DRAFT

STIBNITE AREA RISK EVALUATION REPORT

Prepared for
The Stibnite Area Site Characterization
Voluntary Consent Order Respondents

August 3, 2000

URS

URS Corporation
4582 S. Ulster Street, Suite 1000
Denver, CO 80237

Project No. 6800024343.00

List of Appendices

List of Tables

List of Figures

List of Plates

List of Acronyms and Abbreviations

AB	absorption factor
AF	adherence factor
AOC	Administrative Order on Consent
AT	averaging time
ATSDR	Agency for Toxic Substances and Disease Registry
AWQC	ambient water quality criteria
BA	bioavailability
BNA	Bureau of National Affairs
BT/NO	Bradley tailing neutralized ore
BTO	Bradley Tunnel Outlet
bw	body weight
°C	degrees Centigrade
C/Q	dispersion coefficient
$CaCO_3$	calcium carbonate
Canadian Superior	Canadian Superior Mining Company
CEC	cation exchange capacity
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
C_f	concentration in food or water
CFf	unit conversion factor for fish
cfs	cubic feet per second
CFs	unit conversion for soil
CFw	unit conversion for water
Cl^-	chloride ion
CLP	Contract Laboratory Program
cm	centimeters
COPI	chemical of potential interest
C_s	concentration in soil, sediment, or water
CSM	conceptual site model
d	day
DMEA	Defense Minerals Exploration Administration
DQO	Data Quality Objectives
ED	exposure duration
EDI	estimated daily intake
EF	exposure frequency
EFSFSR	East Fork of the South Fork of the Salmon River
EIS	Environmental Impact Statement
ERL	effects range-low
ERM	effects range-median
ET	exposure time
EVA	EVA Environment Consultants
EVS	EVS Environment Consultants
°F	degrees Fahrenheit
F	area use factor
f_d	study duration
FDA	Food and Drug Administrative
f_i	intertaxon extrapolation
Forest Service	United States Department of Agriculture Forest Service
fps	feet per second
FSEC	freshwater sediment effects concentrations
FSP	Field Sampling Plan
f_t	toxicity test endpoint

g	grams
GLNPO	Great Lakes National Program Office
h	hour
HEAST	Health Effects Assessment Summary Tables
Hecla	Hecla Mining Company
Hg^o	metallic mercury
Hg^{2+}	mercuric ion
HI	hazard index
HQ	hazard quotient
HSDB	Hazardous Substances Data Bank
IDAPA	Idaho Administrative Procedures Act
IDEQ	Idaho Department of Health and Welfare Division of Environmental Quality
IDFG	Idaho Department of Fish and Game
IDHW	Idaho Department of Health and Welfare
IF	(human) fish ingestion rate
I_f	(wildlife) ingestion rate of food or water
IN	inhalation rate
IRIS	Integrated Risk Information System
IS	(human) soil ingestion rate
I_s	(wildlife) ingestion rate of soil, sediment, or water
ISD	(human) sediment ingestion rate
ISW	(human) surface water ingestion rate
kg	kilograms
L	liters
LD_{50}	median lethal dose
LOAEL	lowest observed adverse effects level
LOEC	lowest observable effect concentration
m	meters
m^3	cubic meters
MCL	Maximum Contaminant Level
meq	milli-equivalents
mg	milligrams
mL	milliliters
Mobil	Mobil Corporation
NA	Not analyzed
NAS	National Academy of Sciences
NC	not collected
ND	not detected
NOAEL	no observed adverse effects level
OMEE	Ontario Ministry of Environment and Energy
ORNL	Oak Ridge National Laboratory
oz	ounce
PA/SI	Preliminary Assessment/Site Investigation
PC	aqueous permeability constant
PEC	probable effect concentration
PEF	particulate emission factor
PM_{10}	respirable particles
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RBC	risk based concentration
RER	Risk Evaluation Report
RfD	reference dose
RME	Reasonable Maximum Exposure
SA	skin surface area

SAB	Science Advisory Board
sec	second
SF	slope factors
SMI	Stibnite Mine, Incorporated
SQG	Sediment Quality Guideline
Stibnite Group	Stibnite Site Characterization Voluntary Consent Order Respondents
TEC	threshold effect concentration
TRD	Toyota Racing Developments
TRV	toxicity reference value
TRW	toxicity review workgroup
µg	micrograms
µm	micrometers
UCL	upper confidence limit
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	U.S. Geological Survey
VCO	Voluntary Consent Order
WAD	weak acid dissociable
WER	water effect ratio

1. EXECUTIVE SUMMARY

The revised Draft Risk Evaluation Report (RER) is based on current Site conditions, chemical and biological data, and habitat characterization presented in the Draft Site Characterization Report (SCR) (Stibnite Group, 2000). The RER assesses whether chemical or physical stressors described in the Draft SCR are likely to pose unacceptable risks to the environment or to human health.

1.1 INTRODUCTION

In January 1997, Stibnite Mine, Incorporated (SMI), Hecla Mining Company (Hecla), and the Mobil Corporation (Mobil), collectively known as the Stibnite Area Site Characterization Voluntary Consent Order Respondents (or Stibnite Group) signed a Voluntary Consent Order (VCO) with the Idaho Department of Health and Welfare Division of Environmental Quality (IDEQ) to perform a Site Characterization and Risk Evaluation of the Stibnite Site. The Site is a mining area located along the East Fork of the South Fork of the Salmon River (EFSFSR), 14 miles southeast of Yellow Pine, Idaho (Figure 1-1). The Stibnite Site boundaries are shown in Figure 1-2, Stibnite Site Areas of Investigation and Figure 1-3, 1997 and 1999 Soil Sample Locations in Meadow Creek Valley and Defense Minerals Exploration Administration (DMEA) Dump.

The Daft RER is conducted to identify and address potential environmental effects from mining activities at the Stibnite Site that may pose unacceptable risks to the environment or human health. Mining and mineral processing, primarily for gold and antimony, have occurred at the Stibnite Site intermittently since the early 1900s. The ore deposits consisted of significant tonnages of oxidized gold ore overlying sulfide mineralization, which is characterized by metal sulfides. Historic or recent mining activities (principally related to mineral processing, extraction, and beneficiation) may be associated with releases of constituents such as metals and sediment or with physical disturbances that may have adversely affected environmental media (soil, sediment, groundwater, and surface water) or habitat condition.

The site characterization field investigations were conducted in 1997 and 1999. The characterization included sampling of soil, groundwater, surface water, sediment, and seeps and springs, as well as characterization of aquatic, terrestrial, and riparian habitat and characterization of aquatic biota. The Draft SCR was submitted to IDEQ in March 2000 under separate cover (Stibnite Group, 2000).

This Draft RER includes aquatic, terrestrial, and human health risk evaluations for the Stibnite Site. The risk evaluation provides an evaluation of the chemical or physical stressors likely to pose unacceptable risks to the ecological resources or to human health. Information compiled in the Draft SCR and the results of this risk evaluation are to be used to support future remedy decisions for the Site, if warranted.

The Draft SCR and Draft RER were performed in accordance with the VCO requirements as specified in the VCO Exhibit B, Stibnite Area Site Characterization Scope of Work and with the IDEQ-approved Stibnite Area Site Characterization Field Sampling and Mapping Work Plan (Work Plan) (Stibnite Group, 1997a), Stibnite Area Risk Evaluation Work Plan (Stibnite Group, 1997b), and Stibnite Area Site

Characterization Field Sampling and Mapping Work Plan Addendum (Stibnite Group, 1999). The work was performed in a manner consistent with the U.S. Environmental Protection Agency (USEPA) guidance for remedial investigations and risk assessment under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

1.2 RECLAMATION WORK

Independent of the VCO site characterization work, reclamation activities were undertaken in 1998 under an Administrative Order on Consent (AOC) entered into between the USEPA, the United States Department of Agriculture-Forest Service (Forest Service), and ExxonMobil to stabilize and reclaim the Bradley tailing neutralized ore (BT/NO) disposal area and minimize surface water contamination of Meadow Creek. The Bradley Tailing Diversion and Reclamation Project, implemented by ExxonMobil in 1998, included constructing a new 4,575-foot-long Meadow Creek on the south side of the BT/NO disposal area; building a new drainage channel on the north side; lining the old Meadow Creek diversion channel to reduce seepage; closing the pond, covering about 5 acres of exposed tailing at the upper end of the BT/NO disposal area, and restoring the flow of Meadow Creek through the wetland above the disposal area; regrading and revegetating the 100-acre BT/NO disposal area; and revegetating the banks of the diversion channel and installing voluntary stream restoration features such as channel pools and large boulders. The construction work was completed in 1998, and revegetation was completed in 1999. The reclamation project will reduce infiltration of water into the BT/NO disposal area, reduce migration of particulates from the tailing, and has already improved water quality in Meadow Creek. Long-term water quality monitoring is continuing.

By the end of 1999, most of the SMI facilities and haul roads had been reclaimed under a reclamation plan approved by IDEQ, Idaho Department of Lands, and the Forest Service and implemented by the Department of Lands. Reclaimed areas included the leach pads and ponds, SMI office area, crusher site, pilot plant, former camps, and about 90 percent of the haul roads and exploration roads. A few remaining areas are to be closed and reclaimed in 2000.

1.3 SITE DESCRIPTION AND HISTORY

The physical environment at the Stibnite Site consists of narrow forested valleys (at an elevation of about 6,000 feet above sea level) surrounded by steep mountains rising to about 8,700 feet. Granite bedrock is penetrated by a large ring fault system containing oxide and sulfide ores rich in gold, silver, mercury, antimony, and tungsten. Up to 60 feet or more of glacial deposits (gravels, sands, and silts) are present in the valley floors. Winters are cold and wet; precipitation (about 31 inches per year) falls mainly as snow between mid October and April. Chief streams at the Site are the EFSFSR and several tributaries, including Meadow Creek and Sugar Creek.

Much of the Site is open space. Public land is administered by the Krassel Ranger District Payette National Forest, but most of the Site is privately owned. There are no permanent or year-long residents at the Site, and surrounding Forest Service land is not occupied. Seasonal workers are present at the site when

reclamation activities or remediation and monitoring activities are occurring. Current land use at the Site includes ongoing closure and reclamation activities and remediation activities at the BT/NO disposal area in upper Meadow Creek. Within the Site boundaries, recreational activities such as hunting, fishing, or camping are minimal but could increase in the future.

Mining for gold, antimony, and tungsten has occurred at the Stibnite Site since the early 1900s. Major historic mining activities were the Meadow Creek Mine and Yellow Pine Mine (in the EFSFSR channel), and related ore processing facilities (active from 1919 through 1952, operated by the Bradley Mining Company and its predecessors). During this period, mine tailing was disposed of in the Meadow Creek Valley floor and waste rock was placed along the banks of the EFSFSR downstream of the Yellow Pine Pit (now the Glory Hole) and along the EFSFSR downstream of Meadow Creek. In addition, a smelter was operated at the Meadow Creek Mine intermittently for a few years starting in 1949 and ending in 1952.

More recently (1982 to 1998) gold mining took place in the West End Pit, with mineral beneficiation (on/off leach pads or permanent heap leach) conducted in Meadow Creek Valley. Operators included Canadian Superior Mining Company (a former subsidiary of Mobil), Pioneer Metals Corporation, SMI, Hecla, and others. Since 1982, in accordance with and Environmental Impact Statement (EIS) prepared by and operating permits issued by the Forest Service, neutralized ore from the on/off leach pads was used to encapsulate the Bradley tailing in upper Meadow Creek, and various fill material, including waste rock and neutralized ore, has been used to cover historic mining areas and tailing in the Meadow Creek Valley.

Historic mining-related activities have also resulted in alterations to stream configuration and habitat. These alterations include the Glory Hole, a large pond created in 1955 when the flow of the EFSFSR was no longer diverted around the Bradley Mining Company's Yellow Pine Pit; Bradley waste rock dumps along the EFSFSR below the Glory Hole; the Bradley tailing impoundment/neutralized ore disposal area; Meadow Creek channel diversions; and debris deposits resulting from the catastrophic failure of the dam on Blowout Creek in 1965.

1.4 SUMMARY OF SITE CHARACTERIZATION FINDINGS

The principal environmental concern at the Site is potential release of metals, cyanide, other chemical constituents, and sediment, from Bradley tailing, neutralized ore, or other historic or recent mining-related sources to surface water such that stream beneficial uses or water quality are significantly impaired. Potential impacts to the terrestrial and riparian environment and to human health are also concerns.

For the 1997 Site Characterization investigation, the Site was divided into three areas based on geography and operational history. The area boundaries are shown on Figures 1-2 and 1-3. Site features are shown on Plate 1. Area 1 is the Meadow Creek Valley beginning about one-half mile upstream of the new Meadow Creek Diversion Channel and extending down to the confluence with the EFSFSR. Surface water features in Area 1 are Meadow Creek, the Meadow Creek Pond (drained as of 1998), the Meadow Creek Diversion Channel (reconstructed in 1998), and the lower portion of Blowout Creek. The chief physical features in Area 1 are the BT/NO disposal area in upper Meadow Creek, Bradley tailing deposits in lower

Meadow Creek, the historic Meadow Creek Mine and mineral processing site area, and former SMI and Hecla leach pads and associated facilities area.

Area 2 is the EFSFSR from the eastern site boundary to the confluence with Midnight Creek; this stream segment includes the confluence with Garnet Creek. The chief features related to mining activities in Area 2 are physical disturbances related to the historic town of Stibnite, historic Bradley tailing and waste rock along portions of the EFSFSR, or more recent support operations (such as the contractor shop and Primary and Secondary trailer camps).

Area 3 is termed the Glory Hole, extending from the EFSFSR at Midnight Creek to one-quarter mile downstream of the confluence with Sugar Creek; this area includes Midnight Creek, Hennessey Creek, the Glory Hole, West End Creek, and Sugar Creek. This area contains the historic Yellow Pine Pit (Glory Hole) mined by Bradley Mining Company, Bradley waste rock dumps, historic mining tunnels, and numerous recent mining areas (pits).

The 1997 and 1999 Site Characterizations at the Stibnite Site included:

- Collection and analysis of surface water, groundwater, seeps and springs, and surface soil samples in areas suspected to be affected by mining-related impacts as well as at reference stations upgradient of mining impacts;
- Characterization of aquatic, terrestrial, and riparian habitat, including field surveys and mapping; and
- Sampling of sediment, benthic macroinvertebrates, and fish.

The principal findings of the site characterization are summarized below:

1. Surface water quality in the Meadow Creek and EFSFSR drainage improved substantially between 1997 and 1999 following implementation of the Bradley Tailing Diversion and Reclamation Project. This conclusion is based on significantly reduced levels (by 35 to 85 percent) of antimony and arsenic in surface water, the two constituents most characteristic of the site. Individual results for arsenic in 1999 were below Idaho and USEPA chronic water quality criteria for the protection of freshwater aquatic life. All but a few results for total antimony (maximum = 35 micrograms per liter [μg/L]) were below the USEPA proposed chronic criterion of 30 μg/L.

2. Meadow Creek Valley:

    a. The physical aquatic habitat in the Diversion Channel and lower Meadow Creek is influenced by limited riparian cover and reduced instream cover. Although Bradley tailing deposits occur at or below the surface in most of lower Meadow Creek Valley, only small portions of the streambank are comprised of unstable tailing. These patches represent 4 to 6 percent of the length of lower Meadow Creek (Figure 7-2).

    b. Concentrations and loading of antimony in surface water increase, particularly between Stations MC-2A and MC-2B. These stations are downgradient of most of the historic Bradley facilities

and are in an area of Bradley tailing deposits that are often in contact with the water table. Groundwater attribution to surface water is the probable source of increased loadings.

c. In spite of elevated levels of antimony and arsenic in groundwater compared with upgradient sampling locations, arsenic concentrations in Meadow Creek surface water were below ambient water quality criteria, and all but two results for antimony were below the USEPA proposed criterion of 30 μg/L. Occasional detections of mercury were above the Idaho numeric criterion of 0.012 μg/L total mercury, but were below the USEPA criterion of 0.77 μg/L dissolved mercury.

d. Wetlands and other valley bottom plant communities in Meadow Creek Valley are in good condition, although tailing is present to a greater or lesser degree in all three wetlands investigated. Wetland vegetation in tailing areas is largely indistinguishable from non-tailing areas.

3. Glory Hole:

a. The Glory Hole aquatic habitat is not significantly impaired, based on environmental sampling and aquatic and riparian characterization performed in 1999.

b. The sediments and water quality in the Glory Hole do not pose an unacceptable risk to the indigenous biota because there is a vigorous benthic community and abundant fish; with minor exceptions, water quality results were below relevant water quality criteria for the protection of freshwater aquatic life; and average sediment concentrations of metals other than arsenic meet most freshwater sediment quality guidelines.

c. The Glory Hole is primarily a sediment trap. The potential for sediment resuspension from the Glory Hole is low, as is the potential for adverse effects downstream, if resuspension were to occur.

4. Evidence of current impairment of aquatic or riparian habitat by historic mining activities occur primarily in Meadow Creek Valley and in a portion of the EFSFSR above and below the bridge at the main access road. Some of the highest quality aquatic habitat on the Stibnite Site is found in the EFSFSR downstream of Meadow Creek and upstream of the Glory Hole.

5. EFSFSR below the Glory Hole:

a. Satisfactory aquatic habitat in terms of the variety of instream habitat and substrate condition is present in the EFSFSR below the Glory Hole to the main access road. However, the riparian habitat is poor to fair along much of the reach, due to limited vegetation. Steep, erodible banks occur along about 800 feet of the west side of the stream above the main access road (Figure 7-2).

b. Below the main access road bridge, in the stream segment represented by Station 308, the EFSFSR flows through an open, disturbed area below the Northwest Bradley waste rock dump. Substrate is primarily cobble and small boulders. Riparian cover is limited.

c. Metals concentrations in surface water, sediment, and benthic macroinvertebrate tissue were higher in the EFSFSR below the Glory Hole (Stations EF-7 and 308) than in other portions of the EFSFSR. However, 1999 levels of arsenic in surface water were below Idaho and USEPA water quality criteria; a few results for total antimony slightly exceeded the USEPA proposed chronic criterion of 30 µg/L. Mercury was detected in this reach of the EFSFSR only below the confluence with Sugar Creek.

6. Mercury levels in surface water and sediment of Sugar Creek and the EFSFSR below Sugar Creek were substantially higher than elsewhere on site, due to off-site sources of mercury in the Sugar Creek watershed.

7. In groundwater, the highest concentrations of dissolved antimony (about 200 to 2000 µg/L) and arsenic (about 500 to 13,800 µg/L) were observed in samples collected within or in proximity to saturated Bradley tailing. Lower levels elsewhere (e.g., about 20 to 50 µg/L dissolved antimony and 30 to 150 µg/L dissolved arsenic) reflect the natural mineralization of ore bodies in the EFSFSR valley above and below the Glory Hole. However, concentrations over 1,000 µg/L dissolved arsenic were observed in groundwater and seeps near the Meadow Creek Fault Zone on the Meadow Creek Mine hillside. Concentrations in seep samples were consistent with the groundwater results, depending on sampling location.

8. In soil, levels of antimony and arsenic were highest in native ores or material derived from the ores. Mean arsenic concentrations were about 1,350 milligrams per kilogram (mg/kg) in samples at the Meadow Creek Fault zone, 1,200 mg/kg in Bradley tailing, 1,400 mg/kg in neutralized ore, and 1,900 mg/kg to 4,300 mg/kg in Bradley waste rock. Soil sampling at the Meadow Creek Mine Hillside did not yield conclusive evidence of impacts from historic smelter emissions; rather the variations in metals levels appear to be associated with the proximity to the Meadow Creek Fault Zone and mine exploration areas.

9. All the Bradley waste rock dumps appear to be of similar composition (although antimony levels were variable). Much of the Bradley waste rock dumps and Glory Hole area is sparsely vegetated, and about 23 acres have steep slopes and evidence of erosional features. However, only portions of the steep erodible slopes are directly on the shoreline of the EFSFSR. The poor vegetation is likely due to the adverse physical characteristics of the substrate (lack of nutrients) and a combination of high metals and low pH. Two seeps were identified at the Northwest Bradley waste rock dump in June 1999; these seeps had somewhat higher levels of dissolved antimony and arsenic than most seeps near the Glory Hole, but in themselves are not considered a significant source of loading to the EFSFSR.

10. No threatened, endangered, rare, or sensitive terrestrial animal or plant species are known to occur at the Stibnite site, other than an experimental reintroduction of the gray wolf; some sensitive plant species could potentially be present within natural vegetation areas.

1.5 AQUATIC ECOLOGICAL RISK EVALUATION

A risk evaluation of the aquatic ecosystem on the Stibnite Site was performed in accordance with current USEPA guidance for ecological risk assessments. The primary water bodies comprising the on-site aquatic ecosystem are Meadow Creek, EFSFSR, and Sugar Creek. Using the results of the surface water sampling (1999), sediment sampling (1997 and 1999), benthic macroinvertebrate sampling and analysis (1999), and aquatic characterization studies (1997 and 1999), potential risk to aquatic organisms in on-site streams and the Glory Hole was evaluated for four exposure areas and ten Site aquatic stations.

A total of six measurement endpoints was considered in evaluating the two aquatic assessment endpoints: 1) protection of salmonid fish populations and 2) protection of the benthic macroinvertebrate community. The focus of risk assessments in exposure areas was on fish, while the risk at aquatic stations addressed both fish and benthic macroinvertebrates. In the four exposure areas (Meadow Creek, Upper EFSFSR, Lower EFSFSR, and Sugar Creek) three measurement endpoints were evaluated: surface water quality, physical habitat, and fish tissue residue levels. At the ten Site aquatic stations, six aquatic measurement endpoints were measured or described (metals in surface water and sediment, metals in fish and benthic macroinvertebrate tissues, benthic macroinvertebrate community analysis, and physical habitat descriptions). The ten aquatic stations and the streams are: MC-1C, 322, and 319 (Meadow Creek); 365, 310, Glory Hole, EF-7, 308, and 314 (EFSFSR); and 316 (Sugar Creek). Surface water quality and sediment quality were quantitatively evaluated through calculation of hazard quotients (HQs). The measurement endpoints and their relative importance in evaluating risk to fish and benthic macroinvertebrates are listed below:

Relative Importance of Aquatic Measurement Endpoints for Fish and Invertebrates

Measurement Endpoint	Risk to Fish[1]	Risk to Benthic Invertebrates[2]
Surface Water Quality (HQ)	1	3
Sediment Quality (HQ)	Not Evaluated	2
Physical Habitat	2	Not Evaluated
Benthic Community	Not Evaluated	1
Benthic Tissue Metal Residue	Not Evaluated	4
Fish Tissue Metal Residue	3	Not Evaluated

[1] Evaluated for exposure areas and aquatic stations.

[2] Evaluated for aquatic stations only.

In the evaluation of the various measurement endpoints, the importance of each measurement endpoint was weighted as shown (e.g., surface water quality is most important in evaluating risk to fish; results of the benthic community analysis is most important in evaluating risk to benthic macroinvertebrates). Concentrations of metals in water were compared with current Idaho and USEPA water quality criteria (IDHW, 1998; BNA, 1999; USEPA, 1976, 1992b, 1998b, 1999); metals in sediment were compared with

recent compilations of sediment screening benchmarks (Table 7-9 and 7-10) (EVS, 1998; Macdonald et al., 1999). Water quality and sediment quality were evaluated quantitatively by calculating hazard quotients (HQs) based on these comparisons. The remaining measurement endpoints were evaluated qualitatively.

The overall potential for unacceptable risks to fish and benthic macroinvertebrates is described as "unlikely", "possible", or "likely" for this evaluation. For the measurement endpoints quantitatively evaluated (water quality and sediment quality), risk is considered "unlikely" if the HQ is less than 1 and "possible" if the HQ is greater than 1. For the four measurement endpoints qualitatively evaluated, judgements were made as to the likelihood of the endpoint representing a stressor (chemical or physical) to the receptor. Stressors described as representing a "possible" risk may occur but are not expected to have any significant effects on the receptors. Measurement endpoints described as "unlikely" are not expected to have any measurable effect on the receptor.

Risks to fish based on the three aquatic measurement endpoints considered in each of the four exposure areas is summarized in the following table:

Potential of Risk to Fish in Exposure Areas

Exposure Area	Water Quality	Physical Habitat	Tissue Residue	Overall Risk
Meadow Creek	Unlikely	Possible	Unlikely	Unlikely
Upper EFSFSR	Unlikely	Unlikely	Unlikely	Unlikely
Lower EFSFSR	Unlikely	Possible	Unlikely	Unlikely
Sugar Creek	Unlikely	Possible	NC[1]	Unlikely

[1]Fish tissue samples not collected at station.

Considering all three measurement endpoints, especially water quality, it is "unlikely" that fish are at potential risk in any area. However, the habitat in portions of Meadow Creek, Lower EFSFSR, and Sugar Creek may represent a physical stressor to fish. In Meadow Creek, unstable banks were found along three sections of the creek. Overall, approximately 700 feet on the south-east bank and 400 feet on the north-west bank were considered unstable, although most of these unstable reaches were vegetated. Half of the areas are adjacent to tailing deposits. In most of Lower EFSFSR, the streambanks have limited riparian cover. Steep, erodible banks occur along about 800 feet of the west bank above the bridge at the main access road. In Sugar Creek, the average percent surface fines at Station 316 was 36 percent, which is in the range of fines that may lead to a loss of viable spawning habitat; however, suitable gravel spawning areas are present in lower Sugar Creek. Downstream of Station 316, riparian vegetation provides only limited cover. Upstream of the station, the stream banks are only moderately stable, due in part to a road cut directly adjacent to the stream.

The potential for risk to fish and benthic macroinvertebrates at aquatic stations was evaluated for a total of six measurement endpoints. The potential for risk to fish and benthic macroinvertebrates at the ten aquatic stations are summarized in the following two tables.

Potential of Risk to Fish at Aquatic Stations

Station	Surface Water	Physical Habitat	Tissue Residue	Overall Risk
MC-1C	Unlikely	Possible	NC[1]	Unlikely
322	Unlikely	Possible	Unlikely	Unlikely
319	Unlikely	Unlikely	NC[1]	Unlikely
365	Unlikely[2]	Possible	NC[1]	Unlikely
310	Unlikely[2]	Unlikely	Unlikely	Unlikely
G. H.[3]	Unlikely	Unlikely	NC[1]	Unlikely
EF-7	Unlikely	Possible	NC[1]	Unlikely
308	Unlikely	Possible	Unlikely	Unlikely
314	Unlikely	Unlikely	Unlikely	Unlikely
316	Unlikely	Unlikely	NC[1]	Unlikely

[1]Fish tissue samples not collected at station.
[2]Surface water quality based on results from Station 313.
[3]Glory Hole.

The overall potential for risk to fish at each of the ten aquatic stations is evaluated as "unlikely" based principally on the surface water quality. However, elements of the physical habitat at five aquatic stations (MC-1C, 322, 365, EF-7, and 308) may represent physical stressors to fish. At all five stations, riparian vegetation is sparse (Stations 365, EF-7, and 308) or missing (Stations MC-1C and 322). Instream cover for fish is limited at four stations (MC-1C, 322, 365, and EF-7). Some evidence of streambank erosion is seen at two stations (365 and 308).

Potential of Risk to Benthic Macroinvertebrates at Aquatic Stations

Station	Benthic Community	Sediment Quality	Surface Water	Tissue Residue	Overall Risk
MC-1C	Unlikely	Possible	Unlikely	NC[1]	Unlikely
322	Unlikely	Possible	Unlikely	Unlikely	Unlikely
319	Unlikely	Possible	Unlikely	Unlikely	Unlikely
365	Unlikely	Possible	Unlikely[2]	Unlikely	Unlikely
310	Unlikely	Possible	Unlikely[2]	Unlikely	Unlikely
G. H.[3]	Unlikely	Possible	Unlikely	NC[1]	Unlikely
EF-7	Possible	Possible	Unlikely	NC[1]	Possible
308	Possible	Possible	Unlikely	Possible	Possible
314	Unlikely	Possible	Unlikely	Unlikely	Unlikely
316	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely

[1]Benthic macroinvertebrate tissue samples not collected at station.
[2]Surface water quality based on results from Station 313.
[3]Glory Hole.

The overall potential for risk to benthic macroinvertebrates is evaluated as "possible" at two stations in the EFSFSR (EF-7 and 308) but "unlikely" for the remaining eight stations. Overall "possible" risks at Stations EF-7 and 308 are due to the combination of "possible" ratings for the benthic community and sediment quality.

The current designated beneficial uses of the EFSFSR waters include, among others: cold water biota and salmonid spawning. The dissolved oxygen standard for salmonid spawning is described as a minimum of 6.0 mg/L or 90 percent of dissolved oxygen saturation (8.2 mg/L), whichever is greater. The salmon spawning temperature maximum is 13°C with a maximum daily average of 9°C (IDHW, 1998), and for bull trout (*Salvelinus confluentus*), the temperature criterion is 10°C, expressed as an average of daily maximum temperatures over a 7-day period during June, July, and August (40 CFR 131.33). In addition to dissolved oxygen and temperature standards, salmonid spawning requirements also include all toxic substance standards for the protection of aquatic life.

Dissolved oxygen measurements at all stream stations in 1999 (Appendix A1 of Stibnite Group, 2000) were greater than 8.2 mg/L.

Maximum temperatures in 1999 at most of the EFSFSR stations (except for Station 369) were lower than the 10°C maximum for bull trout. Temperatures in Meadow Creek in July (10.9 to 12.8°C) and September 1999 (10.7 to 12.5°C) were greater than the 10°C maximum. The warmer water temperatures in Meadow Creek are not expected to adversely affect the spawning of bull trout, however, since they cannot migrate upstream past the Glory Hole.

There are no unique toxic substance standards for the designated uses of salmonid or bull trout spawning that are not included in the general aquatic life standards (IDHW, 1998). Therefore, the risk evaluation performed in Section 7.5 is applicable to the protection of salmonids, including bull trout, as well as all other on-site aquatic receptors.

The potential for future risk to aquatic organisms from resuspension of sediments in the Glory Hole and movement downstream also was evaluated. Two related questions were addressed: 1) Will sediments in the Glory Hole be mobilized during various flow events or during seasonal turnover? and 2) If sediments are resuspended, will they pose a risk to the aquatic community downstream?

Physical conditions in the Glory Hole and calculated bottom velocities indicate that the potential for sediment resuspension is low in the 2-year and 100-year events and low-to-moderate in the 500-year event. The 100-year event is considered to be the largest flow event of reasonable concern. Therefore, resuspension of sediment, if it were to occur, is a transient event that would not have long-term adverse effects on the aquatic community. The Glory Hole probably does experience the physical conditions that permit seasonal (spring and fall) turnover. However, because the depth of each turnover event will vary in response to numerous factors, it cannot be determined if the currents associated with a turnover event are sufficiently high to resuspend sediments.

It is unlikely that bottom sediment from the Glory Hole would pose an unacceptable downstream risk to aquatic biota because: 1) resuspension of sediments has a low frequency and is a transient event, 2) in-place sediments are not toxic based on the analysis of the benthic macroinvertebrate community in the Glory Hole, and 3) Glory Hole sediments would be mixed with stream sediments and redeposition would occur over an extended length of the EFSFSR, after the transient event.

1.6 TERRESTRIAL ECOLOGICAL RISK EVALUATION

A risk evaluation of the terrestrial ecosystem on the Stibnite Site was performed in accordance with current USEPA guidance for ecological risk assessments. Using the results of soil, sediment, surface water, seep, and fish tissue sampling from 1997 and 1999, potential risk to terrestrial populations or communities was evaluated for 17 exposure locations (including five small "hot spot" locations).

Two terrestrial assessment endpoints were evaluated: 1) protection of the upland and riparian plant communities and 2) protection of populations of wildlife functional groups. The measurement endpoints considered in the evaluation of assessment endpoints were: 1) upland and riparian habitat condition (vegetation and soil mapping; soil profiles) and 2) soil, sediment, and water chemical analyses and comparisons with toxicological endpoints.

The overall potential for unacceptable risks to plant communities and wildlife populations is described as "unlikely" or "possible." Risk was considered "unlikely" if expected exposure and resulting HQs were less than 1 and "possible" if the HQs were greater than 1. Stressors described as representing a "possible" risk may occur but are not expected to have any significant effects on the assessment endpoints. Measurement endpoints described as "unlikely" are not expected to have any measurable effect on the assessment endpoints. Risks to the habitat, plant community, or wildlife at several exposure locations is described as "unlikely or possible" because of a range of conditions present at the locations.

Risks to habitat, plant communities, and wildlife populations based on the two terrestrial measurement endpoints evaluated for each of the exposure locations are described in detail in Table 8-12 and are summarized in the following table:

Potential of Risk to Terrestrial in Exposure Locations

Risk Classification	Exposure Location	Risk to Habitat or Plant Community	Risk to Wildlife Populations
Unlikely Risk			
	BT/NO Disposal Area		X
	Meadow Creek Hillside	X	X
	Upgradient Wetland	X	X
	Upgradient Wetland Hot Spot	X	X
	Keyway Wetland	X	X
	Smelter Stack	X	X
	DMEA Dump	X	X
	BD-6 (antimony outlier in NW Bradley Dump)		X
Unlikely or Possible Risk			
	Lower Meadow Creek Valley	X	X
	Meadow Creek Forested Wetland	X	X
	Southeast Bradley Waste Rock Dump		X
	Northwest Bradley Waste Rock Dump		X
	Northeast Bradley Waste Rock Dump		X
	BD-6 (antimony outlier in NW Bradley Dump)	X	
	EFSFSR and Midnight Creek		X

Risk Classification	Exposure Location	Risk to Habitat or Plant Community	Risk to Wildlife Populations
	EFSFSR and Glory Hole		X
	Sugar Creek		X
	Seeps in Areas 1 and 3		X
Possible Risk			
	BT/NO Disposal Area	X	
	Southeast Bradley Waste Rock Dump	X	
	Northwest Bradley Waste Rock Dump	X	
	Northeast Bradley Waste Rock Dump	X	

Possible risk is shown for terrestrial habitat or plant communities at four exposure locations: BT/NO Disposal Area, Southeast Bradley Waste Rock Dump, Northwest Bradley Waste Rock Dump, and Northeast Bradley Waste Rock Dump. Risk to the plant community at three locations is due primarily to arsenic and mercury concentrations in soils. In addition, plants in the BT/NO Disposal Area are exposed to high antimony concentrations in soil. Risk to the soil invertebrate community also is due primarily to exposure to high arsenic concentrations in soil. Chemical risks to habitats or the plant communities at all other exposure locations are evaluated as being either "unlikely" or "unlikely or possible." No habitat or plant community is evaluated as having "likely" risk.

Overall risk to the wildlife populations at nine exposure locations is judged to be "unlikely or possible." These judgements are based on possible risks from exposure to high antimony, arsenic, and/or mercury concentrations in soil that are reduced by the small areas involved and the sparse vegetation/habitat available at the locations. Risk to wildlife populations at all other locations also is evaluated as "unlikely". No wildlife populations are evaluated as having "possible" or "likely" risk.

1.7 HUMAN HEALTH RISK EVALUATION

The human health risk assessment evaluated potential human health risk for reclamation workers and future recreational users assumed to be exposed to multiple media (soil, sediment, surface water, and fish) in nine exposure areas and five miscellaneous small areas of concern. The exposure areas included several subareas and wetlands within Meadow Creek Valley, the EFSFSR, (including tributaries), the Glory Hole, and the Bradley waste rock dumps. Miscellaneous small areas of concern included the smelter stack, DMEA Dump, Bailey Tunnel Outlet (BTO), and two sample locations with unique characteristics (i.e., UW-1 in the Meadow Creek Upgradient Wetland and sample location BD-6 in the Northwest Bradley waste rock dump).

Groundwater, surface water, and seep water were evaluated qualitatively for suitability as drinking water sources. Subsurface materials (e.g., tailing deposits) related to historic mining and milling operations in Meadow Creek Valley were also evaluated qualitatively for potential human exposure.

Reclamation workers were assumed to work for 80 days (one season) at any one of the nine exposure areas and for 10 days at the miscellaneous small areas of concern. Recreational users were assumed to visit for

12 days/year for 30 years at any one of the nine exposure areas and to have one-time contact at the small areas of concern. Exposure routes evaluated were soil ingestion, dermal contact, and inhalation; sediment ingestion; surface water ingestion and dermal contact; and fish ingestion.

1.7.1 SUMMARY OF HEALTH RISK RESULTS

Cancer risk and non-cancer hazard indices (HIs) were calculated for each chemical of potential interest (COPI), receptor, and exposure area using standard USEPA methodologies. Results were compared to USEPA's generally acceptable cancer risk range of 1E-06 to 1E-04 and to a hazard index (HI) of 1. HIs above 1 indicate a potential cause for concern for non-cancer effects but do not indicate that an adverse effect will necessarily occur.

The only constituents that contributed significantly to overall health risk estimates were antimony, arsenic, and, at the Smelter Stack area, mercury. Because the toxic effects of these chemicals are different, that is, they affect different endpoints in the body, the non-cancer effects are not additive (USEPA 1989a). Therefore, HIs were reported for each constituent separately, and maximum HIs are listed in this summary.

Human health risk results are shown in Table 9-8 and are summarized below.

- Cancer risk estimates were within or less than USEPA's acceptable cancer risk range of 1E-06 to 1E-04, for all scenarios evaluated, except for the recreational user at the Keyway Wetland (CR = 3E-04).
- It is unlikely that recreational exposure at the Keyway Wetland poses an unacceptable risk of cancer under realistic exposure conditions. The cancer risk estimate of 3E-04 assumed ingestion of wetland water at a rate of 2 L/day, 12 days/year, for 30 years, which is unrealistically conservative for this exposure area. Considering a lower, but still conservative, rate of exposure (for example, ingestion of 1 L/day for 5 days/year for 30 years), the excess cancer risk would be 6E-05, which is within EPA's generally acceptable range.
- HIs ranged from less than 1 to 4 in all exposure areas, except for three miscellaneous small areas of concern. There is a low probability of unacceptable health hazard at exposure areas with HIs of 5 or less due to the conservative estimates of exposure frequency and duration and chronic toxicity values (applicable to lifetime exposure) that were used in estimating non-cancer hazard.
- Maximum constituent-specific HIs were 10 or above for one or both receptors at three miscellaneous small areas of concern:
  - DMEA Dump (reclamation worker HI = 34; recreational user HI = 10), primarily due to ingestion and dermal absorption of arsenic in the dump material. The DMEA Dump poses a potential non-cancer health hazard under the exposure assumptions evaluated.
  - The smelter stack ash (reclamation worker HI = 736, recreational user HI = 226), soil at the smelter stack (reclamation worker HI = 14; recreational user HI = 4); and smelter stack wood (reclamation worker HI = 8, recreational user HI = 2). Antimony, arsenic, and mercury contributed to HIs above 1 at this area. The smelter stack materials pose a potential non-cancer health hazard under the exposure assumptions evaluated.

- Location BD-6 at the Northwest Bradley waste rock (reclamation worker HI = 73, recreational visitor HI = 22), due to ingestion and dermal absorption of antimony and arsenic at this sample location. In spite of the magnitude of the HIs, there is a low probability of actual health risk because exposure potential is minimal (the maximum HI for the rest of the Northwest Bradley waste rock dump area was 3).

Table 9-26 summarizes the exposure areas ranked by relative risk levels. Areas with very low to no potential for unacceptable health risk under the exposure conditions evaluated are listed below:

- BT/NO Disposal Area
- Meadow Creek Mine Hillside
- Upgradient Wetland, including Location UW-1
- Lower Meadow Creek Valley
- Keyway Wetland
- Meadow Creek Forested Wetland
- EFSFSR, Southeast Bradley waste rock, and Midnight Creek
- Glory Hole, EFSFSR, Northwest Bradley waste rock, and Hennessey Creek
- Northeast Bradley waste rock and Sugar Creek
- BTO (incidental ingestion of surface water)
- Location BD-6 (Northwest Bradley waste rock sample location)

Two miscellaneous small areas of concern pose a potential for unacceptable non-cancer health effects under the exposure conditions evaluated are:

- DMEA Dump and
- Smelter Stack ash (both receptors); Smelter Stack soil and smelter stack wood (reclamation worker)

1.7.2 SURFACE WATER AND GROUNDWATER AS DRINKING WATER

In most surface water exposure areas evaluated (Table 9-23), concentrations of antimony (8 to 127 μg/L) and arsenic (12 to 463 μg/L) exceeded maximum contaminant levels (MCLs) for drinking water and water quality criteria for consumption of water and fish. Levels of arsenic, but not antimony, also exceeded the Idaho numeric criterion for consumption of fish only.

These exceedances of water quality criteria applicable to lifetime consumption by humans do not represent an actual threat to health at the Stibnite Site because:

- no unacceptable health risk was estimated in the risk assessment for incidental ingestion of surface water, for ingestion of surface water as drinking water by recreational users (except for drinking 2 L/day at Keyway Wetland), or for fish ingestion, and
- the likelihood of lifetime or long-term consumption is negligible.

In groundwater (Table 9-24), concentrations of antimony and arsenic in most wells, whether in mining-impacted areas or not, exceeded one or both federal MCLs for drinking water. These results indicate that the quality of untreated groundwater does not meet standards for an approved source of public water supply. However, groundwater at the Stibnite Site is not a source of drinking water, and therefore the exceedances of arsenic and antimony MCLs do not represent an actual threat to health under current conditions.

1.7.3 SEEPS

A screening-level evaluation of arsenic in seep water ingestion was performed as a guide to potential health concerns, if small amounts of seep water were ingested on a one-time basis.

At most seeps, no significant health hazards were identified for ingestion of 500 milliliters (mL) of seep water, because maximum estimated arsenic doses were equal to or below a dose at which no effects have been reported in humans from short term exposures (Table 9-25). At seeps impacted by Bradley tailing, maximum estimated arsenic doses were up to 4 times higher than the dose at which mild gastrointestinal effects have been reported in humans (0.02 mg/kg-day). Cancer risk estimates at all seeps were within or below USEPA's generally acceptable risk range of 1E-06 to 1E-04.

1.7.4 SUBSURFACE SOIL IN MEADOW CREEK VALLEY

Human exposure to subsurface soil in the Lower Meadow Creek Valley could occur through construction activities and in residential scenarios. However, construction activities and residential activities are not expected in the Lower Meadow Creek Valley for the following reasons.

- The presence of buried tailings makes the Lower Meadow Creek Valley unsuitable, both structurally and from a risk perspective, for commercial and residential buildings.
- Mining activities are not expected to occur in the foreseeable future.

Therefore, no human exposure to Lower Meadow Creek Valley subsurface soil is expected.

1.8 CONCLUSIONS

The risk evaluations are based primarily on Site conditions in 1999 for chemical and habitat information and exposure scenarios, following the 1998 reclamation work in upper Meadow Creek Valley at the BT/NO disposal area. The principal findings of the aquatic, terrestrial/riparian, and human health risk evaluations for the Stibnite Site are:

Aquatic Risk Evaluation. Conclusions from the aquatic ecological risk evaluation are listed below:

- Considering the three measurement endpoints applicable to fish, especially water quality, it is unlikely that fish are at risk in any of the four areas or at any of the ten aquatic stations. However,

the physical habitat in portions of Meadow Creek, Lower EFSFSR, and Sugar Creek may represent physical stressors to fish.

- The potential for risk to benthic macroinvertebrates is possible at two stations in the EFSFSR below the Glory Hole (EF-7 and 308), based primarily on the measurement endpoints of quality of the benthic community and sediment quality (i.e., metals concentrations). Risk to benthic invertebrates is "unlikely" at the remaining eight stations. Chemical or physical stressors described as representing a "possible" risk may occur but are not expected to have any significant effects on the receptors.
- In the Glory Hole, the potential for sediment resuspension is low-to-moderate in the 100- and 500-year events, and it is unlikely that, if resuspended, bottom sediment from the Glory Hole would pose an unacceptable risk to downstream aquatic organisms.

Terrestrial and Riparian Risk Evaluation. Conclusions from the terrestrial ecological risk evaluation are listed below:

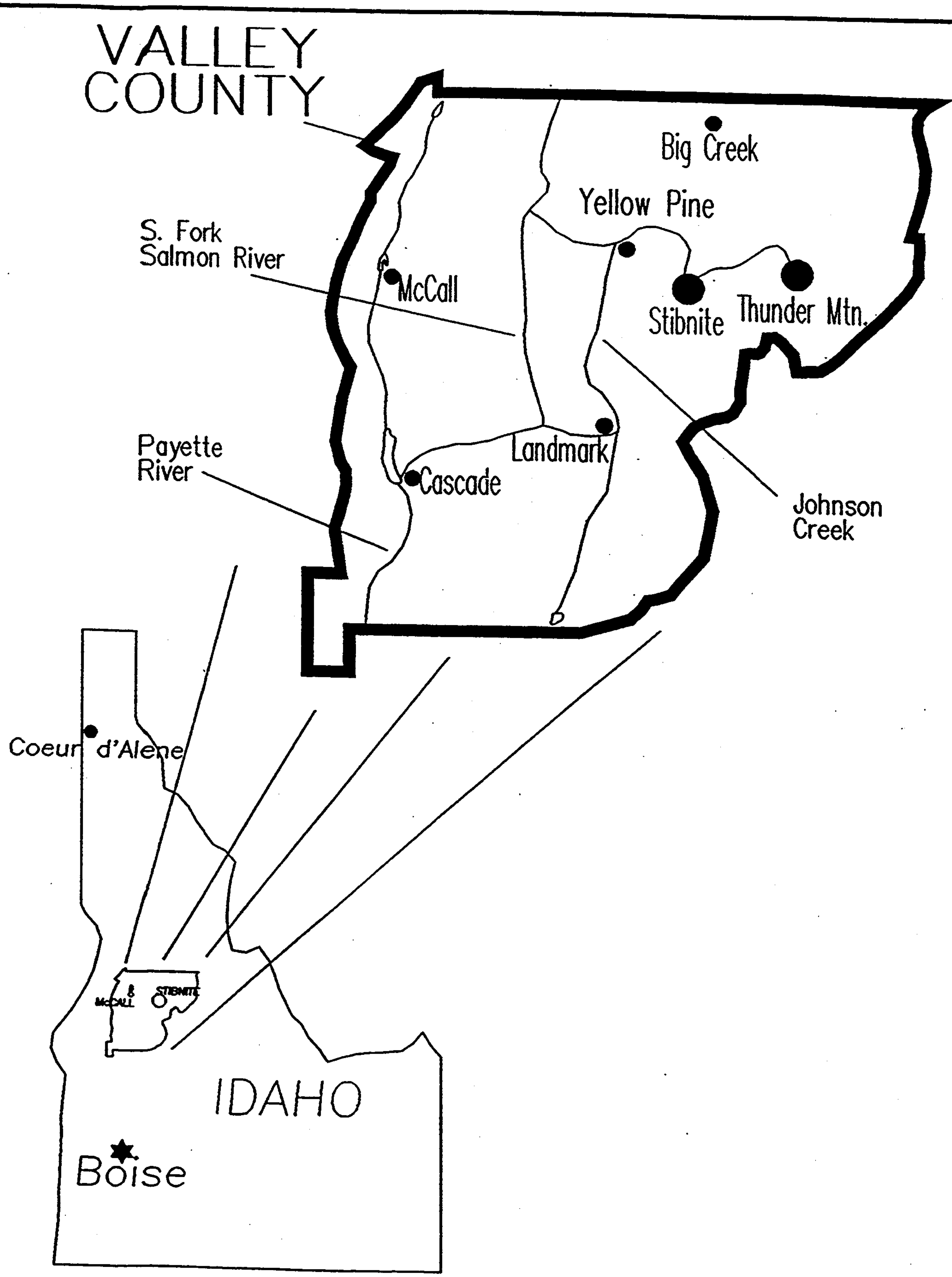
- "Possible" risk is shown for terrestrial habitat or plant communities at four exposure locations: BT/NO Disposal Area, Southeast Bradley Waste Rock Dump, Northwest Bradley Waste Rock Dump, and Northeast Bradley Waste Rock Dump. Risk to the plant community at three locations is due primarily to exposure to high levels of arsenic and mercury in soils. "Possible" risk at the BT/NO Disposal Area is due to high soil levels of antimony.
- No habitat or plant community is evaluated as having "likely" risk.
- Risk to the wildlife populations at nine exposure locations is judged to be "unlikely or possible." These judgements are based on possible risks from exposure to high antimony, arsenic, and/or mercury concentrations in soil that are reduced by the small areas involved and the sparse vegetation/habitat available.
- Risk to wildlife populations at all other locations is "unlikely".
- No wildlife populations are evaluated as having "possible" or "likely" risk.

