3.0 STREAMLINED RISK EVALUATION AND ASSESSMENT

3.1 STREAMLINED HUMAN HEALTH RISK ASSESSMENT

Consistent with ADEQ guidance (Notice of Proposed Rulemaking Title 18, Environmental Quality Chapter 9, Department of Environmental Quality Remedial Action, 2006), "if conditions at a site indicate that the more insoluble forms of inorganic mercury are present, a simple chemical speciation in conjunction with published bioavailability studies for the species present is adequate for demonstrating the protection of human health."

The following table provides the proposed exposure assumptions that were used in assessing any potential arsenic and mercury hazard associated with exposure (dermal, inhalation and ingestion) to soil/sediment and in developing the remedial cleanup level associated with the occasional visitor.

Parameter	Value	Reference
Reference Dose – Methyl Mercury	1×10^{-4} mg/kg/d	EPA, IRIS
Reference Dose – Mercury and compounds (CAS # 7487-94-7)	3×10^{-4} mg/kg/d	EPA, IRIS
Reference Dose – Elemental Mercury	8.6×10^{-5} mg/kg/d	EPA, IRIS
Cancer Slope Factor - Arsenic	1.5 CSF_o 15 CSF_i	EPA, IRIS
Exposure Frequency	52 day/yr (once a week)	EE/CA, Saginaw Hill, Pima County, Arizona, November, 2005; Bureau of Land Management
Exposure duration – adult/adolescent	1 year	EPA, default
Body Weight – adult/adolescent	55 kg	EPA Exposure Factor Handbook
Surface Area	0.57 m^2/day	EPA, default
Soil adherence fraction	0.07 mg/cm^2	EPA default
ABS	0.1 (methyl mercury only)	EPA, default
PEF	1.36×10^9 m^3/kg	Soil Screening Guidance, EPA default
Soil ingestion rate – adult/adolescent	50 mg/day	EPA Exposure Factor Handbook
Inhalation rate – adult/adolescent	20 m^3/day	EPA default

The exposure parameters used were those employed by ADEQ and EPA in developing the ARARs, as modified for the site-specific receptor and site conditions used by the Bureau of Land

Management for recreational visitors (BLM, Risk Management Criteria for Metals at BLM Mining Sites, 2004). Due to the limited accessibility and terrain, it is assumed that the occasional visitor is not a toddler or child but an adolescent/adult. Therefore, as a conservative measure, a lower body weight (55 kg versus 70 kg) is proposed to account for the higher exposure dose (mg/kg of body weight) of an adolescent compared to an adult. The frequency of exposure (e.g., 52 days a year) is consistent with that established by the BLM for a mining site in Arizona (Saginaw Hill, Pima County). Based on the EPA Exposure Factor Handbook, a 50 mg/day soil ingestion rate is proposed (EPA, 1996).

The modified EPA Region 9 PRG equation provided below was used as the basis for the development of the site-specific recreational receptor that includes oral, dermal and particulate inhalation exposure routes. Since mercury and arsenic species present are not considered a volatile chemical, the Particulate Emission Factor (PEF) was used in the place of the volatilization factor per EPA guidance. This equation is consistent with BLM ((BLM, Risk Management Criteria for Metals at BLM Mining Sites, 2004).

Combined Exposures to Carcinogenic Contaminants in Recreational Soil

Risk-Based Soil Concentration (mg/kg) =

$$\frac{(TR \times BW \times AT_a)}{[EF \times ED \times (CSF_o \times IR_s/10^6\ mg/kg) + (CSF_o \times \{SA \times ABS \times AF\}/10^6\ mg/kg) + (CSF_i \times IR_i/PEF)]}$$

Where:

Target Risk (TR) = $1x\ 10^{-6}$
Body Weight (BW) = 55 kg
Averaging Time for Carcinogens (AT_c) = 25550 days
Exposure Frequency (EF) = 52 days/yr
Exposure Duration (ED) = 24 years
Cancer Slope Factor (CSF) = arsenic specific
Soil ingestion rate (IR_s) = 50 mg/day
Surface Area (SA) = 0.57 m^2/day
Soil Adherence Factor (AF) = 0.2 mg/cm^2
Absorption (ABS) = N/A for inorganics
Inhalation Rate (IR_i) – 20 m^3/day
Particulate Emission Factor (PEF) = $1.36 \times 10^9 m^3/kg$

