The level of copper found in sample 3 (nearly 250 times higher than the rest of the data set) skewed the EPC estimation far right of the mean distribution of the data set. However, at this time, the levels of copper at the site are considered to represent a public health hazard since the estimated doses for child tourists/visitors and hostel workers exceed the LOAELs identified in the critical studies used in the derivation of acute and intermediate health-based guidelines established by the ATSDR (ATSDR 2004).

These findings are based on the estimated exposure doses exceeding less serious gastrointestinal health effect levels in humans (e.g., nausea and vomiting). However, the estimated non-cancer hazards are associated with some uncertainty because: (a) the exposure point concentrations may be biased high due to a hot spot in one sampling location. This is demonstrated by location-specific evaluation presented in Appendix E. As seen in Tables E2 and E3, the estimated non-cancer hazards for copper are considered a public health hazard for only one location # 3 with the EPC of 294,000 mg/kg; (b) it is uncertain if the form of copper (copper sulfate) that was used in the critical study is the same as the form of copper that exists inside the mill site; (c) the bioavailability of copper from soil is likely to be lower than that from drinking water used in the critical study; and (d) these conclusions are based on intermediate and acute LOAEL due to the unavailability of the chronic NOAEL and LOAEL for copper.

Cancer Risks

Arsenic and chromium VI are the only known carcinogens that were identified as contaminants of potential concern at this site. Since the site-specific species of chromium has not been determined, the common default conservative approach is to assume that all chromium is in the hexavalent form even though chromium at this site is most likely in a lower valence (i.e., Cr III), less toxic form, which is also non-carcinogenic. Nonetheless exposure doses for arsenic and chromium were calculated for estimating carcinogenic risks and the results are shown in Appendix Tables B5 and the estimated cancer risks are shown in Table A5.

For tourists/visitors, cancer risks were estimated separately for children and adults, and were also combined to evaluate cancer risks from exposures occurring as a child and into adulthood. The combined estimated cancer risks are the most conservative values, followed by childhood exposures, and exposures occurring as an adult. As shown in Table A5, the combined (child and adult) estimated cancer risk from exposure to arsenic and chromium is $1.4 * 10^{-5}$, which means 14 additional cancer cases might occur out of a million people exposed to arsenic and chromium in soil at the site. This level of risk is largely attributable to exposure to arsenic in soil with chromium contributing very little to the overall combined cancer risk. Relative to the EPA target cancer risk range of $1 * 10^{-6}$ – $1 * 10^{-4}$, or one excess cancer case out of a million exposed individuals to 100 excess cancer cases out of a million exposed individuals, the estimated cancer risks from visiting the Ute-Ulay millsite are associated with a low increased risk of developing cancer.

As shown in Table A5, the estimated cancer risks for hostel workers are also within the acceptable cancer risk range. However, the estimated cancer risks are near the mid-point of the acceptable range at $5.3 * 10^{-5}$, or 53 excess cancer cases might occur out of a million exposed individuals. Once again, arsenic is the major risk driver for the estimated carcinogenic risks. The estimated cancer risk from chromium exposures is lower than the low-end of the EPA target cancer risk range of $1 * 10^{-6}$ – $1 * 10^{-4}$. Thus, there is little difference between the estimated cancer risk from arsenic exposure and the total cumulative cancer risk from exposure to arsenic and chromium (i.e. arsenic is the primary risk driver). Overall, the estimated cancer risks for hostel workers and tourists/visitors are associated with a low increased risk of developing cancer.

Acute Noncancer Health Hazard Evaluation

Acute exposures, occurring over a period of one day, using higher ingestion rates, were also evaluated in this health consultation. Child recreational users are the focus of the acute evaluation. Arsenic is the primary contaminant of concern for acute risks because it has been shown that short-term exposures to arsenic can present a health risk. It should be noted that acute health effects can occur from exposure to copper as well. However, copper was already evaluated using acute and intermediate duration (15-365 days) health-based guidelines at an ingestion rate of 200 mg/day and exposures were found to be a concern at levels above the Lowest-Observed-Adverse-Effect Level (LOAEL). Therefore, it can be assumed that copper exposures would also be above the acute LOAEL using pica ingestion rate of 5,000 mg for young children exhibiting pica behavior.

The estimated exposure dose for acute 1-day exposure (5,000 mg) to arsenic at the exposure point concentration of 177.3 mg/kg is 0.06 mg/kg-day and the ATSDR acute health-based guideline is 0.005 mg/kg-day. Thus, the estimated acute dose is approximately 12 times higher than the acute health-based guideline. 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 LOAEL of 0.05mg/kg-day. The acute oral LOAEL was initially identified in a study of soy sauce that had inadvertently been contaminated with arsenic. The study involved 220 people that had consumed the soy sauce. The duration of exposure was 2-3 weeks in most cases. At the LOAEL dose, 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 is approximately equal to the LOAEL. However, not all of the arsenic in soil is considered bioavailable. Recently, EPA has recommended a default value of 60% Relative Bioavailability for arsenic in soil (EPA 2012). Based on this assumption, the estimated dose would decrease to 0.04 mg/kg-day, which is just below the LOAEL of 0.05mg/kg-day for less serious health effects, but is still well above the acute health-based guideline of 0.005 mg/kg-day. Overall, this indicates a potential for less serious health effects for very young children (2-3 years of age) who are most likely to exhibit pica behavior. It should, however, be noted that the millsite is located in mountainous terrain. It is also unlikely that young children would be allowed to roam freely in the millsite building because of the physical hazards present. Therefore, a pica scenario may not be very likely to actually occur.

Evaluation of Lead Exposures

Tourists/Visitors (Recreational Users)
As mentioned previously, exposure to lead for child and adult tourists/visitors was evaluated using EPA models, the IEUBK and the ALM, respectively. The results of the IEUBK model for children are shown below in Table 2 and the ALM results for adults are shown in Table 3. The IEUBK model results indicate that lead exposures at the site are of potential concern for child tourists/visitors. The predicted geometric mean blood lead level for these children is 4.1 μg/dL with an estimated 33.2% of all children exposed to lead while visiting the site as having blood lead levels greater than 5 μg/dL. The results of the ALM also indicate elevated fetal blood lead levels for pregnant tourists/visitors. Specifically, the ALM estimated that 9.0% of adults would have fetal blood lead levels greater than 5 μg/dL with a geometric mean fetal blood level of 2.3 μg/dL following exposure to lead in soil at the site. All of the results show more than 5% of children and fetuses of pregnant workers have predicted blood lead levels above CDC's reference value of 5 μg/dL. Therefore, exposure to lead by tourists/visitors is considered a public health hazard for young children and the developing fetus of pregnant women. To protect the health of tourists/visitors, exposures to lead in soil at the Ute-Ulay millsite should be reduced.