Human Health Risk Evaluation. Conclusions from the human health risk evaluation are listed below:

- There is very low to no potential for unacceptable health risk at all main exposure areas and wetlands, most miscellaneous small areas of concern in subsurface soil, and at most seeps. This conclusion is based on HIs and excess cancer risk levels within USEPA acceptable ranges, or consideration of conservative assumptions that affect the interpretation of the numerical risk results if results somewhat exceeded the targets (e.g., HIs <5) and the evaluation of exposure pathways.
- Two miscellaneous small areas of concern (the DMEA Dump and Smelter Stack) pose a potential for unacceptable non-cancer health effects under the exposure conditions evaluated, based on HIs of 10 or above for the soil ingestion and dermal absorption pathways.
- Surface water and groundwater concentrations of arsenic and antimony exceeded drinking water MCLs or other quality criteria protective of lifetime consumption of water and or fish. However, the risk assessment calculations showed no unacceptable health risk for ingestion of surface water

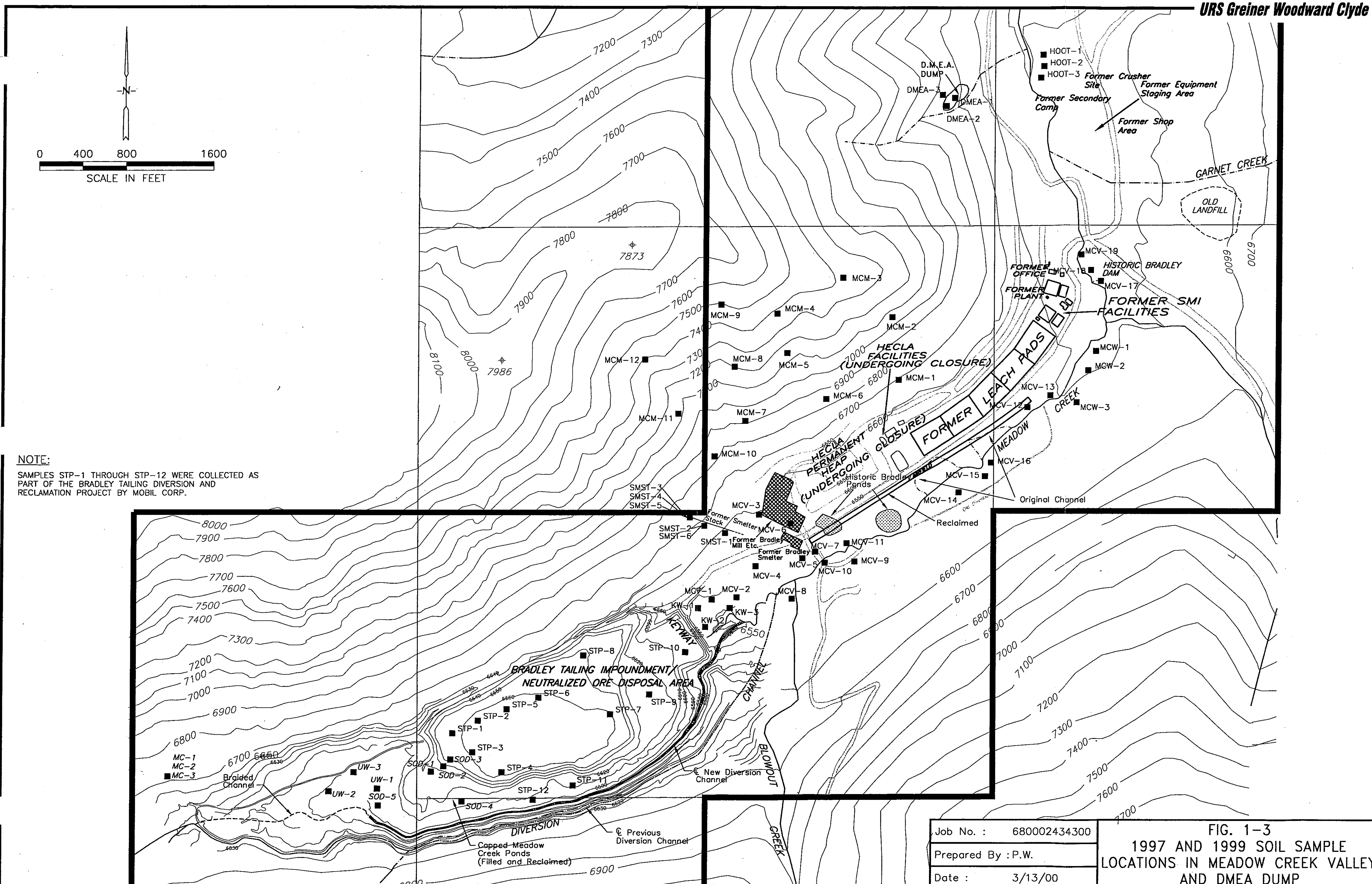
or fish under the exposure conditions evaluated (with the possible exception of Keyway Wetland water ingested at a rate of 2 L/day in the recreational scenario). Furthermore, neither surface water nor groundwater is used as a source of water at the site.

- Short-term ingestion exposure to seeps, except possibly for seeps emerging from Bradley tailing deposits in lower Meadow Creek Valley may pose the potential for mild acute effects.



Job No. : 24343	FIGURE 1-1
Prepared by : C.R.P.	STIBNITE AREA LOCATION MAP
Date : 7/31/98	STIBNITE MINE

SAL-TB



Job No. :	680002434300
Prepared By :	P.W.
Date :	3/13/00

FIG. 1-3
1997 AND 1999 SOIL SAMPLE LOCATIONS IN MEADOW CREEK VALLEY AND DMEA DUMP

2. INTRODUCTION

This revised Draft RER is an ecological and human health risk evaluation for the Stibnite Site, a mining area located along the EFSFSR, 14 miles southeast of Yellow Pine, Idaho (Figure 1-1). The Stibnite Site boundaries are shown in Figures 1-2 and 1-3. This report was prepared in partial fulfillment of the Stibnite Area Site Characterization VCO, which was signed in January, 1997, by SMI, Hecla, Mobil, and IDEQ. In December 1997, the USEPA terminated the VCO with SMI. The currently active VCO respondents, Hecla and ExxonMobil, are referred to collectively as the Stibnite Group. This report is a companion document to the Draft SCR (Stibnite Group, 2000), which was submitted under separate cover to IDEQ.

The site characterization and risk evaluation were performed in accordance with the VCO requirements as specified in the VCO Exhibit B, Stibnite Area Site Characterization Scope of Work and with the IDEQ-approved Work Plan (Stibnite Group, 1997a), Stibnite Area Risk Evaluation Work Plan (Stibnite Group, 1997b) and the Work Plan Addendum (Stibnite Group, 1999). This revised Draft RER was also prepared in light of comments on the initial Draft RER (Stibnite Group, 1998) from IDEQ, U.S. Fish and Wildlife Service (USFWS), Forest Service, and the USEPA. The work was performed in a manner consistent with USEPA guidance for remedial investigations under CERCLA.

The site characterization and risk evaluation were conducted to identify and address potential environmental effects from mining activities at the Stibnite Site that may pose unacceptable risks to the environment or human health. Mining and mineral processing, primarily for gold and antimony, have occurred at the Stibnite Site intermittently since the early 1900s, due to the presence of large deposits of gold, silver, mercury, antimony, and tungsten ores. These deposits had significant tonnages of oxidized gold ore overlying sulfide mineralization, which is characterized by iron, antimony, mercury, and arsenic sulfides. Historic mining activities (principally related to mineral processing and deposits of extraction and beneficiation waste material) may be associated with releases of chemical constituents and sediments or with physical disturbances that may have adversely affected environmental media (soil, sediment, groundwater, and surface water) or habitat condition.

The objectives of the Stibnite Area Site Characterization studies, which were conducted in the summer and fall of 1997 and the summer of 1999, were to:

- Distinguish areas of natural mineralization and areas that are affected by mining activities, based on historic and current data;
- Identify, if possible, the sources of the effects;
- Characterize affected media and identify site-related constituents;
- Characterize the terrestrial, riparian, and aquatic habitat condition based on field surveys and chemical data;
- Provide data adequate for human health and ecological risk assessment; and
- Provide a central comprehensive repository for current and relevant historic site data.

The risk evaluation assesses whether chemical or physical stressors or mining-impacted areas identified and evaluated in the site characterization are likely to pose a significant adverse effect on valued ecological

resources or human health. Information compiled in the Draft SCR (Stibnite Group, 2000) and the results of the risk evaluation will be used to support future remedy decisions for the Site, if unacceptable risk from mining-related impacts is identified and deemed to warrant remediation.

Reclamation work conducted in 1998 and 1999 at the BT/NO disposal area in upper Meadow Creek has resulted in significant improvements in water quality in Meadow Creek and further downstream in the EFSFSR as reported in Stibnite Group (2000). The reclamation work was conducted by ExxonMobil under an AOC with USEPA and the Forest Service. In addition, long-term improvements to terrestrial and riparian habitat and in water quality are expected from current and planned reclamation activities in former mining and processing areas that are being implemented by the Idaho Department of Lands.

2.1 PURPOSE AND SCOPE OF THE RISK EVALUATION

The RER is based on current site conditions, chemical and biological data, and habitat characterization presented in the Draft SCR (Stibnite Group, 2000). The RER assesses whether chemical or physical stressors and mining-impacted areas identified and evaluated in the Draft SCR are likely to pose a significant adverse effect on human health or the environment. The risk evaluation identifies potentially affected habitat and exposed receptors of concern, chemical and physical stressors, potential exposure pathways, and degree of hazard. In accordance with the VCO, the Draft RER also presents "relevant and applicable standards for protection of [stream] beneficial uses, human health and the environment in the Stibnite Area and ... describe[s] any needed changes to existing beneficial use designations for parts of the Stibnite area." Information gathered in the Draft SCR and the results of the RER will be used to support future remedial decisions, if necessary, to reduce unacceptable Site-related environmental or health risk at the Site.

2.2 APPROACH FOR RISK ASSESSMENT

Following are descriptions of the general approaches used in ecological risk evaluation (both aquatic and terrestrial) and in human health risk evaluation. The technical approaches for the risk evaluations are consistent with guidelines established by the USEPA for assessing health and environmental impacts. The chief risk assessment guidance documents that were used are listed below. Other guidance documents, regulations, and scientific literature are cited as appropriate in the report.

- Guidelines for Ecological Risk Assessment (USEPA, 1998a)
- Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (USEPA, 1997a)
- Priorities for Ecological Protection: An Initial List and Discussion Document for USEPA (USEPA, 1997b)
- Framework for Ecological Risk Assessment (USEPA, 1992a)
- Risk Assessment Guidance for Superfund - Volume I: Human Health Evaluation Manual, Part A (USEPA, 1989a)
- Exposure Factors Handbook (USEPA, 1989b)
- Exposure Factors Handbook (USEPA, 1997c)

- Integrated Risk Information System (IRIS) (USEPA, 1998b)
- Guidance for Data Usability in Risk Assessment (USEPA, 1992b)
- Data Quality Objectives Process for Superfund (USEPA, 1993)
- Guidance for the Data Quality Objectives Process (USEPA, 1994)

2.2.1 ECOLOGICAL RISK EVALUATION

The overall approach for the ecological risk evaluations of the Stibnite Site (Sections 7 and 8) is generally consistent with the approach for assessing risk to humans (Section 9). The general approach for conducting the ecological risk evaluation follows the USEPA Data Quality Objectives (DQO) process for Superfund (USEPA, 1993). The DQO process consists of a series of planning steps based on the scientific method that is designed to ensure that the type, quantity, and quality of environmental data collected and used in decision making are appropriate for their intended purpose. The DQO process focuses on clearly defining the problem to be resolved (i.e., identification of risk and, as appropriate, remediation of unacceptable risk) by focusing on the decisions to be made and the overall quality of data necessary to make those decisions. By employing the DQO process, the risk evaluation process is expected to produce the information necessary for making management decisions.

The DQO approach was applied to planning data collection activities at the Stibnite Site. The overall objective of the Work Plan (Stibnite Group, 1997a) and the Work Plan Addendum (Stibnite Group, 1999) was to support the site-specific risk evaluations (ecological and human health). Thus, sampling was designed to collect the data -- and only the data -- necessary for risk evaluation. The ecological risk evaluations address risk to ecological endpoints by identifying the potentially exposed receptors and affected habitat, chemical and physical stressors contributing to risk, source media and exposure pathways, exposure locations, and degree of risk. The evaluations provide the basis for making risk management decisions for the aquatic and terrestrial environments. Such decisions will include identifying the types and locations of potential remedial activities that could reduce ecological risk to acceptable levels.

2.2.2 HUMAN HEALTH RISK EVALUATION

The overall approach used to evaluate health risk is consistent with USEPA guidance in Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual (USEPA, 1989a). USEPA Region X guidance was referred to for dermal exposure assessment (USEPA Region X, 1998). The risk evaluation was performed in accordance with the Stibnite Area Risk Evaluation Workplan (Stibnite Group, 1997b), with the following exceptions:

- Because current land use has changed since the submittal of the Work Plan in August 1997 (i.e., mining operations have ceased), the "Current Part-time Resident" and the "Current Recreational User" are no longer present. Therefore, these receptors were not evaluated in the risk assessment.
- Exposure conditions for workers have also changed. Since mining operations have ceased, workers no longer reside at the site, and estimated duration of employment at the site is one season for a remediation worker to complete closure activities or perform focused remediation work.

- Because additional site characterization was performed in 1999, the three exposure areas for human health risk assessment originally described in the Workplan were modified to reflect the diversity of areas investigated.

The human health risk evaluation includes the following topics.

- Current and future land use and identification of potential receptors
- Exposure areas and media evaluated
- Exposure pathway assessment
- Exposure assumptions
- Constituents evaluated
- Calculation of exposure point concentrations
- Toxicity information used in the risk evaluation
- Characterization of risk
- Lead Exposure Assessment
- Qualitative Evaluation of Surface Water, Groundwater, Seep Water, and Subsurface Soil
- Uncertainty evaluation
- Summary and conclusions

2.3 OBJECTIVES OF THE AQUATIC RISK EVALUATION

The ecological risk evaluation for the aquatic ecosystem addresses potential risk to aquatic organisms (benthic macroinvertebrates and fish) in the streams that flow through the Stibnite Site. The primary streams include (from upstream to downstream): Meadow Creek, EFSFSR, and Sugar Creek. The primary purpose of the aquatic risk evaluation is to perform a scientific evaluation of aquatic risk that can be used to make informed decisions regarding the need for remedial action. The aquatic ecosystem on the Site has been and continues to be affected by various chemical and physical stressors, both naturally occurring and site-related. Risk management decisions for streams found to experience adverse impacts that pose a significant threat to the health of the aquatic ecosystem must be made with an understanding of the sources of impacts, their actual effects, and interactions of chemical and physical stressors and an appreciation of which remediation activities would be effective in addressing identified risks to the aquatic ecosystem.

2.4 OBJECTIVES OF THE TERRESTRIAL ECOLOGICAL RISK EVALUATION

The ecological risk evaluation for terrestrial ecosystems covers the upland and riparian habitat areas within the Stibnite Site. The purpose of the terrestrial ecological risk evaluation, as stated in the Risk Evaluation Work Plan (Stibnite Group, 1997b) is 1) to identify significant physical and chemical stressors on habitat and on wildlife, 2) to evaluate their extent and interactions in order to support problem formulation and risk management decision-making, and 3) to provide data to be used in developing decision criteria related to the selection of preferred remedial alternatives.

In accordance with USEPA guidelines (USEPA, 1998a), the terrestrial risk evaluation identifies significant factors or scenarios that will drive risk management decisions, rather than evaluating the universe of

possible wildlife receptors and exposure pathways. Therefore, this ecological risk evaluation was prepared to address the principal risk management decision objective of determining what constitutes a potentially unacceptable risk to the environment (i.e., specific valued ecological resources) such that remedial measures are warranted.

2.5 OBJECTIVES OF THE HUMAN HEALTH RISK EVALUATION

The human health risk evaluation addresses potential health risk associated with exposure to site-related chemical constituents in environmental media or biota (fish) at the Site. The overall objective is to determine if human exposure to Site-related constituents may result in unacceptable risk such that action may be warranted to reduce exposure. The risk evaluation considers site-specific exposure conditions under current and future land use, and the evaluation identifies pathways and constituents that are the primary contributors to unacceptable risk levels (if any).

2.6 REPORT ORGANIZATION

The RER contains the following principal sections:

1.0 Executive Summary

2.0 Introduction

3.0 Site Description

4.0 Summary of Site Characterization Program and Findings

5.0 Data Used in Risk Evaluation

6.0 Constituents of Potential Interest

7.0 Aquatic Ecological Risk Evaluation

8.0 Terrestrial and Riparian Risk Evaluation

9.0 Health Risk Evaluation

10.0 Report Summary and Conclusions

11.0 References

References (Section 11) are listed by section of the Draft RER; references from Sections 1 and 10 are in Section 11.1; references from Sections 2 through 6 are in Section 11.2; and references from Sections 7, 8, and 9 are in Sections 11.3, 11.4, and 11.5, respectively.

3. SITE DESCRIPTION AND MINING HISTORY

This section provides an overview of the general physical and biological environment at the Site and a summary of the mining history of the Site.

3.1 SITE DESCRIPTION

3.1.1 LOCATION, TOPOGRAPHY, AND CLIMATE

The Stibnite Site is part of a mining area located along the EFSFSR, 14 miles southeast of Yellow Pine, Idaho (Figure 1-1). The Stibnite Site boundaries are shown in Figures 1-2 and 1-3. Site features are shown on Plate 1, Stibnite Area Site Map and Sample Locations.

The Site includes an area along the EFSFSR, starting in Meadow Creek one-half mile upstream of the Meadow Creek Diversion Channel and extending to the north one-quarter mile downstream of the confluence of Sugar Creek and the EFSFSR (Figure 1-2). The boundary between the Payette and Boise National Forests follows the EFSFSR through the center of the area. However, the entire area of the Stibnite Site is administered by the Krassel Ranger District, Payette National Forest. Most mining operations at the Stibnite Site have been conducted on land that is privately owned, but some activities, such as neutralized ore disposal, have occurred on land that is federally managed (Figure 3-1).

The terrain consists of narrow forested valleys (at an elevation of about 6,000 feet above sea level) surrounded by steep mountains rising to about 8,700 feet. The climate is characterized by harsh, long winters and cool, dry summers, during which short-term, high-intensity storms occur. The mean annual temperature for the Stibnite Site is 39 degrees Fahrenheit (°F). January is usually the wettest and coldest month and July is the warmest and driest. Mean annual precipitation for the Stibnite Site is approximately 31 inches, falling mostly as snow between mid October and April. Spring rains and warm days melt most of the snow by mid-June.

3.1.2 GEOLOGY AND HYDROGEOLOGY

The geology is characterized by granitic rock of the Idaho Batholith. Generally, quartz monzonite, an igneous-intrusive rock, underlies most of the Site. A roof pendant of Precambrian metasedimentary rocks overlies the intrusive quartz monzonite of the east side of the valley. Glaciation during the Pleistocene Epoch resulted in up to 60 feet or more of glacial-fluvial-colluvial deposits in the valley floors, consisting of silts, sands, and gravels. The mountainsides are covered with a very thin layer of granular soil and occasional talus deposits. Boulders up to 20 feet in diameter are scattered near the valley edges.

The most significant geologic feature of the area is the series of ring faults that cut through the granitic rocks and Precambrian metasedimentary rock of the area. The large ring-fault system contains gold, silver, mercury, antimony, and tungsten deposits. These deposits had significant tonnages of oxidized gold ore overlying sulfide mineralization. Iron, antimony, mercury, and arsenic sulfides constitute the sulfide

mineralization. The Meadow Creek Fault Zone, West End Fault Zone, and Garnet Creek Fault Zone are three of the major highly mineralized zones within the Site. A plate showing location of geologic features is included in the Draft SCR, Plate 2 (Stibnite Group, 2000).

In the Meadow Creek and EFSFSR valley within the Site, groundwater is found at depths ranging from ground surface to about 20 feet below the surface of the native alluvium. Depth to groundwater is deeper where mining materials or waste rock have been placed on the original surface. Base water level in the Meadow Creek Valley is controlled by Meadow Creek, which acts as a discharge point for shallow groundwater. The direction of groundwater flow beneath the valley floor is parallel to the direction of Meadow Creek. On the valley sides, flow direction is towards Meadow Creek.

Groundwater in the unconsolidated surface materials on hillsides probably derives from infiltration of precipitation and groundwater underflow from the granite bedrock. Groundwater in the glacial and alluvial materials beneath the valley floor is derived from infiltration of precipitation and shallow groundwater flow from upgradient portions of the watersheds. Groundwater discharge is by evapotranspiration, spring flow from numerous seeps and springs, and baseflow to the stream channels.

3.1.3 SURFACE WATER FEATURES AND STREAM CLASSIFICATIONS

Surface water features within the Stibnite Site include the EFSFSR and its tributaries, the Glory Hole pit lake, various springs, and three wetlands in Meadow Creek Valley. Locations of the main surface water features are shown on Plate 1.

The EFSFSR and its tributaries are cold-water streams with moderate to steep gradient and cobble or gravel bottoms. Tributaries from upstream to downstream as they join the EFSFSR are:

- Meadow Creek
- Blowout Creek (flows into Meadow Creek)
- Garnet Creek
- Fiddle Creek
- Midnight Creek
- Hennessey Creek
- Sugar Creek
- West End Creek (flows into Sugar Creek)

The Glory Hole is located in the northern portion of the Site below the confluence of Midnight Creek with the EFSFSR. The Glory Hole was formed in 1955 when the old diversion of the EFSFSR through the Bailey Tunnel failed and the stream returned to its natural channel and into the historic Yellow Pine Pit. A former pond, the Meadow Creek Pond, was located at the southwestern edge of the site above the BT/NO disposal area and adjacent to the Meadow Creek Diversion Channel. In 1995, the pond was divided by a dike into the upper and lower ponds. The ponds were drained in 1998 during ExxonMobil's reclamation work at the BT/NO disposal area, which included restoring the flow path of Meadow Creek through the wetlands above the disposal area.

The wetlands in Meadow Creek Valley are the Upgradient Wetland above the BT/NO disposal area, the Keyway Wetland below the BT/NO disposal area, and a forested wetland in lower Meadow Creek Valley. Other small wetland areas occur in low-lying areas near portions of the EFSFSR.

Discharge measurements at Station 313 (EFSFSR below Meadow Creek) between 1993 to 1997 range from flows of 315 cubic feet per second (cfs) during peak snowmelt in early June to about 10 cfs or less during September. In 1999, flow in the EFSFSR above the Glory Hole ranged from about 225 cfs in late June to about 18 cfs in mid-September. The 2-year peak flow at the inlet to the Glory Hole has been estimated at 313 cfs (see Section 8.8 of Stibnite Group, 2000).

Beneficial stream uses are designated by the State of Idaho. The EFSFSR (source to the mouth) has the following designated beneficial uses: domestic water supply, agricultural water supply, primary and secondary contact recreation, cold water biota, salmonid spawning, and special resource waters. Meadow Creek and Sugar Creek do not have unique beneficial use designations, so they default to all uses designated for the EFSFSR. The EFSFSR (and its tributaries) also is among the Idaho streams that may contain bull trout (*Salvelinus confluentus*). The EFSFSR and its tributaries are, therefore, covered by the water temperature requirements for bull trout (40 CFR 131.33).

3.1.4 FISH AND WILDLIFE

According to the Idaho Department of Fish and Game (IDFG), the primary fish species present at the Stibnite Site include chinook salmon (*Oncorhynchus tshawytscha*), westslope cutthroat trout (*Salmo clarki lewisi*), steelhead (*Salmo mykiss*) (an anadromous form of rainbow trout), resident rainbow trout, and bull trout (*Salvelinus confluentus*). The chinook salmon and the steelhead are migratory, while the cutthroat trout, rainbow trout, and bull trout are resident species. Other species occurring in the area are shorthead sculpin (*Cottus confusus*) and mountain whitefish (*Prospuim williansomi*).

The forested slopes of the Stibnite Site are dominated by subalpine fir, lodgepole pine, Douglas-fir, and Englemann spruce. Understory consists of, among other species, grouse whortleberry, globe huckleberry, and elk sedge. Naturally occurring unforested areas are dominated by grasses and forbs and barren rock outcrops. Areas disturbed by past mining activities are dominated by successional communities. The riparian areas along Meadow Creek and the EFSFSR contain wet meadows and areas dominated by willow and alder shrub.

Large game mammals that may be present at the Site include mule deer, elk, moose, black bear, and cougar. Mountain goat, bighorn sheep, and white-tailed deer utilize the region for summer range between seasonal snow cover. Small mammals likely to occur at or near the Site include weasel, badger, river otter, mink, skunk, bobcat, coyote, red fox, beaver, muskrat, squirrels, and other small rodents. Over 200 bird species are either residents or seasonal visitors. Blue grouse and ruffed grouse are the most important game birds. Spruce grouse and mourning dove are found at lower elevations. Waterfowl that inhabit the area include several species of ducks and shorebirds.

No threatened and endangered avian or terrestrial species are known or expected to occur at the Site (see Section 8.6 of Stibnite Group [2000]).

3.1.5 HUMAN DEMOGRAPHICS AND LAND USE

The Stibnite Site is located 14 miles from the nearest town (Yellow Pine, Idaho). There are no residents at the Site and surrounding Forest Service Land is not occupied. The Primary and Secondary Trailer Camps for mine workers have been dismantled.

The Stibnite Site is largely inactive, except for intermittent monitoring and closure activities. In 1998 and 1999, the SMI facilities, camps, and roads (except for the main access road and the Thunder Mountain Road) were demolished and reclaimed by IDEQ and the Idaho Bureau of Lands. Closure of the Hecla heap is in process. Monitoring of groundwater and surface water near the former SMI leach pads and Hecla heap is conducted in accordance with approved reclamation plans. Environmental monitoring at the BT/NO disposal area was conducted according to the AOC between Mobil, USEPA, and the Forest Service. The Forest Service also conducts periodic monitoring of surface water, sediment, and benthic communities.

Mining operations are not planned or anticipated in the foreseeable future. Both Hecla and IDEQ expect that future activities other than monitoring (such as final closure or focussed reclamation work) will be limited to one season.

Within the Site boundaries, recreational uses such as hunting, fishing, or camping are minimal due to past mining operations, the small size of the tributaries to the EFSFSR which render them less attractive or unsuitable for fishing, and the fact that large portions of the Site are privately owned (Figure 3-1). However, recreational use could increase in the future as remediation, reclamation, and closure programs reach completion.

3.2 SITE HISTORY

The mineral deposits of the Stibnite Site were discovered around 1900 during the Thunder Mountain gold rush. The gold prospects at Meadow Creek were studied but the stamp mills used around the turn of the century could not effectively process the complex gold and antimony ore, so little or no development occurred at that time. The mineral claims were not staked until the demand for metals during World War I stimulated interest in the antimony and mercury deposits of the Stibnite Site (Mitchell, 1995). Figures 3-2 and 3-3 are historic aerial photographs of the Meadow Creek Valley area, including Bradley historic mill and tailing deposits, as it appeared in 1942 and 1979, respectively. Photographs of other site features are included in Section 11 of Stibnite Group (2000).

3.2.1 MEADOW CREEK MINE, 1919 TO 1938

In 1919, Albert Hennessey and two partners formed the Meadow Creek Silver Mines Company to work the Meadow Creek Mine. Between 1920 and 1927, activity at the site was limited to tunneling and

development work on the Meadow Creek Mine and mine camp. In 1927, the Meadow Creek Mine was optioned by F.W. Bradley, whose Yellow Pine Company began active development work. Work completed between 1928 and 1930 included the expansion of the Meadow Creek Camp, construction of the North Camp on Fiddle Creek, construction of the Monday Camp near the mouth of Midnight Creek, construction of the road between Yellow Pine and the Stibnite Site, installation of mining and milling equipment, and construction of two hydroelectric power plants.

The first hydroelectric power plant was located on the edge of Meadow Creek near the milling facilities. An earthen dam was constructed on the East Fork of Meadow Creek (now referred to as Blowout Creek) to create a reservoir. The dam was built in 1929 and enlarged in 1931 and was reportedly 35 feet high, 700 feet long, and had a capacity of approximately 700 acre-feet. A pipeline transported water from the reservoir to the power plant, which supplied electricity for the milling operations. In 1931 the power plant was moved into the mill building. The second dam, which was much smaller, was located on the EFSFSR just below the confluence with Meadow Creek. A 28-inch pipeline, approximately 11,000 feet long, transported water from the dam to the power plant that was located on Sugar Creek near its confluence with the EFSFSR.

The Meadow Creek Mine was an underground mine that was developed along the Meadow Creek Fault Zone. Development occurred from three principal areas which included two tunnels in the Meadow Creek Valley: the North Tunnel in the Fiddle Creek drainage and the Monday Tunnel near the mouth of Midnight Creek. The Monday Tunnel eventually connected to the tunnels in the Meadow Creek Valley. By 1938 the Meadow Creek Mine had over 20,000 feet of underground workings. The minerals that were mined were primarily comprised of stibnite (antimony sulfide), gold, yellow pyrite and black pyrite (iron sulfides), and arsenopyrite (iron-arsenic sulfide). The ore was typically ground to minus 100-mesh and processed in a series of flotation cells to produce a stibnite concentrate and a gold-iron concentrate. The mill began operation on January 3, 1932. It was initially constructed with a capacity of 150 tons per day but was expanded to 200 tons per day in 1932. Due to the complex metallurgy of the ore, the milling processes were modified several times in order to improve recovery rates. The gold-iron concentrates were initially sent through a cyanide circuit for separation of the gold and silver. However, gold could not be recovered by cyanidation due to the presence of too much antimony in the concentrates, and the process was discontinued. The antimony concentrates and the gold-iron concentrates were transported to a government-controlled smelter in Utah for further processing.

Dikes were constructed by Bradley Mining Company along the edge of Meadow Creek just southwest of and adjacent to the milling facilities to create a small tailing impoundment between the mill and the creek. The tailing waste from the milling operations was deposited via slurry pipeline in this area. This original tailing impoundment covered approximately 5 acres and the tailing reached a thickness of approximately 7 feet. It is possible that additional tailing ponds (possibly east of the milling facilities) were used.

The Meadow Creek Mine operated almost continuously from 1932 until it closed in June 1938. Between 1932 and 1938 it was the largest producer of antimony in the United States and was one of the largest producing gold mines in Idaho. According to the United States Bureau of Mines records, the Meadow

Creek Mine produced 303,853 tons of ore between 1926 and 1938. This material yielded 53,035 ounces of gold, 186,451 ounces of silver, 19,818 pounds of copper, and 8,099 pounds of lead. Antimony production is not reported with the other metals. In 1941 the equipment was removed from the Meadow Creek Mine and the mine was allowed to fill with water. By 1943, the underground workings were badly caved.

3.2.2 YELLOW PINE MINE, 1937 TO 1952

The Yellow Pine Mine is located on the EFSFSR about three-quarters of a mile above the mouth of Sugar Creek, near the mouth of Midnight Creek. Albert Hennessey located the first claims in this area in 1923 and several others in 1924 and began minimal development work. The claims were optioned by F.W. Bradley's Yellow Pine Company in 1928 but only minor development work was performed through 1937. Mining from the West Quarry began on September 1, 1937. The ore bodies were larger, but of lower grade, than those of the Meadow Creek Mine. However, because they could be worked by surface methods they were much more economical. This prompted the closure of the Meadow Creek Mine in 1938, but operation of the mill and crusher at the Meadow Creek Camp was maintained. On August 1, 1938, Bradley Mining Company (formerly the Yellow Pine Company) took over all operations.

Between 1938 and 1941, production came from the East and West Quarries located on either side of the EFSFSR and also from underground workings. In 1941, the United States Bureau of Mines discovered a large tungsten-bearing ore body beneath the EFSFSR, and associated government price supports prompted the company to focus all efforts on tungsten production. The majority of this production came from underground workings. By 1942, exploration on the tungsten ore body, conducted under the direction of the War Production Board, showed that it was suitable for open-pit mining. In March 1943 the Bailey Tunnel was completed. This tunnel diverted the flow of the EFSFSR from the confluence with Midnight Creek to an outlet on Sugar Creek. The tunnel measured 7 by 9 feet and was approximately 3,500 feet long. During development of the open pit, approximately 1 million cubic yards of overburden was removed from the top of the ore body and placed in dumps on both sides of the EFSFSR below the pit and on the south side of Sugar Creek above its confluence with the EFSFSR. From 1943 on, all mining in the Yellow Pine Mine was by open-pit method.

Much of the exploration work on the Yellow Pine ore bodies was performed under the Strategic Materials Act signed by President Roosevelt in 1939. Extensive diamond drilling, trenching, and mapping activities were performed in and around the Stibnite Site by the United States Geological Survey (USGS) and United States Bureau of Mines between 1939 and 1942. Bradley Mining Company was also the recipient of government-sponsored exploration programs and was awarded two contracts by the DMEA to explore for antimony. This work was carried out by Bradley Mining Company between 1953 and 1955.

The Bradley mining operations in the Yellow Pine Mine were primarily for the production of antimony, except between 1941 and 1945 when tungsten was the primary mineral produced. Because of the typical ore grades and fluctuations in market prices, gold was also targeted in order to make mining profitable. The ores that were mined were similar to those from the Meadow Creek Mine and were primarily comprised of stibnite (antimony sulfide), yellow pyrite and black pyrite (iron sulfides), arsenopyrite (iron-

arsenic sulfide), and scheelite (tungsten). The ores were typically ground to minus 100-mesh for processing. The tungsten ore typically required grinding to minus 200-mesh. The same crusher and mill were used for processing the ores from the Meadow Creek Mine and the Yellow Pine Mine. In 1945 an in-pit crushing plant was constructed in the Yellow Pine Mine open pit, and most of the grinding equipment was moved from the mill at the Meadow Creek Camp to the new crushing plant.

The milling processes were modified several times throughout the life of the mine in order to improve recovery rates and also to provide for the tungsten production. Due to the lower antimony content of the Yellow Pine Mine ore body, the cyanide circuit could be used for the recovery of gold and silver. In addition to the process changes, the mill was expanded several times, increasing its capacity to approximately 2,500 tons per day by 1946. One of the flow diagrams generated by the Bradley Mining Company describing the milling process states that the reagents added during the milling included copper sulfate, lead acetate, caustic soda, soda ash, chlorine, cresylic acid, oleic acid, xanthate, and sodium silicate.

The tailing waste generated from the Yellow Pine Mine was disposed of in the Meadow Creek Valley. Prior to 1942, approximately 1,000 feet of lower Meadow Creek were diverted to provide additional room for the tailing impoundment. Through 1946 the tailing was deposited throughout the Meadow Creek Valley to just below its confluence with the EFSFSR. The tailing reached a thickness of up to 10 feet. During the winter months, the tailing was reportedly pumped directly into Meadow Creek (Mitchell, 1995). Much of these tailing deposits are visible along Meadow Creek in Figures 3-2 and 3-3.

In September 1946, a large tailing impoundment was constructed in the upper Meadow Creek Valley upstream of Blowout Creek (see Figure 3-3). Bradley Mining Company constructed a dike across the valley to contain the tailing and dug a diversion channel nearly a mile long to divert Meadow Creek around the tailing impoundment. The diversion channel was constructed along the south side of the valley and joined Blowout Creek. Tailing was deposited in the upper Meadow Creek Valley from late 1946 until mining operations ceased in 1952. The tailing filled the original Meadow Creek streambed. By 1952, the Bradley tailing deposit in the impoundment was approximately 1,400 feet wide by 2,000 feet long and up to 45 feet thick. There are an estimated 3.7 to 4.2 million cubic yards of Bradley tailing in the impoundment.

There are numerous springs from the north and south hillsides in the tailing impoundment area. Because the Bradley tailing blocked the original Meadow Creek channel, water from the springs formed the Meadow Creek Pond behind the tailing impoundment. Bradley Mining Company installed a culvert pipe to decant the water from the pond and carry it parallel to the diversion channel to enter Meadow Creek below the impoundment (Mitchell, 1995).

In May 1948, the Bradley Mining Company began construction of a gold-antimony smelter next to the mill at the Meadow Creek Camp. The exhaust stack was constructed on the hillside northwest of the smelter. The smelter was completed in July 1949 and was considered state-of-the-art for the time. Due to metallurgical problems, the smelter operated only intermittently from 1949 through 1952 and briefly again in 1956 to 1957. The difficulties due to the complex metallurgy of the ore were not finally solved until

June 1951. When operating properly, slag was tapped at a rate of about 1 ton per minute. The granulated slag was pumped to a disposal area west of the smelter.

Mining operations ceased in the Yellow Pine Pit in 1952 with the collapse of the antimony market after the government withdrew price supports. When the mine closed, the pit measured approximately 1,500 by 2,500 feet and was over 450 feet deep. Most of the underground workings were removed during the mining of the pit. During its operation, the mine was the nation's leading producer of antimony. It was also the nation's leading producer of tungsten between 1941 and 1945. Approximately 30 percent of the total tungsten and 90 percent of the antimony for the nation's wartime needs were mined from the Stibnite Site. The mine was also one of the largest producing gold mines in Idaho. According to U.S. Bureau of Mines records, the Yellow Pine Mine produced 4,344,459 tons of ore and reprocessed 74,570 tons of old tailing between 1939 and 1952. This material yielded 256,443 ounces of gold; 1,497,223 ounces of silver; 25,514 pounds of copper; and 7,211 pounds of lead. In addition, the property produced 59,341,502 pounds of antimony and 844,779 units of tungsten (a unit of tungsten is equivalent to 20 pounds of tungsten trioxide). The Yellow Pine Mine had supported a local community at the Stibnite Site that had a population as high as 1,500 residents. The town at the Stibnite Site had approximately 160 homes, a school house, service station, hospital, general store, and a large recreation hall with a bowling alley, restaurant, and auditorium.

3.2.3 SPORADIC ACTIVITY OR IDLE, 1953 TO 1978

The mill and smelter were shut down by August 1952, after operations in the Yellow Pine Mine were suspended. Bradley Mining Company performed exploration activities through 1955 under the Strategic Minerals Act, but there was no additional mining. Between 1956 and 1957 about 2,000 tons of cathode antimony that the Bradley Mining Company purchased from Sunshine Mining Company were refined in the smelter and sold to the U.S. government. After the cathode antimony was processed, the smelter was dismantled and moved to another site. In 1958 the property was placed on a caretaker basis and was essentially a ghost town. By 1960, Bradley Mining Company was no longer maintaining a caretaker at the mine. For the next decade the property remained idle. All but five houses from the town of Stibnite had been moved to other Idaho towns by 1964.

In 1955, after 12 years of carrying the EFSFSR around the Yellow Pine Mine pit, the Bailey Tunnel was reportedly abandoned, and the EFSFSR was allowed to flow into the open pit creating a small lake (now referred to as the Glory Hole). In 1999, the depth of water in the Glory Hole was 44 feet at its deepest point. The EFSFSR flows through the mining area, adjacent to the Northwest Bradley waste rock dump, until it joins the original channel near the confluence with Sugar Creek.

At some point during this time, the Meadow Creek Pond ceased to drain through the culvert pipe and pond overflow eventually eroded a channel through the tailing along the south side of the valley. Aerial photos from the 1960s and 1970s show that both of the diversion channels in upper and lower Meadow Creek constructed by Bradley Mining Company failed after mining operations ceased. The failure of the upper Meadow Creek diversion channel around the south side of the Bradley tailing impoundment allowed the

stream to flow through the channel that the pond overflow had eroded through the tailing. Prior to 1962, the diverted section of lower Meadow Creek returned to its natural channel by eroding through the tailing. Between 1952 and 1979, an estimated volume of 10,000 cubic yards of tailing was eroded into the EFSFSR from the Bradley tailing impoundment (JMM, 1981).

In 1958, the dam on Blowout Creek was breached by Bradley Mining Company after an inspection by Forest Service engineers. The breach was reported to be 60 feet wide at the top and 20 feet wide at the base. The remaining depth of the reservoir was 8 feet and the threat of a catastrophic failure was reported to have been removed. On June 10, 1965, the dam failed as a result of record snow melt and runoff rates. The surge of flood water scoured the stream channel to a depth of 100 feet in the area below the dam and deposited a debris flow at the confluence with Meadow Creek. Large volumes of tailing and sediment were carried into Meadow Creek, the EFSFSR, and to the Glory Hole. The effects of the surge on top of the record runoff caused damage in the EFSFSR as far downstream as Yellow Pine (approximately 14 miles downstream). It was estimated that about 5 miles of the Forest Service road were destroyed, along with several bridges (KK Consulting, 1997).

In 1970, Bradley Mining Company's property was leased by Ranchers Exploration and Development Company. Exploration drilling for antimony was conducted, and the deposit was said to be one of the largest in the world. Plans were made to put the property into production, but nothing came of them.

3.2.4 GOLD MINING AND RECLAMATION, 1978 TO 1999

In 1978 and 1979, Canadian Superior Mining Company (Superior), a former subsidiary of Mobil Corporation and since dissolved, conducted a pilot-scale operation for extracting gold from low-grade oxide ore. Before mining began, and as part of the EIS required by the Forest Service, several baseline studies were done by Superior (JMM, 1979; 1981). These studies and the EIS issued in 1981 document the pre-existing contamination and other impacts resulting from the Bradley operations. The studies included soil, groundwater, and surface water sampling, and evaluation of effects on vegetation, aquatic condition, and benthic macroinvertebrates. The operating permit issued by the Forest Service required that extensive remedial efforts be undertaken by Superior to mitigate the environmental effects and threats of releases from the Bradley milling operation and tailing deposits.

In 1982, Superior and Twin River Developments (TRD) formed a joint venture to commence open pit mining with ore from the West End Mine located near the ridge top in the West End Creek drainage. Due to the difficulties with accessing the site and harsh winter climate, mining was performed on a seasonal basis. Superior and TRD constructed a five-celled lined leach pad, ponds, plant, and refinery in the Meadow Creek Valley. The leach pads were constructed over a portion of the old runway that had served the Bradley Mining Company. The ore was typically crushed to minus 2-inches and loaded onto the heap leach pads. Gold was extracted from the ore with a dilute sodium cyanide solution. The gold-laden solution was piped to the processing plant next to the leach pads and collected in a lined pond. The solution was pumped through a series of carbon columns that extract the gold-cyanide complex. The

barren solution was then pumped back onto the leach pad to complete the circuit. When the ore was adequately leached, the cyanide was neutralized with either hypochlorite or a peroxide solution.

Superior and TRD were granted permission to operate from the Forest Service by incorporating reclamation of some of the historic Bradley mining disturbances into the mine plans. As outlined in the 1981 EIS (JMM, 1981), which was produced under the direction of the Forest Service, the reclamation plan provides for an overall reclamation program for the mine sites, disturbed areas, and the existing Bradley tailing pile in order to reduce surface wind erosion, total suspended particulate concentrations, and sediment production. The on/off leach pad system was employed so that the neutralized ore could be used to stabilize and encapsulate the Bradley tailing that had been deposited in the upper Meadow Creek Valley by the Bradley Mining Company.

Superior operated at Stibnite from 1982 through the 1984 season, with all mining occurring in the West End Pit. There was no mining during the 1985 season due to Superior being acquired by Mobil. The major reclamation activities completed by Superior during their two years of operations included:

- Reconstruction of and upgrades to the Meadow Creek Diversion Channel around the Bradley tailing impoundment upstream of Blowout Creek;
- Construction of the Keyway at the base of the Bradley tailing impoundment to prevent potential mass failure of the partially saturated tailing pile;
- Realignment of the lower Meadow Creek Channel that was meandering through the Bradley tailing adjacent to the old runway;
- Encapsulation of Bradley tailing adjacent to the old runway with waste rock material;
- Construction of the leach pads, processing facilities, and new runway;
- Construction of the Primary and Secondary camps and ancillary facilities;
- Construction of the Upper West End waste dump (including initial reclamation activities);
- Construction of the West End Creek diversion (french drain) beneath the Upper and Lower West End dumps (the lower dump was not actually constructed at this time); and
- The encapsulation of a majority of the Bradley tailing impoundment on upper Meadow Creek with neutralized ore material.

Pioneer Metals Corporation bought Superior's interest in the Stibnite site in 1985 and resumed mining operations during the 1986 season using the same facilities (on/off leach pad system and neutralized ore disposal at the upper Bradley tailing impoundment). Pioneer subsequently sold 50 percent of its interest to Barrier Reef, Inc. Pioneer continued mining operations through the 1990 season. During their period of operation, Pioneer mined ore from the West End Pit, the West End Extension Pit, and the Splay Pit, which was located on the ridge top adjacent to the West End Pit. The major activities completed by Pioneer included:

- Construction of the Lower West End dump;
- Backfilling of the West End Pit; and
- Encapsulation of the remaining exposed Bradley tailing impoundment with neutralized ore, up to the edge of the Meadow Creek Pond.

In 1990, Pioneer received a Notice of Violation from IDEQ for cyanide concentrations in Meadow Creek. The cyanide releases were the result of placing neutralized ore with residual cyanide in it directly into the Meadow Creek Pond during the 1989 season in an attempt to corral the Bradley tailing slimes that were displacing into the pond as the neutralized ore was being spread out to cover the tailing. Mitigation efforts were undertaken, and water quality analyses performed by the IDEQ laboratory indicated that cyanide concentrations in Meadow Creek and the pond declined to below the acute water quality standard within several months. However, detectable concentrations of cyanide were present in the Meadow Creek Pond for several years.

Pegasus Gold, Inc., a wholly owned subsidiary of MinVen Gold Corporation, took over Pioneer's interests in early 1991. Dakota Mining Corp., formerly MinVen, mined gold in the Stibnite Site, via its subsidiary SMI, noncontinuously from 1991 through the 1997 season. SMI used the same facilities as Pioneer and Superior (on/off leach pads and neutralized ore disposal at the Bradley tailing impoundment). During their period of operation, SMI mined ore from the West End Pit, the Midnight Pit, the Northeast Pit, the West End Extension Pit (Stibnite Pit), and the Garnet Creek Pit. SMI was shut down after a shortened 1993 season due in part to the listing of the chinook salmon as a threatened species. The property remained idle during the 1994 season.

Mining operations resumed in 1995 after a Biological Assessment was performed and a Reasonable and Prudent Alternatives package was prepared by the Forest Service outlining reclamation actions to be undertaken to counter the potential adverse impacts to the salmon caused by continued mining activities. SMI also was required to obtain a new cyanidation permit. SMI continued to operate through the 1997 season, when operations were suspended due to a depressed gold market. By 1998, SMI decided to initiate final closure of the mine operations, based on the depressed gold market, remaining oxide gold reserves, permitting requirements, and associated economics. The major activities completed by SMI during their operation included:

- Construction of the DMEA dump in the West End area;
- Replacement of the liners on the leach pads and ponds in the processing facility;
- Remediation of diesel contamination from leaking underground storage tanks;
- Backfilling of the Splay Pit, West End Pit, Midnight Pit, Northeast Pit, and Garnet Creek Pit;
- Reshaping and armoring of the Lower West End dump and DMEA dump;
- Stabilization of Bradley tailing and establishment of vegetation within the flood plain of Meadow Creek downstream of the Keyway;
- Reclamation activities and establishment of long-term water management in the West End area.

Hecla mined oxide gold ore from the Homestake ore body, east of the Yellow Pine Mine, between 1988 and 1992. The Homestake deposit was discovered by the U.S. Bureau of Mines during its strategic minerals investigations in 1939. The ore was said to resemble that of Bradley's East Quarry of the Yellow Pine Mine. During 1988, Hecla's ore was leached using Pioneer/Barrier Reef's facilities, and neutralized ore was placed at the disposal area at the Bradley tailing impoundment. During the 1989 season, Hecla prepared the area west of the Pioneer/Barrier Reef leach pads for construction of a permanent heap. The

new leach pad was constructed near the entrance of the old Meadow Creek Mine, on top of the Bradley milling facilities. Hecla encapsulated the remains of the smelter site and Meadow Creek Camp ruins with neutralized ore, waste rock, and alluvial fill while constructing their facilities. A french drain was constructed beneath the permanent heap leach pad to divert water from the springs in the north hillside away from the pad liner.

The ore from the Homestake Pit was hauled to a crusher located next to the Glory Hole where it was crushed to minus 2-inches. The crushed ore was then hauled to the agglomerator where it was mixed with cement and loaded onto the leach pad using a conveyor. Gold was extracted from the ore with a dilute sodium cyanide solution. The gold-laden solution drained from the heap into a lined pond. The solution was pumped through a series of carbon columns that adsorbed the gold-cyanide complex. The barren solution was then pumped back onto the leach pad to complete the circuit.

In 1995, SMI entered into an AOC with the USEPA Region 10 to mitigate environmental problems associated with the historic Bradley tailing in the upper Meadow Creek Valley.. The AOC required SMI to stabilize the upper Meadow Creek Diversion Channel and to treat the flow exiting the Keyway to meet water quality standards. In accordance with approved plans, SMI used overburden from the Garnet Creek Pit to stabilize the remaining Bradley tailing around the tailing impoundment and to stabilize the upper Meadow Creek diversion channel. A dike was constructed across the Meadow Creek Pond near the upgradient extent of the Bradley tailing, creating an upper and lower pond. The dike was constructed to prevent migration of the tailing in the pond so the lower pond could be backfilled and the remainder of the Bradley tailing could be encapsulated. After building the dike, the pond outlet channel that had eroded through the Bradley tailing was backfilled with overburden.