Arsenic (mg/kg) = 359 mg/kg

Combined Exposures to Noncarcinogenic Contaminants in Recreational Soil

Hazard-Based Soil Concentration (mg/kg) =

$$\frac{(HQ \times BW \times AT_n)}{[EF \times ED \times (1/RfD_o \times IR_s/10^6\ mg/kg) + (1/RfD_o \times \{SA \times AF \times ABS\}/10^6\ mg/kg) + (1/RfD_i \times IR_i/PEF)]}$$

Where:

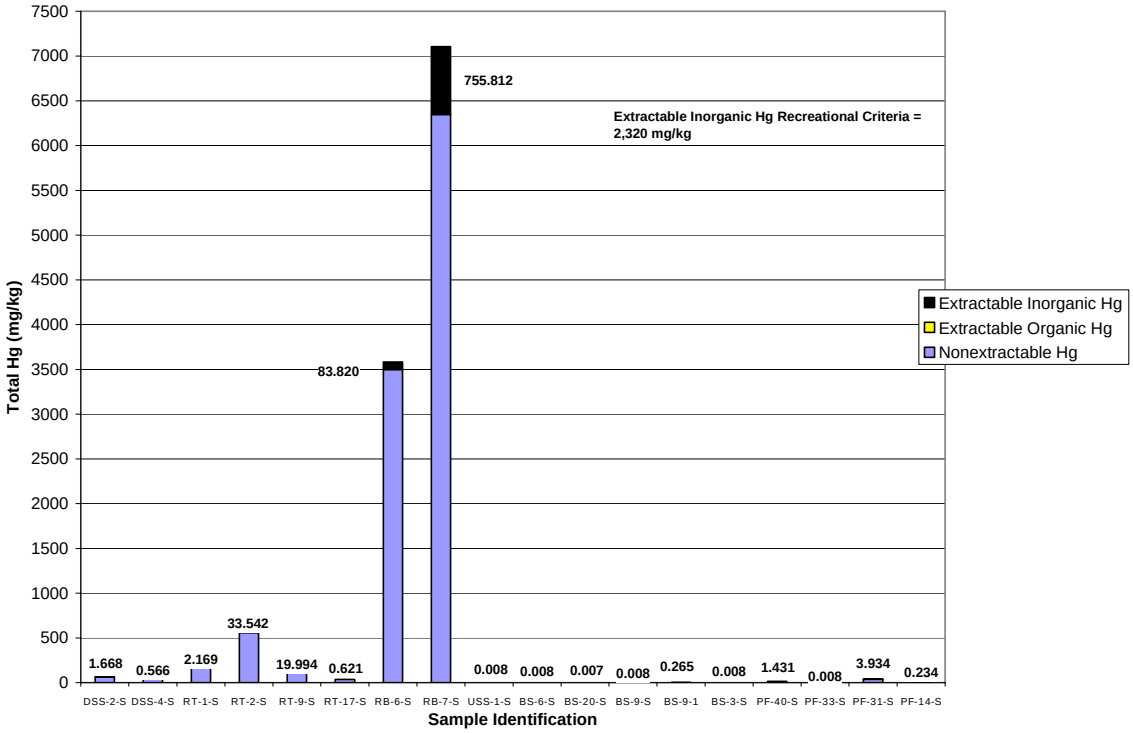
Hazard Quotient (HQ) = 1
Body Weight (BW) = 55 kg
Averaging Time for Noncarcinogens (AT_n) = 365 days
Exposure Frequency (EF) = 52 days/yr
Exposure Duration (ED) = 1 year
Oral Reference Dose (RfD_o) = mercury-species specific
Soil ingestion rate (IR_s) = 50 mg/day
Absorption (ABS) = 0.2 mg/cm
Surface Area (SA) = 0.28 m^2/day
Soil Adherence Factor (AF) = 0.1 (methyl mercury only)
Inhalation Reference Dose (RfD_i)= mercury-species specific
Inhalation Rate (IR_i) – 20 m^3/day
Particulate Emission Factor (PEF) = 1.36 x 10^9 m^3/kg