Table 2. IEUBK Model Results for Child Tourists/Visitors

Time Weighted Site Soil Lead Concentration (in mg/kg)	Age Group (Months)	Geometric Mean Blood Lead Concentration of Child Tourists/Visitors (μg/dL)	Percent of Child Tourists/Visitors with a predicted Blood Lead Level greater than 5 μg/dL
424	0-84	4.1	**33.2**

NOTE: mg/kg = milligram lead per kilogram soil, μg/dL = micrograms lead per deciliter of blood. 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 reference blood lead value.

Table 3. Adult Lead Model Results for Adult Tourists/Visitors

Soil lead Concentration (in mg/kg)	Geometric Mean Fetal Blood Lead Concentration (μg/dL)	Probability of fetal Blood Lead Exceeding 5 (μg/dL)
7,000	2.3	**9.0**

NOTE: mg/kg = milligram lead per kilogram soil, μg/dL = micrograms lead per deciliter of blood. The 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.

Hostel Workers

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 4. The ALM model was performed for pregnant female hostel workers, which is thought to be protective of non-pregnant females and male adult workers. The results of the ALM indicate a potential for excessive lead exposure while working at the site. Specifically, the ALM predicted a geometric mean blood lead concentration in the fetus of 8.8 μg/dL and that 68.5% of all pregnant female hostel workers would have fetal blood lead concentrations greater than 5 μg/dL. The output is well above CDC's reference level for blood lead levels. Therefore, exposure to lead while working at the hostel is considered a public health hazard for the developing fetuses of pregnant women.

Table 4. 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)
7000	8.8	**68.5**

NOTE: μg/dL = micrograms lead per deciliter of blood. The 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.

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.

- There is no land-use data to support the exposure frequency and/or exposure duration assumptions used in this assessment. 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, health protective/conservative assumptions were made which are likely to overestimate health risks.

- Site-specific chromium speciation has not been conducted at the Ute-Ulay Mine and Mill site. Therefore, the species of chromium was conservatively assumed to be Cr (VI) because of the availability of oral cancer slope factor for Cr (VI) (NJDEP 2009). 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 additivity to estimate cumulative cancer and non-cancer risks is likely to over- or under-estimate risk due to synergistic and antagonistic interactions.

- For lead risk evaluation, there is uncertainty about how well the risk estimates predicted by modeling based on the 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. In this evaluation, the blood lead level of 10 µg/dL has been modified to 5µg/dL in the IEUBK model to be consistent with the new 2012 CDC reference value. In addition, there may be an underestimation of risk for lead based on the use of 5 µg/dL of blood lead level as a reference in light of the recent evidence that there is no safe level of lead.

- The estimated non-cancer hazards for child tourists/visitors and hostel workers for exposure to copper at the site are associated with some uncertainty because the exposure point concentration is biased high due to the concentration of copper in one location (sample #3), which is not technically considered a true soil sample because the sample contains a mixture of waste material and soil. This composite sample was collected from a drum and bag of material labeled copper sulfate as well as the soil surrounding the drum and bag. This uncertainty is further demonstrated by location-specific evaluation presented in Appendix E. As seen in Tables E2 and E3, the estimated non-cancer hazards for copper are considered a public health hazard for only one location (# 3) with the EPC of 294,000 mg/kg. It should be noted regarding the evaluation for copper that the conclusions are based on intermediate and acute LOAEL due to the unavailability of the chronic NOAEL and LOAEL for copper. This indicates that short-term exposures could occur above the acute and intermediate LOAEL.

- There is some uncertainty due to the use of 0-4 inches depth interval data (vs. 0-2 inches) to represent surface soil exposures.

- 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.

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 tourists/visitors, ages 0-7 years, were included in this evaluation because they are most representative of the young children that are likely to be at the Ute-Ulay Mine and Mill site. Lead was the primary contaminant of concern for children. The IEUBK modeling that was conducted indicates that young children could be exposed to excessive amounts of lead while visiting the site. Exposure to copper in site soils was also identified as a potential concern for child tourists/visitors since the estimated non-cancer dose for copper exceeds the acute and intermediate LOAEL values for copper. Thus, it is recommended that exposure to copper and lead be reduced to protect young children visiting the site for recreational 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 the information gathered from the CDPHE Project Manager (Personal Communication with Mark Rudolph, August 27, 2013). The levels of lead found at this site could be harmful to young children that are exposed on a regular basis while living there. If this assumption changes in the future, CCPEHA should be contacted to confirm the conclusion made in this evaluation.

Conclusions

CCPEHA and ATSDR have reached four conclusions regarding current and future exposures to soil at the Ute-Ulay Mine and Mill Site:

Exposure to lead in mixed soil and mine waste material at the Ute-Ulay Mine and Mill site could harm the health of young children (age 0-7 years) and pregnant women visiting the site for recreational purposes. This conclusion was reached because the results of the IEUBK model predicted blood lead levels in young children that are well above CDC's reference blood lead level 5 μg/dL. The predicted geometric mean blood lead level for children is 4.1μg/dL with an estimated 33% of all child recreational users having blood lead levels greater than or equal to 5 μg/dL. For pregnant woman visiting the site, the Adult Lead Model predicted that exposure to lead in soil/mine waste could result in a geometric mean blood lead concentration in the fetus of 2.3 μg/dL with 9.0% of all pregnant visitors would have fetal blood lead concentrations greater than 5 μg/dL

Exposure to lead in mixed soil and mine waste material at the Ute-Ulay Mine and Mill site could harm the developing fetus of pregnant hostel workers. This conclusion was reached because the ALM predicted elevated blood lead levels in the fetus of pregnant hostel workers following exposure to lead in surface soil. Specifically, the ALM predicted a geometric mean blood lead concentration in the fetus of 8.8 μg/dL with 68.5% of all pregnant 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 the information gathered from the CDPHE Project Manager. The levels of lead found at this site could be harmful to young children that are exposed on a regular basis while living there. Please see the recommendations section for more information on this issue.

Acute (1-day) and long- term chronic exposures to copper in mixed soil and waste material at the Ute-Ulay Mine and Mill site could harm the health of child visitors (recreational users) and hostel workers. This conclusion was reached because the estimated doses for child visitors and hostel workers exceed the LOAELs for copper identified in the critical studies used by ATSDR to establish the acute and intermediate non-cancer health-based guidelines for copper. Specifically, the estimated dose of copper for child visitors is 0.12 mg/kg-day and 0.15 mg/kg-day for hostel workers, which is well above the human intermediate and acute LOAELs of 0.091 and 0.0731 mg/kg-day, respectively. These conclusions are based on the estimated exposure doses exceeding less serious gastrointestinal health effect levels in humans (e.g., nausea and vomiting). It is, however, important to note that these conclusions regarding exposure to copper at the site are associated with some uncertainty because the exposure point concentration is biased high due to the concentration of copper in one location (sample #3), which is not technically considered a true soil sample because the sample contains a mixture of waste material and soil. This composite sample was collected from a drum and bag of material labeled copper sulfate as well as the soil surrounding the drum and bag. This uncertainty is further demonstrated by location-specific evaluation presented in Appendix E. As seen in Tables E2 and E3, the estimated non-cancer hazards for copper are considered a public health hazard for only one location (# 3) with the EPC of 294,000 mg/kg. It should be notedregarding the evaluation for copper, that the conclusions are based on intermediate and acute LOAEL due to the unavailability of the chronic NOAEL and LOAEL for copper. This indicates that short-term exposures of acute and intermediate duration could occur above the acute and intermediate LOAELs.