The backfilling of the pond outlet channel resulted in the pond level rising to an all-time high during the spring of 1996. This resulted in additional saturation of the Bradley tailing and of the neutralized ore material on top of the tailing and an increase in metals release to Meadow Creek. In 1996, SMI constructed a temporary channel through the backfill that helped lower the pond level and continued with the expansion and reinforcement of the upper Meadow Creek diversion channel to meet the 500-year flood design.

During the 1997 season, SMI began construction of a new diversion channel in the same location as the temporary channel that was constructed in 1996. This channel was excavated through the historic Bradley tailing and into the native alluvium. The plan was to construct the channel deep enough to drain the Meadow Creek Pond, lower the water table in the BT/NO disposal area, and reduce flow exiting the Keyway. However, due to adverse conditions encountered during construction and financial limitations placed on SMI by the depressed gold market, the new diversion channel was not completed, nor was the Keyway treatment system constructed. USEPA terminated the AOC with SMI in December 1997. A new diversion channel was completed by Mobil in 1998 under a new AOC (described at the end of this section).

Hecla finished mining ore from the Homestake Pit in 1991. The permanent heap was finished with a height of about 110 feet and covered about 12 acres. The heap also included about 200,000 tons of oxide ore stockpiled from the Bradley operations. Hecla began neutralization of the heap in 1992 using a bio-

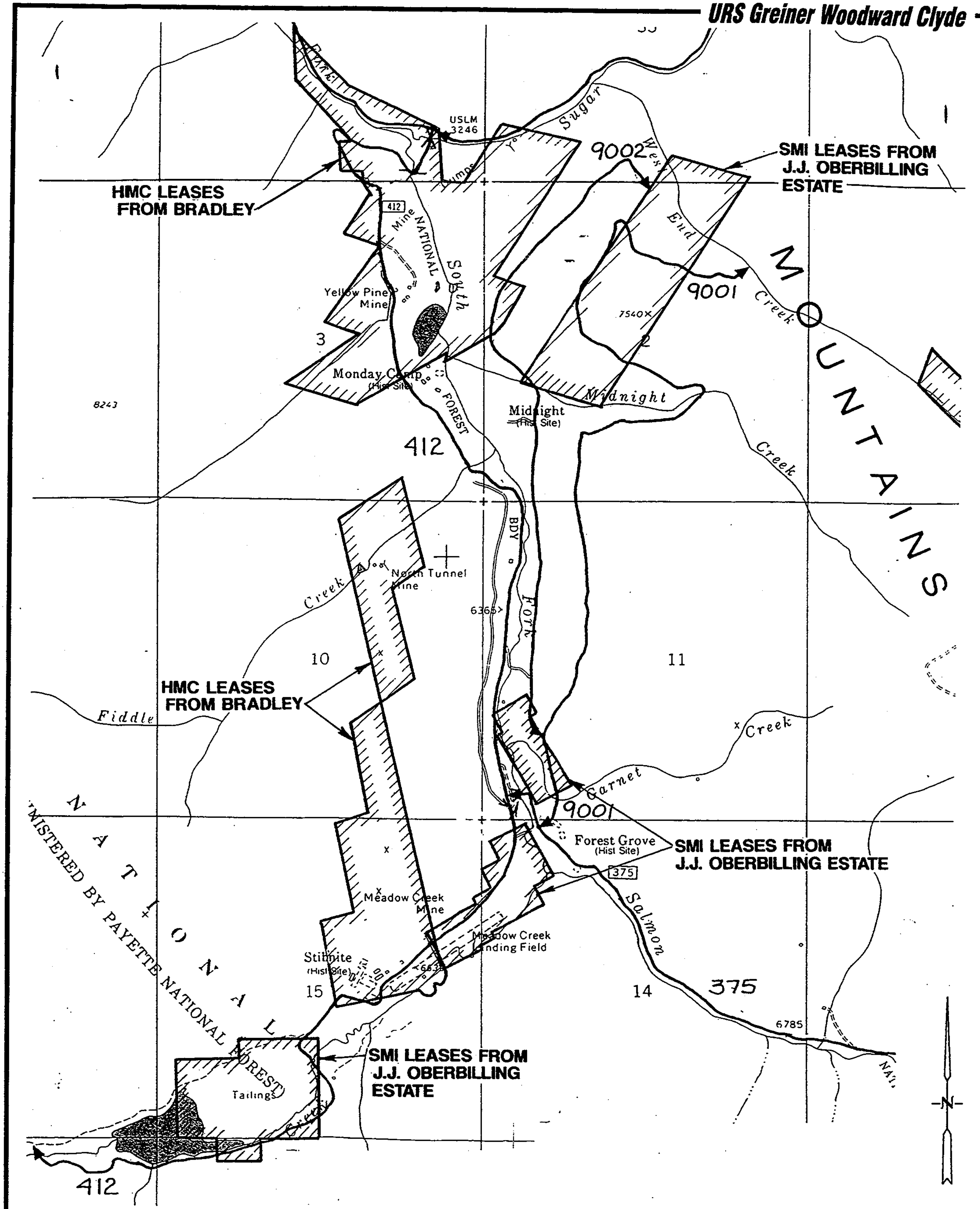
neutralization process. The heap leach operation is now undergoing reclamation activities in order to complete closure of the area. The major activities completed by Hecla during their operations included:

- Reclamation of the historic Bradley milling facilities and smelter site;
- Reclamation of the original Bradley tailing pond located adjacent to the smelter;
- Reclamation of much of the Yellow Pine Mine's West Quarry located downstream of the Glory Hole;
- Partial reclamation of the Northwest Bradley waste rock dump sites near Sugar Creek;
- Reclamation of the Homestake Pit area; and
- Stabilization and resloping along the EFSFSR near Hecla's fuel storage facilities.

In May 1998, a new AOC was signed between Mobil Oil Corporation, USEPA, and the Forest Service to stabilize and reclaim the BT/NO disposal area and minimize surface water contamination of Meadow Creek. The Bradley Tailing Diversion and Reclamation Project, implemented by Mobil in 1998, included constructing a new 4,575-foot-long Meadow Creek on the south side of the BT/NO disposal area; building a new drainage channel on the north side; lining the old Meadow Creek diversion channel to reduce seepage; closing the pond, covering about 5 acres of exposed tailing at the upper end of the BT/NO disposal area, and restoring the flow of Meadow Creek through the wetland above the disposal area; regrading and revegetating the 100-acre BT/NO disposal area; and revegetating the banks of the diversion channel and installing voluntary stream restoration features such as channel pools and large boulders. The construction work was completed in 1998, and revegetation continued in 1999. The reclamation project will reduce infiltration of water into the BT/NO disposal area, reduce migration of particulates from the tailing, and has already improved water quality in Meadow Creek. Long-term water quality monitoring is continuing.

By the end of 1999, most of the SMI facilities and haul roads had been reclaimed under a reclamation plan approved by IDEQ, Idaho Department of Lands, and the Forest Service and implemented by the Department of Lands. Reclaimed areas included the leach pads and ponds, SMI office area, crusher site, pilot plant, former camps, and about 90 percent of the haul roads and exploration roads. A few remaining areas are expected to be closed and reclaimed in 2000.

URS Greiner Woodward Clyde



SMI – STIBNITE MINING INC.
HMC – HECLA MINING CO.
BRADLEY – BRADLEY MINING CO.
PROPERTY BOUNDARY
375 ROAD NUMBER

NOT TO SCALE

Job No. :	6800024343.00
Prepared By : TGC	
Date :	7/11/00

FIGURE 3–1
PRIVATELY OWNED PARCELS WITHIN THE STIBNITE SITE
STIBNITE MINE

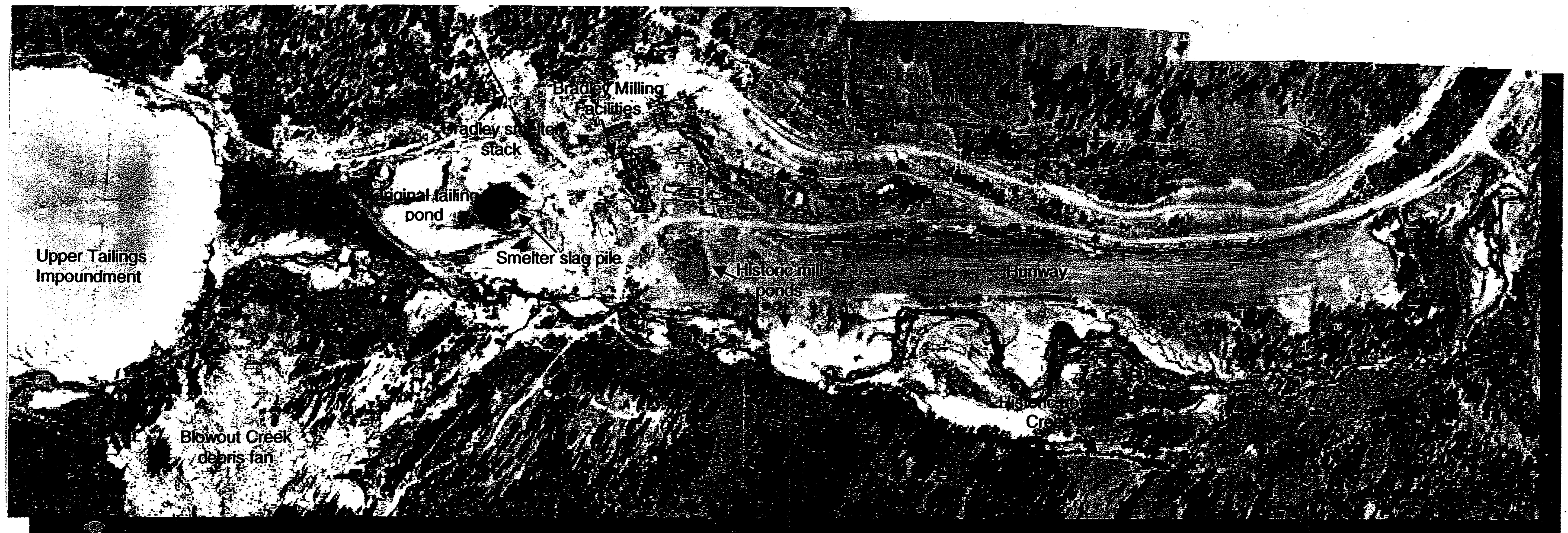
24343022

URS Greiner Woodward Clyde

NOTE THE TAILING DEPOSITION THROUGHOUT THE VALLEY AND THE TOWN OF STIBNITE IN THE BACKGROUND

Job No. : 680002434300	FIGURE 3-2 MEADOW CREEK VALLEY (CIRCA 1942) STIBNITE MINE
Prepared By : TGC	
Date : 7/11/00	

WPA005



Job No. : 680002434300	FIGURE 3–3	
Prepared By : T.G.C.	MEADOW CREEK VALLEY 1979	
Date : 7/11/00	STIBNITE MINE	

4343TB2

4. SUMMARY OF SITE CHARACTERIZATION PROGRAM AND FINDINGS

This section summarizes the results of the 1997 and 1999 Site Characterization field investigations and characterization of aquatic terrestrial, and riparian habitats. More detail regarding the sampling, analysis, and results is available in the SCR (Stibnite Group, 2000).

For the Site Characterization investigation, the Site was divided into three areas based on geography and operational history. Area 1 is the Meadow Creek Valley beginning about one-half mile upstream of the new Meadow Creek Diversion Channel and extending down to the confluence with the EFSFSR. Area 2 is the EFSFSR from the eastern Site boundary to the confluence with Midnight Creek. Area 3, referred to as the Glory Hole, includes the EFSFSR from Midnight Creek to the northern site boundary as well as the lower reaches of Sugar Creek.

Potential sources of chemical or physical stressors in each investigation area are listed below.

Area 1: Meadow Creek Valley

- Historic Meadow Creek Mine
- Historic Meadow Creek Mine processing facilities (now dismantled and removed or buried)
- Historic Bradley tailing impoundments and deposits in Meadow Creek Valley
- Meadow Creek Mine hillside behind the historic Bradley facilities
- Neutralized ore at neutralized ore disposal area
- Waste rock in valley floor
- SMI leach pads and cyanide plant
- Hecla heap leach operations
- Smelter stack ruins above the historic Bradley facilities

Area 2: EFSFSR

- Historic Bradley tailing
- Primary and Secondary Camps (now dismantled and regraded)
- Garnet Creek Pit
- DMEA dump

Area 3: Glory Hole

- Historic Yellow Pine Mine (Glory Hole)
- Historic Bradley waste rock dumps on the EFSFSR above and below the Glory Hole and on Sugar Creek
- West End, Homestake, and Midnight Pits
- Historic BTO on Sugar Creek

Primary chemical stressors of concern are metals (especially antimony and arsenic) and weak acid dissociable (WAD) cyanide. Chloride and nitrates/nitrites have also been associated with mineral processing and mining activities. Physical stressors of concern are sediment release to surface water, including the potential for erosion of mine waste material along stream banks and resuspension of Glory Hole sediments, and loss or severe impairment of aquatic or terrestrial habitat

Environmental samples were collected and analyzed in accordance with procedures outlined in the Site Characterization Field Sampling Plan (FSP) and Quality Assurance Project Plan (QAPP), which are part of the 1997 Work Plan (Stibnite Group, 1997a), and corresponding addenda in the 1999 Work Plan Addendum (Stibnite Group, 1999). Chemical analytical data collected under the VCO underwent data quality review using guidance from the USEPA Contract Laboratory Program (CLP) Functional Guidelines. In addition, usability of historic data and compliance monitoring data in site characterization was confirmed based on split sample evaluation and review of laboratory certification and quality assurance programs.

4.1 SURFACE WATER SAMPLING

Three rounds of surface water sampling were performed in 1997 and four rounds were performed in 1999 for the Site Characterization. In 1997, 29 stations were sampled on June 28–July 8, August 21, and October 28–31. Two storm events were also sampled in 1997, one by the Forest Service and one by the Stibnite Group. In 1999, 24 stream stations were sampled on June 10–12, June 22–25, July 16–18, and September 15–25. Water in the Glory Hole also was sampled in July and September 1999 at three locations and 2 to 3 depths at each location. Flow measurements in 1999 from the stream sampling locations were used to calculate metals loadings to support source identification.

Many of the surface water sampling stations also were sampled under other monitoring programs conducted by SMI, Hecla, Mobil, and IDEQ. Tables showing all of the surface water data for the Site from 1996, 1997, and 1999 are included in Appendix B of the Draft SCR (Stibnite Group, 2000).

Surface water quality was evaluated by comparing chemical analytical results from the 1999 sampling with Idaho and USEPA water quality criteria, adjusted, if necessary, for an estimated average site-specific hardness of 36 milligrams per liter (mg/L). Results for antimony were compared with proposed USEPA water quality criteria. The USEPA has not promulgated water quality criteria for antimony. Criteria for most metals are based on dissolved concentrations, with the exception of aluminum, antimony, iron, mercury, and selenium. The water quality criteria used are listed in Table 7-7.

The evaluation of surface water quality focused primarily on antimony, arsenic, mercury, and WAD cyanide because these constituents were most indicative of constituents attributable to historic or recent mining activities. Other trace metals were either detected much less frequently or not at all, or occurred at comparable levels at reference stations. Aluminum, for example, was frequently detected at all stations, including reference locations, at levels above the chronic USEPA freshwater quality criterion of 87 μg/L. Elevated levels of antimony and arsenic occurred in Meadow Creek and the EFSFSR prior to recent mining

activities, as indicated in the Environmental Background Report and Final EIS (JMM, 1979; 1981) and in surface water data for the period 1978 to 1981.

In 1997, individual sample results at all main stream stations on Meadow Creek and the EFSFSR ranged from 4 to 135 μg/L for total antimony and 7.3 to 101 μg/L for dissolved arsenic. The arsenic concentrations were all below the USEPA chronic water quality criterion for the protection of freshwater aquatic life of 150 μg/L dissolved arsenic. The 1997 mean concentrations ranged from 28 to 74 μg/L for total antimony and from 43 to 99 μg/L for total arsenic.

In 1999, following implementation of the Bradley Tailing Diversion and Reclamation Project, concentrations of antimony and arsenic at each Meadow Creek and EFSFSR station were one-third to two-thirds lower than 1997 levels. Mean concentrations ranged from 7 to 26 μg/L for total antimony and from 32 to 60 μg/L for total arsenic. The greatest improvement was seen at Stations 322, 319, and 313 on Meadow Creek and the EFSFSR below Meadow Creek. For example, at Station 322 below the Meadow Creek Diversion Channel and the BT/NO disposal area, total antimony and dissolved arsenic decreased by 85 percent and 50 percent, respectively, between 1997 and 1999. All sample results for dissolved arsenic (<7 to 96 μg/L) were below the USEPA chronic criterion of 150 μg/L dissolved arsenic. Additionally, all but two results for total antimony, which ranged from <5.3 to 35 μg/L, were below the USEPA proposed chronic freshwater quality criterion of 30 μg/L.

Surface water concentrations of antimony and arsenic were highest at Meadow Creek Stations MC-2B and 319 (below the historic Bradley features and tailing deposits in lower Meadow Creek Valley), in the EFSFSR at Station 308 below the Glory Hole and Northwest Bradley waste rock dump, and in Midnight Creek Station 321.

Antimony and dissolved arsenic concentrations were somewhat higher in sample UW-1 from the Upgradient Wetland above the BT/NO disposal area, at Station KW-1 below the Keyway, and (for antimony) at Station BTO (Bailey Tunnel Outlet on Sugar Creek). However, flows at these locations were very low, and the small loading from these sources does not result in significant effects on stream water quality. For example, the discharge from the Upgradient Wetland (Station MC-1A) is comparable in quality to that at the Meadow Creek reference Station 320.

Trace levels of WAD cyanide were reported in a few Meadow Creek and EFSFSR samples in 1997 (in 4 of 53 samples). In 1999, reported results were estimated values less than 3 μg/L or were non-detectable. The chronic water quality criterion for WAD cyanide is 5.2 μg/L.

Individual results for mercury (total) were greater than the Idaho water quality criterion (0.012 μg/L) in Meadow Creek, in the EFSFSR, and in Sugar Creek in 1996 and 1997. Concentrations of mercury were consistently elevated in Sugar Creek due to sources upstream of the Site. Of the 35 samples analyzed for total mercury in 1999, only three samples had detected concentrations of mercury. Dissolved mercury was not detected above its USEPA recommended chronic criterion of 0.77 μg/L in any sample.

Overall, surface water quality in the Meadow Creek and EFSFSR improved substantially between 1997 and 1999, following implementation of the Bradley Tailing Diversion and Reclamation Project. For example,

- At Meadow Creek Station 322 below the new Diversion Channel and Keyway Wetland, total antimony concentrations were reduced by 85 percent and arsenic by 50 percent in 1999 compared to 1997.
- At all stations in main streams of Meadow Creek and the EFSFSR, average concentrations of total antimony and arsenic were one-third to two-thirds lower than in 1997.
- Individual results for arsenic in 1999 were below Idaho and USEPA chronic water quality criteria for protection of freshwater aquatic. All but a few results for total antimony (maximum = 35 µg/L) were below the USEPA proposed criterion of 30 µg/L. When detected (infrequently), mercury concentrations exceeded the Idaho numeric criterion of 0.012 µg/L total mercury but were lower than the USEPA criterion of 0.77 µg/L dissolved mercury.

In the Glory Hole, water samples were collected from two or three depths at three locations in the Glory Hole in July, August, and September, 1999. All metals results were lower than applicable water quality criteria for protection of freshwater aquatic life. However, five samples collected in September had antimony concentrations between 31 and 33 µg/L, slightly greater than the proposed USEPA chronic criterion of 30 µg/L.

Loadings were calculated for total antimony, dissolved arsenic, and sulfate based on 1999 surface water quality data and flow measurements. The principal increases in loading were seen in lower Meadow Creek, the Glory Hole, and the EFSFSR between Stations 308 and 314 (especially sulfate). Evaluation of all environmental data suggests that the chief sources of loading are Bradley tailing deposits throughout lower Meadow Creek Valley, natural mineralization at and near the Glory Hole, and a variety of sources including the Bradley waste rock dumps, Hennessey Creek, and Sugar Creek below Station 308.

4.2 GROUNDWATER SAMPLING

The groundwater investigation for the Site Characterization focused on Meadow Creek Valley because this is the area where the mill and smelter operations and recent heap leach operations are most likely to have impacted the groundwater quality. In Area 1, 27 monitoring wells were sampled for the 1997 investigation (3 rounds) and most were resampled in 1999 (2 rounds). Of these, 10 wells are located in the BT/NO disposal area and 17 are in the area of the Hecla and former SMI processing facilities. Limited groundwater characterization was also performed in other portions of the Stibnite Site: in Area 2, eight wells along the EFSFSR were sampled in 1997, including wells in the former Primary and Secondary Camps; and in Area 3, three wells were sampled in 1997, one in the West End Creek drainage and two in the Midnight Creek drainage.

Analytical data from the VCO site characterization, compliance monitoring performed by Hecla, SMI, and IDEQ, as well as previous monitoring results (primarily from the period 1994 to 1996) are included in Appendix B of the SCR (Stibnite Group, 2000). Monitoring well locations are shown on Plate 1.

Arsenic and antimony were the chief constituents that were associated with groundwater that is impacted by historic Bradley tailing in the Meadow Creek area. Bradley tailing material is present in the BT/NO disposal area and throughout the lower portion of Meadow Creek Valley, where it has been covered with several feet of waste rock, alluvial fill, and neutralized ore material. The static water levels that were measured in 1997 and 1999 indicated that the groundwater table rose high enough to contact the bottom of the historic tailing throughout most of the Meadow Creek Valley.

Dissolved arsenic levels over 12,000 µg/L and dissolved antimony over 1,000 µg/L were associated with wells screened totally or partially in tailing or just beneath tailing. Concentration ranges for dissolved antimony and arsenic for different portions of the Site are listed below.

- BT/NO disposal area: dissolved antimony (2 to 1,160 µg/L), dissolved arsenic (3 to 12,700 µg/L);
- Lower Meadow Creek Valley: dissolved antimony (3 to 3,070 µg/L), dissolved arsenic (7 to 13,800 µg/L);
- EFSFSR (Area 2): dissolved antimony (2 to 138 µg/L), dissolved arsenic (4 to 266 µg/L);
- West End and Midnight Creek watersheds (Area 3): dissolved antimony (10 to 39 µg/L), dissolved arsenic (76 to 154 µg/L).

High levels of dissolved arsenic (up to about 1,000 µg/L) were found in groundwater near the highly mineralized Meadow Creek Fault Zone, as evidenced by samples from upgradient well UG-2 (above the SMI leach pads) and spring SPMC-5, which emerges at the surface expression of the Meadow Creek Fault Zone near the Meadow Creek Mine adits.

Mercury was rarely detected in filtered groundwater samples, but mercury was detected in unfiltered samples. Total mercury concentrations ranged from 0.2 to 76.5 µg/L in wells in Area 1 (Meadow Creek Valley, including the BT/NO disposal area), 0.2 to 8.2 µg/L in wells in Area 2 (along the EFSFSR), and 0.2 to 11.4 µg/L in wells in the West End Creek and Midnight Creek drainages in Area 3.

Groundwater quality in most of the EFSFSR below Meadow Creek and in the West End Creek and Midnight Creek drainages appears consistent with natural mineralization, based on comparison to local pre-mining constituent levels in surface water in West End Creek, and to levels in an upgradient reference well in the Midnight Creek drainage. One possible exception is well LA-2, near the EFSFSR and the Thunder Mountain Road, where concentrations of dissolved arsenic levels (200 µg/L) were somewhat elevated above reference levels, possibly due to impacts from tailing that was deposited in this area during the Bradley operations.

In conclusion, the greatest impacts to groundwater quality are seen in areas in Meadow Creek Valley where the Bradley tailing is saturated or intermittently in contact with the water table. Groundwater quality in this area appears to affect surface water quality in lower Meadow Creek, as indicated by increased concentrations and loading of arsenic and antimony among surface water stations MC-2A, MC-2B and 319.

4.3 SEEPS AND SPRINGS SAMPLING

In 1997, 16 seeps were sampled, most of them located on the hillside above Meadow Creek, in lower Meadow Creek Valley, and near the Glory Hole. In 1999, 11 seeps near the Glory Hole and Bradley waste rock dumps and seep SPMC-8 in lower Meadow Creek Valley were sampled. Locations of seeps and springs are shown on Plate 1.

Antimony and arsenic concentrations are highest in seeps and springs in contact with Bradley tailing in Meadow Creek Valley, but relatively high naturally occurring levels can also be seen in water in highly mineralized zones such as the Meadow Creek Fault Zone. For example, three seeps that emerge from areas with Bradley tailing deposits had maximum concentrations of dissolved antimony and arsenic of over 2,000 µg/L, and spring SPMC-5 at the Meadow Creek Fault Zone had the highest concentrations of dissolved arsenic (443 to 2,600 µg/L) of the springs not influenced by Bradley tailing.

Trace metals other than antimony and arsenic (i.e., cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc) were detected sporadically or not at all in filtered samples; these metals are not considered indicative of mining-related impacts to shallow groundwater or seeps.

Seeps and springs in Bradley tailing-impacted areas of the Meadow Creek Valley may transport dissolved or suspended constituents to surface water in Meadow Creek. However, flow rates are low in comparison to stream volume, and many springs are intermittent. Therefore, in themselves the seeps and springs are not likely to be a significant source of constituent loading to Meadow Creek.

Water quality was similar in many springs near the Meadow Creek Fault Zone and at the Glory Hole, Homestake Pit, and Garnet Creek. Water in these springs does not flow through mine waste material but rather through native ore bodies. Water quality in these springs was therefore concluded to be characteristic of mineralized zones. For example, concentrations of dissolved antimony (7 to 261 µg/L), arsenic (9 to 278 µg/L), and other trace metals are fairly similar in springs SPMC-4, SPMC-7, and SPMC-10 in the Meadow Creek Valley, SPEF-3 and SPGC-1 in the middle portion of the EFSFSR, and SPGH-1 through SPGH-9 at the Glory Hole.

Only two seeps were identified that flow through mine waste rock: SPNW-1 and SPNW-2 at the base of northwest Bradley waste rock dump above the EFSFSR, about 150 feet downstream from the bridge at the main access road. Samples from these seep areas had somewhat higher levels of dissolved antimony (202 to 257 µg/L) and arsenic (231 to 647 µg/L) than seeps SPGH-1 through SPGH-9 at the Glory Hole.

Sulfate levels were variable, ranging from 4 to 136 mg/L in the 1999 samples. The pH levels in all seeps ranged from 6.3 to 8.1, with most occurring between 7 and 8. Therefore, acid leachate is not characteristic of seeps in the Stibnite mining area.

4.4 SURFACE SOIL SAMPLING

The surface soil sampling program focused on the following areas of potential concern:

- Meadow Creek Mine hillside behind the former Bradley smelter;
- Smelter stack ruins on the Meadow Creek Mine hillside;
- Wetlands in upper and lower Meadow Creek Valley;
- Meadow Creek Valley soils, which may contain Bradley tailing, neutralized ore, and waste rock;
- BT/NO disposal area;
- Former Primary and Secondary Camps;
- DMEA dump; and
- Historic Bradley waste rock dumps along the EFSFSR above and below the Glory Hole and above Sugar Creek.

During the 1997 Site Characterization, 52 site samples were collected from six areas affected by mining activities and 21 reference samples were collected from mineralized and non-mineralized zones in upgradient areas away from the direct influence of mining activities. In 1999, 46 samples were collected at the Bradley waste rock dumps and in wetlands. At each sample location, the surface cover, terrain, physical features, soil type, and characteristics were recorded in field notes. The soil sample locations are shown on Plate 1 and Figure 1-3.

The areas targeted for soil sampling were characterized by higher concentrations of arsenic, antimony, and mercury than occurred in reference samples from non-mining areas. For example, mean arsenic concentrations ranged from about 1200 mg/kg to 4300 mg/kg in the Bradley waste rock dumps, Bradley tailing, neutralized ore, and soil near the smelter stack ruins. Mean arsenic levels were lower (273 to 717 mg/kg) in Meadow Creek Valley, Meadow Creek Mine hillside, and Meadow Creek wetlands, where surficial materials include both mineralized and non-mineralized materials.

Mean antimony levels were highest (790 to 1400 mg/kg) in Bradley tailing samples from the BT/NO disposal area and lower Meadow Creek Valley. Mean antimony levels were much lower (54 to 124 mg/kg) in neutralized ore, the former camps, and soil at the smelter stack ruins. Mean antimony levels were variable in the Bradley waste rock dumps, ranging between 1 and 329 mg/kg, depending on the dump area sampled.

Mean mercury levels were between 0.2 and 2 mg/kg in all areas sampled, except the DMEA dump (mean mercury = 6 mg/kg) and soil at the smelter stack ruins (mean mercury = 126 mg/kg).

Analytes other than antimony, arsenic, and mercury generally occurred in concentrations comparable to concentrations in reference samples. The few exceptions include relatively higher concentrations of chloride, chromium, copper, lead, and nickel in tailing samples at the BT/NO disposal area and some affected samples in lower Meadow Creek Valley.

Most soils (except for the historic Bradley waste rock dump samples) were alkaline compared to the reference value of 100 mg/kg $CaCO_3$. The pH levels were slightly alkaline (8 to 9) for some samples from

the neutralized ore in the BT/NO disposal area. The pH levels were relatively low (4 to 5) in the Bradley waste rock dump samples. The pH in samples from other areas was generally near 7.

The Meadow Creek Mine hillside behind the former Bradley smelter site was sampled to evaluate possible impacts from deposition of past smelter emissions. The Meadow Creek Fault Zone passes through the Meadow Creek Mine hillside and parts of the hillside are disturbed by past exploration and mining activities. Average concentrations of antimony (7.5 mg/kg) and arsenic (386 mg/kg) from sample locations on the Meadow Creek Mine hillside are comparable to the concentrations in samples from the mineralized reference stations in upper Midnight Creek in Area 3 (average antimony = 6.5 mg/kg; average arsenic = 200 mg/kg). The distribution of metal concentrations across the hillside does not exhibit a gradient such as might be anticipated if former smelter emissions were a source of significant impact to the hillside, but rather appears to be a function of proximity to the Meadow Creek Mine and fault zone.

Wetland soil sample locations were well-vegetated with expected species, even where tailing was present, with the exception of one location in remnant tailing above the BT/NO disposal area where vegetation has not yet re-established itself after the 1998 improvements to the drainage through the wetland.

All the Bradley waste rock dumps appear to be comprised of similar material and no significant differences in chemical composition were noted (although antimony levels were variable). Samples from gullies, and the field mapping of soil types and erosional features, did not suggest that different types of materials would be subject to future erosion. The dumps are typically barren or sparsely vegetated, with a high fraction of cobble and boulders. The pH at the dumps was relatively low (between 4 and 5) compared to most other areas at the site (pH typically between 5.8 and 9).

Special areas targeted in the 1999 investigation were the DMEA dump and Smelter Stack remains, including ash. The DMEA dump samples contained the highest levels of arsenic (up to 9460 mg/kg) and ash-impacted soil near the concrete base of the smelter stack contained the highest levels of mercury (up to 471 mg/kg) and among the highest arsenic levels (up to 3750 mg/kg) observed in soil sampling at the Stibnite Site.

In summary, nearly all areas sampled in the soil investigation had average concentrations of antimony, arsenic, and mercury in excess of levels in non-mining areas. This is not unexpected because areas were targeted for sampling that were known or suspected of containing Bradley tailing, waste rock, neutralized ore, or native ore. These materials derive from highly mineralized native rock in the Stibnite mining area.

4.5 SEDIMENT AND BENTHIC MACROINVERTEBRATE SAMPLES

The Forest Service and IDEQ sampled sediment and benthic macroinvertebrates (for community and tissue analysis) at 8 to 10 stations in 1996 and 1997. Benthic macroinvertebrates were collected by IDEQ and the Forest Service from 12 stations in 1999. Results from all stations indicate moderate to high biotic complexity/habitat integrity. In addition, benthic samples were collected from four locations (three replicates at each location) in the Glory Hole in 1999. Benthic macroinvertebrate densities in the Glory Hole samples were high, and the number of taxa were typical for the soft sediment habitat. Further

descriptions of sediment and benthic macroinvertebrate sampling results are provided in Section 7.3; details are provided in Section 8.5 of Stibnite Group (2000).

4.6 FISH TISSUE SAMPLES AND BULL TROUT SURVEY IN GLORY HOLE

The Forest Service, with assistance from the Stibnite Group, collected fish for chemical analysis at five stations in 1997. Results of the whole body analysis are compared with toxicity screening benchmarks compiled by Jarvinen and Ankley (1999) in Section 7.7.

In 1999, a total of 229 bull trout were collected from the EFSFSR drainage in a population study sponsored by The Payette National Forest, Idaho Department of Fish and Game, and the University of Idaho. Over half (125) were caught in the Glory Hole. Steelhead/rainbow trout, cutthroat, and mountain whitefish also were noted in the Glory Hole.

4.7 AQUATIC HABITAT CHARACTERIZATION

Physical habitat in streams was characterized at 10 aquatic stations in 1997 and at two additional stations in 1999 (MC-1C in the Meadow Creek Diversion Channel and EF-7 in the EFSFSR below the Glory Hole). Qualitative characterizations also were performed for the stream reaches between stations. Detailed descriptions of aquatic habitat are provided in Section 8.5 of Stibnite Group (2000) and are summarized in Sections 7.3 and 7.7 and Figure 7-2 of this report.

Physical stream habitat was found to be impaired primarily in lower Meadow Creek Valley (Stations MC-1C and 322) and the EFSFSR immediately above and below the bridge on the main access road to the site (including Stations EF-7 and 308). The lower-quality habitat is primarily a function of sparse instream and riparian cover and erodible streambanks.

In Meadow Creek, unstable banks were found along three sections of the creek. Overall, approximately 700 feet on the south-east bank and 400 feet on the north-west bank were considered unstable, although most of these unstable reaches were vegetated. Half of the areas are adjacent to tailing deposits. In most of Lower EFSFSR, the streambanks have limited riparian cover. Steep, erodible banks occur along about 800 feet of the west bank above the bridge at the main access road. In Sugar Creek, the average percent surface fines at Station 316 was 36 percent, which is in the range of fines that may lead to a loss of viable spawning habitat; however, suitable gravel spawning areas are present in lower Sugar Creek. Downstream of Station 316, riparian vegetation provides only limited cover. Upstream of the station, the stream banks are only moderately stable, due in part to a road cut directly adjacent to the stream.

4.8 GLORY HOLE CHARACTERIZATION

The Glory Hole investigation conducted in 1999 included bathymetry, velocity measurements, and bank stability mapping, as well as sampling and analysis of surface water, seep water, sediment, and benthic macroinvertebrate community structure. The objectives of the study were to:

- Describe physical characteristics of the Glory Hole,
- Evaluate the potential for mobilization of sediments under various flow events, including seasonal turnover, if present;
- Assess whether erosional features and seeps are significant sources of loading that may result in impairment of the aquatic system in the Glory Hole; and
- Collect data to evaluate the potential risk to in-situ aquatic life posed by water and sediment in the Glory Hole and the potential for unacceptable risk to downstream aquatic receptors if resuspension of Glory Hole sediments may occur.

4.8.1 PHYSICAL DESCRIPTION

Water in the Glory Hole was 44 feet deep at the deepest point (measured on July 13–16, 1999). The majority of the Glory Hole pool is over 20 feet deep, with a central area over 40 feet in depth occupying about 0.7 acres. Alluvial fans exist on the eastern and southern margins of the pool, the highwall of the Yellow Pine Pit is on the west side, and the Glory Hole outlet flows over a rocky shelf that controls water levels in the lake. Woody debris is a significant component of the bottom sediments.

Current moves clockwise from the inlet toward the west wall of the Glory Hole, with a significant backcurrent or eddy flow in the eastern half of the pool. Most current is found in the upper 15 feet of water column, and the average current velocity on the bottom was estimated to be 0.05 feet per second.

4.8.2 SEDIMENT RESUSPENSION POTENTIAL

The potential for resuspension of sediments is described in Section 7.10 and discussed in detail in Section 8.8 of Stibnite Group (2000).

4.8.3 SOURCES OF LOADING TO THE GLORY HOLE

Erosional areas and seeps were evaluated as potential sources of metals loading to the Glory Hole. Although the Yellow Pine Pit contains areas of evident erosion, it does not have erosional features that are likely to deliver significant amounts of sediment directly to the Glory Hole lake. Steep and erosive areas mostly occur on the upper slopes of the Yellow Pine Pit. None connect directly to the water surface, but rather are separated from the aquatic habitat of the Glory Hole by more stable areas such as mine excavation terraces and alluvial fans. The shoreline of the Glory Hole lake is considered mostly stable, consisting of rock outcrop, wetlands, mostly stable alluvial fans and mine terraces on bedrock and moderately stable flat to gentle slopes.

The seeps that emerge from the highwalls above the Glory Hole do not appear to contribute significantly to exceedances of water criteria in the Glory Hole, because water quality criteria were met for all constituents in all Glory Hole samples, except for some total antimony results (maximum = 33 μg/L) that slightly exceeded the proposed USEPA chronic criterion of 30 μg/L. The seep water concentrations were consistent with the natural mineralization of ores in this reach of the EFSFSR, through which the seeps flow.

Additional descriptions of erosional areas and seeps around the Glory Hole are provided in Section 8.8 of the Draft SCR (Stibnite Group, 2000).

4.9 WILDLIFE AND TERRESTRIAL HABITAT CHARACTERIZATION

Terrestrial studies conducted in 1997 and 1999 included characterization of soils, vegetation (habitat), and wildlife, and identification of rare or sensitive plant and animal species. The scope of work for the original site characterization studies of terrestrial and riparian habitats was described in the Stibnite Area Site Characterization Field Mapping Plan, which was attached as Appendix C to the Work Plan (Stibnite Group, 1997a). The 1997-1998 site characterization studies included mapping and characterization of soils and vegetation (habitat) based on field studies and aerial photograph interpretation. Characterization of wildlife and special status species was based on literature review and limited field observations. The study area for soils and vegetation studies included all areas known or suspected to be affected by mining activities, plus a 200-foot buffer zone and some adjacent areas such as Blowout Creek, and slightly exceeded the designated boundaries of the Stibnite Site. The products of the study included maps, data sheets, descriptions of soil and habitat types, and assessment of ecological conditions.

The scope of work for the 1999 studies was described in the Work Plan Addendum (Stibnite Group, 1999). Specifically, the scope covered the following:

- Additional or more detailed field mapping and characterization of erosional features, soils, vegetation, and habitat condition (Glory Hole, Bradley Waste Rock Dumps, wetland upgradient from Bradley Tailings Impoundment).
- Location and description of any Bradley tailing deposits between the northeast and southeast dumps.
- Habitat condition and description of reclamation on the Bradley tailing impoundment, which has been recontoured and reclaimed since the original site characterization.
- Mapping of historic facilities and tailing depositional areas in Lower Meadow Creek Valley.
- Description of bank materials and stability in Lower Meadow Creek.

The results of these studies are presented in detail in Section 8.6 of the Draft SCR (Stibnite Group, 2000).

Information on wildlife was assembled from the literature and limited field observations. Over 150 different wildlife species have been identified as potentially occurring in the Stibnite Site (see Table 8.6-9 in the Draft SCR). Of this total, 17 species were observed during various field surveys. Big game, including elk, mule deer, and moose are commonly observed in the area. Fifteen species of raptors potentially occur, and seven species of water-dependent birds may be present. Wildlife expected includes several amphibians, one reptile, numerous migratory birds, predatory mammals, small game, and bats.

No endangered or threatened wildlife species are known or expected to occur. However, suitable habitat for ten rare or sensitive species occurs within the study area, although none of the species are known to occur. These species include five raptors, two woodpeckers, a bat, wolverine, and wolf.

A summary of habitats by location is provided in Table 4-1. Details of habitats, soils, and wildlife are provided in Section 8.6 of the Draft SCR (Stibnite Group, 2000) and are summarized below.

Terrestrial habitat in Meadow Creek Valley has been affected by mining operations, primarily the riparian habitats located in the valley bottom. About 15 acres of lower Meadow Creek Valley have historic tailing deposits on the soil surface, but nearly all of this area is good condition wetlands, meadow and forest, with the exception of about 1.1 acres of unvegetated tailing. About 360 feet (6 percent) of the right bank of lower Meadow Creek and 230 feet (4 percent) of the left bank are unstable and in tailing, and other discontinuous portions of streambank with tailing are currently stable but susceptible to erosion. In the vicinity of the confluence with Blowout Creek, Meadow Creek flows through alluvium deposited by the Blowout Creek dam failure, and there are some areas of bank instability in the alluvium. Most other portions of the valley bottom are permitted reclamation or operational areas. The hillside north of the Hecla and former SMI leach pads, Meadow Creek Mine area, and smelter stack area on the north side of the valley also is in poor to fair condition, associated with cuts and fills, steep slopes, erosion, and heavy big game use.

The DMEA dump, which occupies less than 1 acre, provides poor habitat, largely because it is barren. Much of the valley slopes is undisturbed, but some areas along this reach of the EFSFSR are in poor to fair condition due to historic activities such as vegetation clearing for operational areas, cuts and fills, and erosion and deposition in riparian areas along the EFSFSR.

The Bradley waste rock dumps and Glory Hole occupy about 110 acres. Soils are mainly derived from mining, including mine excavations, mine waste rock, and reclaimed mine waste rock. Vegetation is sparse or absent in many areas, but reclaimed portions have varying amounts of vegetation cover. About 23 acres have erosive soils and 38.5 acres have moderately erosive soils. However, as noted previously, steep erosive slopes that are adjacent to the EFSFSR occur only along 800 feet of the west bank of the EFSFSR above the bridge at the main access road, along about 100 feet of shoreline on the southeast side of the Glory Hole, and along about 450 feet on the west bank of the EFSFSR between Midnight Creek and the Glory Hole. In total, the steep erodible slopes immediately adjacent to the EFSFSR occupy about 15 percent of the shoreline from Midnight Creek to Station 314, including the Glory Hole perimeter.

The riparian habitat along the EFSFSR above and below the Bradley dumps and Glory Hole is in poor to fair condition because of past scouring and deposition.

4.10 SUMMARY OF SITE CHARACTERIZATION FINDINGS

1. Surface water quality in the Meadow Creek and EFSFSR drainage improved substantially between 1997 and 1999 following implementation of the Bradley Tailing Diversion and Reclamation Project. This conclusion is based on significantly reduced levels (by 35% to 85%) of antimony and arsenic, the two constituents most characteristic of the site. Individual results for arsenic in 1999 were below Idaho and USEPA chronic water quality criteria for the protection of freshwater aquatic life. All but a few results for total antimony (maximum = 35 μg/L) were below the USEPA proposed chronic criterion of 30 μg/L.

2. Meadow Creek Valley:

    a. The physical aquatic habitat in the Diversion Channel and lower Meadow Creek is reflected in limited riparian cover and reduced instream cover. Although Bradley tailing deposits occur at or below the surface in most of lower Meadow Creek Valley, only small portions of the streambank are comprised of unstable tailing. These patches represent 4 to 6 percent of the length of lower Meadow Creek (Figure 7-2).

    b. Concentrations and loading of antimony in surface water increase, particularly between Stations MC-2A and MC-2B. These stations are downgradient of most of the historic Bradley facilities and are in an area of Bradley tailing deposits that are often in contact with the water table. Groundwater is the probably source of increased loadings in surface water.

    c. In spite of elevated levels of antimony and arsenic in groundwater, arsenic concentrations in Meadow Creek surface water were below ambient water quality criteria, and all but two results for antimony were below the USEPA proposed chronic criterion of 30 μg/L. Occasional detections of mercury were above the Idaho numeric chronic criterion of 0.012 μg/L total mercury, but were below the USEPA chronic criterion of 0.77 μg/L dissolved mercury.

    d. Wetlands and other valley bottom plant communities in Meadow Creek Valley are in good condition, although tailing is present to a greater or lesser degree in all three wetlands investigated. Wetland vegetation in tailing areas were largely indistinguishable from non-tailing areas.

3. Glory Hole:

    a. The Glory Hole aquatic habitat is not significantly impaired, based on environmental sampling and aquatic and riparian characterization performed in 1999.

    b. The sediments and water quality in the Glory Hole do not pose an unacceptable risk to the indigenous biota because there is a vigorous benthic community and abundant fish; with minor exceptions, water quality results were below relevant water quality criteria for the protection of freshwater aquatic life; and average sediment concentrations of metals other than arsenic meet most freshwater sediment quality guidelines.

    c. Most of the slopes around the Glory Hole are stable or moderately stable and are not expected to be significant sources of sediment to the Glory Hole; steep slopes susceptible to erosion occur along about 425 feet the EFSFSR above the Glory Hole.

    d. Seeps discharging into the Glory Hole flow through native mineralized zones and in themselves are not a significant source of loading to the Glory Hole.

4. The Glory Hole is primarily a sediment trap. The potential for sediment resuspension in the Glory Hole is low, as is the potential for adverse effects downstream were resuspension to occur.

    a. The estimated bottom velocities under the 2-year and 100-year events are lower than the velocity required to resuspend unconsolidated fine-grained sediments and the average grain size sediment in the Glory Hole. The potential for resuspension is considered low to moderate under a 500-year flow event.

    b. Although seasonal turnover could occur during isothermal conditions (expected to be of short duration), turnover is not expected to produce the bottom current velocities needed to suspend sediments.

    c. The potential for significant adverse effects downstream is low because resuspension potential is low, in-place sediments do not appear to be toxic to the indigenous fauna, and velocities necessary to resuspend sediment would result in long-distance transport and mixing of fine-grained material prior to settling in a low-velocity environment.

5. Evidence of current impairment of aquatic or riparian habitat by historic mining activities was observed primarily in Meadow Creek Valley and in a portion of the EFSFSR above and below the bridge at the main access road. Some of the highest quality aquatic habitat on the Stibnite Site is found in the EFSFSR downstream of Meadow Creek and upstream of the Glory Hole.

6. EFSFSR below the Glory Hole:

    a. Satisfactory aquatic habitat in terms of the variety of instream habitat and substrate condition is present in the EFSFSR below the Glory Hole to the main access road. However, the riparian habitat is poor to fair along much of the reach, due to limited vegetation. Steep, erodible banks occur along about 800 feet of the west side of the stream above the main access road.

    b. Below the main access road bridge, in the stream segment represented by Station 308, the EFSFSR flows through an open, apparently disturbed area below the Northwest Bradley waste rock dump. Substrate is primarily cobble and small boulders. Riparian cover is limited.

    c. Metals concentrations in surface water, sediment, and benthic macroinvertebrate tissue were higher in the EFSFSR below the Glory Hole (Stations EF-7 and 308) than in other portions of the EFSFSR. However, 1999 levels of arsenic in surface water were below Idaho and USEPA water quality criteria; a few results for total antimony slightly exceeded the USEPA proposed chronic criterion of 30 µg/L. Mercury was detected in this reach of the EFSFSR only below the confluence with Sugar Creek.

7. Mercury levels in surface water and sediment of Sugar Creek and the EFSFSR below Sugar Creek were substantially higher than elsewhere on site, due to off-site sources of mercury in the Sugar Creek watershed.

8. In groundwater, the highest concentrations of dissolved antimony (about 200 to 2000 μg/L) and arsenic (about 500 to 13,800 μg/L) were observed in samples collected within or in proximity to saturated Bradley tailing. Lower levels elsewhere (e.g., about 20 to 50 μg/L dissolved antimony and 30 to 150 μg/L dissolved arsenic) reflect the natural mineralization of ore bodies in the EFSFSR valley above and below the Glory Hole. However, concentrations over 1,000 μg/L dissolved arsenic were observed in groundwater and seeps near the Meadow Creek Fault Zone on the Meadow Creek Mine hillside.

9. Concentrations in seep samples were consistent with the groundwater results, depending on sampling location. Sulfate concentrations above 100 mg/L were observed in several seeps in mineralized zones (Glory Hole, Meadow Creek Fault Zone) and near Bradley tailing. The pH levels in all seeps ranged from 6.3 to 8.1. Therefore, acidic seepage is not characteristic of the Stibnite mining area.

10. In soil, levels of antimony and arsenic were highest in native ores or material derived from the ores. Mean arsenic concentrations were about 1,350 mg/kg in samples at the Meadow Creek Fault zone, 1,200 mg/kg in Bradley tailing, 1,400 mg/kg in neutralized ore, and 1,900 mg/kg to 4,300 mg/kg in Bradley waste rock. Soil sampling at the Meadow Creek Mine Hillside did not yield conclusive evidence of impacts from historic smelter emissions; rather the variations in metals levels appear to be associated with the proximity to the Meadow Creek Fault Zone and mine exploration areas.