Methyl Mercury Hazard-Based Soil Concentration (mg/kg) = 770 mg/kg
Mercury Compounds Hazard-Based Soil Concentration (mg/kg) = 2,320 mg/kg
Elemental Mercury Hazard-Based Air Concentration (ug/m^3) =1.6 ug/m^3

While the arsenic concentrations in Site soils are either less than or indistinguishable from background concentrations (Section 2.3.2), arsenic was retained as a COPC for assessment. Based on the site-specific risk-based arsenic criterion for recreational receptors, there is no unacceptable risk since none of the soil arsenic concentrations from any of the AOIs exceed 359 mg/kg and the UCL was 33.6 mg/kg.

The majority of the mercury present in AOI soils was in the form of cinnabar (see Bar Graphs 1-3 in Section 2.3.1). For example, in the AOI with the highest total mercury concentration and the highest frequency of exceeding screening levels (Retort Building), the highest total mercury concentrations (3,583 and 7,105 mg/kg) were speciated and found to contain 2.3% and 10.6% total extractable (both organic and inorganic) mercury compared to approximately 84%-98% non-extractable mercury (see Bar Graphs 1-3 in Section 2.3.1).

The concentration of the various mercury species were compared to the mercury species-specific recreational criteria. The mercury extraction characteristics (extractable and non-extractable) and the toxicity criteria (organic and inorganic) were paired such that methyl mercury soil/sediment criterion corresponded to the extractable organic mercury fraction and mercury and compounds are the extractable inorganic mercury species soil/sediment criterion (Table 2). None of the species-specific recreational soil criteria were exceeded in any of the AOIs. Therefore, no unacceptable risk is expected as a result of exposures to soil/sediment for the recreational visitor to the subject site.



Since a number of the sample results exceeded the mercury ambient air criterion of 310 ng/m^3 (EPA Region 9) that applied to continuous exposure to mercury vapor (e.g., residential), the concentrations were compared to the health-based mercury vapor criterion developed for the recreational visitor of 1.6 ug/m^3 (Section 2.4.3). The mercury vapor concentration in all samples taken in the retort building ranged from 32 – 568 ng/m^3. The average vapor concentration was 334 ng/m^3. None of the individual samples exceeded the health-based mercury vapor concentration based on recreational receptors (1.6 ug/m^3 or 1,600 ng/m^3).

3.2 STREAMLINED ECOLOGICAL RISK ASSESSMENT

The BLM Wildlife and Livestock Risk Management Criteria for mercury in soils ranging from 1 to 45 mg/kg are based on extrapolation from methyl mercury studies in animals. The uncertainties of the values are noted in the document. The importance of the uptake of mercury by plants in deriving these criteria was discussed. As described previously, the predominant species of mercury present are insoluble or non-extractable and would not be transferred to plants. Therefore, these screening criteria as well as those provided by Oak Ridge National Laboratory for terrestrial species are not pertinent to the site since methyl mercury is not present or present at very low concentrations. Furthermore, the aquatic and terrestrial conditions do not favor conversion of inorganic mercury species to organic mercury. No criteria could be located for non-extractable inorganic mercury (mercuric sulfide or cinnabar) the species of mercury that is present to the greatest concentrations in soils at the Site.

The ecological risk assessment prepared by SWCA Environmental Consultants (Appendix I) evaluated the mercury speciation data and concluded that the conditions required for the formation of toxic species of mercury (methyl mercury) are not present at the Pine Mountain Mine site. The report concludes that the mercury concentrations found at the Site are not at levels that would significantly affect the flora and fauna in the area. Specifically, the highest methyl mercury concentrations measured at the Pine Mountain Mine site are less than the experimental low concentration effect on ecological receptor. The report concluded that the potential impacts to minnow reproduction from MeHg reaching Sycamore Creek would be negligible. No other impact to fish in the stream is likely. Furthermore, the report concludes that the vegetative uptake of mercury from the amounts and form of mercury measured in vegetated areas would be low and it would be unlikely that that vegetation, including special status plants, on-site or in the surrounding area is being adversely affected by mercury contamination at the mine.