*Acute exposure (*1-day) *to arsenic in mixed soil and waste material at the Ute-Ulay Mine and Mill site could harm the health of child visitors (recreational users).* This conclusion was reached because the estimated dose of 0.04 mg/kg-day (even using the relative soil bioavailability 0f 60%) is just below the LOAEL of 0.05mg/kg-day for less serious health effects, but is still well above the acute health-based guideline of 0.005 mg/kg-day. This indicates that young children (2-3 years of age) who are most likely to exhibit pica behavior have the possibility of experiencing less serious acute health effects (e.g., gastrointestinal symptoms including nausea, diarrhea, and vomiting) from acute exposure (1-day) to arsenic in soil. It should, however, be noted that the millsite is located in mountainous terrain. It is also unlikely that young children would be allowed to roam freely in the millsite building because of the physical hazards present. Therefore, a pica scenario may not be very likely to actually occur.

Recommendations

The following recommendations have been made to the Hazardous Material and Waste Management Division of CDPHE in order to protect the health of tourists/visitors and hostel workers at the Ute-Ulay Mine and Mill site:

- Exposure to lead should be reduced to protect the health of tourists/visitors, pregnant hostel workers, and hostel workers who could become pregnant.

- Exposure to copper should be reduced to protect the health of child tourists/visitors and hostel workers.

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

- If the future site use differs from our exposure assumptions (e.g., hostel worker children being allowed on site), CCPEHA should be contacted to re-evaluate the conclusions drawn in this evaluation.

The following recommendations have been made for tourists/visitors and hostel workers 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

- Hostel workers should consider the use of nitrile gloves while working in soil/waste material found in the millsite. In addition, people should frequently wash hands, particularly prior to hand to mouth activity and also remove and wash potentially contaminated clothing (boots, pants, etc.) separately.

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:

- Provide copy of health consultation to stakeholders

- CCPEHA will prepare a fact sheet designed to inform hostel workers of the potential chemical hazards at the millsite and the appropriate use of personal protective equipment to reduce the potential for health hazards while working onsite. In addition, CCPEHA will provide any additional health education as requested or necessary.

- Review any additional data collected and update health consultation report on the Ute-Ulay site as requested.

Report Preparation

This Health Consultation for the Ute-Ulay Mine and Mill site ("Millsite") 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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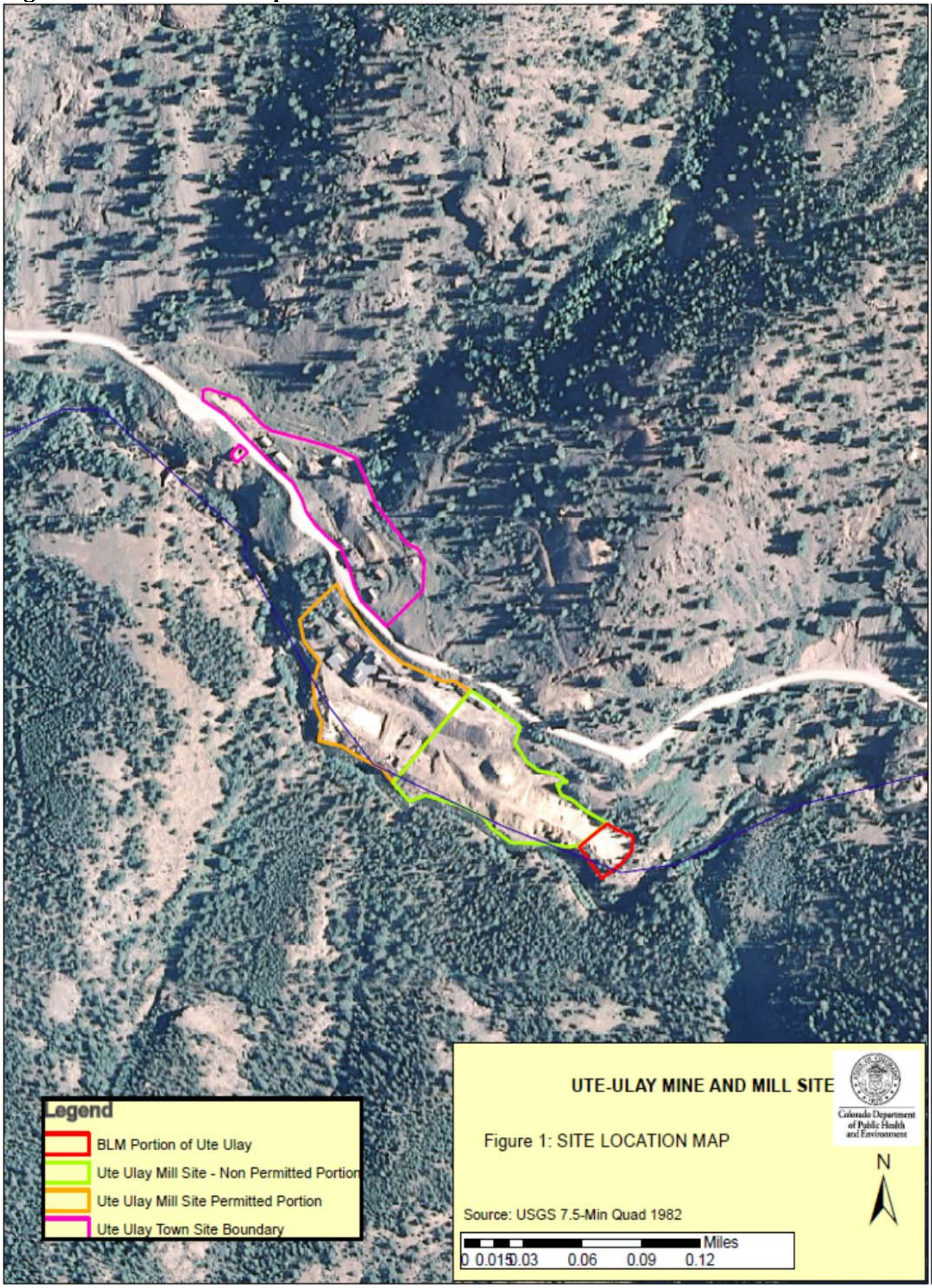
Appendix A. Tables and Figures