11. All the Bradley waste rock dumps appear to be of similar composition (although antimony levels were variable). Much of the Bradley waste rock dumps and Glory Hole area is sparsely vegetated, and about 23 acres have steep slopes and evident erosional features. However, only portions of the steep erodible slopes are directly on the shoreline of the EFSFSR. The poor vegetation is likely due to the adverse physical characteristics of the substrate and a combination of high metals and low pH. Two seeps were identified at the Northwest Bradley waste rock dump in June 1999; these seeps had somewhat higher levels of dissolved antimony and arsenic than most seeps near the Glory Hole, but in themselves are not considered a significant source of loading to the EFSFSR.

Table 4-1

Summary of Upland and Riparian Habitats Potentially Affected by Mining Activities

Area/Location	Habitat Types[1]	Soil Types[2]	Approx. Size (acres)	Condition/Physical and Ecological Stressors	Samples Collected	Elevated Metals in Soils	Soil pH	Comments
Investigation Area 1								
Hillside North of Leachpads	H, F-DF, W-DF	GCB, GC	119	Poor to fair/Erosion, steepness, heavy use by big game	Soil samples MCM 1-4, 6-10	Antimony, arsenic, mercury, silver	6.2 to 7.3 (soil samples) 5.4 to 6.5 (field stations)	Little or no difference in composition and condition between areas of elevated metals and other areas.
Meadow Creek Mine Area	D/H	QCD	6.5	Poor to fair/Alteration or removal of soils by cuts and fills, erosion steepness	Soil sample MCM-5	Antimony, arsenic, mercury, silver	6.9 (soil sample)	Includes mine area and old road switchbacks.
Exposed Tailing Near Lower Meadow Creek	B	MTF	1.1	Poor/Poor growth media for plants, no soil development	Soil samples MCV 14-16	Antimony, arsenic, copper, lead, mercury, selenium, silver, sulfate	3.9 to 7.0 (soil samples)	
Vegetated tailing in Lower Meadow Creek Valley	M, EM, WI, F-LP, EM/SF	MTF	10	Good/Surface tailing deposits, heavy big game browsing	Soil samples MCW 1-3	Antimony, arsenic, cadmium, copper, lead, mercury, selenium, silver (MCW-1 and –2)	4.2 to 6.4	
BT/NO Disposal Area	MWR-R	PR	103	Not rated/Current reclamation area	Soil samples SOD 1-5 STP 1-14	Antimony, arsenic, chromium, copper, lead, mercury, nickel, selenium, silver	6.4 to 9.0 (soil samples)	Reclaimed in summer of 1998.
Blowout Creek Debris Fan and Erosion Cut	B, DR, SDR, DU, SDU, D/SF	VBDF	23	Poor to fair/Poor soil development (lower part). Steepness, erosion (upper part)	--	--	6.6 (field station)	Not affected by contaminant release.
Meadow Creek Valley Reclamation Areas (below Keyway, north of Meadow Creek)	R	MWR	26	Not rated (reclamation area)/ Growth media is mostly mine waste rock	Soil samples MCV 1-7, 11-13	Antimony, arsenic, chromium, copper, iron, lead, mercury, nickel, selenium, silver, sodium	6.0 to 8.8 (soil samples)	These areas were recontoured and seeded in 1992, 1993 and 1996.

Table 4-1

Summary of Upland and Riparian Habitats Potentially Affected by Mining Activities

Area/Location	Habitat Types[1]	Soil Types[2]	Approx. Size (acres)	Condition/Physical and Ecological Stressors	Samples Collected	Elevated Metals in Soils	Soil pH	Comments
Investigation Area 1 (Continued)								
Meadow Creek Valley (undifferentiated alluvium)	M, WI, EM, F-LP	VB, VBW	9	Good/Heavy big game browsing	Soil samples MCV 8-10	Antimony, arsenic, copper, mercury, silver	6.6 (soil samples) 6.2 to 6.8 (field stations)	
Successional Vegetation and Disturbance Mosaics (recent mining activities)	DU, D/DF, B	GC, OP	6	Poor to fair/Past vegetation clearing, cuts and fills	--	--	--	Mainly adjacent to operational areas.
Smelter Stack	SDU	GC	0.3	Fair/stack wood and debris, ash, cuts and fills	Soil samples SMST 1-3, 5	Antimony, arsenic, mercury, selenium, silver	3.5 to 5.8	
Wetland Below Keyway	EM	VBW	2.9	Good/Big game browsing, buried tailing at KW-2	Soil samples KW 1-3	Antimony, arsenic, lead, mercury, silver	7.0 (field station)	SPMC-2 is located on the north edge of the wetland.
Upgradient Wetland	EM, P, EM/SF	VB, VBW	12	Good/1997 flooding, small part of buried tailing	Soil samples UW 1-3	Antimony, arsenic, chromium, copper, lead, mercury, nickel, silver (UW-1 and –2)	6.7 to 6.8	
Investigation Area 2								
Historic Bradley Tailing Below Confluence of Meadow Creek and EFSFSR	M, WI	MTF, VBDF	3.8	Good/Big game browsing	Soil samples MCV 17-19	Antimony, arsenic, lead, mercury, selenium, silver	7.2 to 7.7 (soil samples) 6.8 to 7.2 (field stations)	May have been reseeded in the past.
Residential Areas (Primary and Secondary Camps)	O	O	7	Not rated/No habitat	Soil samples HOOT 1-3, MAN 1-3	Antimony, arsenic, copper, lead, silver	6.0 to 8.1 (soil samples)	

Table 4-1

Summary of Upland and Riparian Habitats Potentially Affected by Mining Activities

Area/Location	Habitat Types[1]	Soil Types[2]	Approx. Size (acres)	Condition/Physical and Ecological Stressors	Samples Collected	Elevated Metals in Soils	Soil pH	Comments
Investigation Area 2 (Continued)								
DMEA Dump	B	MWR	0.7	Poor/Poor soil development, erosion, steepness	DMEA 1-3	Arsenic, mercury, silver	3.1 to 7.4	
Hillside Meadow Above DMEA Dump	H	GCB	1.7	Poor to fair/Erosion, big game browsing	--	--	6.2 (field station)	Upslope from historic mining activities.
EFSFSR Riparian Zone Below Primary Camp	DR	VB, VBDF	4.2	Poor to fair/Scouring, downcutting, deposition, from historic dam failure	--	--	NA	Extends from Primary Camp, north into Area 3.
Partially Disturbed Areas (historic mining activities)	D/LP, DU, B	GC, GTD, VB	26	Poor to fair/Past vegetation clearing, cuts and fills	--	--	NA	Mainly near Fiddle Creek, near EFSFSR below Primary Camp, and near DMEA Dump.
Disturbed and Successional Areas (recent mining activities)	D/LP, D/H, DU, DR, B	MWR, GT, VB, QC	32	Poor to fair/Past vegetation clearing, cuts and fills	--	--	7.2 (field station)	Mainly adjacent to operational areas, such as Primary and Secondary Camps, Shop Area, SMI office, Garnet Pit, and septic tank field.
Investigation Area 3								
Historic Bradley Waste Rock Dumps (NE, NW, SE)	B, SDU, R, SR, BR, EM	MWR, MWR-R, MWR-G	27	Poor/Poor plant growth media, no soil development, steep slopes and erosion	Soil samples BD 1-10, NW 1-14, BT 1-2,NE 1-8, SE 1-4	Antimony, arsenic, lead, mercury, selenium, silver, sodium, (1997 samples) arsenic, mercury, silver (1999 samples)	3.9 to 6.2 (1997 soil samples, average 4.45) 3.5 to 8 (1999 soil samples) 3.9 to 6.3 (field stations)	
Yellow Pine Mine and Monday Camp	B, SDU, DU	E, MWR	55	Poor/Exposed bedrock, steep slopes, erosion, absence of soils	--	--	6.2 (field station at Monday Camp)	

Table 4-1

Summary of Upland and Riparian Habitats Potentially Affected by Mining Activities

Area/Location	Habitat Types[1]	Soil Types[2]	Approx. Size (acres)	Condition/Physical and Ecological Stressors	Samples Collected	Elevated Metals in Soils	Soil pH	Comments
Investigation Area 3 (Continued)								
EFSFSR Riparian Area Above and Below Yellow Pine Pit	DR, WI, D/SF	VBDF, VB	9.5	Poor to fair/Scouring and deposition of coarse alluvium from historic dam failures	--	--	6.0 (field station)	Extends from Area 2 north to the confluence of Sugar Creek.
Partially Disturbed Areas (historic mining activities)	D/LP, D/DF	GTD, GCD, QC	29	Mosaic of fair and good/Old road cuts and other excavations	--	--	--	Mainly around Yellow Pine Pit.
Disturbed and Successional Areas (recent mining activities)	D/DF, D/SF, DU, B, D/LP, D/H	QCD, E	56	Poor to good/ Exploration roads, other excavations and fills	--	--	--	Mainly around SMI mine pits and waste rock piles.

[1]**Habitat Type**
B - Barren (<5% cover)
DR - Riparian successional vegetation
DU - Upland successional vegetation
EM - Emergent wetland (wet meadow)
F-DF Forest - Douglas-fir dominant
F-LP Forest - Lodgepole pine dominant
F-SF Forest - Subalpine fir and/or Engelmann spruce dominant
H - Hillside meadow (moderate to steep slopes)
M - Mesic (Valley) meadow
O - Operational areas
SDR - Sparse riparian successional vegetation
SDU - sparse (5-25% cover) upland successional vegetation
W-DF - Douglas-fir woodland
WI - Willow (and alder) shrubland

[2]**Soil Type**
E - Mine excavation and fill
GC - Granitic colluvial soils, forested
GCB - Granitic colluvial soils, non-forested
GT - Glacial till soils
GTD - Glacial till soils, disturbed by mining-related activities
MTF - Mine tailing
MWR - Mine waste rock
MWR-G – Mine waste rock, glacial till overburden
MWR-R - Mine waste rock, reclaimed
O - Operational areas
QC - Quartzite colluvial soils, forested
R - Rubble and rock lands (talus slopes and rock outcrops)
VB - Valley bottom soils, wetland areas
VBDF - Valley bottom soils, formed from 1966 Blowout Creek debris flow alluvium

5. DATA USED IN RISK EVALUATIONS

The following describes the data for exposure media that are used in the Stibnite Site ecological and human health risk evaluations (Sections 7, 8, and 9).

5.1 SOURCES AND TYPES OF DATA

Table 5-1 summarizes the sources of data used in the risk evaluations. The chemical data include 1999 site characterization data for surface water and sediment samples; 1997 and 1999 site characterization data for groundwater, seeps and springs, and soil; and Forest Service data for sediment, benthic macroinvertebrates, and fish. Aquatic habitat and terrestrial and riparian habitat characterization data also are used in developing the ecological risk assessments. Chemical data summary tables are provided in subsequent sections or relevant appendixes of this report to support the Aquatic Risk Evaluation (Section 7), Terrestrial and Riparian Risk Evaluation (Section 8), and Human Health Risk Evaluation (Section 9).

5.2 CHEMICAL DATA EVALUATION AND USABILITY

Table 5-2 lists the inorganic constituents and other parameters that were analyzed in soil, Glory Hole sediment, and water samples collected during the 1997 and 1999 Site Characterization. These were identified in the Work Plan (Stibnite Group, 1997a) and Work Plan Addendum (Stibnite Group, 1999) as being potentially associated with ores, waste rock, tailing, or mineral processing at the Site. The analyte lists for soil and water included metals (aluminum, antimony, arsenic, cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, selenium, silver, and zinc); inorganics associated with mineral processing reagents (sodium, cyanide, and chloride); selected major ions and nutrients; total and dissolved solids in water; pH; and field parameters.

Environmental samples collected for the 1997 and 1999 Site Characterization were collected and analyzed in accordance with procedures outlined in the Site Characterization FSP and QAPP, which are part of the Work Plan and Work Plan Addendum (Stibnite Group, 1997a; 1999). Chemical analytical data collected under the VCO underwent data quality review using guidance from the USEPA CLP Functional Guidelines.

Field sampling protocols, analytical methods, data validation, and the data usability review were presented in the Draft SCR, Section 7 (Data Validation and Usability), and data validation reports were included as Appendix C of the Draft SCR (Stibnite Group, 2000). A brief summary of data quality and usability is presented here.

Data validation - During validation of the 1997 and 1999 Site Characterization data, only seven results were qualified as unusable, namely, the total selenium results for seven September 1999 groundwater samples. All other analytical data were found to be fully usable for the purposes of site characterization and risk evaluation, although some results were qualified as nondetect or estimated, which did not affect data usability.

Precision, accuracy, completeness, and representativeness - These indicators of data quality were evaluated for the 1997 and 1999 Site Characterization data and were found to be acceptable, following criteria contained in the project QAPP.

Detection limits - The reporting limits for the 1997 Site Characterization data met the requirements specified in the QAPP. However, reporting limits for some samples were elevated, due either to sample dilution to reduce matrix interference or to substitution of the blank concentration as the reporting limit for results qualified as nondetect based on blank contamination. Detection limits for trace metals in surface water and groundwater were also compared to water quality criteria (Draft SCR, Section 7.4.3). Only mercury had detection limits (0.1 µg/L to 0.5 µg/L in 1997 and 1999 groundwater samples, and typically 0.042 µg/L in the 1999 surface water samples) that were above the Idaho chronic water quality criterion (0.012 µg/L). The lower detection limits obtained in the 1999 surface water samples are considered adequate for characterizing mercury impacts to surface water quality.

Compliance monitoring data usability - Usability of non-VCO chemical analytical data was evaluated through a process of corroboration and evaluation of quality assurance measures and indicators. This process considered split sample results analyzed in different laboratories, laboratory certification, analytical methods, and quality assurance/quality control (QA/QC) programs; and detection limits for water samples compared to water quality standards. The usability review (Draft SCR, Section 7.4) concluded that the analytical data provided by various laboratories who performed analyses are of adequate quality to be used in site characterization and risk evaluation.

5.3 DATA AGGREGATION FOR RISK ASSESSMENT

Chemical analytical data were aggregated for the aquatic, terrestrial, and human health risk assessments consistent with the exposure areas outlined below. In contrast to the exposure areas described below, the Stibnite Site was divided into three investigation areas for the purpose of reported results of site characterization in the Draft SCR (Stibnite Group, 2000). Table 5-3 summarizes each exposure area and the samples used in risk assessment.

5.3.1 EXPOSURE AREAS - HUMAN HEALTH AND TERRESTRIAL RISK ASSESSMENTS

The terrestrial and human health risk assessments evaluate the following exposure areas:

<u>Meadow Creek Valley</u>

- Bradley Tailing Impoundment and Neutralized Ore Disposal Area
- Meadow Creek Mine Hillside
- Lower Meadow Creek Valley
- Meadow Creek Upgradient Wetland (excluding location UW-1)
- Keyway Wetland
- Meadow Creek Forested Wetland

EFSFSR

- EFSFSR, Southeast Bradley Waste Rock Dump, and Midnight Creek
- Glory Hole, EFSFSR, Northwest Bradley Waste Rock Dump, and Hennessey Creek
- Northeast Bradley Waste Rock Dump and Sugar Creek

Miscellaneous Small Areas of Concern

- Location UW-1, Upgradient Wetland
- Smelter Stack (soil, ash, wood)
- DMEA Dump
- Location BD-6, Northwest Dump
- BTO

5.3.2 EXPOSURE AREAS AND AQUATIC STATIONS – AQUATIC RISK ASSESSMENT

The aquatic risk assessment evaluates both exposure areas and individual aquatic stations. Water quality data from 1999 are aggregated into four aquatic exposure areas:

- Meadow Creek (including Blowout Creek)
- Upper EFSFSR (including Midnight Creek)
- Lower EFSFSR (including the Glory Hole and Hennessey Creek)
- Sugar Creek

In addition, the physical habitat (1997 and 1999) and fish tissue residue levels of metals (1997) are evaluated for each exposure area.

Water quality data (1999) and sediment quality data (1996, 1997, and 1999) are compiled for ten on-site aquatic stations (from upstream Meadow Creek to downstream EFSFSR):

- MC-1C
- 322
- 319
- 365
- 310
- Glory Hole
- EF-7
- 308
- 316
- 314

In addition, the physical habitat (1997 and 1999), benthic community (1999), and benthic invertebrate and fish tissue residue levels (1997) of metals are evaluated for each station.

5.3.3 GROUNDWATER

Groundwater data collected in 1997 and 1999 from monitoring wells in Meadow Creek Valley and elsewhere are evaluated in the human health risk evaluation to indicate suitability of groundwater as an untreated source of drinking water. The data are presented in detail in the Draft SCR; results are presented as ranges for selected well groups in the health risk assessment.

5.3.4 SEEPS

Numerous seeps and springs were sampled in the 1997 and 1999 Site Characterization, some of which appear to exhibit impacts from mining activities and others of which appear to reflect natural mineralization of ore bodies through which they flow (see Draft SCR, Section 8.3). Seeps that appear to reflect mining impacts were evaluated quantitatively in the terrestrial risk assessment and qualitatively in the human health risk assessment. Seeps that appear to represent effects of natural mineralization of the ore bodies through which they flow were not evaluated in the risk assessment.

Table 5-4 lists all the seeps sampled and observed concentrations of dissolved antimony, arsenic, sulfate, and pH, and highlights those used in the risk evaluations. Antimony and arsenic are the primary constituents of potential concern associated with ore bodies and mining impacts at the site, as indicated in the Draft SCR (Stibnite Group, 2000). Therefore concentrations of these constituents, combined with seep location in relation to potential sources, provide a useful guide in identifying seeps that may be affected by mining-related sources for evaluation in the risk assessment. Results from filtered samples were used to evaluate relative concentrations among seeps, because dissolved-phase metals were considered more representative of release and transport of metals in infiltrating water. However, results from unfiltered samples (total metals) were used in the risk assessments.

The following seeps were evaluated in the risk assessment:

- Lower Meadow Creek Valley: SPMC-2, SPMC-8, and SPMC-9 (affected by proximity to Bradley tailing deposits)
- Glory Hole: SPGH-5 and SPGH-6 (may or may not exhibit historic mining impacts; mining sources undetermined)
- Northwest Bradley Waste Rock Dump: SPNW-1 and SPNW-2 (probably affected by waste rock)

Other seeps that were not included in the risk assessment were either

- upgradient of or unaffected by mining activities (SPMC-1, SPMC-3, SPMC-10, SPGH-1, SPGH-2);
- at the surface expression of the Meadow Creek fault zone (SPMC-5) or in ore bodies near the Glory Hole (SPGH-3, SPGH-4, SPGH-7, SPGH-8, SPGH-9, SPHP-1); or
- in proximity to both mineralized zones and mined areas and have constituent levels that are consistent with seeps emerging from ore bodies (SPMC-4, SPMC-7, SPEF-3, SPGC-1).

Detailed descriptions of each seep are presented in Section 8.3 of the Draft SCR.

5.4 *SEDIMENT*

Limited sediment sampling has been conducted previously by the Forest Service, IDEQ, and the USFWS. Several sediment samples were collected in 1993 from locations throughout the Site and results were presented in the PA/SI prepared by the Forest Service, Payette National Forest (Forest Service, 1993). Samples collected by the USFWS were limited to the Bradley tailing impoundment area in upper Meadow Creek and were published in the 1993 USFWS Report (Burch and Mullins, 1993). However, the stream channel where those samples were collected has been significantly altered since 1993, and these data were not used in Site Characterization. Sediment samples were also collected from eight of the STORET locations in 1996 and 1997 by the Forest Service and IDEQ. The sediment samples were collected from the same locations as the benthic macroinvertebrate samples. Results of these samples were used in the aquatic habitat evaluation described in Section 8.5.

5.5 *SOIL*

Numerous samples of the historic Bradley tailing have been collected over the years. Samples have also been collected from neutralized ore and from surface soil. The results for several of the samples were provided in the Preliminary Assessment/Site Investigation (PA/SI) (Forest Service, 1993). For the PA/SI, one surface soil sample was collected from near the top of the old Meadow Creek Diversion Channel that diverted upper Meadow Creek around the Bradley tailing impoundment. A comparison between the soil sample and the tailing samples showed that the Bradley tailing had higher concentrations of antimony, arsenic, cadmium, copper, lead, selenium, and silver, and the soil sample had higher concentrations of aluminum, chromium, iron, nickel, and zinc. The mercury concentrations were very similar but were slightly higher in the tailing samples. A comparison between the soil sample and the neutralized ore showed that the ore contained higher levels of antimony, arsenic, cadmium, chromium, copper, iron, mercury, nickel, and silver, and the soil sample was higher in lead and zinc. These marked differences in composition reflect differences in source material (i.e., mineralized and non-mineralized). These data were not included in the soils evaluation performed for the Site Characterization because they were not needed to supplement the larger data set collected in the Site Characterization investigation.

5.6 *MACROINVERTEBRATES*

Benthic macroinvertebrate sampling has been conducted nearly every year since 1978 and continues to be performed annually by the Forest Service. A benthic invertebrate injuries study (ABA, 1996) was completed in June 1996 for the Forest Service that evaluated all of the existing data from the Stibnite Site. The results of the previous sampling have shown that the benthic macroinvertebrate communities have improved since 1983, when the Meadow Creek Diversion Channel was reconstructed around the Bradley tailing impoundment. An additional study was performed as part of the Watershed Analysis of the Upper EFSFSR (KK Consulting, 1997). Results of these previous studies are discussed in Section 8.5, Aquatic Characterization.

5.7 FISH

Limited fish tissue analysis has been performed on fish from the area. The results from baseline analyses to determine pre-existing conditions associated with effects of Bradley mining and milling operations are presented in the 1981 EIS (JMM, 1981). The Draft Fishery Resources Technical Report (Rich and Associates, 1997) was prepared for the Payette National Forest to help evaluate the potential impacts associated with Stibnite Mine Expansion previously proposed by SMI before it ceased operations. The Watershed Analysis report (KK Consulting, 1997) also contains technical reports related to fishery resources. Fish sampling and tissue analyses were performed in 1997 by the Forest Service, with assistance from the Stibnite Group. These 1997 data were used in the Draft SCR (Section 8.5, Aquatic Characterization).

Table 5-1

Sources of Data Used in Risk Evaluation

Medium or Ecosystem	Data Source	Data Type	Use in Risk Evaluation
Surface Water (1)	1999 VCO Sampling	Total and dissolved metals and cyanide	Aquatic, terrestrial, and human health
Groundwater	1997 and 1999 VCO Sampling	Total metals	Human health (qualitative)
Seeps and Springs	1997 and 1999 VCO Sampling	Total metals	Terrestrial
Soil	1997 and 1999 VCO Sampling	Inorganics	Terrestrial and human health
Sediment (2)	1996 and 1997 Forest Service	Metals	Aquatic, terrestrial, and human health
	1999 VCO Sampling	Metals	Aquatic, terrestrial, and human health
Benthic Macroinvertebrates (3)	1999 Forest Service	Community structure	Aquatic
	1997 Forest Service	Tissue analyses - metals	Aquatic
Fish	1997 Forest Service	Tissue analyses - metals	Aquatic, terrestrial, and human health
Aquatic Ecosystem	1997 and 1999 Site Characterization	Habitat characteristics	Aquatic
Terrestrial and Riparian Ecosystem	1997 and 1999 Site Characterization	Habitat condition; species	Terrestrial

(1) Surface water data from 1996 and 1997 compliance monitoring and from 1997 VCO sampling also are included in Draft SCR (Stibnite Group, 2000). These data are no longer representative of conditions in Meadow Creek and the EFSFSR following the 1998 removal action at the Bradley tailing impoundment/neutralized ore disposal area and were not used in risk assessment.
(2) Sediment data from reference stations in 1996 used as background because no reference station data are available from 1997 or 1999.
(3) Benthic community analyses from 1996 and 1997 also are reported in the Draft SCR (Stibnite Group, 2000). These data were not used in the risk assessment because they are no longer representative of on-site conditions.

VCO = Voluntary Consent Order for site characterization and risk assessment.

Table 5-2

Analytes for 1997 and 1999 Stibnite Site Characterization

Analyses	Methods	Matrices			
		Surface Water and Seeps	Ground water	Soil	Glory Hole Sediment
Metals Suite (1,2)	6010/6020/7000	1997, 1999	1997, 1999	1997, 1999	1999
Total Cyanide (3)	335.2 or 335.4	1997, 1999	1997, 1999	1999	
WAD Cyanide (3)	ASTM D4374 or SM-4500-I	1997, 1999	1997, 1999		
Total Organic Carbon (TOC)	415.1	1997, 1999			
Alkalinity	310.1	1997, 1999	1997		
Chloride	300.0	1997, 1999	1997, 1999		
Hardness	130.2	1997, 1999	1997		
Nitrate/Nitrite	353.2	1997, 1999	1997, 1999		
Ammonia Nitrogen	350.1			1997	
Ortho-Phosphate	300.0			1997	
Sulfate	300.0	1997, 1999	1997, 1999	1997	
Total Dissolved Solids (TDS)	160.1	1997, 1999	1997, 1999		
Total Suspended Solids (TSS)	160.2	1997, 1999	1997, 1999		
pH	150.1	1997, 1999	1997, 1999	1997, 1999	
Dissolved Oxygen	Field	1997, 1999	1997, 1999		
Specific Conductivity	Field	1997, 1999	1997, 1999		
Temperature	Field	1997, 1999	1997, 1999		
Turbidity	Field	1997, 1999			

(1) Metals Suite: aluminum, antimony, arsenic, cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, selenium, silver, and zinc.
(2) Conducted on unfiltered (total metals) and filtered samples (dissolved metals) for surface water, seeps, and groundwater.
(3) Area 1 samples only.

Table 5-3

Data Aggregation and Exposure Areas for Risk Assessment

Human Health and Terrestrial Ecological Risk Assessment			
Exposure Area	**Media**	**Sample Locations**	**Data Used**
Meadow Creek Valley			
Bradley Tailings Impoundment/ Neutralized Ore Disposal Area	Surface Soil	SOD-1, SOD-2, SOD-3 and STP-1 – STP-12	1997, 1999
Meadow Creek Mine Hillside	Surface Soil	MCM-1 – MCM-12	1997
Lower Meadow Creek Valley	Surface Soil Surface Water Sediment Fish	MCV-1 – MCV-19 368, 322, MC-2A, MC-2B, 319, MC-1A, BL-1 322, 319 322-1, 322-2, 322-3, 310-1, 310-2, 310-3	1997 1999 1997 1997
Upgradient Wetland, excl. location UW-1	Surface Soil Surface Water	UW-2, UW-3 MC-1A	1999 1999
Keyway Wetland	Surface Soil Surface Water	KW-1, KW-2, KW-3 KW-1	1999 1999
Meadow Creek Forested Wetland	Surface Soil	MCW-1, MCW-2, MCW-3	1999
EFSFSR, Southeast Dump, and Midnight Creek			
EFSFSR and Midnight Creek	Surface Water Sediment Fish	313, 324, 321 310, 365 322-1, 322-2, 322-3, 310-1, 310-2, 310-3	1999 1997 1997
SE Bradley Waste Rock Dumps	Surface Soil	SE-1 – SE-4	1999
Glory Hole, EFSFSR, Northwest Dump, Hennessey Creek			
NW Bradley Waste Rock Dumps	Surface Soil	BD-1 – BD-5, BD-7 – BD-10, NW-1 – NW-14	1997, 1999
Glory Hole, EFSFSR, Hennessey Cr.	Surface Water Sediment Fish	GH1-A, GH1-B, GH2-A, GH2-B, GH2-C, GH3-A, GH3-B, 369, EF-7, 308, 314, HC-2 308, 314, EF7, GH4, 369a, 369b 308-1, 308-2, 308-3, 314-1, 314-2, 314-3	1999 1997, 1999 1997
Northeast Dump and Sugar Creek			
NE Bradley Waste Rock Dumps	Surface Soil	BT-1S, BT-2G, and NE-1 – NE-8	1999
Sugar Creek	Surface Water Sediment	SC-3, 316 307, 316	1999 1997
Miscellaneous Small Areas of Concern			
Upgradient Wetland, Location UW-1	Surface Soil Surface Water	UW-1, SOD-5 UW-1	1999 1999
Smelter Stack	Ash Wood Surface Soil	SMST-4 SMST-6 SMST-1, SMST-2, SMST-3, SMST-5	1999 1999 1999
DMEA Dump	Surface Soil	DMEA-1, DMEA-2, DMEA-3	1999
NW Dump, Location BD-6	Surface Soil	BD-6	1997
Bailey Tunnel Portal	Surface Water	BTO	1999
No Exposure			
Diversion Channel (constructed in 1998 with boulder and large cobble substrate)	Surface Water Sediment	MC-1C MC-1C	
Former Primary and Secondary Camps (Demolished and regraded during reclamation)	Surface Soil	HOOT1-HOOT3 and MAN1-MAN3	

Table 5-3

Data Aggregation and Exposure Areas for Risk Assessment

Aquatic Risk Assessment			
Meadow Creek (Meadow Creek Valley and Lower Blowout Creek)	Surface Water	MC-1A, MC-1C, 368, 322, MC-2A, MC-2B, 319, BL-1	1999
	Sediment	MC-1C, 322, 319	1997, 1999
	Fish	322-1, 322-2, 322-3	1997
	Benthics	MC-1C, 322, 319	1999
Upper EFSFSR (Upper EFSFSR and Midnight Creek)	Surface Water	313, 324, 321	1999
	Sediment	365, 310	1997
	Fish	310-1, 310-2, 310-3	1997
	Benthics	365, 310	1999
Lower EFSFSR (Glory Hole, Lower EFSFSR, and Hennessey Creek)	Surface Water	369, GH1-A, GH1-B, GH2-A, GH2-B, GH2-C, GH3-A, GH3-B, EF-7, 308, HC-2, 314	1999
	Sediment	GH1, GH2, GH3, GH4, EF-7, 308, 314	1997, 1999
	Fish	308-1, 308-2, 308-3, 314-1, 314-2, 314-3	1997
	Benthics	GH1, GH2, GH3, GH4, EF-7, 308, 314	1999
Sugar Creek	Surface Water	SC-3, 316	1999
	Sediment	307, 316	1997
	Fish	309	1997
	Benthics	307, 316	1999

Table 5-4

Dissolved Antimony, Arsenic, Sulfate, and pH in Seeps and Springs

Location		Date	Antimony, ug/L	Arsenic, ug/L	Sulfate, mg/L	pH
Meadow Creek Valley Area						
SPMC-1	Hillside above BT/NO Disposal Area	08/11/97	2.1	U < 4	2.48	6.78
		08/22/97	7.2	U < 3	1.76	6.81
		10/27/97	UJ < 3	U < 3	1.88	7.23
SPMC-2	Reclaimed Bradley tailing deposit	08/08/97	406	2000	18.10	7.93
		10/27/97	282 J	2350	5.62	7.83
SPMC-3	Hillside above former Bradley Mill, upgradient of Meadow Cr. fault zone	08/08/97	6.8	U < 4	0.82	7.37
		10/31/97	6.5	U < 8.7	1.25	7.41
SPMC-4	Hillside above Hecla heap, rerouted to west side of heap.	08/08/97	33.6	16.2	12.10	7.12
		10/27/97	93.4 J	57.8	24.10	7.97
SPMC-5	Above NE corner of Hecla heap, at surface expression of Meadow Cr. fault zone.	08/08/97	115	443	273	8.08
		08/22/97	67.6	2600	256	7.09
		10/31/97	23.7	621	68.70	7.89
SPMC-7	Above former SMI leach pads.	08/08/97	79.9	120	0.18	7.09
		10/31/97	83.3	48.8	1.51	7.13
SPMC-8	Reclaimed Bradley tailing deposit	08/08/97	2430	11200	53.3	6.52
		10/31/97	1210	1730	45.2	6.83
		9/16/99	1280	4270	25.6 J	7.03
SPMC-9	Reclaimed Bradley tailing deposit	08/08/97	1560	1660	126	9.21
		08/22/97	1810	1520	278	7.56
		10/31/97	1130	691	75.7	7.83
SPMC-10	Meadow Creek alluvium	08/08/97	11.7	117	0.09	7.02
		08/22/97	7	80.6	0.05	7
		10/31/97	15.6	34.3	0.35	6.83
EFSFSR Above Glory Hole						
SPEF-3	Below DMEA Dump	08/08/97	18	156	171	7.64
		08/22/97	18.7	165	196	7.77
		10/31/97	38.9	174	433	7.77
SPGC-1	Below Garnet Cr. Pit	08/08/97	33.7	250	4.71	8.11
		08/29/97	27.2	200	5.63	7.6
		10/31/97	28.5	187	6.02	7.7
Glory Hole Area - West Side						
SPGH-1	West and south of Glory Hole hillside near former Monday Camp	08/29/97	22.4	34.7	5.79	7.8
		10/30/97	43.2	50.7	6.14	7.77
		7/19/99	13	45	4 J	7.14
		9/18/99	41	51	NA	6.99
SPGH-2	South of Glory Hole above former Monday Camp	08/29/97	56.8	51.8	133	7.62
		10/30/97	64.2	51.5	127	7.66
		7/19/99	7.1	23	6.1 J	7.27
		9/18/99	U < 5.3	27	4.1 J	6.68
SPGH-4	West side Glory Hole on bench	08/29/97	152	79.8	19.6	7.49
		10/30/97	160	63.6	20.2	7.63
		7/18/99	157	71	21.2 J	7.59
		9/18/99	154	65	21.7 J	7.22
SPGH-5	West side Glory Hole below old Bradley mill building	6/25/99	261	8.6 J	NA	7.02
		7/19/99	138	14	120 J	7.11
		9/18/99	178	14 J	101 J	7.15
SPGH-6	West side of Glory Hole near EFSFSR; Outlet of pool fed by SPGH-5 and other seeps.	6/25/99	219	104	NA	7.03
		7/19/99	189	229	128 J	7.04
		9/18/99	232	278	115 J	7.10
SPGH-8	West side of Glory Hole - third lift	7/18/99	163	21	11.1 J	7.97
		9/17/99	156	20 J	11.0 J	7.92

U = Not detected. J = Estimated. Qual = Qualifier.

[shaded] Seep was evaluated in human health and terrestrial ecological risk assessments.

Table 5-4

Dissolved Antimony, Arsenic, Sulfate, and pH in Seeps and Springs

Location		Date	Antimony, ug/L	Arsenic, ug/L	Sulfate, mg/L	pH
Glory Hole Area - East Side						
SPGH-3	East side Glory Hole	08/29/97	57.5	142	5.85	7.68
		10/30/97	55	133	14.7	7.92
		7/18/99	62	129	7.9 J	7.54
		9/17/99	66	136	9.2 J	7.29
SPGH-7	East side of Glory Hole - Northeast highwall	7/18/99	17	128	136 J	8.12
		9/18/99	17	129	110 J	8.07
SPGH-9	East side of Glory Hole - southeast edge of pit lake	7/18/99	64	149	13.4 J	8.08
		9/17/99	68	153	13 J	7.99
Northwest Bradley Waste Rock Dump						
SPNW-1	Bank of EFSFSR below NW dump	6/25/99	215	231	NA	6.79
		7/19/99	257	296	83 J	7.05
		9/18/99	256	292	85 J	7.20
SPNW-2	Bank of EFSFSR below NW dump	6/25/99	202	647		6.34
Homestake Pit						
SPHP-1	Highwall above Homestake Pite	08/08/97	33.2	39.8	1180	6.69
		08/22/97	2.9	60.1	1140	6.70
		10/31/97	4	U < 14	136	7.22

U = Not detected. J = Estimated. NA = Not analyzed.

[shaded] Seep was evaluated in human health and terrestrial ecological risk assessments.

6. CONSTITUENTS EVALUATED IN RISK EVALUATIONS

Criteria for selecting chemical constituents for quantitative risk evaluation were limited to essential nutrient status, major cations and anions, and background reference values in soil, surface water, and sediment. These criteria are discussed below. Table 6-1 summarizes the analytes that were evaluated in the risk assessments.

6.1 SELECTION CRITERIA

Essential nutrient status: Soil concentrations of iron and magnesium are not included in the quantitative risk evaluations because they are essential nutrients, they are naturally occurring in relatively high concentrations, they are abundant rock-forming minerals, and they are generally non-toxic.

Major cations and ions: Ammonia, chloride, nitrates/nitrites, sodium, and sulfate are not included in the quantitative risk evaluations but are considered in the terrestrial ecological risk evaluation.

Background comparison for soil: A background comparison for constituents in soil was performed for the terrestrial ecological assessment. This screening step was performed for three reasons. First, many ecological toxicity reference soil values are near or below regional or site-specific background levels. Therefore, excluding constituents that are within background range is important so that estimates of site-related risk are not artificially elevated or more difficult to interpret. Second, the terrestrial ecological risk calculations are quite voluminous because multiple receptors and food chain effects are evaluated for each chemical at each exposure area. Therefore, eliminating constituents that are within background range reduces unnecessary calculations. Third, and most important, chemicals in soil that are above toxicity reference concentrations but are not above background would not drive remedial decisions. The background comparison for soil is discussed below in Section 6.2.

Background levels were not used to select constituents for the human health risk assessment because most metals at background levels are not potential risk drivers for human health, they do not have a measurable effect on the results or conclusions of the risk assessment, and including all constituents in the calculations does not result in overly voluminous spreadsheets.

Background comparison for surface water and sediment: In the aquatic risk assessment, comparisons are made with background concentrations of metals in surface water and sediment for those metals that had concentrations greater than water quality criteria or sediment screening values. These comparisons are shown in Section 7.7.

Frequency of detection: Low frequency of detection was not used to eliminate constituents from risk assessment for any medium except seeps (see below). However, rarely detected constituents usually do not pose a significant ecological or human health risk because exposure potential is minimal and usually they are not a good basis for developing site remediation goals due to infrequency of occurrence. If appropriate, detection frequency was considered in interpreting the risk evaluation results.

6.2 BACKGROUND EVALUATION FOR SOIL

The background evaluation for soil consisted of comparing maximum detected concentrations of metals in each exposure area to site-specific reference levels. The reference levels were equivalent to two times the mean concentration at a relevant reference area. For chemicals not detected in reference areas, the maximum detection limit (equivalent to half the maximum detection limit multiplied by two) was used as the upper limit for the background range. The use of two times the reference mean as an approximation of an upper limit for background range is from USEPA guidance for screening-level background comparisons (USEPA Region IV, 2000). Constituents whose maximum concentrations were within a factor of two of the mean reference concentrations were not included in the numerical risk calculations for that exposure area. This approach is considered reasonable and protective for purposes of identifying significant site-related risks. If all sample results for a chemical in an exposure area were reported as not detected, the chemical was considered to be not above background. Maximum detection limits for cadmium at some exposure areas were elevated but were not included in risk calculations because cadmium is not site-related.

Upgradient background stations for soil characterization were identified and sampled during the 1997 Site Characterization program. Three samples were collected at each background station. The background stations in upper Meadow Creek Valley were used in evaluating constituent levels in all Meadow Creek exposure areas. The maximum mean reference concentrations from the EFSFSR, Garnet, Fiddle, Midnight, Hennessey or West End Creek background areas were used in evaluating constituent levels at all other exposure areas.

Results of the background comparison for soil are summarized in Table 6-2. The numerical comparisons are shown in more detail in Table 6-3 (Meadow Creek Exposure Areas) and Table 6-4 (Bradley Waste Rock Dumps and Miscellaneous Small Areas of Concern). Review of the numerical comparisons shows that maximum concentrations of constituents eliminated using this approach are usually well within the background range or close to the background mean. Therefore, this approach is not expected to result in an underestimation of site risk.

6.3 SEEP CONSTITUENTS EVALUATED IN RISK ASSESSMENT

Seep constituents are considered only in the terrestrial risk assessment. Metals other than antimony and arsenic were either never or only rarely detected in filtered samples. Minor exceptions to this rule were nickel (68 to 92 µg/L) and zinc (213 and 380 µg/L) in August 1997 samples from SPHP-1 (highwall above the Homestake Pit).

Complete analytical data for seeps are included in tables accompanying Section 8.3 of the SCR (filtered samples) and in Appendix B of the SCR (unfiltered and filtered samples).

6.4 *SUMMARY OF CONSTITUENTS*

Table 6-1 lists the chemical analytes that are evaluated quantitatively and qualitatively in risk assessment. Table 6-2 identifies constituents above reference range for soil that were evaluated in the terrestrial ecological evaluation.

6.5 *TERRESTRIAL AND RIPARIAN HABITAT CHARACTERIZATION*

The purpose of the terrestrial and riparian habitat characterization is to document habitat condition in order to help distinguish naturally occurring conditions from degraded conditions attributable to mining-related physical or chemical stressors. The characterization is performed in accordance with objectives and procedures detailed in the Work Plan (Stibnite Group, 1997a) and Work Plan Addendum (Stibnite Group, 1999).

Characterization of habitat condition in the terrestrial and riparian ecosystems is identified as a primary objective for the site characterization effort because plants are typically more sensitive to toxic effects of mining-related metals than are most terrestrial wildlife. For example, arsenic, if bioavailable, is toxic to terrestrial plants at soil concentrations well below those considered potentially toxic to wildlife (Efroymson et al., 1996; Chaney and Oliver, 1996; Galbraith et al., 1995; Johns, 1995; Sheppard, 1991). The presence of appropriate vegetation in upland and riparian ecosystems largely determines the susceptibility of an area to erosion and the quality and quantity of wildlife habitat. Therefore, habitat condition (measured primarily by vegetation type and cover and soil type and stability) is the primary assessment endpoint for evaluation of terrestrial and riparian ecosystem condition.

The terrestrial and riparian habitat characterization is based on a combination of existing data review, field reconnaissance, development of soil and vegetation mapping unit descriptions, preparation of soils and vegetation maps for upland and riparian areas, and identification of plant and animal species present or likely to be present at the Site. Discussion of the methods and results of the upland and riparian habitat characterization are presented in Section 8.7.

Table 6-1

Constituents Evaluated in Risk Assessments

Constituents Evaluated in Human Health, Terrestrial, or Aquatic Risk Assessment		**Additional Parameters Considered**
<u>Soil and Sediment</u>	<u>Surface Water</u>	**Additional Soil Constituents Considered in Terrestrial Ecological Risk Assessment**
Aluminum (1)	Aluminum	
Antimony	Antimony	
Arsenic	Arsenic	Alkalinity
Cadmium	Cadmium	Chloride
Chromium	Chromium	Iron
Copper	Copper	Magnesium
Lead	Iron	Nitrate/Nitrite
Manganese (1)	Lead	Ammonia Nitrogen
Mercury	Magnesium	Ortho-phosphate
Nickel	Manganese	Sulfate
Selenium	Mercury	
Silver (1)	Nickel	**Additional Parameters Considered in Aquatic Risk Assessment**
Zinc	Selenium	
pH (1)	Silver	
	Zinc	Hardness
		Dissolved oxygen
	<u>Seeps</u>	pH
	Aluminum	Temperature
	Antimony	
	Arsenic	**Additional Water Constituents for Seeps**
	Cadmium	
	Chromium	Alkalinity
	Copper	Chloride
	Lead	Magnesium
	Manganese	Sodium
	Mercury	Sulfate
	Nickel	TDS
	Selenium	TOC
	Silver	TSS
	Zinc	Dissolved oxygen
	pH	Temperature

(1) Not a sediment analyte.

Table 6-2

Constituents with Maximum Soil Concentrations Above Background Range by Area and Chemical (Screening for Terrestrial Ecological Risk Assessment)

	BT/NO Disposal Area	Meadow Creek Mine Hillside	Lower Meadow Creek Valley	Upgradient Wetland, excl. Location at UW-1	Keyway Wetland	Meadow Creek Forested Wetland	SE Bradley Waste Rock Dumps	NW Bradley Waste Rock Dumps	NE Bradley Waste Rock Dumps	Upgradient Wetland, UW-1	Smelter Stack	DMEA Dump	1997 Antimony Outlier, BD NW Bradley Waste Rock Dump
Aluminum	N	Y	N	Y	N	Y	N	N	N	N	N	N	N
Antimony	Y	Y	Y	N	Y	Y	N	Y	N	Y	Y	N	Y
Arsenic	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cadmium	Y	N	N	N	N	Y	N	N	N	N	N	N	N
Chromium	Y	N	Y	Y	Y	Y	N	N	N	N	N	N	N
Copper	Y	N	Y	Y	Y	Y	N	N	N	Y	N	N	Y
Cyanide	Y	NA	NA	N	Y	N	NA	NA	NA	N	NA	NA	NA
Lead	Y	Y	Y	Y	Y	Y	N	N	N	Y	Y	N	Y
Manganese	N	Y	N	N	N	N	N	N	N	N	N	N	N
Mercury	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Nickel	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N
Selenium	N	N	Y	N	Y	Y	N	Y	N	Y	Y	Y	Y
Silver	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Zinc	N	Y	Y	Y	N	Y	N	N	N	N	N	N	Y

BT/NO = Bradley Tailing/Neutralized Ore
N = Not above background range
NA = Not analyzed
Y = Above background range

Table 6-3

Background Comparison for Soil: Meadow Creek Exposure Areas

Analyte	Reference Average (1)	Reference Range (Ref. Ave. x 2) (2)	BT/NO Disposal Area (3)	Max. > Ref. Range ?	Meadow Creek Mine Hillside (3)	Max. > Ref. Range ?	Lower Meadow Creek Valley (3)	Max. > Ref. Range ?	Upgradient Wetland, excl. UW-1 (3)	Max. > Ref. Range ?	Keyway Wetland (3)	Max. > Ref. Range ?	Meadow Creek Forested Wetland (3)	Max. > Ref. Range?
Aluminum	9300	18600	6820	N	18900	Y	15600	N	43300	Y	13000	N	34200	Y
Antimony	1.81	3.62	238	Y	23.8	Y	4280	Y	ND	N	333	Y	1550	Y
Arsenic	5.68	11.36	2290	Y	1460	Y	2020	Y	24.4	Y	634	Y	1230	Y
Cadmium	ND <0.1	0.1	2.7	Y	ND	N	ND	N	ND	N	ND	N	0.13	Y
Chromium	2.92	5.84	23.5	Y	5.01	N	18.3	Y	39.9	Y	7.1	Y	14.3	Y
Copper	3.55	7.1	30.7	Y	6.68	N	147	Y	12.1	Y	19.6	Y	68.8	Y
Cyanide	NA	NA	1.84	Y	NA	--	NA	--	ND	N	0.27	Y	ND	N
Lead	2.72	5.44	60	Y	6.03	Y	54.9	Y	9.4	Y	47.8	Y	160	Y
Manganese	368	736	461	N	4690	Y	442	N	206	N	233	N	199	N
Mercury	ND <0.1	0.1	4.1	Y	1.13	Y	1.39	Y	0.11	Y	0.89	Y	3.1	Y
Nickel	2.01	4.02	42.7	Y	5.14	Y	36.1	Y	21	Y	5.9	Y	8	Y
Selenium	ND <0.3	0.3	ND	N	ND	N	11.7	Y	0.19	N	0.52	Y	5.3	Y
Silver	ND <0.1	0.1	0.81	Y	0.3	Y	4.3	Y	0.1	N	2.8	Y	19.6	Y
Zinc	25.7	51.4	28	N	68.4	Y	289	Y	67.7	Y	40.9	N	70.9	Y

(1) Average (mg/kg) of three samples MC-1, MC-2, and MC-3, collected at one upgradient location in Meadow Creek Valley (Draft SCR Table 8.4-6 [Stibnite Group, 2000]). Detection limits are provided f
(2) A value of 2 times the background mean was adopted as an upper limit for background range, in keeping with USEPA Region IV recommendations (USEPA Region IV, 1996). For NDs, the maximum detection limit (equivalent to half the maximum detection limit multiplied by two) was adopted as the upper limit for background range.
(3) Maximum concentrations (mg/kg) are indicated in data tables in Appendix B of the Draft SCR (Stibnite Group, 2000).

BT/NO = Bradley tailing/Neutralized ore
Y = Yes, maximum detected site concentration exceeds background range.
N = No, maximum detected site concentration does not exceed background range. If all sample results were reported as ND for an area, the site concentration was not considered to be above background.
ND = Not detected.
NA = Not analyzed.
-- = Not applicable because not analyzed.
excl. = excluding hot spot sample.