Figure 1. Site Location Map



SOURCE: CDPHE 2012

Table A1. Mixed Soil and Mining Waste Material Sampling Locations and Rationale

Sample ID	Location	Rationale
UUMM-SO1	Soil composite sample in Mine and Mill Site from top level.	Test for contaminants in soil available to recreations tourists frequenting the Site area and for disposal characterization.
UUMM-SO2	Soil composite sample in Mine and Mill Site from second level.	Test for contaminants in soil available to recreations tourists frequenting the Site area and for disposal characterization.
UUMM-SO3	Soil composite sample in Mine and Mill Site from second level.	Test for contaminants in soil available to recreations tourists frequenting the Site area and for disposal characterization.
UUMM-SO4	Soil composite sample in Mine and Mill Site from second level.	Test for contaminants in soil available to recreations tourists frequenting the Site area and for disposal characterization.
UUMM-SO5	Soil composite sample in Mine and Mill Site from screw/auger bin on third level.	Test for contaminants in soil available to recreations tourists frequenting the Site area and for disposal characterization.
UUMM-SO6	Soil composite sample in Mine and Mill Site from inside float cells on third level.	Test for contaminants in soil available to recreations tourists frequenting the Site area and for disposal characterization.
UUMM-SO7	Soil composite sample in Mine and Mill Site from under third level.	Test for contaminants in soil available to recreations tourists frequenting the Site area and for disposal characterization.
UUMM-SO8	Soil composite sample in Mine and Mill Site from under third level.	Test for contaminants in soil available to recreations tourists frequenting the Site area and for disposal characterization.

Sample ID	Location	Rationale
UUMM-SO9	Soil composite sample in Mine and Mill Site from lowest level where tunnel goes to Buckeye building.	Test for contaminants in soil available to recreations tourists frequenting the Site area and for disposal characterization.
UUMM-SO10	Soil composite sample in Mine and Mill Site from Buckeye building.	Test for contaminants in soil available to recreations tourists frequenting the Site area and for disposal characterization.
UUMM-SO11	Soil composite sample in Mine and Mill Site from Buckeye building.	Test for contaminants in soil available to recreations tourists frequenting the Site area and for disposal characterization.
UUMM-SO12	Soil composite sample in Mine and Mill Site from Assay Office/Bldg.	Test for contaminants in soil available to recreations tourists frequenting the Site area and for disposal characterization.

SOURCE: CDPHE 2012

Table A2. Analytical Results for Heavy Metals in Mixed Soil/Waste Material at the Ute-Ulay Millsite (CDPHE 2012)

Analyte	Mill Building									Buckeye Building		Assay Office Building
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10	Sample 11	Sample 12
Aluminum	2,150	223	65	2,010	1,430	2,870	1,880	2,340	735	5,030	3,960	11,400
Arsenic	191	9.4	60.7	56.6	113	225	378	165	117	91	73	16.9
Cadmium	7.3	1.1	30.3	93	2.2	19.5	23.3	9.2	10.3	25	39.2	6.2
Chromium	4.2	3.5	1.2	17.5	8.4	10.9	2.9	6.5	4.9	6.5	4.1	3.7
Copper	436	43.8	294,000	453	253	835	1,180	648	298	516	414	50
Iron	11,400	822	1,580	9,860	8,440	31,800	23,200	11,600	10,000	14,800	12,400	17,200
Lead	3,400	224	247	47,800	582	5,480	5,430	1,720	887	8,770	9,720	881
Manganese	225	26.8	106	995	325	494	366	1,190	410	1,400	1,480	690
Magnesium	205	81.2	101	2,680	162	245	210	240	105	1,390	1,090	3,040
Mercury	0.11	0.11	0.055	0.19	0.061	0.047	0.11	0.064	0.04	0.18	0.17	0.13
Nickel	4.5	1.1	577	9.9	3.4	17	2.9	7.1	3	5.1	3.3	4.9
Selenium	3	3.4	91	2.7	2.5	4.9	3.5	2.6	2.6	2.6	2.5	2.7
Silver	15.6	1.6	7.5	53.4	12.7	45.8	23	13.6	9.5	22.1	18.7	2
Zinc	1,170	162	607	18,100	311	2,800	3,430	1,470	1,720	4,090	7,180	732
Cyanide	-	-	-	-	-	-	0.64	0.36	0.17	-	-	-

Note: All Results are shown in units of milligram per kilogram (mg/kg).

Table A3. Selection of Contaminants of Potential Concern in Soil

Analyte	Minimum Detected Concentration (in mg/kg)	Mean Concentration (in mg/kg)	Maximum Detected Concentration (in mg/kg)	ATSDR Comparison Value (in mg/kg)	EPA RSL (in mg/kg)	Selected as COPC	Surface Soil Samples that Exceed the Comparison Value
Aluminum	65	2841	11,400	**$50,000^{E}$**	$77,000^{n}$		
Arsenic	9.4	131	378	0.5^{C}	**0.39^{c}**	X	All
Cadmium	2.2	24	93	**5^{E}**	70^{n}	X	All except #2 and #5 (1,3,4,6,7,8,9,10,11,12)
Chromium (as Cr VI)	2.9	6.7	17.5	**50^{E}**	0.29^{c}	X	All
Copper	43.8	24,927	294,000	**500^{E}**	$3,100^{n}$	X	3,6,7,8,10
Iron	822	12,759	31,800	NA	**$55,000^{n}$**		
Lead	224	7,095	47,800	NA	**400^{n}**	X	All except # 2and #3 (1,4,5,6,7,8,9,10,11,12)
Manganese	26.8	642	1,480	$3,000^{R}$	**$1,800^{n}$**		
Magnesium	81.2	796	3,040				
Mercury	0.04	0.12	0.19	NA	**10^{n}**		
Nickel	2.9	58	577	**$1,000^{R}$**	$1,500^{n}$		
Selenium	3.0	3.8	4.9	**300^{E}**	390^{n}		
Silver	2.0	20.3	53.4	**300^{R}**	390^{n}		
Zinc	162	3,742	18,100	**$20,000^{E}$**	$23,000^{n}$		
Cyanide	N/a	N/a	N/a	$1,000^{E}$	**47^{n}**		

NOTES: mg/kg = milligram analyte per kilogram soil, COPC = Contaminant of Potential Concern, ATSDR = Agency for Toxic Substances and Disease Registry, RSL = Regional Screening Level, **bolded** comparison values were used for COPC selection, ^{E} = Environmental Media Evaluation Guide, ^{C} = Cancer Risk Evaluation Guide, ^{R} = Reference Dose Media Evaluation Guide, ^{n} = non-cancer, ^{c} = cancer, NA = Comparison Value Not available

Table A4.Estimated Non-Cancer Hazard Quotients

COPC	Estimated Non-Cancer Hazard Quotient for Child Tourists/Visitors	Estimated Non-Cancer Hazard Quotient for Adult Tourists/Visitors	Estimated Non-Cancer Hazard Quotient for Adult Hostel Workers
Arsenic	2.6E-01	2.8E-02	3.2E-01
Cadmium	2.3E-01	2.5E-02	2.9E-01
Chromium	3.8E-03	4.1E-04	4.8E-03
Copper	**2.9E+00**	3.2E-01	**3.7E+00**
Hazard Index	**3.4E+00**	3.7E-01	**4.3E+00**

NOTE: COPC = Contaminant of Potential Concern. 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 A5. Estimated Cancer Risks

COPC	Estimated Cancer Risk for Child Tourists/Visitors	Estimated Cancer Risk for Adult Tourists/Visitors	Lifetime Estimated Cancer Risk for Tourists/Visitors	Estimated Cancer Risk for Adult Hostel Workers
Arsenic	9.99E-06	4.28E-06	1.43E-05	5.20E-05
Chromium	1.63E-07	7.00E-08	2.33E-07	8.51E-07
Total Cancer Risk	*1.02E-05*	*4.35E-06*	*1.45E-05*	*5.29E-05*

NOTE: COPC = Contaminant of Potential Concern. 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 Tourist/Visitors (recreational users), and
- Hostel Workers

The recreational use exposure scenario evaluated in this health consultation is considered complete for past, current, and 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 millsite. 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. Chronic Exposure Factors

Receptor	Tourists/Visitors	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 are presented below in Table B2.

Table B2. Exposure Point Concentration Results

Contaminant of Potential Concern	ProUCL Recommended EPC (in mg/kg)	Statistical Basis of Calculated EPC
Arsenic	177.3	95% KM (t) UCL
Cadmium	53.1	95% KM (Chebyshev) UCL
Chromium	8.7	95% KM (BCA) UCL
Copper	268,314	99% Chebyshev (Mean,Sd) UCL

NOTE: EPCs were calculated with EPA ProUCL Version 4.1.00

To calculate the estimated exposure doses for each receptor, the appropriate variable from Tables B1 and B2 is inserted into the following equations. The resulting dose is in units of milligrams of contaminant per kilogram body weight a day or (mg/kg-day). The resulting non-cancer dose estimations are shown in Table B3. It should be noted that it was assumed in this evaluation that 100% of metal contaminants found in soil at the site were bioavailable, except where otherwise noted (lead). The reduced bioavailability of metals in general is addressed qualitatively in the uncertainty discussion.

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 Tourists/Visitors ingestion dose of Arsenic, Table B3 =>
(177.3 mg/kg * 100 mg/day * 10^{-6} kg/mg * 12 days per year * 24 years) / (70 kg. * 8,760 days) =
8.3 * 10^{-6} (8.3E-06) mg/kg-day

Table B3. Estimated Dose Results for Non-Carcinogenic Health Effects

COPC	Estimated Non-Cancer Dose for Child Tourists/Visitors (in mg/kg-day)	Estimated Non-Cancer Dose for Adult Tourists/Visitors (in mg/kg-day)	Estimated Non-Cancer Dose for Adult Hostel Workers (in mg/kg-day)
Arsenic	7.8E-05	8.3E-06	9.7E-05
Cadmium	2.3E-05	2.5E-06	2.9E-05
Chromium	3.8E-06	4.1E-07	4.8E-06
Copper	1.2E-01	1.3E-02	1.5E-01

NOTE: COPC = Contaminant of Potential Concern, mg/kg-day = milligram per kilogram a 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 valency 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. The resulting carcinogenic exposure doses from incidental ingestion of soil are shown below in Table B4.

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 Tourists/Visitors , Table B3 =>
(8.7 mg/kg * 10^{-6} kg/mg * 200 mg/day * 12 days/year * 6 years) / (33kg. * 25,550 days)
= 3.8 * 10^{-7} mg/kg/day

Table B4. Estimated Dose Results for Carcinogenic Health Risks

COPC	Estimated Cancer Dose for Child Tourists/Visitors (in mg/kg-day)	Estimated Cancer Dose for Adult Tourists/Visitors (in mg/kg-day)	Estimated Lifetime Cancer Dose for Tourists/Visitors (in mg/kg-day)	Estimated Non-Cancer Dose for Adult Hostel Workers (in mg/kg-day)
Arsenic	6.66E-06	2.86E-06	9.52E-06	3.47E-05
Chromium	3.27E-07	1.40E-07	4.67E-07	1.70E-06

NOTE: Lifetime Cancer Doses include exposure as a child and as an adult.

Acute Health Risk Evaluation

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. Summary report for the ATSDR soil-pica workshop. June 2000, Atlanta, Georgia. Atlanta: US Department of Health and Human Services. March 20, 2001. Available at: http://www.atsdr.cdc.gov/child/soilpica.html.

Equation 3. Acute Non-cancer Soil Ingestion Dose

Non-Cancer Dose = (C_s * IRP * 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 B5 =>
(177.3 mg/kg * 5,000 mg/day * 10^{-6} kg/mg * 1 day per year) / (15 kg.) = **0.059 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. 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 accumulates in the body, primarily in the skeleton. Lead body burdens vary significantly 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 significant 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

It is important to note that risks of lead exposure are not based on theoretical calculations and are not extrapolated from data on lab animals or high-dose occupational exposures. 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 significant 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 percentile 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 Tourists/Visitors 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 predicts 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 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 of10 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, the 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 Concentrations by Exposure Unit

Lead Exposure Point Concentration (in mg/kg)	Exposure Frequency (in days)	Averaging Time (in days)	Time Weighted Average Lead Concentration (in mg/kg)
7,000	12	365	424

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 7,000 (site-wide average lead concentration) = 231 ppm
Lead home = 0.967 x 200 ppm (default) = 193 ppm
Lead site weighted (PbS_w) = 231 + 193 = 424 ppm

Table C2. Child Tourists/Visitors 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

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

Table C3. Adult Tourists/Visitors and Hostel Worker Adult Lead Model Inputs

Description of Exposure Variable	Input Value	Units
Soil lead concentration	7,000 site-wide average lead concentration	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)	Adult Tourists/Visitors: 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 non-cancer 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 ATSDRTox Profile and/or EPA IRIS database. In addition, the largertoxicological/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 approaches or exceeds a Lowest-Observed -Adverse-Effect-Level (LOAEL), it is considered *to cause harm* for longer term exposures, but requires further evaluation 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

Toxicity Assessment for Cancer Effects

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 Soil MRL (in mg/kg-day)	Source	EPA Oral Reference Dose (in mg/kg-day)	Source
Aluminum	**1.0**	Chronic	1.0	PPRTV
Arsenic	**0.005/ 0.0003**	Acute/ 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 & Intermediate MRL	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: bolded 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 Soil from Each Sampling Point (FOR RISK MANAGEMENT PUPOSES 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 health risks were conducted in the same manner as the health consultation with the exception of sampling location. This means that the exposure factors used here are the same as those used in the site-wide evaluation. 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. Therefore, the following health risks could be overestimated and should not be used solely to make conclusions regarding public health.

The estimated sample-specific non-cancer health risks are shown below in Tables E1-E4 for recreational users and hostel workers. Tables E5-E8 show the estimated sample-specific cancer risks. Potential health risks associated with lead exposure are shown in Tables E9-E11. Health risks of potential concern are briefly noted following the tables.