Table 6-4

Background Comparison for Soil: Bradley Waste Rock Dumps and Miscellaneous Small Areas of Concern

Analyte	Reference Average (1)	Reference Range (Ref. Ave. x 2) (2)	SE Bradley Dump (3)	Max. > Ref. Range ?	NW Bradley Dump excl. BD-6 (3)	Max. > Ref. Range ?	NE Bradley Dump (3)	Max. > Ref. Range?	Upgradient Wetland UW-1 (3)	Max. > Ref. Range ?	Smelter Stack (3)	Max. > Ref. Range ?	DMEA Dump (3)	Max. > Ref. Range ?	NW Dump Antimony Outlier Sample BD-6 (3)	Max. > Ref. Range ?
Aluminum	31567	63134	4740	N	16000	N	15800	N	20200	N	13500	N	4400	N	6850	N
Antimony	11.75	23.5	0.7	N	915	Y	19.1	N	689	Y	292	Y	7.4	N	16400	Y
Arsenic	200	400	4970	Y	5330	Y	7570	Y	983	Y	3750	Y	9460	Y	4790	Y
Cadmium	0.08	0.16	ND	N	ND	N	ND	N	ND	N	0.09	N	ND	N	0.09	N
Chromium	25	50	5.7	N	30.1	N	32.5	N	10.1	N	6.1	N	6.4	N	8.57	N
Copper	9.15	18.3	7.4	N	17.9	N	14.7	N	286	Y	8.3	N	6.3	N	26.5	Y
Cyanide	NA	NA	NA	--	NA	--	NA	--	ND	N	NA	--	NA	--	NA	--
Lead	8.03	16.06	11.5	N	10.1	N	10.8	N	754	Y	16.6	Y	9.2	N	34.7	Y
Manganese	1563	3126	587	N	543	N	545	N	147	N	370	N	885	N	130	N
Mercury	0.16	0.32	2.6	Y	3.8	Y	2.3	Y	2.3	Y	471	Y	9.9	Y	13.6	Y
Nickel	19.9	39.8	4	N	17.7	N	22.3	N	8.2	N	2.8	N	ND	N	2.89	N
Selenium	ND <0.3	0.3	ND	N	1.6	Y	0.42	Y	1.1	Y	66.7	Y	0.35	Y	7.7	Y
Silver	0.09	0.18	0.54	Y	5.6	Y	2.6	Y	2.2	Y	4.1	Y	3.4	Y	6.79	Y
Zinc	71.9	143.8	53.9	N	134	N	39.5	N	48.2	N	47.3	N	42.7	N	150	Y

(1) Highest average concentration (mg/kg) from upgradient background locations in the EFSFSR and Fiddle, Garnet, Hennessey, Midnight, Meadow and West End creeks (Draft SCR Tables 8.4-6, 8.4-8, and 8.4-10 [Stibnite Group, 2000]). Detection limits are provided for NDs.
(2) A value of 2 times the reference mean was adopted as an upper limit for background range, in keeping with USEPA Region IV recommendations (USEPA Region IV, 1996). For NDs, the maximum detection limit (equivalent to half the maximum detection limit multiplied by two) was adopted as the upper limit for background range.
(3) Maximum concentrations (mg/kg) are indicated in data tables in Appendix B of the Draft SCR (Stibnite Group, 2000).

Y = Yes, maximum site concentration exceeds background range.
N = No, maximum site concentration does not exceed background range.
ND = Not detected at site.
NA = Not analyzed.
-- = Not applicable because not analyzed.
excl. = excluding hot spot sample.

7. AQUATIC ECOLOGICAL RISK EVALUATION

Following is the risk evaluation of the aquatic ecosystem on the Stibnite Site. As described above, the primary water bodies comprising the on-site aquatic ecosystem include Meadow Creek, Sugar Creek, and the EFSFSR. The aquatic ecological risk evaluation generally follows the approach described in the Stibnite Area Risk Evaluation Work Plan (Stibnite Group, 1997). The risk evaluation also incorporates revisions based on comments received on the Draft Risk Evaluation Report (RER) (Stibnite Group, 1998a) from the involved resource agencies plus discussions with IDEQ during a risk evaluation meeting on May 8, 2000.

7.1 APPROACH

The overall approach for the aquatic ecological risk evaluation of the Stibnite Site is described in Section 2.2. The aquatic ecological risk evaluation for the Site is performed in accordance with current USEPA guidance for ecological assessments of hazardous waste sites. The principal guidance documents are:

- Guidelines for Ecological Risk Assessment (USEPA, 1998a)
- Framework for Ecological Risk Assessment (USEPA, 1992a)

The Guidelines for Ecological Risk Assessment (USEPA, 1998a) expands upon the concepts and principles originally presented in the Framework document (USEPA, 1992a), yet the Guidelines for Ecological Risk Assessment document is not prescriptive in that it retains considerable flexibility to accommodate a wide range of site scales and complexity. Additional detailed guidance and information usable for the aquatic risk evaluation are presented in: water quality criteria documents (e.g., USEPA, 1992b, 1995a); Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (USEPA, 1997a); the series of ECO Updates prepared by the USEPA Office of Solid Waste and Emergency Response; various published ecological risk assessment books (e.g., Suter, 1993), and scientific journal articles.

Based on the paradigm for risk assessments contained in USEPA guidance (1992a, 1998a), the aquatic risk evaluation for the Site consists of three principal parts:

- Problem Formulation
- Analysis
- Risk Characterization

These three parts of ecological risk assessment are illustrated in Figure 7-1. In the figure, hexagon boxes incorporate actions, rectangular boxes indicate inputs to the process, and circles represent outputs.

The aquatic ecological risk evaluation (Section 7) is organized into the following major sections:

Section	Title
7.1	Approach
7.2	Nature of the Problem
7.3	Problem Formulation
7.4	Analysis
7.5	Risk Characterization
7.6	Risk Estimation
7.7	Risk Description
7.8	Uncertainty in the Aquatic Ecological Risk Evaluation
7.9	Stations UW-1, KW-1, and BTO
7.10	Glory Hole Projections
7.11	Stream Designated Uses
7.12	Aquatic Ecological Risk Summary

7.2 NATURE OF THE PROBLEM

A principal purpose of the aquatic ecological risk evaluation is to produce a scientific evaluation of aquatic risk that enables managers to make informed decisions regarding whether remediation activities are warranted.

The aquatic ecosystem on the Site is complex in that it has been affected by various chemical and physical stressors, both naturally occurring and site-related. In order to make informed risk management decisions, it is essential to understand the potential effects of chemical stressors and to be able to separate physical habitat influence from chemical effects. For example, fishery resources in the EFSFSR may be limited because of the scarcity of appropriate fish habitat, especially spawning substrate, or because of conditions outside the watershed, rather than because of a chemical stressor. Metals in surface waters and sediment may be due to natural conditions, site-related activities, or a combination of both. Similarly, fish habitat may be limited because of naturally occurring conditions (e.g., high stream gradient, extreme elevation, lack of pool and glide areas, sedimentation from seasonal or episodic high runoff) or sedimentation from site activities. Understanding the aquatic ecosystem on the Site and the various factors that may affect the quality of the system will permit reasonable and focused risk management decisions.

7.3 PROBLEM FORMULATION

The first part of the risk evaluation, Problem Formulation, integrates available information regarding:

- Characterization of the aquatic ecosystem
- Identification and characteristics of stressors (chemical and physical)
- Ecological effects of chemical stressors
- Assessment and measurement endpoints
- Conceptual site model for aquatic receptors and exposure pathways

7.3.1 CHARACTERIZATION OF THE AQUATIC ECOSYSTEM

The physical/chemical habitat of the aquatic ecosystem on the Stibnite Site is fully characterized in the Draft SCR (Stibnite Group, 2000). Surface water quality for streams on the Site is described in Section

8.1, and physical habitat and sediment quality are described in Section 8.5 of Stibnite Group (2000). Results of biological sampling, including benthic macroinvertebrates (community and tissue analyses) and fish (populations and tissue analyses) also are described in Section 8.5. In Section 8.7 of the Draft SCR (Stibnite Group, 2000), abiotic habitat data and biological data are integrated into one discussion.

For the purpose of characterizing the environment of the Stibnite Site based on sources of metals (Stibnite Group, 2000), it was divided into three investigation areas as follows:

Investigation Area	Description
Area 1	Meadow Creek drainage
Area 2	Upper EFSFSR to above Midnight Creek
Area 3	Lower EFSFSR from Midnight Creek to below Sugar Creek; Sugar Creek

However, as described in Section 7.4.1, for the purpose of assessing exposure and potential risk to aquatic organisms, Station 321 (Midnight Creek) is moved from Area 3 to Area 2. This station is located upstream of the cascade portion of EFSFSR that drains into the Glory Hole. The cascade portion of the stream provides a physical barrier between Areas 2 and 3 and is expected to impede movement of fish. By including water quality data from Station 321 in Area 2, calculated concentrations of metals for upper EFSFSR are consistent with potential exposure of aquatic organisms upstream of the EFSFSR cascade. Also, because of the unique water quality characteristics of Sugar Creek (i.e., a substantial source of mercury upstream of the Stibnite Site), Sugar Creek is evaluated separately from the EFSFSR in Area 3.

For the remainder of the aquatic risk evaluation, the four exposure areas are referred to as:

Exposure Area	Description
Meadow Creek	Meadow Creek drainage, including Blowout Creek
Upper EFSFSR	Upper EFSFSR, including Midnight Creek
Lower EFSFSR	Lower EFSFSR from below Midnight Creek to below Sugar Creek, including Hennessey Creek and the Glory Hole
Sugar Creek	Sugar Creek

Physical habitat characteristics, sediment quality, benthic macroinvertebrates, and fish were sampled in 1997 and 1999 at the 12 aquatic habitat stations listed in Table 7-1 and shown in Figure 7-2 as filled or half-filled circles. In 1999, surface water quality samples were collected from a total of 25 stream stations and three Glory Hole stations on the Site:

1999 Water Quality Sampling Stations

Areas	Background Stations	Site Stations	Other Site Stations (evaluated separately)
Meadow Creek	320	MC-1A, MC-1C, 368, BL-1, 322, MC-2A, MC-2B, 319	UW-1, KW-1
Upper EFSFSR	EF-2	313, 324, 321	
Lower EFSFSR	EF-2, HC-1A	369, GH-1, GH-2, GH-3, EF-7, 308, HC-2A, 314	
Sugar Creek	309	SC-3, 314	BTO

In 1999, water quality samples were not collected at two of the aquatic stations in the EFSFSR (365 and 310) sampled in 1997. Of the 25 water quality stations, four stations (320, EF-2, HC-1A, and 309) serve as background stations and three stations (UW-1, KW-1, and BTO) are considered separately. These three stations are not compiled with the other stations because: 1) each is a unique situation that is recognized as a potential "hot spot" and is not representative of conditions in the area; 2) each typically has flow rates lower than 1 cfs and according to Idaho Administrative Procedures Act (IDAPA) 16.01.02 (*Water Quality Standards and Wastewater Treatment Requirements*), water quality standards do not apply to ephemeral waters and for aquatic life uses, optimal flow is 1 cfs or greater; 3) each provides only limited aquatic habitat; and 4) UW-1 is located in a puddle near the Upgradient Wetland and is not directly connected with the main stem of Meadow Creek. Locations of all surface water sampling stations are illustrated in Figure 7-3.

Summaries of the 1999 surface water quality sampling (metals and cyanide) from all main-stem surface water quality sampling stations are presented in Tables 7-2 and 7-3 of this report. Total metals are shown in Table 7-2, and dissolved metals are shown in Table 7-3. Surface water quality results from the three stations evaluated individually (UW-1, KW-1, and BTO) are presented in Table 7-4 (total metals) and Table 7-5 (dissolved metals). Full discussions of aquatic habitat, surface water, sediment, fish, and benthic macroinvertebrate studies of the Stibnite Site are presented in the Draft SCR (Stibnite Group, 2000), and results of all 1999 surface water quality sampling are presented in Appendix B of that report.

7.3.1.1 Meadow Creek

A portion of Meadow Creek flows through a 4,575-foot-long diversion channel constructed around the BT/NO disposal area. The channel was constructed in 1998 as part of the Bradley Tailing Diversion and Reclamation Project conducted by Mobil under the AOC with USEPA and the Forest Service. The project goals were to stabilize the Meadow Creek Channel, isolate the Bradley tailing from the creek, minimize migration of particulate matter from the Bradley tailing, close the former Meadow Creek Ponds that had backed up behind the Bradley tailing impoundment, and regrade and revegetate the BT/NO disposal area to reduce infiltration and runoff. The bottom surface of the channel was constructed of boulders, cobbles, and coarse gravel. A benthic community was beginning to establish itself when sampling was conducted in 1999. Although instream and riparian cover is currently limited, the BT/NO disposal area and stream banks have been reseeded with multiple grasses and forbs.

Below the Diversion Channel, Meadow Creek meanders through meadow, wetland, and wooded areas. Historic mining activities (principally tailing deposition, channelization, the 1965 Blowout Creek debris flow, and encapsulation and reclamation of portions of the valley bottom with waste rock and fill) have affected current riparian condition.

Adverse effects on the physical aquatic habitat in upper and lower Meadow Creek are reflected in limited riparian cover, reduced instream cover, and, in mid Meadow Creek, increased percent surface fines. A diagram of three key habitat characteristics (riparian vegetation, bank stability, and percent surface fines) of the Stibnite Site aquatic ecosystem is shown in Figure 7-2, and a summary of aquatic habitat characteristics is presented in Table 7-6.

Surface water quality improved markedly between 1997 and 1999 following implementation of the reclamation project at the BT/NO disposal area. For example:

- At Meadow Creek Station 322 below the new Diversion Channel and below the Keyway Wetland, total antimony was reduced by 85 percent and arsenic by 50 percent in 1999 compared to 1997 (Table 8.1-9).
- At each Meadow Creek station sampled in 1999, the average surface water concentrations of total antimony (7 to 20 μg/L) and total arsenic (32 to 44 μg/L) were less than half the 1997 average concentrations (Table 8.1-9). Individual sample results were below ambient water quality criterion for protection of freshwater aquatic life of 150 μg/L (dissolved arsenic) and were below the USEPA proposed criterion of 30 μg/L (total antimony). Surface water quality criteria for metals are provided in Table 7-7.
- Total or dissolved mercury was detected (detection limit of 0.042 μg/L) in four of twenty 1999 samples in lower Meadow Creek, ranging in concentration from 0.044 μg/L (total) to 0.085 μg/L (dissolved). These levels exceeded the Idaho chronic criterion of 0.012 μg/L (total mercury) but were below the USEPA recommended criterion of 0.77 μg/L (dissolved mercury). In prior years, mercury was non-detect at a detection limit of 0.2 to 0.5 μg /L.

In 1997 sediment samples collected from lower Meadow Creek, concentrations of antimony and arsenic ranged from 1 to 22 mg/kg and from 15 to 99 mg/kg, respectively (Table 7-8). The arsenic levels were higher than at background Station 320 in 1996 (4.7 mg/kg); no sediment samples were collected from Station 320 in 1997 or 1999. Antimony levels in Meadow Creek were generally between the mid and high sediment quality guideline (SQG) values of 2 and 64 mg/kg (Table 7-9). Arsenic levels all were greater than the consensus-based threshold effect concentration (TEC) of 9.8 mg/kg, and most were higher than the probable effect concentration (PEC) of 33 mg/kg (Table 7-10). The two sets of sediment screening values are described in Section 7.3.3.2 below. Arsenic in sediment may have resulted in adverse effects on the benthic macroinvertebrate community; however, as described below, the benthic community was either not impaired or was slightly impaired.

With the exception of Station MC-1C, located in the new Diversion Channel, the 1999 total bioassessment scores for the benthic macroinvertebrate community at all Meadow Creek stations exceeded 70 percent of the maximum possible score (indicative of moderate biotic complexity/habitat integrity), and the total

bioassessment score at Station 319 (mouth of Meadow Creek) improved between 1998 and 1999 (Figure 7-4). This improvement in the benthic macroinvertebrate community is concurrent with construction of the new Diversion Channel and resulting improvement in water quality. The long-term (1983-1999) trend at Station 319 is one of marked improvement – from a total bioassessment score of 22 percent in 1983 to 77 percent in 1999 (ABA, 2000).

Benthic macroinvertebrate tissue concentrations of metals (Table 7-11) were generally low to moderate with higher than average concentrations of four metals (antimony, iron, lead, and selenium) found among the 1995, 1996, and 1997 data. No consistent correlation between sediment and invertebrate tissue concentrations of metals was noted (Stibnite Group, 2000).

Three fish tissue samples were collected from Station 322 in 1997. The analysis showed site-wide maximum whole-body concentrations of seven metals for an individual fish: aluminum, antimony, arsenic, iron, lead, manganese, and mercury (Table 7-12). The elevated concentrations of antimony, arsenic, and mercury parallel the elevated concentrations seen in the Meadow Creek surface waters from 1997.

7.3.1.2 Upper East Fork South Fork Salmon River

The EFSFSR between about Thunder Mountain Road and Midnight Creek (Area 2) provides some of the highest quality aquatic habitat in the Stibnite Site. The aquatic physical habitat shows little evidence of current impairment and is typical for mountain streams in terms of diversity of instream habitat, quantity and quality of instream and riparian cover, and percent surface fines (Figure 7-2).

Surface water quality in the EFSFSR improved markedly between 1997 and 1999. For example, at the two stations sampled in 1999, the average surface water concentrations of total antimony (13 and 18 μg/L) and total arsenic (25 and 31 μg/L) were one-third to two-thirds the 1997 average concentrations. The average concentrations, as well as individual sample results, were below the ambient water quality criterion for the protection of freshwater aquatic life of 150 μg/L dissolved arsenic and the USEPA proposed criterion of 30 μg/L total antimony.

Sediment levels of antimony (2 to 19 mg/kg) and arsenic (40 to 57 mg/kg) were higher than those measured at background Station 315 in 1996 (<1.0 mg/kg [antimony] and 19.6 mg/kg [arsenic]); no sediment samples were collected from Station 315 in 1997 or 1999. Antimony levels in EFSFSR in 1996 and 1997 were generally slightly higher than the mid SQG of 2 mg/kg (Table 7-9). Arsenic levels all were greater than the PEC of 33 mg/kg (Table 7-10). Despite these arsenic levels, the benthic community was not adversely affected.

Benthic macroinvertebrate bioassessment scores improved from 1998 to 1999 at two of the three stations sampled both years in Area 2 – Stations 315 and 310. Overall, in the EFSFSR, invertebrate community composition and densities do not change substantially between the upper background station (Station 315) and most downstream EFSFSR station (Station 314) as the river traverses the Stibnite Site (Figure 7-5). Mayfly abundance and taxa richness were very high in the 1999 Stibnite samples, especially the EFSFSR samples, and selected mayflies (i.e., intolerant taxa) tend to be one of the groups most sensitive to metals

(ABA, 2000). Based on the benthic macroinvertebrate results, it appears that any adverse effects from metals are minimal in the EFSFSR.

Benthic macroinvertebrate tissue levels of metals were generally moderate when compared to other 1995-1997 Stibnite Site tissue samples (Table 7-11). Maximum levels of antimony, copper, and lead were found in samples collected at Station 365 in 1995, and the maximum level of copper was found in benthic tissues collected at Station 365 in 1997. Maximum 1997 levels of cadmium and zinc were found in tissues collected at background Station 315.

Metals in whole-body fish tissue samples collected at EFSFSR Station 310 in 1997 were generally low-to-moderate compared with other Stibnite Site stations. However, site-wide maximum tissue levels of copper, magnesium, and selenium were measured in one of the Station 310 tissue samples (Table 7-12).

7.3.1.3 Lower East Fork South Fork Salmon River

The aquatic habitat in this portion of the EFSFSR is generally good, being characterized by a diversity of instream habitat and acceptable substrate condition, composed primarily of boulders, cobbles, and gravel, with low to moderate embeddedness. However, most of this portion of the EFSFSR is characterized by limited riparian cover associated with disturbed area, Bradley waste rock, and glacial till along the stream banks. Steep, erodible banks occur along about 800 feet of the west bank above the bridge at the main access road where the northwest Bradley waste rock descends to the water's edge. Along the upper two thirds (1,800 feet) of the channel between the Glory Hole and the bridge, the waste rock ends a distance away from the stream, and level vegetated areas line the shore. A summary diagram of three key habitat characteristics (riparian vegetation, bank stability, and percent surface fines) is presented in Figure 7-2.

Water quality in the EFSFSR improved between 1997 and 1999. Individual 1999 results for arsenic were below the ambient water quality criteria for the protection of freshwater aquatic life. Antimony concentrations in lower EFSFSR and Midnight Creek were at or slightly above the proposed USEPA chronic criterion of 30 μg/L in several samples collected at stream Stations 321, EF-7, and 308 and in the Glory Hole at Stations GH-1, 2, and 3. These antimony concentrations, which were higher than upstream at EFSFSR Station 324, appear to be due to naturally high concentrations in Midnight Creek where total antimony levels measured at upstream Station MI-1 in 1997 were 36-52 μg/L. Total mercury levels were greater than the Idaho criterion of 0.012 μg/L at Stations 321 and 314.

Sediment levels of antimony (up to 35 mg/kg) and, especially, arsenic (up to 1522 mg/kg) are higher in EFSFSR stations below Midnight Creek than in EFSFSR stations above Midnight Creek. Arsenic levels were higher than the PEC of 33 mg/kg (Table 7-10). In 1997, Station 308 had elevated metals concentrations in sediment relative to other stations with site-wide maximum concentrations of four metals (antimony, arsenic, iron, and zinc). Station 314, downstream of Sugar Creek, had sediment metals levels that are lower than at Station 308 but generally higher than other EFSFSR stations. In 1999, Station EF-7, immediately downstream of the Glory Hole, was found to have sediment concentrations of arsenic, chromium, copper, iron, lead, mercury, and zinc that were as high or higher than at Station 308 in 1997 (Table 7-8).

There are no marked longitudinal trends in the 1999 benthic macroinvertebrate data among the lower EFSFSR stations as shown in Figure 7-5. Except for Stations 369A/B, upstream of the Glory Hole, total bioassessment scores at all EFSFSR stations were 74 percent or greater (moderate to high biotic complexity/habitat integrity). The biological community at EFSFSR Station 314, located downstream of the entire Stibnite Site including Sugar Creek, reflects the effects on water and sediment quality from throughout the Site and has a total bioassessment score of 81 percent (indicative of high habitat complexity and biotic integrity) (ABA, 2000). Given the high mayfly abundance and taxa richness found in the benthic macroinvertebrate samples, it appears that any adverse effects from metals on the benthic community are minimal in lower EFSFSR.

Benthic macroinvertebrate tissue concentrations of metals from 1996-1997 paralleled the levels of metals in sediments at the lower EFSFSR stations. At Station 308 (EFSFSR), site-wide maximum benthic macroinvertebrate tissue levels of five metals were measured in either 1996 or 1997 (Table 7-11).

In 1997, concentrations of metals in fish tissues were determined for two stations in lower EFSFSR. The highest fish tissue concentration of zinc was found at Station 314 (EFSFSR), but Station 308 had no maximum fish tissue metal concentrations (Table 7-12).

7.3.1.4 Sugar Creek

Sugar Creek physical aquatic habitat is not thought to be directly impacted by Site mining activities. However, areas of limited vegetation and relatively high percent surface fines in the sediment are found. Elevated levels of mercury have been found in surface water, sediment, and in benthic invertebrate and fish tissues. These mercury results, which are characteristic of Sugar Creek, are due to off-site upgradient sources of mercury. In 1999, total mercury was detected at 0.15 to 0.39 μg/L in surface water samples from Sugar Creek and EFSFSR Station 314 below Sugar Creek (Table 7-2). These levels exceeded the Idaho chronic water quality criterion of 0.012 μg/L total mercury, but dissolved mercury was below the USEPA recommended criterion of 0.77 μg/L. The highest sediment levels of mercury (2 to 4 mg/kg) also were found in Sugar Creek and EFSFSR Station 314 below Sugar Creek (1997 data; Table 7-8). These levels were greater than the PEC for mercury (Table 7-10) and all other available freshwater sediment quality guidelines for mercury (Table 7-9).

Total bioassessment scores at the three stations in Sugar Creek (Figure 7-6) have been in the moderate to high range of biotic complexity/habitat integrity for streams in the area (i.e. 75-85 percent) from 1994 to 1999. There are no significant long-term trends between years or stations. Scores in 1996 were slightly lower, however, presumably due to increased flood disturbance earlier in that year (ABA, 2000).

Maximum levels of mercury were measured in Sugar Creek benthic macroinvertebrate tissue samples (Table 7-11). Also, the three highest concentrations of mercury in fish tissue were measured in the whole-body tissue samples collected from background Station 309 in Sugar Creek (Table 7-12). These results parallel mercury concentrations measured in Sugar Creek sediment and surface water samples.

7.3.2 IDENTIFICATION AND CHARACTERISTICS OF STRESSORS

Stressors to the aquatic ecosystem at the Stibnite Site are both chemical (e.g., inorganics in surface water and sediment) and physical (e.g., unstable stream banks). All site-related metals (and cyanide) that were detected in surface water or sediment under the Site Characterization (Tables 7-2 through 7-5 and Table 7-8) are considered COPIs and will be quantitatively evaluated in the Risk Characterization (Section 7.4).

7.3.2.1 Aluminum and Iron

For the purpose of assessing risk to aquatic receptors, aluminum and iron are not considered to be site-related and are not included in the list of surface water COPIs. Aluminum is not quantitatively evaluated in the aquatic RER because:

- Aluminum is not listed in 40 CFR Part 131.36 (Section 304(a) Criteria for Priority Toxic Pollutants) (USEPA, 1997b) as a toxic pollutant.
- Aluminum does not have Idaho numeric water quality criteria (chronic or acute) (Table 7-7).
- Aluminum is one of the most common elements in the earth's crust, constituting an average of 4.7 percent (geometric mean) of the surface soils in Idaho (Shacklette and Boerngen, 1984).
- Aluminum is not site-related. During the two sampling events in June 1999, total aluminum concentrations were greater than 80 µg/L at all three background stations (Stations 320 [Meadow Creek], EF-2 [EFSFSR], and 309 [Sugar Creek]), and concentrations were greater than the recommended USEPA chronic criterion of 87 µg/L at the background stations in EFSFSR and Sugar Creek.
- Aluminum is found only during the period of seasonally high suspended solids levels. In July and September when the spring runoff flows and higher suspended solids (i.e., natural soil minerals) had passed, aluminum concentrations at all stations were lower than the chronic criterion.

Because of the large uncertainty associated with the USEPA chronic total iron surface water criterion (1000 µg/L), iron is not quantitatively evaluated in the RER. Iron is not included as a COPI in the aquatic risk portion of the RER for several reasons:

- There is no Idaho State water quality criterion for iron (Table 7-7)
- Iron is not considered a priority toxic pollutant in water (USEPA, 1998b)
- The USEPA chronic criterion for iron was presented in 1976 (USEPA, 1976) and has not been revised or updated with additional toxicity data since that date. The 1,000 µg/L (total iron) criterion was based on a field study of site receiving acid mine drainage (FWPCA, 1967). However, the Site surface water pH is circumneutral (Appendix B of the Draft SCR [Stibnite Group, 2000]).
- Because the criterion was based on the results of one field study, it is not consistent with current USEPA methods for deriving water quality criteria (Suter and Tsao, 1996).
- Based on the 1999 surface water quality sampling results, total iron concentrations seldom exceeded 1,000 µg/L, and the respective dissolved iron concentrations (dissolved metals are more

representative of the bioavailable fraction) were typically more than an order of magnitude lower than total iron concentrations.

7.3.2.2 Background Comparisons

Those inorganics (metals and cyanide) in sediment and surface water that exceed benchmarks are compared with background concentrations. Background surface water samples were collected in 1999 upgradient of site activities in Meadow Creek, EFSFSR, Sugar Creek, and Hennessey Creek. Background sediment samples were collected in 1996 at stations in Meadow Creek, EFSFSR, and Sugar Creek. No background sediment samples were collected/analyzed in 1997, and in 1999 sediment samples were collected only at the new stations in Meadow Creek (Station MC-1C), EFSFSR (Station EF-7), and in the Glory Hole (Stations 369 and GH-1—GH-4). If surface water or sediment concentrations of an ecological risk-driving metal at a sampling station or group of stations within a stream reach exceed concentrations at relevant background stations, the metal is retained as a chemical of interest (COI). If, however, on-site concentrations of the metal are the same or less than background, the metal is not retained for further evaluation in the ecological risk description for that station or area of a stream.

7.3.2.3 Physical Stressors

Physical stressors to the aquatic ecosystem on the Site can include, among others, habitat characteristics such as water temperature extremes, high water velocity, steep stream gradients, lack of cover (protection from predators), and sedimentation of the bottom substrate. Physical habitat characteristics that are identified as potential physical stressors to aquatic biota are qualitatively evaluated in Section 7.4 (Risk Characterization).

7.3.3 ECOLOGICAL EFFECTS OF CHEMICALS

7.3.3.1 Surface Water

Chronic standards, also termed "Continuous Criteria," are defined as the highest concentration of a chemical to which aquatic life can be exposed for an extended period of time (4 days) without deleterious effects. Acute standards, also termed "Maximum Criteria," are defined as the highest concentration of a pollutant to which aquatic life can be exposed for a short period of time (1 hour) without deleterious effects (USEPA, 1992b).

The Idaho chronic and acute water quality numeric criteria (IDHW, 1998; BNA, 1999) for toxic substances (e.g., metals and inorganics), which are based on Section 131.36 of USEPA (1992b), are presented in Table 7-7 for waters having a hardness of 36 mg/L as $CaCO_3$, the average surface water hardness at all main-stem surface water quality stations (excluding background stations) during 1999. The criteria for six metals (cadmium, chromium III, copper, lead, nickel, silver [acute], and zinc) vary with water hardness, which affects the bioavailability and toxicity of these metals. Also shown in Table 7-7 are the USEPA recommended water quality criteria (USEPA, 1976; 1998b; 1999). A water effect ratio (WER) of 1.0 is assumed (in lieu of site-specific data) for calculation of all metals water quality criteria.

There are no promulgated Idaho or USEPA water quality criteria for antimony; therefore, the numeric values presented are proposed USEPA (1988; 1991) antimony criteria. With the exception of antimony, mercury (Idaho chronic numeric criterion), selenium, and WAD cyanide, all criteria are based on dissolved metals. Antimony, mercury (Idaho chronic criterion), and selenium standards are based on total recoverable metals. As discussed in detail in Section 7.7.1, toxicological data for antimony are limited and the proposed USEPA criteria are not enforceable.

According to the description of inorganics concentrations in surface water provided in Section 7.3.1 (Tables 7-2 and 7-3), four inorganics (antimony, arsenic, lead, and mercury) may be site-related (i.e., site concentrations exceed background station concentrations) and had concentrations in 1999 that exceed Idaho water quality numeric criteria (IDHW, 1998; BNA, 1999; USEPA, 1992b), USEPA recommended criteria (1976, 1998b, 1999), or USEPA proposed criteria (USEPA, 1988; 1991).

Antimony is recognized as having very low toxicity to aquatic animals (OMEE, 1996). Insufficient toxicity data are available to develop water quality criteria; therefore, only proposed chronic and acute criteria for total antimony (30 and 88 µg/L) are available (USEPA, 1988; 1991). Chronic exposure to antimony can cause reduced growth or reduced levels of survival in fish (OMEE, 1996).

The Idaho chronic and acute water quality criteria for dissolved arsenic are 190 and 360 µg/L, respectively, and the USEPA recommended chronic and acute criteria are 150 and 340 µg/L (Table 7-7). Chronic exposure to elevated arsenic can cause impacts to reproduction, growth, or enzyme functions of fish (USEPA, 1980).

The Idaho chronic and acute water quality criteria for dissolved lead are 0.8 and 20 µg/L, respectively, and the USEPA recommended chronic and acute criteria are 1.0 and 20 µg/L at an average hardness of 36 mg/L as $CaCO_3$ (Table 7-7). Chronic exposure to elevated lead can cause spinal deformities in trout and reduced reproductive success in invertebrates (USEPA, 1985a).

The Idaho chronic criterion for total mercury (0.012 µg/L) is based on the potential biomagnification of methyl mercury to levels exceeding the FDA action level of 1.0 mg/kg in fish tissue. According to the description provided in USEPA (1995a), insufficient chronic data were available to calculate a final chronic value using the usual procedures. Instead, the USEPA recommended chronic criterion for dissolved mercury (0.77 µg/L) is based on acute toxicological effects to the four most sensitive organisms tested (crayfish, amphipod, and two species of cladocerans) and an estimated acute-to-chronic ratio. While rainbow trout and coho salmon were not as acutely sensitive to mercury as these four invertebrates, the estimated acute-to-chronic ratio applied to the acute criterion to estimate the chronic criterion may result in an overestimate of the chronic criterion (USEPA, 1995b).

7.3.3.2 Sediment

Comparisons of metals concentrations in stream sediments are made with a variety of sediment screening values for freshwater systems. Table 7-9 presents ranges of SQGs from the recent compilation of available sediment values for metals prepared by EVS (1998). The SQGs selected for inclusion in Table 7-9 are all

presented on a dry-weight basis for freshwater sediments; however, the values for different metals may not be directly comparable since they may have been developed using different procedures and for different purposes. Also, the number of sediment values presented in EVS (1998) for each metal vary widely – from over 35 values for metals such as cadmium or copper to fewer than 10 for antimony and selenium. The low, mid, and high SQG values shown in Table 7-9 were selected from whatever values were presented in EVS (1998).

Some guidelines are based on empirical data, others are based on laboratory data or a combination of empirical and laboratory data. Many of the low SQGs are background concentrations measured in pristine mid-west streams. Many of the mid SQG values shown are effects range-low values (ERLs) from the USEPA Great Lakes National Program Office (GLNPO) and are based on toxicological studies of amphipods or chironomids reported by Ingersoll et al. (1996). As defined by Long and Morgan (1990) and Long et al. (1995), an ERL is the concentration below which adverse effects (e.g., loss of sensitive taxa) were rarely observed or predicted for benthic biota. Ingersoll et al. (1996) used the lower 15th percentile of freshwater effects concentrations in place of the lower 10th percentile (Long and Morgan, 1990; Long et al., 1995) to estimate concentrations below which adverse effects on benthic biota are not expected. Similarly, many of the high SQGs are effects range-median values (ERMs) from the GLNPO. ERMs are concentrations above which adverse effects are frequently or always observed or predicted among most benthic species (Long and Morgan, 1990; Long et al., 1995); Ingersoll et al. (1996) based their calculation of ERMs on the 50th percentile of freshwater effects concentrations.

To help in the application of SQGs in the screening of sediment concentrations of contaminants, MacDonald et al. (1999) examined the available guidelines, and using a step-wide approach, developed two screening values termed freshwater sediment effects concentrations (FSECs). The two consensus-based values for each metal (Table 7-10) are:

- Threshold effect concentrations (TECs) -- concentrations *below which adverse effects are not expected* (MacDonald et al., 1999) and
- Probable effect concentrations (PECs) -- concentrations *above which adverse effects are expected* (MacDonald et al., 1999).

The predictive ability of the TECs and PECs was then statistically evaluated by MacDonald et al. (1999). Except for mercury (34 percent correct prediction of non-toxicity), the predictive ability for the metals TECs ranged from 72 percent correct for chromium to 82 percent for copper, lead, and zinc. The calculated PECs were found to correctly predict toxicity from 77 percent for arsenic to 94 percent for cadmium. There are no TECs or PECs available for seven sediment analytes (aluminum, antimony, iron, magnesium, manganese, selenium, and silver) due to lack of acceptable SQGs.

To clarify comparisons with Stibnite Site sediment data and to take advantage of the efforts of MacDonald et al. (1999), comparisons are based on TECs for all metals having TEC values (Table 7-10). For those metals without TEC values, comparisons of Stibnite sediments are made with other conservative sediment screening values, such as freshwater ERLs as listed in Table 7-9, to facilitate interpretation of the results.

7.3.4 ASSESSMENT AND MEASUREMENT ENDPOINTS

Ecological endpoints to be considered in the aquatic risk evaluation are generally characterized as assessment endpoints and measurement endpoints (USEPA 1989, 1992a). Assessment endpoints are formal expressions of the environmental values that are to be protected, and measurement endpoints are measurable environmental characteristics that are related to the valued characteristics that are to be protected (Suter, 1993). When an assessment endpoint can be directly measured, the measurement and assessment endpoints are the same. In most cases, however, measurement endpoints are needed because assessment endpoints cannot be directly measured.

Assessment endpoints are identified based on the following three considerations (USEPA, 1992a):

- Ecological relevance (structure and function of the ecosystem)
- Policy goals and societal values (endangered, threatened, or species of special concern)
- Susceptibility to the constituents of concern (i.e., chemical stressors)

At the Stibnite Site, the primary assessment endpoints for the aquatic ecological evaluation can be stated as:

- Protection of salmonid fisheries populations because:
  1. Salmonids are top-level carnivores in the aquatic ecosystem (ecological relevance);
  2. Four species (chinook salmon, steelhead, bull trout, and westslope cutthroat trout) are state or federally protected (societal values); and
  3. Salmonids are exposed to chemical stressors in surface water and physical stressors as expressed in the physical habitat (susceptibility to constituents of concern)

- Protection of the benthic macroinvertebrate community because:
  1. Benthic macroinvertebrates are the primary food source for the salmonid fisheries (ecological relevance); and
  2. Benthic macroinvertebrates are exposed to chemical stressors in sediment and surface water (susceptibility to constituents of concern)

The primary measurement endpoints associated with both assessment endpoints are comparisons of measured water quality and sediment quality with state, federal, and published criteria or guidelines. Surface water quality results are compared with Idaho water quality numeric criteria (IDHW, 1998; BNA, 1999; USEPA, 1992b), USEPA recommended criteria (1976, 1998b, 1999), or USEPA proposed criteria (USEPA, 1988; 1991). Metals concentrations in sediment are compared with TEC and PEC values from MacDonald et al. (1999) (Table 7-10) or one of the compiled SQGs from EVS (1998) (Table 7-9). These measurement endpoints are quantitatively evaluated through the calculation of hazard quotients (HQs) wherein the measured concentrations are divided by the environmental benchmarks (see Section 7.6).

Secondary measurement endpoints include analyses of the benthic macroinvertebrate community, tissue levels of metals (i.e., metals residues) in fish and benthic macroinvertebrates that may be associated with toxic effects in the organisms, and physical stressors to the aquatic habitat (e.g., unstable stream banks,

sedimentation). These measurement endpoints are not quantitatively evaluated through the calculation of HQs. While potentially as important as chemical contamination, the potential effects of these measurement endpoints on risk estimates for salmonid fishes and benthic macroinvertebrates are discussed qualitatively in the Risk Description (Section 7.7).

7.3.5 CONCEPTUAL SITE MODEL

An aquatic ecological conceptual site model (CSM) diagram is shown in Figure 7-7. This is a refinement of the CSM originally presented in the Draft RER (Stibnite Group, 1998) and reflects the quantitative comparisons of surface water and sediment results with available criteria and screening values. The aquatic CSM illustrates the movement of chemical stressors through the environment from contaminant sources (i.e., mining activities) to environmental media (e.g., water, sediment), and then to the aquatic receptors. The accumulation of metals in fish and invertebrate tissues is inherent in the "Direct Contact/Uptake" pathway in the CSM. The CSM also depicts the fact that some mining activities have had physical effects on aquatic habitats.

The CSM is based on existing site data, selected assessment endpoints, appropriate measurement endpoints, and aquatic receptor organisms. It summarizes known information and anticipated movements of chemicals between abiotic elements (e.g., groundwater movement to surface water), abiotic-to-biotic movement (e.g., direct contact of fish with water), and between biotic elements (fish preying on benthic invertebrates). For the assessment endpoint of "protection of salmonid fisheries," the aquatic receptor category is salmonid fishes; for the assessment endpoint of "protection of the benthic macroinvertebrate community," the aquatic receptor category is benthic macroinvertebrates.

7.4 ANALYSIS

The analysis phase of ecological risk assessment consists of a technical assessment of the potential for and likely magnitude of exposure of aquatic receptors to the chemical and physical stressors. Toxicological effects on aquatic organisms exposed to metals (i.e., ecological response analyses) also are discussed.

7.4.1 EXPOSURE ANALYSIS

In the exposure analysis, surface water and sediment quality data collected from the Site are compiled for use in characterizing exposure of aquatic receptors to chemical stressors. In compiling the site-specific data, the following factors were considered in order to develop an understanding of the likely magnitude and duration of aquatic receptor exposure:

- Spatial variability in metals concentrations,
- Movements of receptors (e.g., movements of fish and relative immobility of benthic macroinvertebrates), and
- Habitat quality of the various stream segments

Water quality data from 1999 are used to characterize exposure of aquatic organisms. Surface water quality samples were collected on the following dates in 1999: June 10-12, June 22-25, July 16-18, and September 15-25. A total of 25 stream stations and three Glory Hole stations (2 to 3 depths at each station) were sampled during 1999. These data are discussed in detail in Section 8.1 of the Final SCR (Stibnite Group, 2000) and are presented in Tables 7-2 through 7-5 of this report. A summary of water quality data is discussed in Section 7.3.1. The 1999 surface water quality data are used exclusively to characterize exposure concentrations because they more accurately reflect current conditions than the 1997 or earlier water quality data. Water quality data collected by IDEQ in 1999 and data collected in 1998 and 1999 from Meadow Creek as part of the monitoring during construction of the new Meadow Creek Diversion are not used in the exposure calculations and risk analysis because they did not undergo data validation.

Surface water and sediment quality data for the Site are aggregated using two different strategies:

1. Aggregate all 1999 surface water quality data for each of the four exposure Areas: Meadow Creek, Upper EFSFSR, Lower EFSFSR, and Sugar Creek. As described in Section 7.3.1, water quality data from Station 321 (Midnight Creek upstream of the cascade portion of EFSFSR) are considered part of the Upper EFSFSR instead of the Lower EFSFSR. Sediment data from the aquatic stations in each area are not included in the quantitative evaluation of exposure areas since the exposure assessment (and risk) for each area is for the exposure of mobile fish only.

2. Evaluate all 1999 surface water quality data from each of the nine Site stream stations (a.k.a. aquatic stations) where aquatic data (water quality, sediment quality, benthic macroinvertebrates, tissue residue data, and physical habitat data) were collected (Stations MC-1C, 322, 319, 365, 310, EF-7, 308, 316, and 314). Also evaluate data collected in 1999 from the Glory Hole. Because water quality samples were not collected at EFSFSR Stations 365 or 310 in 1999, water quality data from Station 313, situated between 365 and 310, are used to characterize the water quality at the two neighboring aquatic stations. For each aquatic station, the maximum concentrations of the 1999 surface water quality analyses are used as the exposure concentrations.

3. Sediment data from 1997 and 1999 for each of the aquatic stations also are evaluated in the exposure analyses for benthic macroinvertebrates and fish. Maximum 1999 sediment concentrations from the Glory Hole are used as exposure concentrations.

7.4.1.1 Data Aggregation for Exposure Areas

The aggregation of water quality data into four exposure areas (Meadow Creek, Upper EFSFSR, Lower EFSFSR, and Sugar Creek) is performed because mobile aquatic species (i.e., fish) are apt to move throughout a given stretch of stream in response to habitat quality, season, or reproductive status. They are unlikely, however, to move past the steep cascade section of EFSFSR immediately upstream of the Glory Hole. By aggregating the data as described, the average water quality for each area is expected to be representative of exposure concentrations seen by mobile aquatic biota during 1999. Compilation of individual aquatic station data into areas permits isolation of possible differences in water quality due to

localized sources that could impact the immobile benthic invertebrate community or fish that tend to remain in one stretch of a stream.

The exposure concentration of each inorganic in surface water used for assessing risk in each exposure area is the lower of the 95% upper confidence limit (UCL) of the mean (USEPA, 1992c) or the maximum measured concentration (USEPA, 1989). In calculation of the 95% UCL, one-half the sample detection limit is used for any non-detected sample results for inorganics with at least one detected concentration in an area. Tabulations of individual metal and cyanide concentrations in surface water samples collected during 1999 from all water collection stations (excluding UW-1, KW-1, BTO, and background stations) within each of the four aquatic exposure areas are presented in Appendix A Tables A1-1 through A1-4.

Stations UW-1, KW-1, and BTO are considered separately from the other stations because: 1) each is a unique situation that is recognized as a potential "hot spot" and is not representative of conditions in the area; 2) each typically has flow rates lower than 1 cfs and according to IDAPA 16.01.02 (*Water Quality Standards and Wastewater Treatment Requirements*), water quality standards do not apply to ephemeral waters and for aquatic life uses, optimal flow is 1 cfs or greater; 3) each provides only limited aquatic habitat; and 4) UW-1 is located in a small ponded area near the Upgradient Wetland and is not directly connected with the main stem of Meadow Creek. Background stations, including Stations 320 (Meadow Creek), EF-2 (EFSFSR), HC-1A (Hennessey Creek), and 309 (Sugar Creek), also are excluded from the area-wide data compilations because they are considered background stations not affected by site activities.

Calculated exposure concentrations of metals and WAD cyanide for each area are presented in Appendix A. The distribution of data for each inorganic in each area is tested. If the distribution of data is lognormal, the 95% UCL is calculated using log-transformed data. If the distribution is normal or is neither normal nor lognormal, the 95% UCL is calculated using untransformed data.

A summary of the exposure concentrations (i.e., lower of the 95th UCL or the maximum) for each surface water analyte and exposure area is shown in Table 7-13. Only those analytes having Idaho water quality numeric criteria (IDHW, 1998; BNA, 1999; USEPA, 1992b), USEPA recommended criteria (USEPA, 1976; 1998b; 1999), or USEPA proposed criteria (USEPA, 1991) are shown. Water quality stations included in each of the exposure areas (listed from upstream to downstream) are as follows:

- Meadow Creek -- Stations MC-1A, MC-1C, 368, 322; BL-1 (Blowout Creek); MC-2A, MC-2B, and 319.
- Upper EFSFSR -- Stations 313 and 324, and 321 (Midnight Creek).
- Lower EFSFSR -- Stations 369; GH1-A, GH1-B, GH2-A, GH2-B, GH2-C, GH3-A, GH3-B (Glory Hole); EF-7; HC-2 (Hennessey Creek); 308, and 314.
- Sugar Creek -- Stations SC-3 and 316.

The 1999 water quality stations are illustrated in Figure 7-3.

Sediment data from the aquatic stations in each area are not included in the quantitative evaluation of exposure areas since the exposure assessment (and risk) for each area is for the exposure of mobile fish

only. Sediment data are, however, considered in the exposure analyses for benthic macroinvertebrates and fish at each of the aquatic stations discussed below.

7.4.1.2 Data Aggregation for Aquatic Stations

Both surface water and sediment are quantitatively evaluated for the exposure of fish and benthic macroinvertebrates at each of the aquatic stations. For the purposes of assessing exposure and risk, it is assumed that fish are exposed to inorganics in surface water and benthic macroinvertebrates are exposed to inorganics in surface water and sediment as illustrated in the CSM (Figure 7-7). Exposure concentrations of inorganics in surface water for each of the nine on-site aquatic stations potentially impacted by mining activities are the maximum concentrations measured in the four sampling events of 1999 (Table 7-14). The nine aquatic sampling stations include: MC-1C, 322, 319, 365, 310, EF-7, 308, 314, and 316. Of these, Stations MC-1C and EF-7 are new stations that were added in 1999. Station MC-1C was added to assess the aquatic habitat in the new Diversion Channel in upper Meadow Creek that was constructed in 1998. Station EF-7 was added to assess the habitat in the EFSFSR downstream of the Glory Hole and upstream of Station 308 adjacent to the historic Northwest Bradley waste rock dump.

In addition to the stream stations, the Glory Hole is considered a station for the purpose of assessing risk. A total of 14 water samples were collected at three locations (GH1, GH2, and GH3) and at two or three depths in July and September 1999. The maximum concentrations from among the 14 samples are the exposure concentrations for the Glory Hole. Also, as discussed above, the maximum surface water quality values from Station 313 are used to represent exposure concentrations at Stations 365 and 310.

Sediment quality data collected at the aquatic stations in 1997 and 1999 are used to assess the exposure of benthic macroinvertebrates to metals in sediment. The 1997 sediment data are used for seven of the nine aquatic stations because these data are the most recent data available; the seven aquatic stations are: 322, 319, 365, 310, 308. 316, and 314. For the two new stream stations (MC-1C and EF-7) and the Glory Hole, sediment samples were collected in 1999 and the results are used to assess exposure. In the Glory Hole, the maximum measured concentrations from the four locations sampled (GH1, GH2, GH3, and GH4) are used as the exposure concentrations. For the purpose of comparing sediment concentrations at site aquatic stations with background concentrations (Stations 320, 315 [EF-2], and 309), data from 1996 are used because sediment data from the background stations are not available for 1997 or 1999. All available sediment quality data for ten metals from 1996, 1997, and 1999 are presented in Table 7-8.

7.4.2 ECOLOGICAL RESPONSE ANALYSIS

Full discussions of surface water criteria and sediment quality guidelines used in the risk characterization are provided in Section 7.3.3. Descriptions of the toxicological effects of exceedances of these criteria and guidelines also are presented.