Table E1. Non-cancer Dose Results for Tourists/Visitors

Receptor Population (By Location)	Arsenic Dose (in mg/kg-day)	Cadmium (in mg/kg-day)	Chromium (in mg/kg-day)	Copper (in mg/kg-day)
Sample 1 Child	8.4E-05	3.2E-06	1.8E-06	1.9E-04
Sample 1 Adult	9.0E-06	3.4E-07	2.0E-07	2.0E-05
Sample 2 Child	4.1E-06	4.8E-07	1.5E-06	1.9E-05
Sample 2 Adult	4.4E-07	5.2E-08	1.6E-07	2.1E-06
Sample 3 Child	2.7E-05	1.3E-05	5.3E-07	1.3E-01
Sample 3 Adult	2.9E-06	1.4E-06	5.6E-08	1.4E-02
Sample 4 Child	2.5E-05	4.1E-05	7.7E-06	2.0E-04
Sample 4 Adult	2.7E-06	4.4E-06	8.2E-07	2.1E-05
Sample 5 Child	5.0E-05	9.6E-07	3.7E-06	1.1E-04
Sample 5 Adult	5.3E-06	1.0E-07	3.9E-07	1.2E-05
Sample 6 Child	9.9E-05	8.5E-06	4.8E-06	3.7E-04
Sample 6 Adult	1.1E-05	9.2E-07	5.1E-07	3.9E-05
Sample 7 Child	1.7E-04	1.0E-05	1.3E-06	5.2E-04
Sample 7 Adult	1.8E-05	1.1E-06	1.4E-07	5.5E-05
Sample 8 Child	7.2E-05	4.0E-06	2.8E-06	2.8E-04
Sample 8 Adult	7.7E-06	4.3E-07	3.1E-07	3.0E-05
Sample 9 Child	5.5E-06	4.0E-06	2.8E-06	2.8E-04
Sample 9 Adult	5.5E-06	4.8E-07	2.3E-07	1.4E-05
Sample 10 Child	4.0E-05	1.1E-05	2.8E-06	2.3E-04
Sample 10 Adult	4.3E-06	1.1E-05	2.8E-06	2.3E-04
Sample 11 Child	3.2E-05	1.7E-05	1.8E-06	1.8E-04
Sample 11 Adult	3.4E-06	1.7E-05	1.8E-06	1.8E-04
Sample 12 Child	7.4E-06	2.7E-06	1.6E-06	2.2E-05
Sample 12 Adult	7.9E-07	2.9E-07	1.7E-07	2.3E-06

Table E2. Non-Cancer Hazard Quotients for Tourists/Visitors

Receptor Population (By Location)	Arsenic	Cadmium	Chromium	Copper	Hazard Index
Sample 1 Child	2.8E-01	3.2E-02	1.8E-03	4.8E-03	3.2E-01
Sample 1 Adult	3.0E-02	3.4E-03	2.0E-04	5.1E-04	3.4E-02
Sample 2 Child	1.4E-02	4.8E-03	1.5E-03	4.8E-04	2.1E-02
Sample 2 Adult	1.5E-03	5.2E-04	1.6E-04	5.1E-05	2.2E-03
Sample 3 Child	8.9E-02	1.3E-01	5.3E-04	**3.2E+00**	**3.4E+00**
Sample 3 Adult	9.5E-03	1.4E-02	5.6E-05	3.5E-01	3.7E-01
Sample 4 Child	8.3E-02	4.1E-01	7.7E-03	5.0E-03	5.0E-01
Sample 4 Adult	8.9E-03	4.4E-02	8.2E-04	5.3E-04	5.4E-02
Sample 5 Child	1.7E-01	9.6E-03	3.7E-03	2.8E-03	1.8E-01
Sample 5 Adult	1.8E-02	1.0E-03	3.9E-04	3.0E-04	1.9E-02
Sample 6 Child	3.3E-01	8.5E-02	4.8E-03	9.2E-03	4.3E-01
Sample 6 Adult	3.5E-02	9.2E-03	5.1E-04	9.8E-04	4.6E-02
Sample 7 Child	5.5E-01	1.0E-01	1.3E-03	1.3E-02	6.7E-01
Sample 7 Adult	5.9E-02	1.1E-02	1.4E-04	1.4E-03	7.2E-02
Sample 8 Child	2.4E-01	4.0E-02	2.8E-03	7.1E-03	2.9E-01
Sample 8 Adult	2.6E-02	4.3E-03	3.1E-04	7.6E-04	3.1E-02
Sample 9 Child	1.8E-02	4.0E-02	2.8E-03	7.1E-03	6.9E-02
Sample 9 Adult	1.8E-02	4.8E-03	2.3E-04	3.5E-04	2.4E-02
Sample 10 Child	1.3E-01	1.1E-01	2.8E-03	5.7E-03	2.5E-01
Sample 10 Adult	1.4E-02	1.1E-01	2.8E-03	5.7E-03	1.3E-01
Sample 11 Child	1.1E-01	1.7E-01	1.8E-03	4.5E-03	2.8E-01
Sample 11 Adult	1.1E-02	1.7E-01	1.8E-03	4.5E-03	1.9E-01
Sample 12 Child	2.5E-02	2.7E-02	1.6E-03	5.5E-04	5.4E-02
Sample 12 Adult	2.6E-03	2.9E-03	1.7E-04	5.9E-05	5.8E-03

NOTE: Values bolded in red indicate that the estimated doses exceed the health-based guideline

Public health implications of non-lead COPCs

As shown in Table E2, the only sample-specific dose for tourists/visitors that exceeds the health-based guideline is copper found in sample # 3 (Child recreational user). Sample 3 was collected from the mill building. It was mentioned in CDPHE 2012 that copper sulfate may have been used in this area, which could be the cause of the elevated concentration of copper. It should also be noted that the estimated dose of copper for the child tourist/visitor in this area also exceeds the acute and intermediate duration LOAEL for copper. This indicates that gastrointestinal health effects may be possible if children are actually being exposed to copper at the levels defined in this evaluation.

The following dose estimates are sample-specific doses for hostel workers.

Table E3. Non-cancer Dose Results 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)
Sample 1 Adult	1.0E-04	4.0E-06	2.3E-06	2.4E-04
Sample 2 Adult	5.2E-06	6.0E-07	1.9E-06	2.4E-05
Sample 3 Adult	3.3E-05	1.7E-05	6.6E-07	1.6E-01
Sample 4 Adult	3.1E-05	5.1E-05	9.6E-06	2.5E-04
Sample 5 Adult	6.2E-05	1.2E-06	4.6E-06	1.4E-04
Sample 6 Adult	1.2E-04	1.1E-05	6.0E-06	4.6E-04
Sample 7 Adult	2.1E-04	1.3E-05	1.6E-06	6.5E-04
Sample 8 Adult	9.0E-05	5.0E-06	3.6E-06	3.6E-04
Sample 9 Adult	6.4E-05	5.6E-06	2.7E-06	1.6E-04
Sample 10 Adult	5.0E-05	1.1E-05	2.8E-06	2.3E-04
Sample 11 Adult	4.0E-05	1.7E-05	1.8E-06	1.8E-04
Sample 12 Adult	9.3E-06	3.4E-06	2.0E-06	2.7E-05