7.5 RISK CHARACTERIZATION

Within the Risk Characterization, the likelihood of adverse toxicological effects to ecological receptors based on surface water quality results from 1999 and sediment quality results from 1997 and 1999 is evaluated. Starting with the quantitative risk estimates (Section 7.6, Risk Estimation), identified physical habitat conditions and results from fish and benthic macroinvertebrate studies are used to help interpret the results, and the overall expected consequences of identified adverse effects are described (Section 7.7, Risk Description). A summary of the quantitative and qualitative measurement endpoints directly evaluated in the risk characterization is shown below:

Measurement Endpoint	Risk to Fish[1]	Risk to Benthos[2]
Surface Water Quality	Quantitative	Quantitative
Sediment Quality	Not Evaluated	Quantitative
Physical Habitat	Qualitative	Not Evaluated
Benthic Community	Not Evaluated	Qualitative
Benthic Tissue Residue	Not Evaluated	Qualitative
Fish Tissue Residue	Qualitative	Not Evaluated

[1] Evaluated for exposure areas and aquatic stations
[2] Evaluated for aquatic stations

7.6 RISK ESTIMATION

The basic quantitative method for estimating chemical risks to fish and benthic macroinvertebrates from exposure to site COPIs in surface water or sediment involves the comparison of measured concentrations of metals/inorganics with appropriate water quality or sediment quality benchmarks. Estimates of risk to fish within exposure areas are based on comparisons of the 1999 surface water quality results (dissolved or total, as appropriate) with water quality criteria (Table 7-15). Estimates of risk to fish and macroinvertebrates at each of the ten aquatic stations (including the Glory Hole) are based on comparisons of 1999 water quality results with criteria (for the protection of fish and macroinvertebrates) and 1997/1999 sediment quality results with sediment screening values (for the protection of benthic macroinvertebrates) (Tables 7-16 and 7-17).

This general approach is referred to as the Quotient Method and maintains that potential risk to an ecological receptor is represented by the ratio of the COPI exposure concentration to a contaminant-specific toxicity-based threshold (Barnthouse et al., 1982a,b; 1986). This ratio is termed the HQ and is calculated as follows:

HQ = COPI Exposure Concentration / COPI Chronic Threshold Concentration

Hazard quotients greater than one (1) indicate that chemical exposures may exceed levels of expected toxicological tolerance in the receptor species and suggest the need for further evaluation. The quotient method has several advantages, including simplicity, flexibility, and amenability to the consideration of commonly derived ecotoxicological data.

Individual HQ values can be summed into a hazard index (HI) in consideration of possible cumulative effects due to multiple chemicals (USEPA, 1998a). The addition of HQ values into a HI assumes that the mechanism of toxicity is the same, the toxic endpoints are the same, and the toxic effects of the metals and cyanide are approximately additive. However, the overall toxicity of a mixture of metals may be more or less than predicted by an HI and does not consider synergistic or antagonistic interactions among the inorganics. For the Stibnite aquatic risk evaluation, HQ values are not added into a HI for the reasons outlined above and for one additional reason. HQ values for inorganics in surface water and sediment are based on comparisons with water quality and sediment benchmarks, and when the exposure concentrations are lower than the conservative benchmarks, the aquatic organisms are assumed to be adequately protected (i.e., not at risk). Therefore, the summation of fractional HQ values into a HI is not valid (e.g., $0.3 + 0.5 + 0.4 \neq 1.2$).

Following (Section 7.6.1) are the results of calculating risk estimates for the exposure of fish to inorganics in surface water in the four exposure areas. In Section 7.6.2, risk estimates are described for fish and benthic macroinvertebrates exposed to inorganics in surface water and sediment at the ten Site aquatic sampling stations.

7.6.1 RISK ESTIMATION FOR EXPOSURE AREAS

Results of the risk calculations for the four exposure areas (Meadow Creek, Upper EFSFSR, Lower EFSFSR, and Sugar Creek) are presented in Table 7-15. For each exposure area, the chronic water quality criteria (lower of the Idaho or USEPA criteria) from Table 7-7 are shown in the first column; the calculated 1999 exposure concentrations in surface water (i.e., lower of the maximum or the 95% UCL of the mean) of metals and WAD cyanide from Table 7-14 are in the second column, and the calculated HQ values are in the last column. The HQ values reflect potential risk to mobile aquatic receptors (i.e., fish) that may utilize streams within each exposure area. If an analyte was not detected in any 1999 surface water samples from an area, "ND" is shown in the "Exposure Concentration" column and a dash (--) is in the "HQ" column. Where WAD cyanide was not an analyte (Lower EFSFSR and Sugar Creek), "NA" is shown in the "Exposure Concentration" column and a dash is in the "HQ" column.

Although surface water quality standards are available for both chromium III and chromium VI (Table 7-7), water samples were analyzed for total chromium and dissolved chromium only. Results of the samples analyses were compared to the standard for chromium III and not to the standard for chromium VI because, based on typical pH and Eh of freshwater streams, the predominant form of chromium in on-site streams is most likely chromium III (USEPA, 1979; Brookins, 1988). The pH of on-site streams was neutral (7.0) or slightly basic (>7.0) in 1997 (Appendix B of Stibnite Group, 2000).

<u>**Meadow Creek.**</u> In the Meadow Creek Area, only total mercury has a surface water HQ value (2.1) that exceeds 1. The total mercury HQ is based on two detected concentrations of total mercury out of 32 samples (Table 7-2) and exceedance of the Idaho numeric chronic criterion of 0.012 μg/L (Table 7-7). The HQ for dissolved mercury (0.52) is less than 1 based on the USEPA recommended mercury chronic criterion of 0.77 μg/L. HQs for five other inorganics (antimony, arsenic, WAD cyanide, lead, and zinc) are

less than 1. Six metals (cadmium, chromium, copper, nickel, selenium, and silver) were not detected in any 1999 Meadow Creek surface water samples.

Upper East Fork South Fork Salmon River. In the Upper EFSFSR Area, total antimony has a surface water HQ of 1.3, and total mercury has a HQ of 3.9. All of the individual detections of total antimony above the USEPA proposed chronic criterion of 30 µg/L were from four samples collected at Station 321 in Midnight Creek (Table 7-2). The total mercury HQ is based on one detected concentration of total mercury at Station 321 out of 12 samples collected in the Area. HQs for four other inorganics (arsenic, copper, WAD cyanide, and zinc) are less than 1. Seven metals (cadmium, chromium, lead, dissolved mercury, nickel, selenium, and silver) were not detected in any 1999 Upper EFSFSR Area surface water samples.

Lower East fork South Fork Salmon River. In the Lower EFSFSR Area, only total mercury has a HQ (4.6) that is greater than 1. The total mercury HQ is based on two detections of mercury at EFSFSR Station 314, which is located downstream of Sugar Creek, a recognized source of non-site-related mercury. Total mercury was not detected in any other EFSFSR stations. WAD cyanide was not a surface water analyte in the Lower EFSFSR Area. Five metals (antimony, arsenic, dissolved mercury, silver, and zinc) have HQs less than 1. Six metals (cadmium, chromium, copper, lead, nickel, and selenium) were not detected in any 1999 Lower EFSFSR Area surface water samples.

Sugar Creek. In the Sugar Creek Area, only total mercury has a HQ (2.5) that is greater than 1. Five metals (antimony, arsenic, copper, lead and dissolved mercury) have HQs less than 1. WAD cyanide was not a surface water analyte in the Sugar Creek Area. Six metals (cadmium, chromium, nickel, selenium, silver, and zinc) were not detected in any 1999 Sugar Creek Area surface water samples.

Summary. Total mercury exposure concentrations at all four areas were greater than the Idaho chronic criterion of 0.012 µg/L. With a detection limit of 0.042 µg/L (and ½ the detection limit = 0.021 µg/L), any detection of total mercury results in an exceedance of the state criterion. Also, this criterion is not based on toxicity to aquatic organisms (but rather toxicity to humans who may ingest fish), and dissolved mercury concentrations at all areas were lower than the USEPA recommended chronic criterion of 0.77 µg/L. The exposure concentration of total antimony in the Upper EFSFSR Area was greater than the proposed USEPA chronic criterion of 30 µg/L. There are no promulgated Idaho or USEPA criteria for antimony (Table 7-7). No other surface water concentrations of metals were greater than criteria. As described in Section 7.7.1, antimony is recognized as a relatively non-toxic metal, and the proposed USEPA (1988) chronic criterion for antimony is overly conservative. A summary of metals in exposure area surface waters with HQs greater than one is presented below:

Exposure Area	Surface Water Metals and HQs
Meadow Creek	Mercury, total (2.1)
Upper EFSFSR	Antimony (1.3), Mercury, total (3.9)
Lower EFSFSR	Mercury, total (4.6)
Sugar Creek	Mercury, total (2.5)

Interpretations of the results of the risk calculations for exposure areas are presented in Section 7.7 (Risk Description).

7.6.2 RISK ESTIMATION FOR AQUATIC STATIONS

Quantitative risk estimates for fish and benthic macroinvertebrates at the ten Site aquatic stations are described below. Risk to fish is estimated based on surface water quality results from the four sampling events in 1999 (Tables 7-2 and 7-3). Quantitative risk to benthic macroinvertebrates is estimated based on sediment quality results from 1997 and 1999 (Table 7-8) plus surface water quality results Tables 7-2 and 7-3).

7.6.2.1 Surface Water

Exposure concentrations of metals in surface water for each station are based on maximum detected concentrations measured in 1999 and presented in Table 7-14. Chronic HQs for surface water at each station (Table 7-16) are based on comparisons of the maximum concentrations with lower of the Idaho or USEPA chronic water quality criteria listed in Table 7-7.

Station MC-1C. At Station MC-1C in the new Meadow Creek Diversion, only three inorganics (antimony, arsenic, and WAD cyanide) were detected. The remaining ten inorganics had no detected concentrations in any of the four samples collected. None of the three detected inorganics had a maximum concentration that was greater than the respective chronic criterion; consequently, none of the HQs are greater than one (Table 7-16).

Station 322. At Station 322 (Meadow Creek below the Diversion), five analytes (antimony, arsenic, WAD cyanide, total mercury, and zinc) were detected and have HQ values. The remaining eight metals were not detected in any samples. Of the five detected inorganics, only total mercury has a HQ greater than one (4.5) based on one detected concentration of 0.054 μg/L (Table 7-2) compared with the Idaho chronic criterion of 0.012 μg/L. However, dissolved mercury, with an USEPA chronic criterion of 0.77 μg/L, was not detected in any surface water samples at a detection limit of 0.042 μg/L (Table 7-3).

Station 319. At Station 319 (Meadow Creek above EFSFSR), three analytes (antimony, arsenic, and WAD cyanide) were detected and have HQ values; however, all three have maximum concentrations that are less than the respective chronic criterion and resulting HQs lower than 1.

Stations 365 and 310. Surface water quality samples were not collected in 1999 at Station 365 (EFSFSR below Meadow Creek) or Station 310 (EFSFSR at the former Secondary Camp). However, samples were collected in 1999 at Station 313 which is located midway between the two station. For the purpose of estimating risk from inorganics in surface water at Stations 365 and 310, results from Station 313 are used. Based on the 1999 results from this station, three metals (antimony, arsenic, and copper) were detected, but none had a maximum concentration that is greater than the chronic criterion and all HQs are less than 1 (Table 7-16). The remaining ten analytes were not detected in any samples collected at Station 313 in 1999. (Tables 7-2 and 7-3).

Glory Hole Stations. In the Glory Hole (Stations GH1, GH2, and GH3), four metals were detected in water – antimony, arsenic, dissolved mercury, and silver. The remaining eight analytes (WAD cyanide was not an analyte at any aquatic stations below Station 313) were not detected in any of the 14 samples collected in 1999. Total antimony has a HQ exceeding one (1.1) based on a maximum detected concentration (33 µg/L) greater than the proposed USEPA chronic criterion of 30 µg/L. The HQs for arsenic, dissolved mercury, and silver are all lower than one.

Station EF-7. At Station EF-7 (EFSFSR below the Glory Hole), two metals were detected -- antimony and arsenic. The remaining 10 analytes (WAD cyanide was not an analyte at any aquatic stations below Station 313) were not detected in any of the four samples collected in 1999. Total antimony has a HQ exceeding one (1.1) based on one detected concentration (32 µg/L) greater than the proposed USEPA chronic criterion of 30 µg/L. The HQ for arsenic is lower than one.

Station 308. At Station 308 (EFSFSR below the historic Bradley waste rock dump), two metals were detected – antimony and arsenic. Both metals were detected in all samples (Tables 7-2 and 7-3) and have HQ values of 1.2 and 0.64 (Table 7-16), respectively. None of the other ten metal analytes were detected in any of the four samples collected in 1999.

Station 316. At Station 316 (Sugar Creek above EFSFSR), four metals (antimony, arsenic, copper, and total mercury) were detected in at least one of the four samples collected in 199. Total mercury, which was detected in the two June samples, has a HQ of 21 based on the maximum detected value of 0.25 µg/L and the Idaho chronic criterion of 0.012 µg/L. Dissolved mercury was not detected in any sample from Station 316. All of the other detected metals have HQs less than 1.

Station 314. At Station 314 (EFSFSR below Sugar Creek), four metals (antimony, arsenic, total mercury, and silver) were detected in at least one sample. Total mercury, which was detected in the two June samples, has a HQ of 33 based on the maximum detected value of 0.39 µg/L. Dissolved mercury was not detected in any sample from Station 314. The other three detected metals have HQs less than 1.

Summary. Total antimony and total mercury were the only two surface water metals with HQs greater than 1 at the aquatic stations. Total antimony has HQ values greater than 1 at three aquatic stations, based on comparisons with the proposed USEPA chronic criterion of 30 µg/L. There are no promulgated Idaho or USEPA criteria for antimony. Total mercury has HQ values exceeding 1 at three stations (Station 322 in Meadow Creek, Station 316 in Sugar Creek, and Station 314 downstream of Sugar Creek) based comparisons with the Idaho criterion of 0.012 µg/L. None of the remaining inorganic analytes have surface water concentrations at the aquatic stations greater than a chronic criterion. A compilation of aquatic stations with surface water HQs greater than 1 is shown below:

Aquatic Station	Surface Water Metals and HQs
MC-1C	None
322	Mercury, total (4.5)
319	None
365	None
310	None
Glory Hole	Antimony (1.1)
EF-7	Antimony (1.1)
308	Antimony (1.2)
316	Mercury, total (21)
314	Mercury, total (33)

7.6.2.2 Sediment

Exposure concentrations of metals in sediment at each aquatic station are based on maximum concentrations measured in 1997 or 1999 (for Stations MC-1C and EF-7) and presented in Table 7-8. HQs for sediment at each station (Table 7-17) are based on comparisons of the measured concentrations with the consensus-based threshold effect concentrations (TECs) (Table 7-10) that were developed by MacDonald et al. (1999) for seven metals (arsenic, cadmium, chromium, copper, lead, mercury, and zinc). Comparisons of antimony and selenium sediment concentrations were made with the mid SQGs (Table 7-9) compiled by EVS (1998) because TECs are not available for these metals. Because there are no promulgated criteria or standards available for sediments, all calculated sediment HQs are considered to be "Screening HQs".

Station MC-1C. At Station MC-1C (new Meadow Creek Diversion), three metals in sediment (antimony, arsenic, and mercury) had concentrations measured in 1999 that were greater than sediment screening values. The resulting screening HQs for antimony, arsenic, and mercury are 10, 38, and 1.4, respectively (Table 7-17). Three metals have screening HQs less than 1 (chromium, copper, and zinc), and two metals (cadmium and selenium) were not detected in sediment.

Station 322. At Station 322 (Meadow Creek below the diversion), the arsenic concentration in sediment was greater than the TEC with a resulting screening HQ of 1.5. The concentrations of five metals (antimony, chromium, copper, lead, and zinc) were lower than their respective sediment screening values. Three other metals (cadmium, mercury, and selenium) were not detected in the sediment sample collected in 1997.

Station 319. Concentrations of two metals at Station 319 (Meadow Creek above the EFSFSR) were greater than sediment screening values. Antimony and arsenic have screening HQs of 11 and 10, respectively. Three metals (cadmium, mercury, and selenium) were not detected, and four metals (chromium, copper, lead, and zinc) were detected but had concentrations lower than sediment screening values.

Station 365. In 1997, sediment concentrations of antimony and arsenic at Station 365 were greater than sediment screening values with resulting screening HQs of 7.7 and 5.1 (Table 7-17). Three metals (cadmium, mercury, and selenium) were not detected in sediment, and four metals (chromium, copper, lead, and zinc) had concentrations lower than screening values and screening HQs lower than 1.

Station 310. At Station 310 (EFSFSR at former Secondary Camp) in 1997, sediment concentrations of antimony and arsenic were greater than the sediment screening values. Screening HQs for antimony and arsenic are 9.5 and 5.8. Cadmium, mercury, and selenium were not detected in sediment at Station 310, and chromium, copper, lead, and zinc were detected but had concentrations lower than TECs (Table 7-10).

Glory Hole Stations. Sediment in the Glory Hole was sampled in 1999. Maximum concentrations from the four locations sampled (one composite sample per location) show that antimony, arsenic, and mercury have concentrations greater than respective sediment screening values. Antimony and arsenic have screening HQs of 64 and 63 based on concentrations of 128 and 612 mg/kg, respectively. Mercury has a screening HQ of 11 (Table 7-17). The remaining six metals have screening HQs less than 1.

Station EF-7. Sediment at Station EF-7 (EFSFSR below the Glory Hole) was sampled in 1999. Results of that composite sample show that antimony, arsenic, and mercury have concentrations greater than respective sediment screening values. Arsenic, with a concentration of 1490 mg/kg, has a screening HQ of 150. Antimony and mercury have screening HQs of 5.0 and 7.8 (Table 7-17). The remaining six metals were either not detected or have HQs less than 1.

Station 308. At Station 308 (EFSFSR below the northwest Bradley waste rock dump), antimony, arsenic, and mercury have screening HQs greater than 1 based on sediment sample results from 1997. Calculated screening HQs for the three metals are 18, 160, and 2.5, respectively. Cadmium and selenium were not detected, and four metals (chromium, copper, lead, and zinc) have HQs less than 1.

Station 316. In lower Sugar Creek (Station 316), two metals (arsenic and mercury) have sediment concentrations greater than screening values and screening HQs greater than 1 (3.8 for arsenic and 11 for mercury). Two metals (cadmium and selenium) were not detected in sediment, and four metals (chromium, copper, lead, and zinc) have HQs less than 1.

Station 314. At EFSFSR Station 314 (below Sugar Creek), antimony, arsenic, and mercury have sediment concentrations that exceed screening values and screening HQs greater than 1. Screening HQs for these three metals are 17 (antimony), 9.4 (arsenic), and 17 (mercury). Cadmium and selenium were not detected in 1997. Four metals (chromium, copper, lead, and zinc) were detected but have HQs less than 1.

Summary. In summary, at a majority of aquatic stations, antimony, arsenic, and mercury concentrations were greater than the sediment screening values. Antimony concentrations were greater than the mid SQG of 2 mg/kg at eight of ten stations. Arsenic concentrations were greater than the TEC of 9.79 at all ten aquatic stations. Mercury concentrations at six stations were greater than the TEC of 0.18 mg/kg. A summary of metals in sediment with screening HQs greater than 1 is presented below:

Aquatic Station	Sediment Metals and Screening HQs
MC-1C	Antimony (10), Arsenic (38), Mercury (1.4)
322	Arsenic (1.5)
319	Antimony (11), Arsenic (10)
365	Antimony (7.7), Arsenic (5.1)
310	Antimony (9.5), Arsenic 5.8)
Glory Hole	Antimony (64), Arsenic (63), Mercury (11)
EF-7	Antimony (5.0), Arsenic (150), Mercury (7.8)
308	Antimony (18), Arsenic (160), Mercury (2.5)
316	Arsenic (3.8), Mercury (11)
314	Antimony (17), Arsenic (9.4), Mercury (17)

Interpretations of the results of the risk calculations for metals in surface water and sediment are presented in Section 7.7.

7.7 RISK DESCRIPTION

The HQ values calculated for chemical stressors in Section 7.6 (Risk Estimation) provide a starting point for descriptions of potential risk to aquatic organisms. A better appreciation of the ecological significance of the risk estimates is provided through the application of numerous additional lines of evidence or "weight-of-evidence" provided in this section of the aquatic risk evaluation. A similar weight-of-evidence approach was recently proposed by Menzie et al. (1996). As described in Section 7.5 above, additional measurement endpoints qualitatively considered in interpreting the quantitative results are: physical stressors to the aquatic habitat, benthic macroinvertebrate community, benthic tissue metals residues, and fish tissue metals residues. These qualitative measurement endpoints are selectively considered in evaluating the quantitative risk estimates for fish and benthic macroinvertebrates in exposure areas and aquatic stations:

Qualitative Measurement Endpoints

Measurement Endpoint	Exposure Areas	Aquatic Stations
Physical Habitat	Fish	Fish
Benthic Community	Not Evaluated	Benthic Macroinvertebrates
Benthic Tissue Metal Residue	Not Evaluated	Benthic Macroinvertebrates
Fish Tissue Metal Residue	Fish	Fish

Because the relative significance of the quantitative risk estimates and qualitative measurement endpoints is different for the two aquatic communities (fish and benthic macroinvertebrates), each measurement endpoint is uniquely weighted in the evaluation of risk to each aquatic community. Considering all lines of evidence, the following illustrates the weighting applied to all aquatic measurement endpoints:

Relative Importance of Aquatic Measurement Endpoints for Fish and Invertebrates

Measurement Endpoint	Risk to Fish[1]	Risk to Benthic Invertebrates[2]
Surface Water Quality (HQ)	1	3
Sediment Quality (HQ)	Not Evaluated	2
Physical Habitat	2	Not Evaluated
Benthic Community	Not Evaluated	1
Benthic Tissue Metal Residue	Not Evaluated	4
Fish Tissue Metal Residue	3	Not Evaluated

[1] Evaluated for exposure areas and aquatic stations.
[2] Evaluated for aquatic stations only.

As shown in this table, the most important factors considered in evaluating overall risk to fish are surface water quality and physical habitat. Fish tissue levels of metals also are considered. In contrast, the estimated risk to the benthic macroinvertebrate community relies most heavily on the results of the benthic macroinvertebrate community analysis that was completed for samples collected in 1999 and reported in ABA (2000). Sediment quality, surface water quality, and benthic tissue residue levels also are considered in the evaluation of risk to the benthic macroinvertebrate community.

For each aquatic measurement endpoint and for each area or aquatic station, the potential for unacceptable risk to the aquatic receptors (salmonid fish and benthic macroinvertebrates) is classified as "unlikely", "possible", or "likely". For the measurement endpoints quantitatively evaluated (water quality and sediment quality), risk is considered "unlikely" if the HQ is less than 1 and "possible" if the HQ is greater than 1. For the four measurement endpoints qualitatively evaluated, judgements are made as to the likelihood of the endpoint representing a stressor (chemical or physical) to the receptor. Stressors described as representing a "possible" risk may occur but are not expected to have any significant effects on the receptors. Stressors described as "unlikely" are not expected to have any measurable effect on the receptor. If any stressors are described as "likely", they would be expected to have measurable effects on the receptor.

Because surface water and sediment quality were evaluated quantitatively in the risk evaluation of the aquatic organisms, the validity of HQs based on these two measurement endpoints are discussed prior to discussions of the qualitative aquatic measurement endpoints. A summary of comparisons of the measured benthic macroinvertebrate and fish tissue levels of metals (i.e., metals residues) with benchmarks compiled by Jarvinen and Ankley (1999) also is presented.

7.7.1 SURFACE WATER QUALITY

Two metals, total antimony and total mercury, are the only surface water inorganics with HQs greater than 1 in exposure areas or aquatic stations. Background station concentrations of metals in water are evaluated since some on-site surface water concentrations of metals may exceed water quality criteria but are nevertheless below concentrations measured at background stations. Also, the technical bases of the water quality criteria for antimony and total mercury are discussed.

7.7.1.1 Background Station Concentrations

Surface water samples were collected in 1999 from four background stations – Station 320 (Meadow Creek), EF-2 (EFSFSR), HC-1A (Hennessey Creek), and 309 (Sugar Creek). With the exception of one sample collected at Station HC-1A (5.8 μg/L) total antimony was not detected in any background station surface water samples (detection limit of 5.3 μg/L). Therefore, all concentrations of antimony that were greater than the proposed USEPA chronic criterion of 30 μg/L are considered site-related.

Total mercury was detected at only one background station, Station 309 in Sugar Creek, at up to 0.27 μg/L. Because the typical detection limit of 0.042 μg/L is higher than the Idaho chronic criterion of 0.012 μg/L (total mercury), any detected concentration of total mercury is an exceedance of the state chronic criterion. Total mercury was not detected at any other background station in 1999 (Table 7-2). Total mercury was detected (and exceeded the chronic criterion) at six stream surface water quality stations in 1999 – Stations 368, 322, 321, SC-3, 316, and 314. Total mercury detected at Stations 368, 322, and 321 is likely due to site-related sources based on an absence of mercury at upstream background stations. The source of mercury at Stations 368 and 322 appears to be from tailing material in the Bailey tailing impoundment or in the Keyway wetland based on a total mercury concentration of 0.118 μg/L at Station KW-1. The source of mercury at Station 321 (Midnight Creek) may be the mineralized area in the upper watershed, but no background station samples were collected in upper Midnight Creek in 1999 to help confirm the source of mercury at Station 321. In contrast, total mercury at Stations SC-3, 316, and 314 likely is due to mercury coming from off-site sources in upstream Sugar Creek. Total mercury was found at Station 309, the background station in Sugar Creek, at up to 0.27 μg/L.

7.7.1.2 Water Quality Criteria

Idaho and USEPA water quality criteria and USEPA proposed criteria (Table 7-7) were used to evaluate potential risk to aquatic organisms. Based on the results of the aquatic risk estimates for exposure areas and individual aquatic stations (Sections 7.5.1 and 7.5.2), antimony, and total mercury are the only analytes that have HQ values exceeding 1. Of these, the benchmark for antimony is a USEPA proposed criterion, and the Idaho total mercury chronic criterion is based on biomagnification of mercury in fish tissue to levels that exceed human health action levels. Both thresholds are overly conservative for assessing aquatic risk as discussed below.

Antimony. The USEPA has proposed surface water quality criteria (chronic and acute) of 30 and 88 μg/L for total recoverable antimony (USEPA, 1988; 1991). However, promulgated criteria for antimony are not included in the list of criteria for priority toxic pollutants (USEPA, 1992b) that are incorporated by background in the Idaho Department of Health and Welfare water quality standards (IDHW, 1998). Water quality criteria for antimony also are not listed in the most recent revision of 40 CFR Part 131.36 (USEPA, 1997b). Antimony (listed as "compound #1") is included in IDHW (1998) as a metal for which criteria should be expressed as the dissolved fraction; however, since no total-to-dissolved conversion factor is provided for antimony in IDHW (1998), and no criteria are included in USEPA (1992b) for antimony, concentrations of total antimony were used as the basis for comparisons to the proposed criteria. As described in USEPA (1988), water quality criteria (e.g., 30 μg/L for antimony) have no regulatory impact

unless they have been adopted by states as a water quality standard. The proposed criteria for total antimony were, therefore, used only for screening antimony concentrations in the Site Characterization (Stibnite Group, 2000) and for calculating aquatic hazard quotients in the ERA.

The basis for the proposed criteria for antimony is described in USEPA (1988). To summarize, the acute criterion is calculated as follows:

$$\text{Acute Criterion} = \frac{\text{Final Acute Value}}{2.0}$$

For antimony, the final acute value equals 175 µg/L, and the resulting acute criterion equals 88 µg/L.

The chronic criterion is calculated as follows:

$$\text{Chronic Criterion} = \frac{\text{Final Acute Value}}{\text{Acute-to-Chronic Ratio}}$$

For antimony, the experimentally-derived acute-to-chronic ratio equals 5.87, and the resulting chronic criterion equals 30 µg/L (USEPA, 1988).

The calculated acute criterion of 88 µg/L is substantially lower than any of the freshwater species mean acute values provided in USEPA (1988). For example, the species mean acute value for rainbow trout (*Oncorhynchus mykiss*), amphipod (*Gammarus pseudolimnaeus*), and caddisfly (*Pycnosyche* sp.) is >25,700 µg/L (Brook et al., 1986). No chronic toxicity results for cold-water species are presented in USEPA (1988).

More recent additional toxicity results for cold-water species exposed to antimony are presented in OMEE (1996). In toxicity tests of rainbow trout, antimony was found to be acutely toxic to fingerlings at a concentration of 37,000 µg/L (96-hour LC_{50}) (Doe et al., 1987). In the same series of tests, the chronic toxicity concentration of antimony to rainbow trout was found to be 16,000 µg/L (30-day LC_{50}). Doe et al. (1987) recommend that the maximum allowable toxicant concentration (MATC), also known as the "chronic value" (Suter, 1993), for antimony be 1.2 mg/L (1,200 µg/L).

In summary, antimony is reported as being relatively non-toxic (OMEE, 1996). Based on 48-hour and 96-hour toxicity tests of the tubificid worm *(Tubifex tubifex),* Khangarot (1991) ranked antimony as the second least toxic metal of 32 metals tested. In consideration of the recent toxicity data for trout and invertebrates presented in OMEE (1996), the proposed USEPA chronic and acute antimony criteria of 30 and 88 µg/L (USEPA, 1988), which are not promulgated as federal or state criteria, are overly conservative.

Total Mercury. The state chronic water quality criterion for mercury (0.012 µg/L; IDHW, 1998) is based on the USEPA Final Freshwater Residue Value and not on the Final Freshwater Chronic Value (1.3 µg/L; USEPA, 1985b) which is two orders of magnitude higher. The Final Freshwater Residue Value for mercury is calculated based on a Federal Department of Agriculture action level of 1 mg/kg in fish tissue to protect human health (USEPA, 1985b; ATSDR, 1997).

The conservative nature of the Final Residue Value is illustrated by data collected in Sugar Creek. In Sugar Creek, which had surface water concentrations of total mercury of up to 3.4 µg/L in 1997 and an average concentration of 0.29 µg/L (Stibnite Group, 1998b), the highest fish fillet concentration of mercury measured in 1997 was 0.29 mg/kg, well below the 1 mg/kg action level. In summary, the Idaho water quality criterion for total mercury (0.012 µg/L) is based on a tissue residue value designed to protect human health; it is not based on the protection of aquatic organisms. In 1998, the USEPA issued its recommended water quality criteria. The recommended chronic criterion for mercury (dissolved), which is 0.77 µg/L (USEPA, 1998b; 1999), was not exceeded in any surface water samples collected in 1999.

7.7.2 SEDIMENT QUALITY

Three metals were found in sediments at concentrations greater than sediment quality screening values, and as a result, have HQs greater than 1 at some aquatic stations. The three metals are antimony, arsenic, and mercury.

7.7.2.1 Background Station Concentrations

Concentrations of metals in sediment at three background stations (Stations 320, 315 [a.k.a. EF-2], and 309) were determined for samples collected in 1996 (Table 7-8). No background station sediment results were available for 1997, and no background station samples were collected in 1999.

Antimony was not detected (detection limit of 1.0 mg/kg) in any of the three background station samples collected in 1996. In 1997, however, antimony was found (1.2 mg/kg) in background Station 309 (Sugar Creek) sediments. Because antimony was either not detected or was found at a concentration lower than the mid SQG of 2 mg/kg (and therefore lower than any concentrations resulting in HQs greater than 1), all detected concentrations of antimony at the aquatic stations are considered to be site-related.

Arsenic was detected at all three background stations in 1996 (Table 7-8). In Meadow Creek, the background station concentration in 1996 (4.67 mg/kg) was less than concentrations measured at the three downstream stations and is less than the TEC of 9.79 mg/kg. Therefore, the arsenic in sediments at Stations MC-1C, 322, and 319, which have HQs greater than 1, is considered to be site-related (i.e., on-site concentrations exceed background station concentrations). In the EFSFSR background Station 315, the arsenic concentration (19.6 mg/kg) is greater than the TEC (9.79 mg/kg) but is less than concentrations measured at downstream EFSFSR aquatic stations. Therefore, arsenic concentrations found in sediments at Stations 365, 310, EF-7, 308, and 314 (50; 57; 1,490; 1,522; and 92; respectively) are all considered to be site-related. In Sugar Creek, arsenic was found at the background station (Station 309) at a concentration of 38.4 mg/kg in 1996 and 49 mg/kg in 1997. Because both results are greater than the concentration found downstream at Station 316 (37 mg/kg), arsenic found at this lower station is not considered to be site-related. In summary, arsenic found in sediments at aquatic stations in Meadow Creek and EFSFSR are considered site-related, but arsenic in sediment at Station 316 (Sugar Creek) is not site-related.

Mercury was detected in sediment at all three background stations in 1996. In Meadow Creek, the background station concentration (0.368 mg/kg) is greater than the concentration measured at downstream Station MC-1C (0.26 mg/kg); therefore, mercury found at Station MC-1C is not considered to be site-related. In the EFSFSR, the background station concentration of mercury (0.215 mg/kg) is less than that measured at Stations EF-7 (1.4 mg/kg); therefore, mercury at Station EF-7 is considered site-related. Mercury at Station 308 (0.45 mg/kg) is greater than at the background station (0.368 mg/kg) and also is considered site-related. In Sugar Creek, the primary source of mercury in sediment is from cinnabar ore deposits upstream of the Site. The off-site source of mercury in Sugar Creek is confirmed by sediment levels measured in 1996 (4.2 mg/kg) and 1997 (4.08 mg/kg at background Station 309) (Table 7-8). Because the background station levels of mercury are greater than those measured downstream at Sugar Creek Station 316 (2.03 mg/kg) or at EFSFSR Station 314 (3.14 mg/kg), mercury in sediments at these two downstream stations is not considered site-related. In summary, mercury found in sediments at EFSFSR Stations EF-7 and 308 is likely site-related based on comparisons with the background station concentration. Mercury found in sediments at Stations MC-1C, 316, and 314 is not considered site-related because of elevated concentrations found at the Meadow Creek and Sugar Creek background stations.

7.7.2.2 Sediment Screening Values

As described in greater detail in Section 7.3.3.2, sediment concentrations from 1997 and 1999 were compared with either consensus-based TECs (Table 7-10) developed by MacDonald et al. (1999) or mid SQGs (Table 7-9) compiled by EVS (1998). Arsenic, cadmium, chromium, copper, lead, mercury, and zinc were compared with TECs, while antimony and selenium were compared with mid SQGs in the absence of applicable TECs. The two sets of sediment screening values represent concentrations below which adverse effects to the benthic community are not expected. As described in Section 7.3.3.2, both sets of sediment screening values have limitations relating to different data compilation procedures, different purposes in their creation, or different amounts of sediment data available for various metals. Although no set of screening values has been developed specifically for use in mountain streams, the TECs by MacDonald et al. (1999) and the SQGs by EVS (1998) do represent two of the most recent efforts to organize and compile sediment benchmarks from a wide variety of sources. Comparisons of measured metals concentrations in Stibnite Site sediments with the screening values provide a screening-level estimate of the toxicity of individual metals to the benthic macroinvertebrates.

7.7.3 BENTHIC TISSUE METAL RESIDUES

In Section 7.6, maximum benthic macroinvertebrate tissue concentrations of metals from 1995-1997 (Table 7-11) were compared with tissue residue benchmarks recently published by Jarvinen and Ankley (1999). Data relating freshwater invertebrate tissue concentrations to observed toxic effects were not available for antimony, arsenic, and iron. No adverse effects on survival, growth, or reproduction of freshwater invertebrates were found for the maximum measured tissue concentrations of cadmium, copper, lead, or mercury. For selenium, the maximum tissue level of 3.8 μg/g was higher than 3.4 μg/g, a level that was associated with reduced survival in *Daphnia magma;* however, in other studies, tissue levels exceeding 10 μg/g had no reported adverse toxic effects (Jarvinen and Ankley, 1999). For zinc, the maximum tissue

level of 326 µg/g measured at background Station 315 (EFSFSR) was higher than a tissue level of 118 µg/g that was related to reduced survival in the amphipod *Hyalella azteca* (Jarvinen and Ankley, 1999). Because a wide range of tissue concentrations are reported as thresholds for observed toxic effects, the metal residue benchmarks are considered to be screening thresholds. Also, because the benthic tissue sample data used was collected in 1996 or 1997 before the new Meadow Creek Diversion was completed and water quality substantially improved (see Section 7.3.1), comparisons with tissue screening thresholds are considered conservative.

7.7.4 FISH TISSUE METAL RESIDUES

Maximum whole-body fish tissue concentrations of metals from 1997 (Table 7-12) also were compared with tissue residue benchmarks recently published by Jarvinen and Ankley (1999). Data relating whole-body salmonid (rainbow trout and brook trout) tissue concentrations to observed toxic effects were not available for aluminum, copper, or selenium. No critical adverse effects (e.g., survival, growth, or reproduction) to salmonids were found for the maximum measured whole-body tissue concentrations of antimony, arsenic, lead, or zinc. All measured concentrations of mercury in Stibnite Site adult fish tissue samples (0.06 to 0.22 mg/kg) are in the range of concentrations (0.04 to 0.9 mg/kg) that are related to reduced survival of larval rainbow trout (Jarvinen and Ankley, 1999). Mercury was found at a maximum whole-body concentration of 0.22 mg/kg at Meadow Creek Station 322. Higher concentrations of mercury (0.25-0.35 mg/kg) were found, however, in fish collected from Sugar Creek background Station 309. Because a wide range of tissue concentrations are reported as thresholds for observed toxic effects, the metal residue benchmarks for fish are considered to be screening thresholds. Also, as discussed for benthic tissues, because the site fish tissue data were collected in 1997 prior to the improved water quality, comparisons with tissue screening thresholds is considered conservative.

7.7.5 RISK DESCRIPTION FOR EXPOSURE AREAS

Risk estimates for fish exposed to metals in surface water in the four exposure areas were quantitatively evaluated in Section 7.6.1, and the applicability of the water quality criteria used for comparison was discussed in Section 7.7.1. The additional aquatic measurement endpoints qualitatively considered in evaluating the risk to fish in the exposure areas include (in decreasing priority order): physical habitat and fish tissue metals residue. Sediment quality is not evaluated for exposure areas because sediment screening values are based on adverse effects on the benthic macroinvertebrate community, not fish. Also, results of comparisons between sediment metals concentrations and sediment screening values may not necessarily reflect the quality of the benthic community as seen in the 1999 benthic data (ABA, 2000). Following are discussions of the additional measurement endpoints for each of the exposure areas.

7.7.5.1 Meadow Creek

Water Quality. In the Meadow Creek Area, only total mercury in surface water has a HQ greater than 1. Total mercury was detected in 2 of 32 samples from the Meadow Creek Area – Stations 368 and 322 in September 1999. Total mercury was not detected at the Meadow Creek background station in 1999, but it was detected at Station KW-1 downstream of the Keyway and at Stations 368 and 322 in Meadow Creek,

suggesting that the source of mercury was from tailing material in the Bailey tailing impoundment or in the Keyway wetland. Because the Idaho criterion for total mercury is not based on its toxic effects on aquatic organisms and dissolved mercury was not detected in any 1999 surface water samples, the potential risk from total mercury in Meadow Creek surface water is unlikely.

Physical Habitat. The second most important aquatic measurement endpoint for fish is physical stressors in the aquatic habitat. Physical habitat was characterized in Stibnite Group (2000) and summarized in Section 7.3.1 for three stations in the Area (Stations MC-1C, 322, and 319). Physical stressors on habitat in the Meadow Creek area include a general absence of riparian cover and instream cover, and sections of moderately stable or unstable stream banks in the middle and lower portions of the stream (Table 7-6 and Figure 7-2). Based on focused surveys conducted in 1999, unstable banks were found along three sections of lower Meadow Creek. Overall, approximately 700 feet on the south-east bank and 400 feet on the north-west bank were considered unstable, although most of these unstable reaches were vegetated. Half of the unstable areas are adjacent to tailing deposits. Additional details of bank stability and riparian vegetation along Meadow Creek are provided in Section 8.6 of Stibnite Group (2000).

It is possible that elements of the physical habitat represent physical stressors to fish in Meadow Creek.

Fish Tissue Residue. Fish tissue samples were collected in 1997 from Station 322 in lower Meadow Creek (Table 7-12). In a comparison of whole body metals concentrations with benchmarks published by Jarvinen and Ankley (1999), the mercury concentration of 0.22 mg/kg at Station 322 is in the middle of the range of concentrations (0.04 to 0.9 mg/kg) that are related to reduced survival of larval rainbow trout. No potential critical effects to salmonids are found in Jarvinen and Ankley (1999) for the tissue levels of any other metals, and all fish collected for analysis in 1997 at Stibnite Site stations appeared to be healthy with no visible sign of stress (e.g., lesions, fin rot). Based on the tissue residue results from Station 322, it is unlikely that tissue residue levels of metals represent a risk to fish.

In summary, overall risk to fish in the Meadow Creek Area is unlikely despite the physical stressors on the physical habitat. Risk from total mercury in surface water (the primary aquatic measurement endpoint) is unlikely. It is unlikely that tissue residue levels of metals represent a risk to fish, based on results of the 1997 analysis.

7.7.5.2 Upper East Fork South Fork Salmon River

Water Quality. In the Upper EFSFSR Area, antimony and total mercury have HQs greater than 1. However, the antimony HQ of 1.3 is based on the proposed USEPA chronic criterion of 30 µg/L that is overly conservative. There are no promulgated Idaho or USEPA criteria for antimony. Total mercury was detected on only one sample collected in Midnight Creek (Station 321), and the total mercury HQ of 3.9 is based on a criterion that is not toxicologically-based. Dissolved mercury was not detected in any Upper EFSFSR Area surface water samples. Overall, risk to fish from metals in surface water is unlikely.

Physical Habitat. Aquatic habitat in Upper EFSFSR was characterized in 1997 at Stations 365 and 310. The EFSFSR between about Thunder Mountain Road and Midnight Creek provides some of the highest quality aquatic habitat in the Stibnite Site. The aquatic physical habitat shows little evidence of impairment and is typical for mountain streams in terms of diversity of instream habitat, quantity and quality of instream and riparian cover, and percent surface fines (Figure 8.5-11). Between Midnight Creek and the Glory Hole, however, riparian vegetation cover is poor and stream bank stability is unstable. Overall, the physical habitat in Upper EFSFSR is unlikely to represent a physical stressor to fish.

Fish Tissue Residue. Fish tissue samples were collected in 1997 from Station 310 in Upper EFSFSR (Table 7-12). Metals in whole-body fish tissue samples were generally low-to-moderate compared to other Stibnite Site stations. In a comparison of whole body metals concentrations with benchmarks published by Jarvinen and Ankley (1999), no critical effects to salmonids are found for the whole-body tissue levels of three metals with compiled data (antimony, arsenic, lead, or zinc). The mercury concentration in one tissue sample (0.15 mg/kg) is in the middle of the range of concentrations (0.04 to 0.9 mg/kg) related to reduced survival of larval rainbow trout. Because only one tissue sample had a mercury concentration within the range of concentrations related to a significant effect, no other metals were elevated, and all collected fish appeared healthy, it is unlikely that fish tissue residue concentrations represent a risk to fish.

Summary. Overall risk to fish in the Upper EFSFSR Area based on the three measurement endpoints considered is unlikely. Only antimony and total mercury in surface water have HQs greater than 1, and the water quality criteria for both metals are overly conservative. Physical habitat in the area is some of the highest quality on the Site; it shows little evidence of current impairment and is typical for mountain streams. Risk related to tissue levels of mercury alone is unlikely based on results of the tissue analysis.

7.7.5.3 Lower East Fork South Fork Salmon River

Water Quality. In the Lower EFSFSR Area, only total mercury in surface water has a HQ greater than 1. Total mercury was detected in 2 of 34 samples from Lower EFSFSR. The two samples were collected at Station 314, located downstream of Sugar Creek, where total mercury was detected at the background station (Station 309). Because total mercury was found at the Sugar Creek background station, the mercury detected at Station 314 likely is due to mercury coming from off-site sources in upstream Sugar Creek. Because no other metal was found in Lower EFSFSR surface water at concentrations greater than criteria, risk to fish from surface water is unlikely.

Physical Habitat. Physical habitat was characterized in Lower EFSFSR for three stations (Stations EF-7, 308 and 314). A diagram of three key habitat characteristics (riparian vegetation, bank stability, and percent surface fines) is presented in Figure 7-2. The aquatic habitat in this portion of the EFSFSR is characterized by a diversity of instream habitat and acceptable substrate condition, composed primarily of boulders, cobbles, and gravel, with low to moderate percent surface fines. However, most of Lower EFSFSR has limited riparian cover. Steep, erodible banks occur along about 800 feet of the west bank above the bridge at the main access road. Along the upper two thirds (1,800 feet) of the channel between the Glory Hole and the bridge, the waste rock ends a distance away from the stream, and level vegetated areas line the shore. The Glory Hole provides additional habitat variety with approximately 5 acres of lake

habitat. Upstream of the Glory Hole, the EFSFSR flows down a cascade section that likely blocks the movement of most fish upstream. Overall, it is possible that the elements of the physical habitat in Lower EFSFSR represent physical stressors to fish.

Fish Tissue Residue. Fish tissue samples were collected in 1997 from Stations 308 and 314 in the Lower EFSFSR. The highest fish tissue concentration of zinc was found at Station 314, but Station 308 had no maximum fish tissue metal concentrations (Table 7-12). No critical adverse effects to salmonids are found in Jarvinen and Ankley (1999) for the zinc concentration measured at Station 314. Mercury levels in tissue at the two stations (0.05 to 0.11 mg/kg) are in the low end of the range of concentrations (0.04 to 0.9 mg/kg) related to reduced survival of rainbow trout larvae (Jarvinen and Ankley, 1999). All fish collected for tissue analysis in 1997 appeared to be healthy with no visible sign of stress. In summary, it appears unlikely that fish tissue residue levels represent a risk to fish in Lower EFSFSR.

Summary. Overall risk to fish in Lower EFSFSR is considered unlikely based on the three measurement endpoints considered. Risk to fish from metals in surface water (the primary aquatic measurement endpoint for fish) is unlikely. It is possible that the physical habitat represents a stressor to fish. The third measurement endpoint, fish tissue residue levels of metals, appears unlikely to represent a risk to fish in the area.

7.7.5.4 Sugar Creek

Water Quality. In the Sugar Creek Area, total mercury in surface water has a HQ greater of 2.5. Total mercury was detected in 5 of 8 samples from the Stations SC-3 and 316 and in 2 of 4 background Station 309 samples. Because total mercury was found at the Sugar Creek background station, the mercury detected downstream likely is due to mercury coming from off-site sources in upstream Sugar Creek. Because no other metal was found in Sugar Creek surface water at concentrations greater than criteria, risk to fish from Site-related metals in surface water is unlikely.

Physical Habitat. Physical habitat was characterized in the Sugar Creek Area at Station 316, and general physical characteristics were noted for the remainder of Sugar Creek. Station 316 is located in a forested area of lower Sugar Creek downstream of BTO and upstream of the confluence with EFSFSR. The average percent surface fines at Station 316 was 36 percent, which is in the range of fines that may lead to a loss of viable spawning habitat (Bjornn et al., 1977; Hunter, 1991). However, suitable gravel spawning areas are present in lower Sugar Creek, and an adult chinook salmon was seen near Station 314 in 1997. Large woody debris and several small pools provide in-stream cover. Downstream of Station 316, riparian vegetation becomes less dense and provides less cover for the stream. Upstream of the station, the stream banks are moderately stable, due in part to a road cut directly adjacent to the stream. Overall, it is possible that the physical habitat of Sugar Creek presents a stressor to fish in the stream.

Fish Tissue Residue. No fish tissue samples were collected in Sugar Creek at stations that may be affected by Stibnite Site activities. The only fish tissues collected in 1997 were from Station 309, the background station for the creek. The three fish collected at Station 309 had the highest levels of mercury (0.25 to 0.35 mg/kg) of any samples collected throughout the Stibnite Site (Table 7-12). These tissue levels are in the

middle of the range of whole-body concentrations that are associated with reduced survival of rainbow trout larvae (Jarvinen and Ankley, 1999). The tissue results are not unexpected given the significant upstream source of mercury to Sugar Creek as seen in the surface water and sediment results (Tables 7-2 and 7-8). No other metals levels in tissue (including antimony, arsenic, lead, or zinc) are within the range of values associate with adverse critical effects to salmonids. Because no fish tissue samples have been collected from lower Sugar Creek, assessment of possible risk cannot be performed.

Summary. Overall risk to fish in Sugar Creek is considered unlikely based on the three measurement endpoints described. Risk to fish from metals in surface water (the primary aquatic measurement endpoint for fish) is unlikely. It is possible that the physical habitat represents a stressor to fish. The third measurement endpoint, fish tissue residue levels of site-related metals, cannot be evaluated.

7.7.5.5 *Exposure Area Summary*

Risks to fish from the three aquatic measurement endpoints considered in each of the four exposure areas is summarized in the following table:

Potential of Risk to Fish in Exposure Areas

Exposure Area	Water Quality	Physical Habitat	Tissue Residue	Overall Risk
Meadow Creek	Unlikely	Possible	Unlikely	Unlikely
Upper EFSFSR	Unlikely	Unlikely	Unlikely	Unlikely
Lower EFSFSR	Unlikely	Possible	Unlikely	Unlikely
Sugar Creek	Unlikely	Possible	NC[1]	Unlikely

[1]Fish tissue samples not collected from lower Sugar Creek.

7.7.6 RISK DESCRIPTIONS FOR AQUATIC STATIONS

As described previously, cumulative risks from chemical and physical stressors to fish and benthic macroinvertebrates are evaluated for each of the ten site aquatic stations. HQs were calculated for the primary measurement endpoints of surface water quality (1999) and sediment quality (1997 and 1999) in Section 7.6, and the applicability of the HQs was discussed previously in Sections 7.7.1 and 7.7.2. In the following discussions, the additional aquatic measurement endpoints are discussed together with the water and sediment quality results.

Interpretations of the results of the risk calculations for metals in surface water and sediment were presented in Sections 7.7.1 and 7.7.2, respectively. Three metals (antimony, arsenic, and mercury) were found in surface water (1999) and sediment (1997 and 1999) at concentrations that were greater than criteria or screening values. However, based on comparisons with background station concentrations and examination of the criteria, HQs at several stations were determined to be invalid or not applicable. The following table summarizes the results of these examinations of calculated HQs. Metals and their related HQs considered valid based on the two comparisons are underlined; those metals not underlined are not considered to represent a site-related potential risk to aquatic organisms. None of the calculated HQs for surface water are considered to be representative of site-related chemical stressors to fish or benthic macroinvertebrates.

Interpretation[1] of Surface Water and Sediment HQs

Aquatic Station	Surface Water HQs[2]	Sediment HQs[2]
MC-1C	None	Antimony (10), Arsenic (38), Mercury (1.4)
322	Mercury, total (4.5)	Arsenic (1.5)
319	None	Antimony (11), Arsenic (10)
365	None	Antimony (7.7), Arsenic (5.1)
310	None	Antimony (9.5), Arsenic 5.8)
EF-7	Antimony (1.1)	Antimony (5.0), Arsenic (150), Mercury (7.8)
308	Antimony (1.2)	Antimony (18), Arsenic (160), Mercury (2.5)
314	Mercury, total (33)	Antimony (17), Arsenic (9.4), Mercury (17)
316	Mercury, total (21)	Arsenic (3.8), Mercury (11)

[1]Underlined metals results interpreted as applicable based on comparisons with background stations and examination of criteria (Section 7.5.2.2). Conversely, results not underlined are not considered applicable for the aquatic station.
[2]HQs greater than 1.

7.7.6.1 Station MC-1C

Water Quality and Sediment Quality. As illustrated above, no metals in surface water at Station MC-1C (i.e., maximums of four samples collected in 1999) have HQs greater than 1. It is possible that sediment concentrations of antimony and arsenic represent a risk to benthic macroinvertebrates based on comparisons with sediment screening values in Tables 7-9 and 7-10. Mercury in sediment likely is not site-related based on a comparison with mercury at Meadow Creek background Station 320.

Benthic Community. The benthic macroinvertebrate community at Station MC-1C has had only one year to become established; however, total invertebrate densities (3,960 per square meter) and taxa richness (39) were relatively high for substrates that have been flooded for only one year. Intolerant (i.e., sensitive) mayflies comprised 33 percent of the community in 1999. The total bioassessment score for Station MC-1C is 55. In view of the high abundance, number of taxa, and number of mayflies at this recently created channel, it is unlikely that the benthic macroinvertebrate community analysis results indicate a stressed community.

Physical Habitat. Station MC-1C is an aquatic station that was added in 1999 to the new Meadow Creek Diversion Channel so that the benthic macroinvertebrate community in the diversion channel upstream of the Keyway could be characterized and compared with the communities at Stations 320 (background station), and 322 (downstream of the Keyway). Station MC-1C is located approximately 1,500 feet upstream of the plunge pool. The channel flows in a series of low-gradient riffles around the newly contoured Bradley tailing impoundment. In-stream cover is very limited -- there are no pools, cut banks, large woody debris (LWD), or overhanging vegetation. Percent surface fines were 25 percent in 1999. This is less than the 30-40 percent threshold for adverse effects on salmonid embryo development in redds as discussed by Bjornn et al. (1977) and Hunter (1991). The only in-stream cover is behind a few large boulders placed mid-stream in the channel. An illustration of three key habitat characteristics is presented in Figure 7-2. Because of the lack of instream cover and riparian vegetation, it is possible that these elements of the aquatic habitat at Station MC-1C represent physical stressors for fish.

Benthic and Fish Tissue Residues. No benthic macroinvertebrate or fish tissue samples have been collected from Station MC-1C.

7.7.6.2 Station 322

Water Quality and Sediment Quality. Because total mercury was detected at a relatively high concentration at the background station, no metals in water have HQs greater than 1 and are believed to be site-related. Arsenic in sediment with a screening HQ of 1.5 may possibly present a risk to benthic macroinvertebrates.

Benthic Community. The 1999 total bioassessment score for Station 322, located below the Keyway was 71 percent (moderate habitat complexity and biotic integrity). The station had nearly as many taxa (62) as the Meadow Creek background station, and had over 19 intolerant mayflies. The overall trend at this station has been downward from 1995 to 1998, while there was virtually no change from 1998 to 1999 (Figure 7-4). In view of the high number of taxa and number of mayflies at Station 322, it is unlikely that the benthic macroinvertebrate community is adversely affected by metals in sediment.

Physical Habitat. Station 322 is located in Meadow Creek downstream of the Meadow Creek Diversion Channel and downstream of the confluence with Blowout Creek. The stream meanders through an open meadow area, and the stream gradient is low (1.0 percent). There is no overhead cover in this area for shade. Streambanks are covered by grasses with a few small alders, which were heavily browsed by elk and other wildlife. The average percent surface fines was <27 percent which is less than the 30-40 percent threshold for adverse effects on salmonid embryo development. Although a large portion of the station is pool habitat, pool quality appears poor because the pools have virtually no in-stream cover or cover along the pool perimeter to support fish. It is possible that the aquatic habitat at Station 322 represents a physical stressor for fish.

Benthic Macroinvertebrate and Fish Tissue Residues. For benthic macroinvertebrates, threshold tissue levels were either not available or maximum measured tissue levels do not exceed any thresholds for all metals except for selenium and zinc. For selenium, the Station 322 tissue level of 3.79 µg/g is higher than 3.4 µg/g, a level that was associated with reduced survival in *Daphnia magma.* However, in other studies, tissue levels exceeding 10 µg/g have no reported adverse toxic effects (Jarvinen and Ankley, 1999). Measured tissue levels of zinc are generally lower than at the Meadow Creek background station and are therefore not considered to be site-related. Macroinvertebrate tissue levels of metals at Station 322 are unlikely to represent a risk to the benthic community.

For fish, threshold tissue levels were either not available or maximum measured on-site tissue levels do not exceed any thresholds for all metals except for mercury. The highest measured concentration of mercury in Station 322 fish tissue (0.22 mg/kg) is the maximum concentration measured on-site and is in the range of concentrations (0.04 to 0.9 mg/kg) that are related to reduced survival of larval rainbow trout (Jarvinen and Ankley, 1999). Because metals are bioaccumulated over time, levels reported by Jarvinen and Ankley (1999) for larval fish likely are the result of exposure to extremely high mercury concentrations in water. In contrast, the tissue levels of mercury measured at Station 322 were in adult fish that appeared healthy

when collected. Also, all concentrations of dissolved mercury at Station 322 in 1997 (when the fish tissues were collected) were less than the chronic criterion of 0.77 µg/L. Because the threshold tissue levels reported in Jarvinen and Ankley (1999) are for larval fish, not adult fish, such as collected on the Stibnite Site in 1997, it is unlikely that mercury reported for fish tissues at Station 322 represents a risk to fish.

7.7.6.3 Station 319

Water Quality and Sediment Quality. As shown above, no metals in surface water (i.e., maximums of four samples collected in 1999) have HQs greater than 1. Sediment concentrations of antimony and arsenic are greater than the sediment screening values in Tables 7-9 and 7-10. However, the benthic macroinvertebrate community, as seen in samples collected at Station 319 in 1999, had a total bioassessment score of 77, the highest of the site aquatic stations in Meadow Creek.

Benthic Community. The total bioassessment score at the mouth of Meadow Creek (Station 319) increased substantially from 1998 to 1999 (from 63 to 77 percent) (Figure 7-4). Contributing to the improvement in the score was a high percentage (30 percent) of intolerant mayflies. The long-term trend at this station (1983-99) is one of substantial improvement from 1983 to 1999. In view of the improving total bioassessment scores at Station 319 and the high percentage of mayflies, it is unlikely that the benthic macroinvertebrate community is adversely affected by metals in sediment.

Physical Habitat. Station 319 on Meadow Creek is located upstream from the confluence with the EFSFSR. The stream flows through a partially wooded meadow area. Riffle-run-pool habitat sequences are common in this reach, although shallow riffles predominate. The primary substrate is cobble, which is interspersed with gravel and sand. The average percent surface fines was 18 percent when characterized in 1997. Instream cover is relatively sparse – only one small piece of LWD, a few small boulders, and pocket pools were present in the channel. Grasses, some mature alders, and pine trees were observed along the streambanks. Some gravel areas are available for spawning. It is unlikely that physical habitat at Station 319 represents a physical stressor for to fish.

Benthic Macroinvertebrate and Fish Tissue Residues. For benthic macroinvertebrates, threshold tissue levels were either not available or maximum measured tissue levels do not exceed any thresholds for all measured metals except for selenium and zinc. For selenium, the Station 319 tissue level of 3.78 µg/g is higher than 3.4 µg/g, a level associated with reduced survival in *Daphnia magma.* However, in other studies, tissue levels exceeding 10 µg/g have no reported adverse toxic effects (Jarvinen and Ankley, 1999). Measured tissue levels of zinc are generally lower than at the Meadow Creek background station and are therefore not considered to be site-related. Macroinvertebrate tissue levels of metals at Station 322 are unlikely to present a risk to the benthic community.

No fish tissue samples were collected at Station 319 in 1997.

7.7.6.4 Station 365

Water Quality and Sediment Quality. No water quality samples were collected at Station 365 in 1999; instead, water quality results from neighboring Station 313 were used. Metal concentrations in surface water at Station 313 (i.e., maximums of four samples collected in 1999) all were lower than state and federal criteria and therefore have HQs less than 1. Sediment concentrations of antimony and arsenic measured in 1997 are greater than the sediment screening values in Tables 7-9 and 7-10. However, the benthic macroinvertebrate community, as seen in samples collected in 1999, had a total bioassessment score of 77, indicative of moderate to high habitat complexity and biotic integrity.

Benthic Community. At Station 365, located downstream of Meadow Creek, the total bioassessment score of 77 percent is one of the highest in EFSFSR (Figure 7-5). The total invertebrate abundance of 9470 organisms per square meter is second only to Station EF-7, downstream of the Glory Hole. Based on the high bioassessment score, it is unlikely that the benthic macroinvertebrate community at Station 365 is stressed by metals in sediment.

Physical Habitat. Station 365 is located on the EFSFSR downstream of the confluence with Meadow Creek. The stream meanders through an open meadow area. Coarser substrate is interspersed with gravel; however, gravel areas were sparse providing little habitat for spawning. The average percent surface fines for Station 365 was 21 percent in 1997. Instream cover was sparse and consisted primarily of small pocket pools formed behind small boulders in the channel. Only two small pieces of LWD were observed at this site. Grasses and some shrubs were growing on the streambanks, although riparian vegetation is generally sparse. Some streambank erosion is evident in downstream areas. It is possible that elements of the physical habitat at Station 365 represent physical stressors for fish.

Benthic Macroinvertebrate and Fish Tissue Residues. For benthic macroinvertebrates, threshold tissue levels were either not available or maximum measured tissue levels do not exceed any thresholds for all measured metals except for zinc. Measured tissue levels of zinc are lower at Station 365 than at the EFSFSR background station and are therefore not expected to be site-related. Macroinvertebrate tissue levels of metals at Station 322 are unlikely to represent a risk to the benthic community.

Fish tissue samples were not collected at Station 365 in 1997.

7.7.6.5 Station 310

Water Quality and Sediment Quality. Similar to Station 365, no water quality samples were collected at Station 310 in 1999; instead, water quality results from Station 313 were used. Metal concentrations in surface water at Station 313 all were lower than state and federal criteria and therefore have HQs less than 1. Sediment concentrations of antimony and arsenic were similar to those at Station 365 and may represent a risk to benthic macroinvertebrates based on comparisons with sediment screening values (Tables 7-9 and 7-10). However, the benthic macroinvertebrate community, as seen in samples collected in 1999, had a total bioassessment score of 80, indicative of high habitat complexity and biotic integrity.

Benthic Community. At Station 310, located near the former Secondary Camp, the total bioassessment score was 80 percent, indicative of high habitat complexity and biotic integrity. The high bioassessment score is due, in part, to high percentages of intolerant mayflies, stoneflies, and caddisflies. Intolerant mayflies, which are sentinels of metal contamination (Clements, 1991, 1994; Clements et al., 1988), constituted 42 percent of the taxa collected at Station 310. In view of the high bioassessment score and the abundance of intolerant macroinvertebrates, it is unlikely that the benthic macroinvertebrate community is adversely affected by metals in the sediment.

Physical Habitat. Station 310 on the EFSFSR is located near the former Secondary Camp. Riffle-run habitat predominates. In the upstream portion of this reach, the channel is spilt by a gravel bar covered by grasses and mature willows. Shallow low-gradient riffle habitat is common in downstream areas. The substrate is primarily cobble interspersed with gravel and sand. The average percent surface fines was <16 percent in 1997. Although no LWD was observed at Station 310, in-stream cover was diverse and included two large scour pools, numerous pocket pools, and several boulders in the middle of the stream channel. Streambanks are covered by grasses; mature willows and alders provide some shade along the stream margins. It is unlikely that the aquatic habitat at Station 310 is a physical stressor for fish.

Benthic Macroinvertebrate and Fish Tissue Residues. For benthic macroinvertebrates, threshold tissue levels were either not available or maximum measured tissue levels do not exceed any thresholds for all metals except for zinc. Measured tissue levels of zinc are lower than at the EFSFSR background station and are therefore not expected to be site-related. Macroinvertebrate tissue levels of metals at Station 322 unlikely represent a risk to the benthic community.

For fish, threshold tissue levels were either not available or maximum measured on-site tissue levels do not exceed any thresholds for all measured metals except for mercury. The highest measured concentration of mercury in Station 310 fish tissue (0.15 mg/kg) is in the range of concentrations (0.04 to 0.9 mg/kg) that are related to reduced survival of larval rainbow trout (Jarvinen and Ankley, 1999). As discussed in Section 7.7.6.2 (Station 322), it is unlikely that the mercury measured in fish tissue represents a risk to fish, since the threshold tissue levels reported in Jarvinen and Ankley (1999) are for larval, not adult fish, such as collected on the Stibnite Site in 1997.

7.7.6.6 Glory Hole

Water Quality and Sediment Quality. The maximum antimony concentration in surface water in 1999 (33 μg/L) was greater than the proposed USEPA chronic criterion of 30 μg/L. However, as discussed in Section 7.5.2.1, antimony is one of the least toxic of the metals and this proposed criterion is overly conservative. There are no promulgated state or federal surface water quality criteria for antimony. As shown in the table in Section 7.6.2 above, antimony, arsenic, and mercury were found in sediment at concentrations greater than screening values with resulting HQs greater than 1. It is possible that these metals represent a risk to benthic invertebrates.

Benthic Community. The Glory Hole was sampled for the first time in September 1999. Three replicate grab samples were collected from each of four stations (GH1, GH2, GH3, and GH4) using a petite Ponar sampler. Unlike the stream stations, the benthic community in the Glory Hole was dominated by pond or lentic taxa, typically found in fine organic sediments of lakes and ponds in the Pacific Northwest. Invertebrate richness was low but typical for fine organic sediments. The very high organism densities found at three of the four stations (35,000 to 192,000 per square meter) indicate a highly productive community. The fauna collected indicate that dissolved oxygen levels in the surface sediments are, at worst, moderate. Taxa associated with nearly anoxic or low dissolved oxygen conditions were not found (ABA, 1999). In contrast to the faunal densities seen at three stations, densities at Station GH2 were substantially lower (287 per square meter) for unknown reasons. Results of the benthic macroinvertebrate community analysis do not indicate a stressed pond benthic community.

Physical Habitat. The Glory Hole (Yellow Pine Pit) is a former mine pit that was formed after mining ceased in 1955 and the EFSFSR, which had been diverted through the Bradley Tunnel to Sugar Creek during mining, eventually flowed into the pit. The water surface of the Glory Hole covers approximately 5 acres. An area of approximately 0.7 acre is at least 40 feet deep, and the majority of the pit is over 20 feet deep. In contrast to the stream sediments, sediment within the Glory Hole is primarily fine-grained coarser material is found near the inlet. Current velocities in the Glory Hole, as measured in July 1999, ranged from 0.7 feet per second near the inlet to an average of 0.05 feet per second near the bottom. A full description of the aquatic habitat of the Glory Hole is presented in Section 8.5.7 of the Draft SCR (Stibnite Group, 2000).

Benthic Macroinvertebrate and Fish Tissue Residues. No benthic macroinvertebrate or fish tissue samples have been collected from the Glory Hole. However, 125 bull trout were collected in 1999 from the Glory Hole as part of a survey of bull trout in the EFSFSR conducted by the Payette National Forest, Idaho Department of Fish and Game, and the University of Idaho. In addition to the bull trout collected, steelhead/rainbow trout, cutthroat trout, and mountain whitefish were noted in the Glory Hole (Hogen and Scarnecchia, 1999).

7.7.6.7 Station EF-7

Water Quality and Sediment Quality. The maximum antimony concentration in surface water in 1999 (32 μg/L) was greater than the proposed USEPA chronic criterion of 30 μg/L. However, as discussed in Section 7.5.2.1, antimony is one of the least toxic of the metals and this proposed criterion is overly conservative. There are no promulgated state or federal surface water quality criteria for antimony. As shown in the table in Section 7.5.1.2 above, antimony, arsenic, and mercury were found in sediment at concentrations greater than screening values with resulting HQs greater than 1. It is possible that these metals represent a risk to the benthic invertebrate community.

Benthic Community. Station EF-7 is located downstream of the Glory Hole and was sampled for the first time in 1999. It had the highest overall invertebrate abundance (10,770/meter^2), number of invertebrate taxa (68), EPT taxa (40), and the second highest percentage of intolerant mayflies (40 percent) of any EFSFSR station. However, the total bioassessment score of 74 percent, while indicative of moderate

habitat complexity and biotic integrity, is lower than all other EFSFSR aquatic stations except Station 308. The relatively low total bioassessment score of 74 percent at EF-7 may be due to the physical effects of the Glory Hole on the food base of the EFSFSR (no organisms that feed on wood [xylophages] were found at Station EF-7). It is possible that the benthic macroinvertebrate community at Station EF-7 is under some physical stress due to its location immediately downstream of the Glory Hole which in 1999 was found to accumulate wood particles in the bottom sediments.

Physical Habitat. Station EF-7 is the second new aquatic station added in 1999; it is located in the EFSFSR approximately 500 feet downstream of the Glory Hole. The river flows around a low oxbow island covered with willows and other riparian vegetation and hits a rock wall near the downstream end of the 200-foot station. The average percent surface fines was <10 percent in 1999. Practically all the stream bank included in the station is stable – either rocky or well-vegetated. In-stream cover at Station EF-7 is somewhat limited, consisting primarily of a deep scour pool where the river cuts around a gravel bar and against the solid rock plus a collection of LWD accumulated at the upstream end of Station EF-7. Riparian vegetation along Station EF-7 also is sparse. It is possible that some elements of the aquatic habitat at Station EF-7 are physical stressors to fish.

Benthic Macroinvertebrate and Fish Tissue Residues. No benthic macroinvertebrate or fish tissue samples have been collected at Station EF-7.

7.7.6.8 Station 308

Water Quality and Sediment Quality. The maximum 1999 antimony concentration in surface water (35 µg/L)was greater than the proposed USEPA chronic criterion. However, antimony is one of the least toxic of the metals and this proposed criterion is overly conservative, and no risk is likely from antimony. There are no promulgated state or federal surface water quality criteria for antimony. It is unlikely that antimony presents a risk to aquatic organisms. As shown in the table above, antimony, arsenic, and mercury were found in sediment at Station 308 in concentrations similar to those found at Station EF-7 with resulting screening HQs greater than 1. Antimony and arsenic sediment concentrations (35.4 and 1,522 mg/kg) were the highest of any Site aquatic station sampled in 1997 or 1999. It is possible that these sediment concentrations of metals represent a risk to the benthic invertebrate community.

Benthic Community. The total bioassessment score of 74, which is the same as at Station EF-7 (Figure 7-5), is the lower than all other stream stations except for MC-1C (new Diversion Channel) and 369 (physically disturbed inlet channel to the Glory Hole). The score of 74 is indicative of moderate habitat complexity and biotic integrity. Although the primary metric score of 89 percent is the highest (tied with Station 314) in the EFSFSR, a low percentage of metal-intolerant invertebrates (mayflies, stoneflies, caddisflies, and dipterans) were found at Station 308. It is possible that the results of the benthic macroinvertebrate community analysis indicate a community adversely affected by metals in sediments.

Physical Habitat. Station 308 is located in an open, and apparently disturbed, area downstream of the Northwest Bradley waste rock dump and upstream of the confluence with Sugar Creek. This stream segment includes a main channel and two small side channels. The substrate is primarily cobble and small

boulders. Fine sand and silt are deposited throughout the reach, particularly in side channels and along margins of the main channel. However, the average percent surface fines of <5 percent is the lowest of any EFSFSR stations. Grasses and stands of willows cover the streambanks providing some shade; otherwise, overhead cover was limited and consisted of a few pine trees along the left bank in the upper part of the reach. Some eroded banks are evident along the hillside. It is possible that elements of the physical habitat at Station 308 represent physical stressors to fish.

Benthic Macroinvertebrate and Fish Tissue Residues. For benthic macroinvertebrates, threshold tissue levels were either not available or maximum measured tissue levels do not exceed thresholds for all measured metals except for zinc. Measured tissue levels of zinc are lower than at the EFSFSR background station and are therefore not considered to be site-related. Macroinvertebrate tissue levels of metals at Station 308 unlikely represent a risk to the benthic community.

Threshold tissue levels for fish were either not available or maximum measured on-site tissue levels do not exceed any thresholds for all metals except for mercury. The highest measured concentration of mercury in Station 308 fish tissue (0.11 mg/kg) is the maximum concentration measured on-site and is in the range of concentrations (0.04 to 0.9 mg/kg) that are related to reduced survival of larval rainbow trout (Jarvinen and Ankley, 1999). As discussed in Section 7.7.6.2 (Station 322), it is unlikely that the mercury measured in fish tissue represents a risk to fish, since the threshold tissue levels reported in Jarvinen and Ankley (1999) are for larval, not adult fish, such as collected on the Stibnite Site in 1997.

7.7.6.9 Station 314

Water Quality and Sediment Quality. The maximum surface water concentration of total mercury at Station 314, located in EFSFSR downstream of Sugar Creek, was greater than the Idaho criterion but was determined to be due to mercury sources upstream in Sugar Creek (Section 7.5.2.1). No other surface water metals concentrations exceeded criteria. Mercury in sediment also was determined to be due to upstream (off-Site) sources in Sugar Creek and therefore not considered Site-related. Antimony and arsenic in sediment, which are site-related, were at concentrations greater than screening values in 1997. If benthic macroinvertebrate community data were not available, it would appear possible that antimony and arsenic in sediment represent a risk to the benthic community.

Benthic Community. Station 314 had a total bioassessment score of 81 percent, indicative of high habitat complexity and biotic integrity. This total bioassessment score is second only to the score of 82 at the upstream background station in EFSFSR (Station 315). In view of the total bioassessment score of 81 percent, it is unlikely that the benthic macroinvertebrate community is adversely affected by metals in the sediment.

Physical Habitat. Station 314 is located downstream from the confluence with Sugar Creek and is the lowest Stibnite Site aquatic station on the EFSFSR. The river widens (average wetted width of 35 feet) and flows through a forested area with numerous tall pines on both sides of the channel providing shade. Cobble is the dominant substrate at Station 314 and was interspersed with gravel and sand. Average percent surface fines was low (8 percent) in 1997. In-stream cover is relatively sparse and includes pocket

pools behind boulders and two pieces of LWD. Undercuts were observed along approximately 30 and 50 percent of the left and right banks, respectively. Streambanks are covered with grasses and appear to be stable. It is unlikely that the aquatic habitat at Station 314 represents a physical stressor for fish.

Benthic Macroinvertebrate and Fish Tissue Residues. Threshold tissue levels for benthic macroinvertebrates were either not available or maximum measured tissue levels do not exceed any thresholds for all metals except for zinc. Measured tissue levels of zinc are lower than at the EFSFSR background station and are therefore not considered to be site-related. Macroinvertebrate tissue levels of metals at Station 314 are unlikely to be representative of a risk to the benthic community.

Threshold tissue levels for fish were either not available or the maximum measured on-site tissue levels do not exceed any thresholds for all metals except for mercury. The highest measured concentration of mercury in Station 314 fish tissue (0.08 mg/kg) is in the range of concentrations (0.04 to 0.9 mg/kg) that are related to reduced survival of larval rainbow trout (Jarvinen and Ankley, 1999). As discussed in Section 7.7.6.2 (Station 322), it is unlikely that the mercury measured in fish tissue collected at Station 314 represents a risk to fish, since the threshold tissue levels reported in Jarvinen and Ankley (1999) are for larval, not adult fish, such as collected on the Stibnite Site in 1997.

7.7.6.10 Station 316

Water Quality and Sediment Quality. The maximum surface water concentration of total mercury (0.25 µg/L) at Station 316, located in Sugar Creek near the confluence with EFSFSR, was greater than the Idaho criterion of 0.012 µg/L but was determined to be due to mercury sources upstream in Sugar Creek (Section 7.5.2.1). No other surface water metals concentrations exceeded criteria. Arsenic and mercury in sediment also were determined to be due to upstream (off-Site) sources and therefore not considered Site-related. Neither surface water nor sediment at Station 316 represent a risk to aquatic organisms.

Benthic Community. There are no marked trends among the Sugar Creek stations as seen in Figure 7-6. Total bioassessment scores at all Sugar Creek stations exceeded 75 percent (moderate to high biotic complexity/habitat integrity) in 1999. Bioassessment scores were 76 percent at the upstream background station (Station 309) and slightly higher at 81 percent (indicative of high habitat complexity and biotic integrity) at Station 316 near the confluence with the EFSFSR. Station 316 is downstream of the drainage from BTO, and the benthic macroinvertebrate community at the station does not appear to be adversely affected by output from the BTO. In view of the high total bioassessment score, it is unlikely that metals in sediments represent a risk to the benthic community at Station 316.

Physical Habitat. Station 316 is located downstream of the historic BTO and West End Creek and upstream of the confluence with the EFSFSR. The station is in a forested area near the mouth of Sugar Creek. The substrate is primarily cobble interspersed with gravel. In 1997, the average percent surface fines was 36 percent, which is in the range of fines that may lead to a loss of viable spawning habitat (Bjornn et al., 1977; Hunter, 1991). Despite the apparent elevated level of surface fines, suitable gravel spawning areas were present in a portion of this stream reach. Large woody debris and several small pools provide in-stream cover. Streambanks are covered with grasses and willows, and the stream channel is

partially shaded by pine trees. Downstream of Station 316, riparian vegetation becomes less dense and provides less cover for Sugar Creek. It is unlikely that the aquatic habitat at Station 316 represents a physical stressor for fish.

Benthic Macroinvertebrate and Fish Tissue Residues. For benthic macroinvertebrates, threshold tissue levels were either not available or maximum measured tissue levels do not exceed any thresholds for all metals except for zinc. Measured tissue levels of zinc are lower than at the Sugar Creek background station and are therefore not considered to be site-related. As a result, macroinvertebrate tissue levels of metals at Station 316 are unlikely to represent a risk to the benthic community.

No fish tissue samples were collected at Station 316 in 1997.

7.7.6.11 Aquatic Station Summary

The potential for risk to fish and benthic macroinvertebrates at aquatic stations was evaluated for a total of six measurement endpoints. Three measurement endpoints (surface water quality, physical habitat, and fish tissue metals residues) were considered in that order for estimating risk to fish. Four measurement endpoints (benthic community analysis, sediment quality, surface water quality, and benthic macroinvertebrate tissue metals residues) were considered in that order for estimating risk to the benthic macroinvertebrate community. Surface water quality and sediment quality were quantitatively evaluated in Section 7.5.1, and the applicability of the resulting HQs was evaluated in Section 7.5.2 above. The remaining aquatic measurement endpoints were evaluated qualitatively. For each aquatic measurement endpoint, the potential for unacceptable risk to aquatic organisms was classified as "unlikely" or "possible." Summaries of the potential of risk to fish and benthic macroinvertebrates are presented in the following tables.

Potential of Risk to Fish at Aquatic Stations

Station	Surface Water	Physical Habitat	Tissue Residue	Overall Risk
MC-1C	Unlikely	Possible	NC[1]	Unlikely
322	Unlikely	Possible	Unlikely	Unlikely
319	Unlikely	Unlikely	NC[1]	Unlikely
365	Unlikely[2]	Possible	NC[1]	Unlikely
310	Unlikely[2]	Unlikely	Unlikely	Unlikely
G. H.[3]	Unlikely	Unlikely	NC[1]	Unlikely
EF-7	Unlikely	Possible	NC[1]	Unlikely
308	Unlikely	Possible	Unlikely	Unlikely
314	Unlikely	Unlikely	Unlikely	Unlikely
316	Unlikely	Unlikely	NC[1]	Unlikely

[1]Fish tissue samples not collected at station.
[2]Surface water quality based on results from Station 313.
[3]Glory Hole.

Potential of Risk to Benthic Macroinvertebrates at Aquatic Stations

Station	Benthic Community	Sediment Quality	Surface Water	Tissue Residue	Overall Risk
MC-1C	Unlikely	Possible	Unlikely	NC[1]	Unlikely
322	Unlikely	Possible	Unlikely	Unlikely	Unlikely
319	Unlikely	Possible	Unlikely	Unlikely	Unlikely
365	Unlikely	Possible	Unlikely[2]	Unlikely	Unlikely
310	Unlikely	Possible	Unlikely[2]	Unlikely	Unlikely
G. H.[3]	Unlikely	Possible	Unlikely	NC[1]	Unlikely
EF-7	Possible	Possible	Unlikely	NC[1]	Possible
308	Possible	Possible	Unlikely	Possible	Possible
314	Unlikely	Possible	Unlikely	Unlikely	Unlikely
316	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely

[1]Benthic macroinvertebrate tissue samples not collected at station.
[2]Surface water quality based on results from Station 313.
[3]Glory Hole.

The potential for risk to fish at each of the ten aquatic stations is evaluated as unlikely. Potential for risk to benthic macroinvertebrates at each station is evaluated as possible at two stations in the EFSFSR (EF-7 and 308), but risk to benthic macroinvertebrates is unlikely for the remaining eight stations.

7.8 UNCERTAINTY IN THE AQUATIC ECOLOGICAL RISK EVALUATION

In the calculation of risk estimates (HQs) in Section 7.6 and formulation of the risk descriptions in Section 7.7, comparisons of Site data were made with available criteria, standards, and screening benchmarks. Inherent in those comparisons was a number of assumptions that were made regarding limitations of the Site data and applicability of the benchmarks. In order to provide a basis for discussions in the Risk Characterization (Sections 7.6 and 7.7), descriptions of the various sources of uncertainty were discussed prior to performing the risk characterization. Following is a list of the uncertainties and backgrounds to the report sections where the effect of the uncertainties are thoroughly discussed:

- Water Quality Data – Section 7.4.1
- Site Sediment Quality Data – Section 7.4.1
- Water Quality Criteria – Sections 7.3.3 and 7.7.1
- Sediment Screening Benchmarks – Sections 7.3.3 and 7.7.2
- Benthic Macroinvertebrate Tissue Residues from 1996 and 1997 – Section 7.7.3
- Fish Tissue Residues from 1997 – Section 7.7.4

7.9 STATIONS UW-1, KW-1, AND BTO

Of the 25 water quality stations, three water quality stations (UW-1, KW-1, and BTO) are considered separately. These three stations are not compiled with the other stations because: 1) each is a unique situation that is recognized as a potential "hot spot" and is not representative of conditions in the area; 2) each typically has flow rates lower than 1 cfs (Table 8.1-18 of Stibnite Group, 2000) and according to IDAPA 16.01.02 (*Water Quality Standards and Wastewater Treatment Requirements*), water quality

standards do not apply to ephemeral waters and for aquatic life uses, optimal flow is 1 cfs or greater; 3) each provides only limited aquatic habitat; and 4) UW-1 is located in a puddle near the Upgradient Wetland and is not directly connected with the main stem of Meadow Creek. Surface water quality results from the three stations are presented in Table 7-4 (total metals) and Table 7-5 (dissolved metals). Sediment sampling, benthic macroinvertebrate sampling, tissue sampling, and physical habitat characterization were not performed at these three stations.

Comparisons of metals at the three stations with water quality criteria (Table 7-7) are not performed as described above. However, comparisons between metals concentrations at main stem stations immediately downstream of the three drainages and the three stations demonstrate that, because of their low flow (typically less than 1 cfs), they are having little or no effect on concentrations of metals in the main streams. At Station UW-1 in September 1999 (the only sampling date), concentrations of antimony, lead, and silver were greater than their respective criteria or proposed criteria (30 µg/L, 0.8 µg/L, and 1.0 µg/L, respectively), but immediately downstream at Meadow Creek Station MC-1C, none of these metals was not detected. At Station KW-1, concentrations of antimony and total mercury were greater than criteria (30 µg/L antimony and 0.012 µg/L total mercury) in one or more samples. Immediately downstream at Station 368 in Meadow Creek, all antimony concentrations were less than half the chronic criterion, and total mercury (0.044 µg/L) was just above the detection limit of 0.042 µg/L. At Station BTO, antimony was greater than the proposed chronic criterion in all four samples, but antimony was not detected in any samples (detection limit of 5.3 µg/L) from Station SC-3 located immediately downstream of BTO in Sugar Creek. In conclusion, metals at the three stations (UW-1, KW-1, and BTO) are unlikely to present a risk to aquatic organisms for two principal reasons: 1) minimal or no habitat is found at these locations, and 2) loadings of metals from the stations to the main streams are not sufficient to cause concentrations to exceed criteria in the main streams immediately downstream of the three stations.

7.10 GLORY HOLE PROJECTIONS

Four principal objectives of the 1999 Glory Hole investigations were addressed in Section 8.8 of the Site Characterization Report (Stibnite Group, 2000) as follows:

1. Will sediments in the Glory Hole be mobilized during a 100-year snow melt, 500-year peak flow event, "typical" flow, or seasonal turnover (if present)?

2. Do sediments or water quality in the Glory Hole pose an unacceptable risk to the aquatic community in the Glory Hole?

3. If sediments in Glory Hole can be resuspended, will they pose an unacceptable risk to the aquatic community or to human health downstream?

4. Are there significant erosional features that are sediment sources to the Glory Hole? Do seeps or springs around the Glory Hole contribute to exceedances of water quality criteria in the Glory Hole?

Discussions of the first and third objectives are presented in this section of the RER, the second objective is discussed within Sections 7.6 and 7.7 above, and the fourth objective is discussed in Sections 8. and 9. of the RER.

7.10.1 GLORY HOLE SEDIMENT MOBILIZATION POTENTIAL

To assess the potential for resuspension of sediments, the water velocity data and physical conditions in the Glory Hole were analyzed to make predictions of scour potential for the 2-year, the 100-year, and 500-year flow events. The specified flow events have the following estimated magnitudes:

- 2-year flow or "typical" event 313 cfs
- 100-year "snow melt" event 612 cfs
- 500-year "storm" flow 751 cfs

Also, temperature profile data were used to assess potential for lake turnover and subsequent resuspension of sediment in the Glory Hole.

7.10.1.1 Sediment Resuspension During Flood Events

The current velocity data collected in July 1999 showed that currents in the Glory Hole form a large backflow or eddy cell. Most of the current existed in the upper 15 feet of water column. Statistical analysis showed the average bottom velocity is 0.05 feet per second (fps) using data from all three transects. The deepest velocity readings represent water flow a minimum of 2.5 feet above the bottom; therefore, the calculated average bottom velocity is conservative.

During the data collection in July, the inlet inflow measured about 62 cfs. The calculated 2-year flow is about 5 times the magnitude of the measured event, the 100-year event is about 10 times the measured event, and the 500-year flow event is about 12 times the measured event. In order to estimate water velocities in the pool during the low frequency events, these ratios were used to scale up the velocities recorded in July. Bottom velocities for the Glory Hole also were estimated by using open channel flow analysis. Average flow velocity and the 3rd quartile statistic of velocity from the data set analysis were both used to balance the equation or to set variables appropriately.

Figure 7-8 shows the three sets of calculated bottom velocities for each of the three flow events. The chart also shows permissible velocities for a range of fine-grained sediments according to Chow (1959). Permissible velocities are thresholds of water velocities below which unconsolidated sediments of various sizes will not be resuspended. All methods of velocity estimation are below the permissible velocity line for the lowest median Glory Hole bottom sediment grain size of 0.04 mm.

Projections of velocities occurring in the Glory Hole during the 2-year, the 100-year, and the 500-year flow events indicate velocities will mostly be below the permissible velocity threshold for unconsolidated fine-grained sediments of 0.04 mm diameter as shown in Figure 7-8. Estimates indicate that the potential for sediment resuspension in the Glory Hole will be low during the 2-year and 100-year events. A low-to-

moderate potential is given to the 500-year event because the conservative (linear scaling) velocity plot is close to the permissible velocity line. Local sediment scour may occur during high-flow events where flow is constricted near the outlet, or where bottom turbulence is created when inlet flows glance against the west high wall. Given the calculation results, however, widespread scour is not probable over the bottom of the Glory Hole. This is especially true during the 100-year event, which is considered to be the maximum event of reasonable concern.

Two physical factors explain why sediment resuspension in the Glory Hole is not likely to be widespread.

- The Glory Hole, as with any in-stream reservoir, is a trap for entrained sediments. During large, high return period flow events, sediment transport rates generally increase in all stream systems as tributaries and flood plain areas provide transportable material from areas seldom scoured by flood flow. High-energy streamflow moving down valley will entrain sediments upstream of the Glory Hole during high-flow events. As streamflow enters the Glory Hole, the channel gradient goes flat, flow energy dissipates, and bedload sediment and the larger fraction of suspended sediment will settle in the pond and delta areas. Sedimentation will be the dominant process rather than erosion and scour during high-flow events in much of the Glory Hole.
- Fine-grained sediment that remains in suspension during flood flow reduces the erosion capacity of flowing water.

7.10.1.2 Turnover Potential

The Glory Hole probably does experience the physical conditions that permit seasonal (spring and fall) turnover. However, because the depth of each turnover event will vary in response to numerous factors (e.g., basin morphology, meteorological conditions, inflow water temperatures and volumes, and water residence times), it cannot be determined from the data available if the currents associated with a turnover event are sufficiently high to resuspend sediments.

The Glory Hole most likely experiences conditions when turnover is possible (i.e., free vertical circulation) twice a year when the vertical temperature stratification is weak or non-existent. In the summer, warmer, less-dense water lies over cooler, denser water; in the winter, the Glory Hole is covered with ice and cold water (less than 4°C) that is less dense than the denser and slightly warmer water. (Note: water is densest at a temperature of 4°C.) The Glory Hole was found to have thermal stratification (i.e., thermocline) in the summer and is ice-covered in the winter (Richter, 2000, personal communication).

Even though the Glory Hole most likely experiences seasonal turnover, it cannot be determined if the currents associated with a turnover event are sufficiently high to resuspend bottom sediments. Because of the annual and seasonal variability of many of the controlling factors, the currents associated with turnover cannot be predicted. However, based on the thermal stratification observed during the July – September 1999 sampling and expected reverse stratification in the winter, the periods of isothermal conditions are expected to be of limited duration. In the spring, if an absence of thermal stratification and high stream flows occur during the same period, currents resulting from the flows are more likely to extend to the

bottom of the Glory Hole than they would if there were a thermocline that restricted currents to the upper portion of the water body.

In summary, physical conditions in the Glory Hole and calculated bottom velocities indicate that the potential for sediment resuspension is low in the 2-year and 100-year events and low-to-moderate in the 500-year event. The 100-year event is considered to be the largest flow event of reasonable concern given the low frequency of a 500-year event; therefore, resuspension of sediment is a minor concern. Sediment falling out of suspension and the reduced effectiveness of sediment-laden waters to scour sediment during high-flow events are factors that also reduce the potential for sediment resuspension. Any sediment scour that does occur will likely be localized to areas near the inlet and at the base of the west high wall. The Glory Hole probably does experience the physical conditions that permit seasonal (spring and fall) turnover. However, because the depth of each turnover event will vary in response to numerous factors, it cannot be determined if the currents associated with a turnover event are sufficiently high to resuspend sediments.

7.10.2 POTENTIAL FOR DOWNSTREAM TOXICITY OF MOBILIZED GLORY HOLE SEDIMENTS

Overall, it appears unlikely that Glory Hole sediments would be resuspended and pose an unacceptable risk to the aquatic community downstream of the Glory Hole. This conclusion is based on the results of the sediment resuspension evaluation in Section 7.5.4..1 and the toxicity potential evaluation in Section 7.5.2. The key elements that support the conclusion of unlikely downstream toxicity are as follows:

- Glory Hole sediments have only a low potential for mobilization under 100- or 2-year flow regimes.
- Glory Hole sediments have a moderate-to-low potential for mobilization under the highly unlikely 500-year flow regime.
- Based on results from the benthic macroinvertebrate analysis (ABA, 1999), sediments in the Glory Hole are apparently not toxic to the benthic community that is currently in direct contact with the *in situ* sediments.
- Under the various projected flow rates (2-, 100-, and 500-year frequency of occurrence), more sediment from the streambed upstream and downstream of the Glory Hole would be suspended than from the bottom of the Glory Hole. This would result in a mixture of Glory Hole sediments with sediments from upstream and downstream of the mine pit, effectively diluting any Glory Hole sediment resuspension.
- If the fine-grained sediments from the Glory Hole were mobilized, they would remain in suspension and not settle out until they encountered low stream velocities similar to those in the Glory Hole. Since these low stream velocities would be found only in small, scattered areas in the EFSFSR (especially under high stream flow conditions), any sediment mobilized from the Glory Hole would be distributed over an extended, but undetermined, length of the EFSFSR.

In conclusion, it appears unlikely that bottom sediment from the Glory Hole would pose an unacceptable downstream risk to aquatic biota because: 1) resuspension of sediments has a low probability, 2) in-place sediments are apparently not toxic, and 3) Glory Hole sediments would be mixed with resuspended stream sediments from upstream and downstream of the pit and scattered over an extended length of the EFSFSR.

7.11 STREAM DESIGNATED USES

The current designated beneficial uses of the EFSFSR waters include: domestic water supply, agricultural water supply, cold water biota, salmonid spawning, primary contact recreation, and secondary contact recreation. Of these designated uses, salmonid spawning has some of the most stringent water quality requirements for dissolved oxygen and temperature. The dissolved oxygen standard for salmonid spawning is described as a minimum of 6.0 mg/L or 90 percent of dissolved oxygen saturation, whichever is greater. The salmon spawning temperature maximum is 13 degrees centigrade (°C) with a maximum daily average of 9°C (IDHW, 1998). In addition to dissolved oxygen and temperature standards, salmonid spawning requirements also include ammonia criteria and the general criteria for aquatic life (pH, dissolved gas, total chlorine residual, and all acute and chronic toxic substance standards for the protection of aquatic life).

The EFSFSR (and its tributaries) also is among the Idaho streams that contain bull trout. The EFSFSR and its tributaries are, therefore, covered by the water temperature requirements for spawning and rearing of bull trout (40 CFR 131.33). These temperature requirements are more stringent than the overall salmonid spawning standards. For bull trout, the temperature criterion is 10°C, expressed as an average of daily maximum temperatures over a 7-day period during June, July, and August (40 CFR 131.33).

Measurements of temperature and dissolved oxygen collected during 1997 water sampling indicate that these requirements for the designated beneficial uses of bull trout spawning and rearing and salmonid spawning were satisfied throughout the Site streams. Average temperatures and dissolved oxygen for the three exposure areas in 1997 are shown in Table 7-18 together with maximum temperature standards and minimum dissolved oxygen standards. Dissolved oxygen standards are based on 90 percent of theoretical water saturation at the maximum measured temperature and an elevation of 5,850 feet (1,800 meters) (Colt, 1984). These estimated dissolved oxygen standards are higher (i.e., more conservative) than the 6 mg/L listed in IDHW (1998). Results from the extended 1997 sampling season show that the bull trout temperature requirements and salmonid spawning dissolved oxygen spawning requirements were met in all areas.

A review of temperature measurements during the four surface water sampling events in June, July and September 1999 (Appendix A1 of Stibnite Group, 2000) shows that maximum temperatures at most of the EFSFSR stations (except for Station 369) were lower than the 10°C maximum for bull trout. Temperatures in Meadow Creek in July (10.9 to 12.8°C) and September 1999 (10.7 to 12.5°C) were greater than the 10°C maximum. Temperatures in Sugar Creek in July 1999 (10.1 to 11.8°C) and the Glory Hole in August (8.6 to 12.0°C) and September (12.6 to 28°C) also were greater than the 10°C maximum for bull trout. It appears that water coming from upstream EFSFSR (e.g., temperature of 6.2°C at EF-2 in September 1999)

is substantially cooler than in Meadow Creek (10.7 to 12.5°C in September 1999). The warmer water temperatures in Meadow Creek are not expected to adversely affect the spawning of bull trout, however, since they cannot migrate upstream past the Glory Hole.

Dissolved oxygen measurements at all stream stations in 1999 (Appendix A1 of Stibnite Group, 2000) were greater than 8.2 mg/L. This dissolved oxygen minimum was calculated as 90 percent of theoretical water saturation (Colt, 1984) at a temperature of 10°C, the maximum temperature threshold for bull trout.

Toxic substance standards for surface water are established for general categories of designated use (e.g., aquatic life and human health). These standards include numeric values for most metals and many organic compounds and are based on the USEPA's Recommended Water Quality Criteria (USEPA, 1976; 1998b; 1999). There are no unique toxic substance standards for the designated uses of salmonid or bull trout spawning that are not included in the general aquatic life standards (IDHW, 1998). Therefore, the risk evaluation performed in Section 7.5 is applicable to the protection of salmonids, including bull trout, as well as all other on-site aquatic receptors.

The EFSFSR waters located at the Site are not currently being used for domestic or agricultural water supplies and are not anticipated to be used for domestic or agricultural water supplies in the foreseeable future. However, the human health risk evaluation in Section 9 qualitatively compares arsenic and antimony concentrations in EFSFSR waters at the Site to Idaho drinking water criteria. The human health risk evaluation also quantitatively evaluates recreational contact with EFSFSR waters at the Site.

7.12 AQUATIC ECOLOGICAL RISK SUMMARY

Potential risks to aquatic organisms (fish and benthic macroinvertebrates) on the Stibnite Site were evaluated for four exposure areas and ten Site aquatic stations. A total of six measurement endpoints were considered in evaluating the two assessment endpoints of protection of salmonid fish populations and protection of the benthic macroinvertebrate community. In the four exposure areas (Meadow Creek, Upper EFSFSR, Lower EFSFSR, and Sugar Creek) three measurement endpoints were evaluated: surface water quality, physical habitat, and fish tissue residue levels. At the ten aquatic stations, six aquatic measurement endpoints were measured or described (metals in surface water and sediment, metals in fish and benthic macroinvertebrate tissues, benthic macroinvertebrate community analysis, and physical habitat descriptions). The ten aquatic stations are: MC-1C, 322, and 319 (Meadow Creek); 365, 310, Glory Hole, EF-7, 308, and 314 (EFSFSR); and 316 (Sugar Creek). The measurement endpoints and their relative importance in evaluating risk to fish populations and benthic macroinvertebrate community are listed below:

Relative Importance of Aquatic Measurement Endpoints for Fish and Invertebrates

Measurement Endpoint	Risk to Fish[1]	Risk to Benthic Invertebrates[2]
Surface Water Quality (HQ)	1	3
Sediment Quality (HQ)	Not Evaluated	2
Physical Habitat	2	Not Evaluated
Benthic Community	Not Evaluated	1
Benthic Tissue Metal Residue	Not Evaluated	4
Fish Tissue Metal Residue	3	Not Evaluated

[1] Evaluated for exposure areas and aquatic stations.
[2] Evaluated for aquatic stations only.

Concentrations of metals in water were compared with Idaho and USEPA water quality criteria (Table 7-7) (IDHW, 1998; BNA, 1999; USEPA, 1976, 1988, 1992b, 1998b, 1999); metals in sediment were compared with recent compilations of sediment screening benchmarks (Table 7-9 and 7-10) (EVS, 1998; Macdonald et al., 1999). Water quality and sediment quality were evaluated quantitatively by calculating HQs based on these comparisons. The remaining measurement endpoints were evaluated qualitatively. The focus of risk assessments in exposure areas was on fish, while the risk at aquatic stations addressed both fish and benthic macroinvertebrates. In the evaluation of the various measurement endpoints, the importance of each measurement endpoint was weighted as shown (e.g., surface water quality is most important in evaluating risk to fish; results of the benthic community analysis is most important in evaluating risk to benthic macroinvertebrates).