Table E4. Non-Cancer Hazard Quotients for Hostel Workers

Receptor	Arsenic	Cadmium	Chromium	Copper	Hazard Index
Sample 1 Adult	3.5E-01	4.0E-02	2.3E-03	6.0E-03	4.0E-01
Sample 2 Adult	1.7E-02	6.0E-03	1.9E-03	6.0E-04	2.6E-02
Sample 3 Adult	1.1E-01	1.7E-01	6.6E-04	**4.0E+00**	**4.3E+00**
Sample 4 Adult	1.0E-01	5.1E-01	9.6E-03	6.2E-03	6.3E-01
Sample 5 Adult	2.1E-01	1.2E-02	4.6E-03	3.5E-03	2.3E-01
Sample 6 Adult	4.1E-01	1.1E-01	6.0E-03	1.1E-02	5.4E-01
Sample 7 Adult	6.9E-01	1.3E-01	1.6E-03	1.6E-02	8.4E-01
Sample 8 Adult	3.0E-01	5.0E-02	3.6E-03	8.9E-03	3.6E-01
Sample 9 Adult	2.1E-01	5.6E-02	2.7E-03	4.1E-03	2.8E-01
Sample 10 Adult	1.7E-01	1.1E-01	2.8E-03	5.7E-03	2.8E-01
Sample 11 Adult	1.3E-01	1.7E-01	1.8E-03	4.5E-03	3.1E-01
Sample 12 Adult	3.1E-02	3.4E-02	2.0E-03	6.8E-04	6.8E-02

NOTE: Values bolded in red indicate that the estimated doses exceed the health-based guideline

The estimated dose for hostel workers from the sample 3 location is also above the health-based guideline for copper. In fact, the health risks from copper are higher for hostel workers than for child tourists (HQ = 3.4 for recreational child vs. HQ = 4.3 for hostel worker).

Table E5. Cancer Dose Results for Tourists/Visitors

Receptor Population (By Location)	Arsenic (in mg/kg-day)	Chromium (in mg/kg-day)
Sample 1 Child	7.18E-06	1.58E-07
Sample 1 Adult	3.08E-06	6.76E-08
Sample 1 Combined	*1.03E-05*	*2.25E-07*
Sample 2 Child	3.53E-07	1.32E-07
Sample 2 Adult	1.51E-07	5.64E-08
Sample 2 Combined	*5.05E-07*	*1.88E-07*
Sample 3 Child	2.28E-06	4.51E-08
Sample 3 Adult	1.93E-08	1.93E-08
Sample 3 Combined	*2.30E-06*	*6.44E-08*
Sample 4 Child	2.13E-06	6.58E-07
Sample 4 Adult	9.11E-07	2.82E-07
Sample 4 Combined	*3.04E-06*	*9.39E-07*
Sample 5 Child	4.25E-06	3.16E-07
Sample 5 Adult	1.82E-06	1.35E-07
Sample 5 Combined	*6.07E-06*	*4.51E-07*
Sample 6 Child	8.45E-06	4.10E-07
Sample 6 Adult	3.62E-06	1.76E-07
Sample 6 Combined	*1.21E-05*	*5.85E-07*
Sample 7 Child	1.42E-05	1.09E-07
Sample 7 Adult	6.09E-06	4.67E-08
Sample 7 Combined	*2.03E-05*	*1.56E-07*
Sample 8 Child	6.20E-06	2.44E-07
Sample 8 Adult	2.66E-06	1.05E-07
Sample 8 Combined	*8.86E-06*	*3.49E-07*
Sample 9 Child	4.40E-06	1.84E-07
Sample 9 Adult	1.88E-06	7.89E-08
Sample 9 Combined	*6.28E-06*	*2.63E-07*
Sample 10 Child	3.42E-06	2.44E-07
Sample 10 Adult	1.47E-06	1.05E-07
Sample 10 Combined	*4.88E-06*	*3.49E-07*
Sample 11 Child	2.74E-06	1.54E-07
Sample 11 Adult	1.18E-06	6.60E-08
Sample 11 Combined	*3.92E-06*	*2.20E-07*
Sample 12 Child	6.35E-07	1.39E-07
Sample 12 Adult	2.72E-07	5.96E-08
Sample 12 Combined	*9.07E-07*	*1.99E-07*

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

Table E6. Estimated Cancer Risks for Tourists/Visitors

Receptor Population (By Location)	Arsenic	Chromium	Total Cancer Risks
Sample 1 Child	1.1E-05	7.9E-08	1.1E-05
Sample 1 Adult	4.6E-06	3.4E-08	4.6E-06
Sample 1 Combined	1.5E-05	1.1E-07	1.5E-05
Sample 2 Child	2.3E-07	2.8E-08	2.6E-07
Sample 2 Adult	3.4E-06	2.3E-08	3.4E-06
Sample 2 Combined	3.6E-06	5.1E-08	3.7E-06
Sample 3 Child	3.2E-06	3.3E-07	3.5E-06
Sample 3 Adult	1.4E-06	1.4E-07	1.5E-06
Sample 3 Combined	4.6E-06	4.7E-07	5.0E-06
Sample 4 Child	2.7E-06	6.8E-08	2.8E-06
Sample 4 Adult	1.3E-05	2.0E-07	1.3E-05
Sample 4 Combined	1.5E-05	2.7E-07	1.6E-05
Sample 5 Child	6.37E-06	1.58E-07	6.53E-06
Sample 5 Adult	2.73E-06	6.76E-08	2.80E-06
Sample 5 Combined	9.10E-06	2.25E-07	9.32E-06
Sample 6 Child	1.27E-05	2.05E-07	1.29E-05
Sample 6 Adult	5.43E-06	8.78E-08	5.52E-06
Sample 6 Combined	1.81E-05	2.93E-07	1.84E-05
Sample 7 Child	2.13E-05	5.45E-08	2.14E-05
Sample 7 Adult	9.13E-06	2.33E-08	9.15E-06
Sample 7 Combined	3.04E-05	7.78E-08	3.05E-05
Sample 8 Child	9.30E-06	1.22E-07	9.42E-06
Sample 8 Adult	3.99E-06	5.23E-08	4.04E-06
Sample 8 Combined	1.33E-05	1.74E-07	1.35E-05
Sample 9 Child	6.59E-06	9.21E-08	6.69E-06
Sample 9 Adult	2.83E-06	3.95E-08	2.87E-06
Sample 9 Combined	9.42E-06	1.32E-07	9.55E-06
Sample 10 Child	5.13E-06	1.22E-07	5.25E-06
Sample 10 Adult	2.20E-06	5.23E-08	2.25E-06
Sample 10 Combined	7.33E-06	1.74E-07	7.50E-06
Sample 11 Child	4.11E-06	7.70E-08	4.19E-06
Sample 11 Adult	1.76E-06	3.30E-08	1.80E-06
Sample 11 Combined	5.88E-06	1.10E-07	5.99E-06
Sample 12 Child	9.52E-07	6.95E-08	1.02E-06
Sample 12 Adult	4.08E-07	2.98E-08	4.38E-07
Sample 12 Combined	1.36E-06	9.93E-08	1.46E-06

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

Estimated cancer Risks

All of the cancer risks estimated for tourists/visitors 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 cancer risks for tourists/visitors occurs in sampling area # 7 with an estimated combined cancer risk of $3 * 10^{-5}$, which means 30 excess cancer cases might occur out of million people exposed.

Table E7. Cancer Dose Results for Hostel Workers

Receptor Population (By Location)	Arsenic (in mg/kg-day)	Chromium (in mg/kg-day)
Sample 1 Adult	3.74E-05	8.22E-07
Sample 2 Adult	1.84E-06	6.85E-07
Sample 3 Adult	2.35E-07	2.35E-07
Sample 4 Adult	1.11E-05	3.42E-06
Sample 5 Adult	2.21E-05	1.64E-06
Sample 6 Adult	4.40E-05	2.13E-06
Sample 7 Adult	7.40E-05	5.68E-07
Sample 8 Adult	3.23E-05	1.27E-06
Sample 9 Adult	1.78E-05	2.44E-07
Sample 10 Adult	1.78E-05	1.27E-06
Sample 11 Adult	1.43E-05	8.02E-07
Sample 12 Adult	3.31E-06	7.24E-07

Table E8. Hostel Worker Estimated Cancer Risks

Receptor Population (By Location)	Arsenic	Chromium	Total Cancer Risks
Sample 1 Adult	5.6E-05	4.1E-07	5.6E-05
Sample 2 Adult	2.8E-06	3.4E-07	3.1E-06
Sample 3 Adult	1.7E-05	1.7E-06	1.8E-05
Sample 4 Adult	1.7E-05	1.7E-06	1.8E-05
Sample 5 Adult	3.32E-05	8.22E-07	3.40E-05
Sample 6 Adult	6.60E-05	1.07E-06	6.71E-05
Sample 7 Adult	**1.11E-04**	2.84E-07	**1.11E-04**
Sample 8 Adult	4.84E-05	6.36E-07	4.91E-05
Sample 9 Adult	2.67E-05	1.22E-07	2.68E-05
Sample 10 Adult	2.67E-05	6.36E-07	2.73E-05
Sample 11 Adult	2.14E-05	4.01E-07	2.18E-05
Sample 12 Adult	4.96E-06	3.62E-07	5.32E-06

NOTE: Values bolded in red indicate that the estimate cancer risks exceed EPA's cancer risk range

The estimated sample-specific cancer risks for hostel workers are at the high end of the EPA acceptable cancer risk range at $1.1 * 10^{-4}$, or 110 excess cancer cases per million people exposed.

The following tables are the lead model output results based on sampling area for tourists/visitors and hostel workers. In general, the IEUBK model results indicate that the lead concentrations in each area could result in elevated blood lead levels for child tourists/visitors and pregnant hostel workers based on the latest CDC recommended blood lead level of 5 micrograms per deciliter. For pregnant tourists/visitors, the adult lead model indicates elevated blood lead resulting from exposure to lead in sampling areas # 1, 4, 6, 7, 8, 10, and 11.

Table E9. IEUBK Model Results for Child Tourists/Visitors

Exposure Unit (EU)	**Time Weighted Site Soil Lead Concentration (in mg/kg)**	**Age Group (Months)**	**Geometric Mean Blood Lead Concentration of Child Tourists/Visitors (μg/dL)**	**Percent of Child tourists/visitors Population with a predicted Blood Lead Level greater than 5 μg/dL**
Sample 1	305	0-84	3.6	**22.9**
Sample 2	201	0-84	3.0	**14.3**
Sample 3	202	0-84	3.0	**14.4**
Sample 4	1765	0-84	9.4	**91.2**
Sample 5	213	0-84	3.1	**15.3**
Sample 6	374	0-84	3.8	**28.8**
Sample 7	372	0-84	3.8	**28.7**
Sample 8	250	0-84	3.3	**18.2**
Sample 9	223	0-84	3.1	**16.0**
Sample 10	482	0-84	4.3	**38.2**
Sample 11	513	0-84	4.5	**40.7**
Sample 12	222	0-84	3.1	**16.0**
Top Level (SO1)	305	0-84	3.6	**22.9**
Level 2	1765	0-84	9.4	**91.2**
Level 3	374	0-84	3.8	**28.8**
Buckeye Bldg	513	0-84	4.5	**40.7**
Assay Bldg (SO-12)	222	0-84	3.1	**16.0**

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

Table E10. Adult Lead Model Results for Tourists/Visitors

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	3400	2	**6.1**
Sample 2	224	1.7	4.0
Sample 3	247	1.7	4.0
Sample 4	47800	5.9	**47.2**
Sample 5	582	1.7	4.2
Sample 6	5480	2.1	**7.7**
Sample 7	5430	2.1	**7.7**
Sample 8	1720	1.8	**5.0**
Sample 9	887	1.8	4.4
Sample 10	8770	2.4	**10.5**
Sample 11	9720	2.6	**11.3**
Sample 12	881	1.8	4.4
Top Level (SO1)	3400	2	**6.1**
Level 2	47800	5.9	**47.2**
Level 3	5480	2.1	**7.7**
Buckeye Bldg	9720	2.6	**11.3**
Assay Bldg (SO-12)	881	1.8	4.4

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

Table E11. 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	3400	5.1	**40.3**
Sample 2	224	1.9	**5.6**
Sample 3	247	1.9	**5.8**
Sample 4	47800	50.6	**99.8**
Sample 5	582	2.2	**8.8**
Sample 6	5480	7.2	**58.7**
Sample 7	5430	7.2	**58.4**
Sample 8	1720	3.4	**21.4**
Sample 9	887	2.5	**11.9**
Sample 10	8770	10.7	**76.8**
Sample 11	9720	11.6	**80.3**
Sample 12	881	2.6	**11.9**
Top Level (SO1)	3400	5.1	**40.3**
Level 2	47800	50.6	**99.8**
Level 3	5480	7.2	**58.7**
Buckeye Bldg	9720	11.6	**80.3**
Assay Bldg (SO-12)	881	2.6	**11.9**

Summary of Sample-Specific Findings

Overall, the sample-specific evaluation indicates potential health risks from copper, arsenic, and lead.

- **For child tourists/visitors**, the evaluation indicates potential health risks resulting from exposure to copper in sampling location # 3 and exposure to lead in all sampling areas.
- **For pregnant tourists/visitors**, the adult lead model predicts elevated blood lead for the developing fetuses resulting from exposure to lead in sampling areas 1, 4, 6, 7, 8, 10, and 11.
- **For Adult tourists/visitors,** exposure to all metals (i.e., copper, arsenic, chromium, and cadmium) examined in this evaluation is below a level of health concern.
- **For adult hostel workers**, exposure to copper in sampling location# 3 and lead in all sampling areas is also a potential concern. In addition, the estimated cancer risks from arsenic exposure in area of sample # 7 are also at the high-end of EPA's acceptable cancer risk range.