As described in Section 7.7, the overall potential for unacceptable risks to fish and benthic macroinvertebrates is described as "unlikely" or "possible." For the measurement endpoints quantitatively evaluated (water quality and sediment quality), risk is considered "unlikely" if the HQ is less than 1 and "possible" if the HQ is greater than 1. For the four measurement endpoints qualitatively evaluated, judgements are made as to the likelihood of the endpoint representing a stressor (chemical or physical) to the receptor. Stressors described as representing a "possible" risk may occur but are not expected to have any significant effects on the receptors. Stressors described as "unlikely" are not expected to have any measurable effect on the receptors.

Risks to fish from the three aquatic measurement endpoints considered in each of the four exposure areas is summarized in the following table:

Potential of Risk to Fish in Exposure Areas

Exposure Area	Water Quality	Physical Habitat	Tissue Residue	Overall Risk
Meadow Creek	Unlikely	Possible	Unlikely	Unlikely
Upper EFSFSR	Unlikely	Unlikely	Unlikely	Unlikely
Lower EFSFSR	Unlikely	Possible	Unlikely	Unlikely
Sugar Creek	Unlikely	Possible	NC[1]	Unlikely

[1]Fish tissue samples not collected at station.

Considering all three measurement endpoints, especially water quality, it is unlikely that fish are at potential risk in any area. However, the habitat in portions of Meadow Creek, Lower EFSFSR, and Sugar Creek may represent a physical stressor to fish. In Meadow Creek, unstable banks were found along three sections of the creek. Overall, approximately 700 feet on the south-east bank and 400 feet on the north-west bank were considered unstable, although most of these unstable reaches were vegetated. Half of the unstable areas are adjacent to tailing deposits. In most of Lower EFSFSR, the streambanks have limited riparian cover. Steep, erodible banks occur along about 800 feet of the west bank above the bridge at the main access road. In Sugar Creek, the average percent surface fines at Station 316 was 36 percent, which is in the range of fines that may lead to a loss of viable spawning habitat; however, suitable gravel spawning areas are present in lower Sugar Creek. Downstream of Station 316, riparian vegetation provides only limited cover. Upstream of the station, the stream banks are only moderately stable, due in part to a road cut directly adjacent to the stream.

The potential for risk to fish and benthic macroinvertebrates at aquatic stations was evaluated for a total of six measurement endpoints. Surface water quality and sediment quality were quantitatively evaluated in Section 7.6, and the applicability of the resulting HQs was evaluated in Section 7.7. The remaining aquatic measurement endpoints were evaluated qualitatively. Summaries of the potential of risk to fish and benthic macroinvertebrates at the ten aquatic stations are presented in the following two tables.

Potential of Risk to Fish at Aquatic Stations

Station	Surface Water	Physical Habitat	Tissue Residue	Overall Risk
MC-1C	Unlikely	Possible	NC[1]	Unlikely
322	Unlikely	Possible	Unlikely	Unlikely
319	Unlikely	Unlikely	NC[1]	Unlikely
365	Unlikely[2]	Possible	NC[1]	Unlikely
310	Unlikely[2]	Unlikely	Unlikely	Unlikely
G. H.[3]	Unlikely	Unlikely	NC[1]	Unlikely
EF-7	Unlikely	Possible	NC[1]	Unlikely
308	Unlikely	Possible	Unlikely	Unlikely
314	Unlikely	Unlikely	Unlikely	Unlikely
316	Unlikely	Unlikely	NC[1]	Unlikely

[1]Fish tissue samples not collected at station.
[2]Surface water quality based on results from Station 313.
[3]Glory Hole.

The overall potential for risk to salmonid fish populations at each of the ten aquatic stations is evaluated as unlikely based principally on the surface water quality. However, elements of the physical habitat at five aquatic stations (MC-1C, 322, 365, EF-7, and 308) may represent physical stressors to fish. At all five stations, riparian vegetation is sparse (Stations 365, EF-7, and 308) or missing (Stations MC-1C and 322). Instream cover for fish is limited at four stations (MC-1C, 322, 365, and EF-7). Some evidence of streambank erosion is seen at two stations (365 and 308).

Potential of Risk to Benthic Macroinvertebrates at Aquatic Stations

Station	Benthic Community	Sediment Quality	Surface Water	Tissue Residue	Overall Risk
MC-1C	Unlikely	Possible	Unlikely	NC[1]	Unlikely
322	Unlikely	Possible	Unlikely	Unlikely	Unlikely
319	Unlikely	Possible	Unlikely	Unlikely	Unlikely
365	Unlikely	Possible	Unlikely[2]	Unlikely	Unlikely
310	Unlikely	Possible	Unlikely[2]	Unlikely	Unlikely
G. H.[3]	Unlikely	Possible	Unlikely	NC[1]	Unlikely
EF-7	Possible	Possible	Unlikely	NC[1]	Possible
308	Possible	Possible	Unlikely	Possible	Possible
314	Unlikely	Possible	Unlikely	Unlikely	Unlikely
316	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely

[1]Benthic macroinvertebrate tissue samples not collected at station.
[2]Surface water quality based on results from Station 313.
[3]Glory Hole.

The overall potential for risk to the benthic macroinvertebrate community is evaluated as possible at two stations in the EFSFSR (EF-7 and 308) but unlikely for the remaining eight stations. Overall possible risk at Stations EF-7 and 308 is due to the combination of "possible" ratings for the benthic community and sediment quality.

The potential for future risk to aquatic organisms from resuspension of sediments in the Glory Hole and movement downstream also was evaluated. Two related questions were addressed:

- Will sediments in the Glory Hole be mobilized during various flow events or during seasonal turnover?
- If sediments are resuspended, will they pose a risk downstream to the aquatic community downstream?

Physical conditions in the Glory Hole and calculated bottom velocities indicate that the potential for sediment resuspension is low in the 2-year and 100-year events and low-to-moderate in the 500-year event. The 100-year event is considered to be the largest flow event of reasonable concern; therefore, resuspension of sediment is a minor concern. The Glory Hole probably does experience the physical conditions that permit seasonal (spring and fall) turnover. However, because the depth of each turnover event will vary in response to numerous factors, it cannot be determined if the currents associated with a turnover event are sufficiently high to resuspend sediments.

It appears unlikely that bottom sediment from the Glory Hole would pose an unacceptable downstream risk to aquatic biota because: 1) resuspension of sediments has a low probability, 2) in-place sediments are apparently not toxic based on results from analysis of the benthic macroinvertebrate community in the Glory Hole, and 3) Glory Hole sediments would be mixed with stream sediments and scattered over an extended length of the EFSFSR.

Table 7-1

Aquatic Sampling Stations[1]

Station No.[2]	Stream	Location
2040320	Meadow Creek	Above Diversion (reference station)
MC-1C	Meadow Creek	In new (1998) Diversion Channel (new in 1999)
2040322	Meadow Creek	Below Diversion, near Blowout Creek
2040319	Meadow Creek	Above EFSFSR
2040315	EFSFSR	Approx. 500 feet above Meadow Creek (reference station); termed Station EF-2 for water quality monitoring
2040365	EFSFSR	Above Main Haul Road box culvert
2040310	EFSFSR	At Secondary Camp
EF-7	EFSFSR	Downstream of the Glory Hole (new in 1999)
2040308	EFSFSR	Above Sugar Creek (below EFSFSR bridge)
2040309	Sugar Creek	Above West End Creek (reference station)
2040307	Sugar Creek	Below West End Creek
2040316	Sugar Creek	Approx. 0.1 mile above EFSFSR; historic sampling may have been performed at Station 2040307, below West End Creek
2040314	EFSFSR	Below Sugar Creek

1 Sampled in 1996, 1997, or 1999 for sediment, physical habitat, benthic macroinvertebrates, or fish tissues. The Glory Hole (Stations GH1, GH2, GH3, and GH4) also considered an aquatic station. Water quality samples also collected in 1999 at most of the aquatic sampling stations.

2 See Figure 7-2 for station locations. All station numbers are reported in the text without the 2040 prefix.

Table 7-2
Surface Water Quality Results
(1999; Total Metals and Cyanide, µg/L)

	Chemical	Aluminum, total				Antimony, total				Arsenic, total			
	Date	6/10/99 -	6/22/99 -	7/16/99 -	9/14/99 -	6/10/99 -	6/22/99 -	7/16/99 -	9/14/99 -	6/10/99 -	6/22/99 -	7/16/99 -	9/14/99 -
Area/Stream	Station	6/12/99	6/25/99	7/18/99	9/25/99	6/12/99	6/25/99	7/18/99	9/25/99	6/12/99	6/25/99	7/18/99	9/25/99
Meadow Creek													
Meadow Creek	2040320	80	61	<79	<52	<5.3	<5.3	<5.3	<5.3	<7J	<7	<7	<7
Meadow Creek	MC-1A	153	114	<94	<52	<5.3	<5.3	<5.3	<5.3	<7J	<7	<7	<7
Meadow Creek	MC-1C	89	77	<99	<52	<5.3	<5.3	7.1	<12	11J	8.8	18J	42
Meadow Creek	2040368	142	101	<117	<52	9.8	7.2	8	<11	22J	17	26	55
Meadow Creek	2040322	<52J	77	<129	<52	5.9	5.9	9.3	<13	32	14	26	54
Blowout Creek	BL-1	113	115	<103	<52	<5.3	<5.3	<5.3	<5.3	<7J	<7	10J	<7
Meadow Creek	MC-2A	83	81	<115	<56	8.9	5.3	7.8	<10	25J	17	21	44
Meadow Creek	MC-2B	73	108	<129	<52	18	13	13	23	38	23	39	67
Meadow Creek	2040319	89	117	<124	<53	26	15	16	22	41	25	39	69
Upper EFSFSR													
EFSFSR	EF-2	71	90	<115	<52	<5.3	<5.3	<5.3	<5.3	<7J	7.1	<7J	9.3
EFSFSR	2040313	80	78	<52	<52	20	10	10	13	24J	17	26	34
EFSFSR	2040324	89	103	<52	<52	27	10	13	22	31J	18	27	46
Midnight Creek	2040321	<52J	143	<110	<52	38	38	48	48	71	65	83	89
Lower EFSFSR													
EFSFSR	2040369	88	122	<52	<54	25	14	19	27	32J	23	32	53
Glory Hole	GH1-A			<52	<52			26	33			64	81
Glory Hole	GH1-B			<52	<52			21	31			61	98
Glory Hole	GH2-A			<52	<52			21	32			48	68
Glory Hole	GH2-B			<52	<52			21	30			48	70
Glory Hole	GH2-C			<52	<52			21	30			50	77
Glory Hole	GH3-A			<52	<59			20	32			47	90
Glory Hole	GH3-B			<52	<52			21	31			49	80
EFSFSR	EF-7	83	<99J	<52	<65	30	19	21	32	34J	25	47	82
EFSFSR	2040308	61	<98J	<52	<53	30	18	22	35	42	28	59	109
Hennessey Creek	HC-1A	<52J	<52J	<70	55	<5.3	<5.3	<5.3	5.8	<7	<7	<7	11
Hennessey Creek	HC-2	91J	<52J	<109	<52	40	25	25	24	48	41	18	14
EFSFSR	2040314	72	<116J	<52	<52	17	11	13	24	24J	21	38	67
Sugar Creek													
Sugar Creek	2040309	119	<118J	<52	<52	<5.3	<5.3	<5.3	<5.3	<7J	<7	<7	8.8
Sugar Creek	SC-3	137	<110J	<52	<52	<5.3	<5.3	<5.3	<5.3	<7J	8.5	10	14J
Sugar Creek	2040316	136	<159	<52	<52	<5.3	<5.3	<5.3	8.3	<7	8.2	12	15J

NS = Not sampled.
NA = Not analyzed.

Table 7-2
Surface Water Quality Results
(1999; Total Metals and Cyanide, µg/L)

Area/Stream	Chemical Date Station	Cadmium, total 6/10/99 - 6/12/99	Cadmium, total 6/22/99 - 6/25/99	Cadmium, total 7/16/99 - 7/18/99	Cadmium, total 9/14/99 - 9/25/99	Chromium, total 6/10/99 - 6/12/99	Chromium, total 6/22/99 - 6/25/99	Chromium, total 7/16/99 - 7/18/99	Chromium, total 9/14/99 - 9/25/99	Copper, total 6/10/99 - 6/12/99	Copper, total 6/22/99 - 6/25/99	Copper, total 7/16/99 - 7/18/99	Copper, total 9/14/99 - 9/25/99
Meadow Creek													
Meadow Creek	2040320	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7J	<1.7
Meadow Creek	MC-1A	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7	<1.7	<1.7	<1.7	1.7	<1.7J	<1.7
Meadow Creek	MC-1C	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7J	<1.7
Meadow Creek	2040368	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7J	<1.7
Meadow Creek	2040322	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7	<1.7	<1.7	<2	<1.7	<1.7J	2
Blowout Creek	BL-1	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7J	<1.7
Meadow Creek	MC-2A	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7J	<1.7
Meadow Creek	MC-2B	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7J	<1.7
Meadow Creek	2040319	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7J	<1.7J
Upper EFSFSR													
EFSFSR	EF-2	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7J	2J
EFSFSR	2040313	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7
EFSFSR	2040324	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7J
Midnight Creek	2040321	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7	<1.7	<1.7	<2.1	<1.7	<1.7J	<1.7
Lower EFSFSR													
EFSFSR	2040369	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7
Glory Hole	GH1-A			<0.63	<0.63			<1.7	<1.7			<1.7	<1.7
Glory Hole	GH1-B			<0.63	<0.63			<1.7	<1.7			<1.7	<1.7
Glory Hole	GH2-A			<0.63	<0.63			<1.7	<1.7			<1.7	<1.7
Glory Hole	GH2-B			<0.63	<0.63			<1.7	<1.7			<1.7	<1.7
Glory Hole	GH2-C			<0.63	<0.63			<1.7	<1.7			<1.7	<1.7
Glory Hole	GH3-A			<0.63	<0.63			<1.7	<1.7			<1.7	<1.7
Glory Hole	GH3-B			<0.63	<0.63			<1.7	<1.7			<1.7	<1.7
EFSFSR	EF-7	<0.63	<0.63J	<0.63	<0.63	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7
EFSFSR	2040308	<0.63	<0.63J	<0.63	<0.63	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7
Hennessey Creek	HC-1A	<0.63	<0.63J	<0.63	<0.63	<1.7	<1.7	<1.7	<1.7	<2.5	<1.7	<1.7J	3.2J
Hennessey Creek	HC-2	<0.63	<0.63J	<0.63	<0.63	<1.7	<1.7	<1.7	<1.7	<2.2	<1.7	<1.7J	<1.7J
EFSFSR	2040314	<0.63	<0.63J	<0.63	<0.63	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7
Sugar Creek													
Sugar Creek	2040309	<0.63	<0.63J	<0.63	<0.63	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7
Sugar Creek	SC-3	<0.63	<0.63J	<0.63	<0.63	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7J
Sugar Creek	2040316	<0.63	<0.63J	<0.63	<0.63	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7J

NS = Not sampled.
NA = Not a[illegible]d.

Table 7-2
Surface Water Quality Results
(1999; Total Metals and Cyanide, µg/L)

Area/Stream	Chemical Date Station	Cyanide, total 6/10/99 - 6/12/99	Cyanide, total 6/22/99 - 6/25/99	Cyanide, total 7/16/99 - 7/18/99	Cyanide, total 9/14/99 - 9/25/99	Cyanide, WAD 6/10/99 - 6/12/99	Cyanide, WAD 6/22/99 - 6/25/99	Cyanide, WAD 7/16/99 - 7/18/99	Cyanide, WAD 9/14/99 - 9/25/99	Iron, total 6/10/99 - 6/12/99	Iron, total 6/22/99 - 6/25/99	Iron, total 7/16/99 - 7/18/99	Iron, total 9/14/99 - 9/25/99
Meadow Creek													
Meadow Creek	2040320	1.6J	<3	<1.5	<1J	1.1J	<5	<1.5	<1J	<92	44J	<34	<16
Meadow Creek	MC-1A	1.1J	<4.1	<1.5	<1J	1.1J	<5	<1.5	<1J	180	88J	<82	<55
Meadow Creek	MC-1C	3.7J	<5.4	<1.5	<1J	2.4J	<5	<1.5	<1J	<120	86J	<78	140
Meadow Creek	2040368	3J	<3	2.9	<1J	1.1J	<5	<1.5	<1J	190	120J	<120	200
Meadow Creek	2040322	1.5J	<5	2.1	<1J	2.8J	<5	<1.5	<1J	60J	94J	<120	190
Blowout Creek	BL-1	1.5J	<5.6	<1.5	<1J	1.1J	<5	<1.5	<1J	160	160J	<48	<100
Meadow Creek	MC-2A	3.2J	<3	<1.5	<1J	2.5J	<5	<1.5	<1J	<130	87J	<100	180
Meadow Creek	MC-2B	4.5J	<8.2	3.1	<1J	2J	<5	<1.5	<1J	150	160J	<120	220
Meadow Creek	2040319	5.3	<4.1	1.8	<1J	2.8J	<5	<1.5	<1J	200	180J	130	200
Upper EFSFSR													
EFSFSR	EF-2	NA	NA	NA	NA	NA	NA	NA	NA	<110	120J	<34	<16
EFSFSR	2040313	2.1J	<3.6	<1.5	<1J	1.3J	<5	<1.5	<1J	140	100J	90	<97
EFSFSR	2040324	NA	NA	NA	NA	NA	NA	NA	NA	140	130J	76	<82
Midnight Creek	2040321	NA	NA	NA	NA	NA	NA	NA	NA	48J	220	<110	<69
Lower EFSFSR													
EFSFSR	2040369	NA	NA	NA	NA	NA	NA	NA	NA	170	150J	74	<87
Glory Hole	GH1-A											65	<110
Glory Hole	GH1-B											81	200
Glory Hole	GH2-A											69	<59
Glory Hole	GH2-B											71	<63
Glory Hole	GH2-C											84	<85
Glory Hole	GH3-A											110	<180
Glory Hole	GH3-B											150	210
EFSFSR	EF-7	NA	NA	NA	NA	NA	NA	NA	NA	140	180	73	<150
EFSFSR	2040308	NA	NA	NA	NA	NA	NA	NA	NA	150	200	100	190
Hennessey Creek	HC-1A	NA	NA	NA	NA	NA	NA	NA	NA	38J	<66	<45	<72
Hennessey Creek	HC-2	NA	NA	NA	NA	NA	NA	NA	NA	110J	<74	140	<45
EFSFSR	2040314	NA	NA	NA	NA	NA	NA	NA	NA	<120	180	65	<100
Sugar Creek													
Sugar Creek	2040309	NA	NA	NA	NA	NA	NA	NA	NA	<120	160	28	<16
Sugar Creek	SC-3	NA	NA	NA	NA	NA	NA	NA	NA	150	140	31	<32
Sugar Creek	2040316	NA	NA	NA	NA	NA	NA	NA	NA	140	170	30	<19

NS = Not sampled.
NA = Not analyzed.

Table 7-2
Surface Water Quality Results
(1999; Total Metals and Cyanide, µg/L)

	Chemical	Lead, total				Magnesium, total				Manganese, total			
Area/Stream	Date / Station	6/10/99 - 6/12/99	6/22/99 - 6/25/99	7/16/99 - 7/18/99	9/14/99 - 9/25/99	6/10/99 - 6/12/99	6/22/99 - 6/25/99	7/16/99 - 7/18/99	9/14/99 - 9/25/99	6/10/99 - 6/12/99	6/22/99 - 6/25/99	7/16/99 - 7/18/99	9/14/99 - 9/25/99
Meadow Creek													
Meadow Creek	2040320	<0.5	<0.5	<0.5	<0.5	810	590	1030	1740	4.4	4.5	2.3	0.94J
Meadow Creek	MC-1A	0.9	1	<0.5	<0.5	880	660	1160	1920	6.8	7.2	6	6.7
Meadow Creek	MC-1C	0.7	1	<0.5	<0.5	1030	740	1270	2220	8.8	8.7	14.8	39.1
Meadow Creek	2040368	1.1	1.1	<0.5	<0.5	1060	780	1400	2610	13.2	10.6	26.4	67.9
Meadow Creek	2040322	<0.5	9.7	<0.5	<0.5	1040	780	1410	2750	13	10	26.6	63.5
Blowout Creek	BL-1	0.5	<0.5	<0.5	<0.5	1390	1100	1920	2340	5	7.3	5	5.4
Meadow Creek	MC-2A	1.8	0.9	<0.5	<0.5	1180	820	1580	2690	11.3	10.1	22.2	53.5
Meadow Creek	MC-2B	0.6	1	<0.5	<0.5	1280	890	1700	2700	17.9	14.3	28.8	55.9
Meadow Creek	2040319	0.5	1	<0.5	<0.5	1290	910	1640	2890	19.3	15.7	27.1	53.8
Upper EFSFSR													
EFSFSR	EF-2	<0.5	<0.5	<0.5	<0.5	1600	1140	2090	2780	5.7	9.2	2.8	<1.61
EFSFSR	2040313	<0.5	4.6	<0.5	<0.5	1510	1020	1820	2910	12.9	10.7	17	26.7
EFSFSR	2040324	<0.5	0.6	<0.5	<0.5	1480	960	1860	3190	11.8	11.3	13.3	19.2
Midnight Creek	2040321	<0.5	<0.5	<0.5	<0.15	5610	4800	7980	8190	3.4	7.9	3.9	3
Lower EFSFSR													
EFSFSR	2040369	<0.5	0.7	<0.5	<0.5	1630	1150	2040	3370	12.4	13.1	10.8	13.5
Glory Hole	GH1-A			<0.5	<0.5			2360	3550			24.4	39.4
Glory Hole	GH1-B			<0.5	<0.5			2200	3560			32.3	65.1
Glory Hole	GH2-A			<0.5	<0.5			2210	3400			22.2	28.3
Glory Hole	GH2-B			<0.5	<0.5			2200	3420			23.9	37.2
Glory Hole	GH2-C			<0.5	<0.5			2130	3410			27	50.1
Glory Hole	GH3-A			<0.5	<0.5			2140	3490			22.3	46.6
Glory Hole	GH3-B			<0.5	<0.5			2150	3450			24.2	50.3
EFSFSR	EF-7	<0.5	0.5	<0.5	<0.5	1720	1110	2150	3540	14.3	12.9	23.3	46
EFSFSR	2040308	0.5	0.6	<0.5	<0.5	1820	1160	2230	5790	18.2	16.1	26.4	38.5
Hennessey Creek	HC-1A	<0.5	<0.5	<0.5	<0.5	330	230	390	620	3.3	3.6	2.4	3.3
Hennessey Creek	HC-2	<0.5	<0.5	<0.5	<0.5	1140	630	790	1090	6.6	3.9	3.6	<2.2
EFSFSR	2040314	<0.5	<0.5	<0.5	<0.5	2070	1400	2480	3750	10.3	11.6	13.8	18.8
Sugar Creek													
Sugar Creek	2040309	<0.5	<0.5	<0.5	<0.5	1600	1340	2070	2700	3.2	6.3	1.58	<0.62
Sugar Creek	SC-3	<0.5	<0.5	<0.5	<0.5	2150	1600	2740	4000	4.3	6.5	1.56	<1.36
Sugar Creek	2040316	<0.5	<0.5	<0.5	<0.5	2240	1660	2840	4080	4.3	6.8	1.62	<2.3

NS = Not sampled.
NA = Not ana

Table 7-2
Surface Water Quality Results
(1999; Total Metals and Cyanide, µg/L)

Area/Stream	Chemical Date Station	Mercury, total				Nickel, total				Selenium, total			
		6/10/99 - 6/12/99	6/22/99 - 6/25/99	7/16/99 - 7/18/99	9/14/99 - 9/25/99	6/10/99 - 6/12/99	6/22/99 - 6/25/99	7/16/99 - 7/18/99	9/14/99 - 9/25/99	6/10/99 - 6/12/99	6/22/99 - 6/25/99	7/16/99 - 7/18/99	9/14/99 - 9/25/99
Meadow Creek													
Meadow Creek	2040320	<0.042J	<0.042J	<0.057	<0.042	<3	<3	<3J	<3J	<1.6J	<1.6J	<1.6	<1.6
Meadow Creek	MC-1A	<0.042J	<0.042J	<0.042	<0.042	<3	<3	<3J	<3J	<1.6J	<1.6J	<1.6	<1.6
Meadow Creek	MC-1C	<0.042J	<0.042J	<0.042	<0.042	<3	<3	<3J	<3J	<1.6J	<1.6J	<1.6	<1.6
Meadow Creek	2040368	<0.042J	<0.042J	<0.042	0.044	<3	<3	<3J	<3J	<1.6J	<1.6J	<1.6	<1.6
Meadow Creek	2040322	<0.042J	<0.042J	<0.042	0.054	<3	<3	<3J	<3J	<1.6J	<1.6J	<1.6	<1.6
Blowout Creek	BL-1	<0.042J	<0.042J	<0.042	<0.042	<3	<3	<3J	<3J	<1.6J	<1.6J	<1.6	<1.6
Meadow Creek	MC-2A	<0.042J	<0.042J	<0.042	<0.042	<3	<3	<3J	<3J	<1.6J	<1.6J	<1.6	<1.6
Meadow Creek	MC-2B	<0.042J	<0.042J	<0.052	<0.042	<3	<3	<3J	<3J	<1.6J	<1.6J	<1.6	<1.6
Meadow Creek	2040319	<0.042J	<0.042J	<0.047	<0.054	<3	<3	<3J	<3	<1.6J	<1.6J	<1.6	<1.6
Upper EFSFSR													
EFSFSR	EF-2	<0.042J	<0.042J	<0.042	<0.075	<3	<3	<3J	<3	<1.6J	<1.6J	<1.6	<1.6
EFSFSR	2040313	<0.042J	<0.042J	<0.042J	<0.06	<3	<3	<3	<3	<1.6J	<1.6J	<1.6	<1.6
EFSFSR	2040324	<0.042J	<0.042J	<0.042J	<0.042	<3	<3	<3	<3.5	<1.6J	<1.6J	<1.6	<1.6
Midnight Creek	2040321	<0.042J	<0.042J	<0.042	0.131	<3	<3	<3J	<3J	<1.6J	<1.6J	<1.6	<1.6
Lower EFSFSR													
EFSFSR	2040369	<0.042J	<0.042J	<0.042J	<0.042	<3	<3	<3	<3	<1.6J	<1.6J	<1.6	<1.6
Glory Hole	GH1-A			<0.042J	<0.056			<3	<3			<1.6	<1.6
Glory Hole	GH1-B			<0.042J	<0.064			<3	<3			<1.6	<1.6
Glory Hole	GH2-A			<0.042J	<0.042			<3	<3			<1.6	<1.6
Glory Hole	GH2-B			<0.042J	<0.063			<3	<3			<1.6	<1.6
Glory Hole	GH2-C			<0.042J	<0.042			<3	<3			<1.6	<1.6
Glory Hole	GH3-A			<0.042J	<0.05			<3	<3			<1.6	<1.6
Glory Hole	GH3-B			<0.042J	<0.059			<3	14.4			<1.6	<1.6
EFSFSR	EF-7	<0.042J	<0.042J	<0.042J	<0.063	<3	<3	<3	<3	<1.6J	<1.6J	<1.6	<1.6
EFSFSR	2040308	<0.042J	<0.042J	<0.042J	<0.045	<3	<3	<3	<3	<1.6J	<1.6J	<1.6	<1.6
Hennessey Creek	HC-1A	<0.042J	<0.042J	<0.042	<0.061	<3	<3	<3J	<3	<1.6J	<1.6J	<1.6	<1.6
Hennessey Creek	HC-2	<0.042J	<0.042J	<0.042	<0.071	<3	<3	<3J	<3	<1.6J	<1.6J	<1.6	<1.6
EFSFSR	2040314	0.098J	0.39J	<0.042J	<0.067	<3	<3	<3	<3	<1.6J	<1.6	<1.6	<1.6
Sugar Creek													
Sugar Creek	2040309	0.27J	0.24J	<0.042J	<0.074	<3	<3	<3	<3	<1.6J	<1.6J	<1.6	<1.6
Sugar Creek	SC-3	0.199J	0.33J	0.047J	<0.042J	<3	<3	<3	<3	<1.6J	<1.6J	<1.6	<1.6
Sugar Creek	2040316	0.153J	0.25J	<0.042J	<0.042J	<3	<3	<3	<3	<1.6J	<1.6J	<1.6	<1.6

NS = Not sampled.

NA = Not analyzed.

Table 7-2
Surface Water Quality Results
(1999; Total Metals and Cyanide, µg/L)

Area/Stream	Chemical Date Station	Silver, total 6/10/99 - 6/12/99	Silver, total 6/22/99 - 6/25/99	Silver, total 7/16/99 - 7/18/99	Silver, total 9/14/99 - 9/25/99	Zinc, total 6/10/99 - 6/12/99	Zinc, total 6/22/99 - 6/25/99	Zinc, total 7/16/99 - 7/18/99	Zinc, total 9/14/99 - 9/25/99	Hardness (mg/L as $CaCO_3$) 6/10/99 - 6/12/99	Hardness (mg/L as $CaCO_3$) 6/22/99 - 6/25/99	Hardness (mg/L as $CaCO_3$) 7/16/99 - 7/18/99	Hardness (mg/L as $CaCO_3$) 9/14/99 - 9/25/99
Meadow Creek													
Meadow Creek	2040320	<0.066	<0.066J	<0.066J	<0.066	<3.6	<3.6	<3.6	<3.6	16.9	15.5	20	33.7
Meadow Creek	MC-1A	<0.066	<0.066J	<0.066J	<0.066	<3.6	<3.6	<3.6	<3.6	19.5	16.7	22.5	36.2
Meadow Creek	MC-1C	<0.066	<0.066J	<0.066J	<0.066	<3.6	<3.6	<3.6	<3.6	23.7	18.1	25.7	42.7
Meadow Creek	2040368	<0.066	<0.066J	<0.066J	<0.066	<3.6	<3.6	<3.6	<3.6	23.7	17.7	25.5	48.4
Meadow Creek	2040322	<0.066	<0.066J	<0.066J	<0.066	<3.6	<3.6	<3.6	<3.6	31.7	18.9	28.9	49.6
Blowout Creek	BL-1	<0.066	<0.066J	<0.066J	<0.066	<3.6	<3.6	<3.6	<3.6	24.9	20.3	29.6	38.0
Meadow Creek	MC-2A	<0.066	<0.066J	<0.066J	<0.066	<3.6	<3.6	4.2	7.2	25.5	21.3	27.9	47.2
Meadow Creek	MC-2B	<0.066	<0.066J	<0.066J	<0.066	<3.6	<3.6	<3.6	<3.6	27.1	20.9	28.7	47.8
Meadow Creek	2040319	<0.066	<0.066J	<0.066J	<0.066	<3.6	<3.6	3.8	<3.6	25.7	19.5	31.2	49.2
Upper EFSFSR													
EFSFSR	EF-2	<0.066	<0.066J	<0.066J	<0.066	<3.6	<3.6	<3.6	19.7	25.3	20.3	27.5	36.6
EFSFSR	2040313	<0.066	<0.066J	<0.066J	<0.066	<3.6	<3.6	<3.6	29	25.3	20.3	29.4	44.9
EFSFSR	2040324	<0.066	<0.066J	<0.066J	<0.066	<3.6	<3.6	<3.6	48	24.9	19.3	31.4	47.6
Midnight Creek	2040321	<0.066	<0.066J	<0.066J	<0.066	<3.6	<3.6	3.6	3.8	77	67.8	90.3	99
Lower EFSFSR													
EFSFSR	2040369	<0.066	<0.066J	<0.066J	<0.066	<3.6	<3.9	<3.6	<6.1	26.9	24.5	34.0	51.2
Glory Hole	GH1-A			<0.066J	<0.066			<3.6	<3.6				
Glory Hole	GH1-B			<0.066J	<0.066			<3.6	<3.6			34.4	52.4
Glory Hole	GH2-A			<0.066J	<0.066			<9.9	<3.6			33.6	51.6
Glory Hole	GH2-B			<0.066J	<0.066			<3.6	<3.6			32.4	51.0
Glory Hole	GH2-C			<0.066J	<0.066			<3.6	18			33.2	51.8
Glory Hole	GH3-A			<0.066J	<0.066			<4.5	<7.2			32.8	51.8
Glory Hole	GH3-B			<0.066J	<0.066			<3.6	<3.6			33.4	50.4
EFSFSR	EF-7	<0.066	<0.066	<0.066J	<0.066	<3.6	<3.6	<3.6	<3.6	28.3	20.9	32.6	51.6
EFSFSR	2040308	<0.066	<0.066	<0.066J	<0.066	<3.6	<3.6	<3.6	<3.6	28.7	21.1	35.8	53.7
Hennessey Creek	HC-1A	<0.066	<0.066	<0.066J	<0.066	<3.6	<3.6	7.5	<5.1	10.3	8.2	12.3	17.3
Hennessey Creek	HC-2	<0.066	<0.066	<0.066J	<0.066	5.8	<3.6	<3.6	<3.6	23.6	12.3	13.8	19.3
EFSFSR	2040314	<0.07	0.129	0.111J	<0.066	<3.6	11.9	<3.6	<3.6	35.5	30.8	39.3	58.3
Sugar Creek													
Sugar Creek	2040309	<0.066	<0.066	<0.066J	<0.066	<3.6	<3.6	<3.6	<3.6	32.7	29	39.9	53.5
Sugar Creek	SC-3	<0.066	<0.066	<0.066J	<0.066	<3.6	<3.6	<3.6	8	39.8	32.0	44.7	63.9
Sugar Creek	2040316	<0.066	<0.066	<0.066J	<0.066	<3.6	<3.6	<3.6	<3.6	40.2	32.4	46.6	64.5

NS = Not sampled.
NA = N[illegible]lyzed.

Table 7-3
Surface Water Quality Results
(1999; Dissolved Metals, µg/L)

	Chemical	Aluminum, dissolved				Antimony, dissolved				Arsenic, dissolved			
Area/Stream	Date Station	6/10/99 - 6/12/99	6/22/99 - 6/25/99	7/16/99 - 7/18/99	9/14/99 - 9/25/99	6/10/99 - 6/12/99	6/22/99 - 6/25/99	7/16/99 - 7/18/99	9/14/99 - 9/25/99	6/10/99 - 6/12/99	6/22/99 - 6/25/99	7/16/99 - 7/18/99	9/14/99 - 9/25/99
Meadow Creek													
Meadow Creek	2040320	<52	<52	<52	<52	<5.3	<5.3	<5.3	<5.3	<7	<7J	<7	<7J
Meadow Creek	MC-1A	<52	<52	<52	<52	<5.3	<5.3	<5.3	<5.3	<7	<7J	<7	<7J
Meadow Creek	MC-1C	<52	<52	<52	<52	<5.3	<5.3	9.2	9.9	14	<7J	22	40
Meadow Creek	2040368	<52	<52	<52	<52	5.7	7.4	9.3	13	24	13J	24	45
Meadow Creek	2040322	<52	<52	<52	<52	10	6.2	11	12	30	12J	30	46
Blowout Creek	BL-1	<52	<52	<52	<52	<5.3	<5.3	<5.3	<5.3	<7	<7J	<11	<7J
Meadow Creek	MC-2A	<52	<52	<52	<52	10	<5.3	8.5	8.6	25	12J	24	36
Meadow Creek	MC-2B	<52	<52	<52	<52	18	13	15	18	39	17J	43	64
Meadow Creek	2040319	<52	<52	<52	<52J	23	12	19	23	40	17J	42	58
Upper EFSFSR													
EFSFSR	EF-2	<52	<52	<52	<52J	<5.3	<5.3	<5.3	<5.3	<7	<7J	<11	7.2J
EFSFSR	2040313	<52	<52	<52	<52	19	11	<13	<15	27	12J	19J	33
EFSFSR	2040324	<52	<52	<52	<52J	21	13	<16	22	28	9.1J	23J	39
Midnight Creek	2040321	<52	<52	<52	<52	42	39	44	51	75	54	75	91
Lower EFSFSR													
EFSFSR	2040369	<52	<52	<52	<52J	25	15	<20	31	32	17J	28J	44
Glory Hole	GH1-A			<52	<52			31	35			59	69
Glory Hole	GH1-B			<52	<52			22	31			56	78
Glory Hole	GH2-A			<52	<52J			25	33			45	70
Glory Hole	GH2-B			<52	<52J			24	34			45	76
Glory Hole	GH2-C			<52	<52J			22	32			44	85
Glory Hole	GH3-A			<52	<52J			27	34			40	67
Glory Hole	GH3-B			<52	<52J			23	35			44	68
EFSFSR	EF-7	<52	<52	<52	<52J	29	17	25	33	38	22	44	68
EFSFSR	2040308	<52	<78	<52	<52J	30	16	26	39	39	24	53	96
Hennessey Creek	HC-1A	<52	<52	<52	<52J	<5.3	<5.3	<5.3	<6.6	<7	<7J	<7	<7J
Hennessey Creek	HC-2	<52	<52	<52	<52J	36	31	29	25	45	39	20	14J
EFSFSR	2040314	<52	<52	<52	<52J	14	9.5	<17	26	26	16	32	57
Sugar Creek													
Sugar Creek	2040309	<52	<52	<52	<52J	<5.3	<5.3	<5.3	<5.3	<7	<7J	<7J	7.1J
Sugar Creek	SC-3	<52	<52	<52	<52	<5.3	<5.3	<5.3	<5.3	<7	<7J	7.7J	11J
Sugar Creek	2040316	<52	<52	<52	<52	<5.3	<5.3	<5.3	6.3	8.2	<7J	8J	16J

NS = Not sampled.

Table 7-3
Surface Water Quality Results
(1999; Dissolved Metals, µg/L)

	Chemical	Cadmium, dissolved				Chromium, dissolved				Copper, dissolved			
Area/Stream	Date Station	6/10/99 - 6/12/99	6/22/99 - 6/25/99	7/16/99 - 7/18/99	9/14/99 - 9/25/99	6/10/99 - 6/12/99	6/22/99 - 6/25/99	7/16/99 - 7/18/99	9/14/99 - 9/25/99	6/10/99 - 6/12/99	6/22/99 - 6/25/99	7/16/99 - 7/18/99	9/14/99 - 9/25/99
Meadow Creek													
Meadow Creek	2040320	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7J	<1.7	<1.7	<1.7	<1.7J	<2	<2
Meadow Creek	MC-1A	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7J	<1.7	<1.7	<1.7	<1.7J	<1.9	<1.7
Meadow Creek	MC-1C	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7J	<1.7	<1.7	<1.7	<1.7J	<2	<1.7
Meadow Creek	2040368	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7J	<1.7	<1.7	<1.7	<1.7J	<2.4	<1.7
Meadow Creek	2040322	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7J	<1.7	<1.7	<1.7	<1.7J	<1.7	<1.7
Blowout Creek	BL-1	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7J	<1.7	<1.7	<1.7	<1.7J	<1.8	<1.7
Meadow Creek	MC-2A	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7J	<1.7	<1.7	<1.7	<1.7J	<1.7	<1.7
Meadow Creek	MC-2B	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7J	<1.7	<1.7	<1.7	<1.7J	<1.7	<2.1
Meadow Creek	2040319	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7J	<1.7	<1.7	<1.7	<1.7J	<1.7	<1.7
Upper EFSFSR													
EFSFSR	EF-2	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7J	<1.7	<1.7	<1.7	<1.7J	<1.7	<1.7
EFSFSR	2040313	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7J	<1.7	<1.7	<1.7	<1.7J	<1.7J	<1.7
EFSFSR	2040324	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7J	<1.7	<1.7	<1.7	<1.7J	4.7J	<1.7
Midnight Creek	2040321	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7J	<1.7	<1.7	<1.7	<1.7J	<1.7	<1.9
Lower EFSFSR													
EFSFSR	2040369	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7J	<1.7	<1.7	<1.7	<1.7J	<1.7J	<1.7
Glory Hole	GH1-A			<0.63	<0.63			<1.7	<1.7			<1.7J	<1.7
Glory Hole	GH1-B			<0.63	<0.63			<1.7	<1.7			<1.7J	<1.7
Glory Hole	GH2-A			<0.63	<0.63			<1.7	<1.7			<1.7J	<1.7
Glory Hole	GH2-B			<0.63	<0.63			<1.7	<1.7			<1.7J	<1.7
Glory Hole	GH2-C			<0.63	<0.63			<1.7	<1.7			<2.5J	<1.7
Glory Hole	GH3-A			<0.63	<0.63			<1.7	<1.7			<1.7J	<1.7
Glory Hole	GH3-B			<0.63	<0.63			<1.7	<1.7			<1.7J	<1.7
EFSFSR	EF-7	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7J	<1.7	<1.7	<1.7	<1.7	<1.7J	<1.7
EFSFSR	2040308	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7J	<1.7	<1.7	<1.7	<1.7	<1.7J	<1.7
Hennessey Creek	HC-1A	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7J	<1.7	<1.7	<1.7	<1.7	<1.9	<2.7
Hennessey Creek	HC-2	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7J	<1.7	<1.7	<1.9	<1.7	<1.7	<1.7
EFSFSR	2040314	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7J	<1.7	<1.7	<1.7	<1.7	<1.7J	<1.7
Sugar Creek													
Sugar Creek	2040309	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7J	<1.7	<1.7	<1.7	<1.7	<1.7J	<1.7
Sugar Creek	SC-3	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7J	<1.7	<1.7	<1.7	<1.7	<1.9J	2.1
Sugar Creek	2040316	<0.63	<0.63	<0.63	<0.63	<1.7	<1.7J	<1.7	<1.7	<1.7	<1.7	<2J	2.9

NS = Not sampled.

Table 7-3
Surface Water Quality Results
(1999; Dissolved Metals, µg/L)

	Chemical	Iron, dissolved				Lead, dissolved				Magnesium, dissolved			
Area/Stream	Date Station	6/10/99 - 6/12/99	6/22/99 - 6/25/99	7/16/99 - 7/18/99	9/14/99 - 9/25/99	6/10/99 - 6/12/99	6/22/99 - 6/25/99	7/16/99 - 7/18/99	9/14/99 - 9/25/99	6/10/99 - 6/12/99	6/22/99 - 6/25/99	7/16/99 - 7/18/99	9/14/99 - 9/25/99
Meadow Creek													
Meadow Creek	2040320	<16	<35	<32	<30	<0.5	<0.5	<0.5	<0.5	800	670	840	1820
Meadow Creek	MC-1A	27	<22	<45	<53	<0.5	<0.5	<0.5	<0.5	870	700	1020	1980
Meadow Creek	MC-1C	<16	<32	<37	<94	<0.5	<0.5	<0.5	<0.5	980	770	1150	2400
Meadow Creek	2040368	21	<22	<55	<130	<0.5	<0.5	<0.5	1.4	1010	840	1240	2820
Meadow Creek	2040322	<16	<24	<65	<130	<0.5	<0.5	<0.5	<0.5	1040	850	1200	2690
Blowout Creek	BL-1	17	<35	<30	<54	<0.5	<0.5	<0.5	<0.5	1330	1170	1640	2520
Meadow Creek	MC-2A	19	<20	<45	<120	<0.5	1.2	<0.5	<0.5	1160	930	1320	2600
Meadow Creek	MC-2B	35	<29	<80	<140	<0.5	<0.5	<0.5	<0.5	1230	960	1400	2720
Meadow Creek	2040319	41	<28	<75	76J	<0.5	<0.5	<0.5	<0.5	1250	970	1390	2590
Upper EFSFSR													
EFSFSR	EF-2	<16	<16	<40	<16J	<0.5	<0.5	<0.5	<0.5	1590	1230	1710	2470
EFSFSR	2040313	17	<21	<33	21J	<0.5	<0.5	<0.5	<0.5	1450	1100	1810	2730
EFSFSR	2040324	19	<16	<26	<16J	<0.5	<0.5	<0.5	<0.5	1420	1070	1870	2960
Midnight Creek	2040321	<16	<16	<27	<32	<0.5	<0.5	<0.5	<0.5	5870	5170	6730	9010
Lower EFSFSR													
EFSFSR	2040369	22	<34	<21	<16J	<0.5	<0.5	<0.5	<0.5	1600	1240	2060	3050
Glory Hole	GH1-A			<34	48J			<0.5	<0.5			2350	3170
Glory Hole	GH1-B			<39	30J			<0.5	<0.5			2170	3120
Glory Hole	GH2-A			<37	73J			<0.5	<0.5			2110	3210
Glory Hole	GH2-B			<30	110			<0.5	<0.5			2120	3180
Glory Hole	GH2-C			<37	210			<0.5	<0.5			2030	3100
Glory Hole	GH3-A			<36	26J			<0.5	<0.5			2150	3120
Glory Hole	GH3-B			<37	18J			<0.5	<0.5			2140	3150
EFSFSR	EF-7	23	27	<31	50J	<0.5	<0.5	<0.5	<0.5	1690	1200	2140	3170
EFSFSR	2040308	31	40	<51	70J	<0.5	<0.5	<0.5	<0.5	1780	1220	2220	3330
Hennessey Creek	HC-1A	<16	<16	<27	<16J	<0.5	<0.5	<0.5	<0.5	320	250	350	530
Hennessey Creek	HC-2	<16	22	<45	<16J	<0.5	<0.5	<0.5	<0.5	1090	660	710	930
EFSFSR	2040314	20	27	<41	<16J	<0.5	<0.5	<0.5	<0.5	1990	1470	2410	3430
Sugar Creek													
Sugar Creek	2040309	<16	<16	<16	<16J	<0.5	<0.5	<0.5	<0.5	1530	1370	2020	2470
Sugar Creek	SC-3	<16	<16	<16	<23J	<0.5	<0.5	<0.5	0.5	2040	1680	2800	3860
Sugar Creek	2040316	<16	29	<16	<60J	<0.5	<0.5	<0.5	<0.5	2150	1770	2810	4010

NS = Not sampled.

Table 7-3
Surface Water Quality Results
(1999; Dissolved Metals, µg/L)

Area/Stream	Chemical Date Station	Manganese, dissolved 6/10/99 - 6/12/99	6/22/99 - 6/25/99	7/16/99 - 7/18/99	9/14/99 - 9/25/99	Mercury, dissolved 6/10/99 - 6/12/99	6/22/99 - 6/25/99	7/16/99 - 7/18/99	9/14/99 - 9/25/99	Nickel, dissolved 6/10/99 - 6/12/99	6/22/99 - 6/25/99	7/16/99 - 7/18/99	9/14/99 - 9/25/99
Meadow Creek													
Meadow Creek	2040320	1.61	2.5	2.4	2.9	<0.042J	<0.042J	<0.042	<0.042J	<3J	<3J	<3	<3
Meadow Creek	MC-1A	5	3.5	5.3	8.4	0.085J	<0.042J	0.084	<0.042J	<3J	<3J	<3	<3
Meadow Creek	MC-1C	8.2	5.7	12.5	38.7	<0.042J	<0.042J	<0.042	<0.042J	<3J	<3J	<3	<3
Meadow Creek	2040368	10.3	7.6	22.6	66.5	0.109J	<0.042J	<0.042	<0.042J	<3J	<3J	<3	<3
Meadow Creek	2040322	11.3	7.2	24.1	64.6	<0.042J	<0.042J	<0.042	<0.042J	<3	<3J	<3	<3
Blowout Creek	BL-1	2.5	2.6	3.8	5.8	<0.042J	<0.058J	0.053	<0.042J	<3J	<3J	<3	<3
Meadow Creek	MC-2A	10.2	6.6	19.7	51.7	<0.042J	<0.042J	0.057	<0.042J	<3J	<3J	<3	<3
Meadow Creek	MC-2B	17.9	9.9	24.1	56.9	<0.042J	<0.045J	0.082	<0.042J	<3J	<3J	<3	<3
Meadow Creek	2040319	16.9	9.8	22.7	49.8	<0.042J	<0.099J	<0.042	<0.042J	<3J	<3J	<3	<3
Upper EFSFSR													
EFSFSR	EF-2	1.01	1.46	1.4	2.7J	<0.042J	<0.042J	0.066	<0.042J	<3J	<3J	<3	<3
EFSFSR	2040313	10.3	6.4	14.5	24.2J	<0.042J	<0.042J	<0.042J	<0.042J	<3J	<3J	<3	<3
EFSFSR	2040324	8.3	5.4	11.4	17.7J	<0.042J	<0.042J	<0.042J	<0.042J	<3J	<3J	<3	<3
Midnight Creek	2040321	<0.96	<1.03	0.96	4.2	<0.042J	<0.088J	<0.042	<0.042J	<3	<3J	<3	<3
Lower EFSFSR													
EFSFSR	2040369	8.8	6.4	8.7	10.7J	<0.042J	<0.042J	<0.042J	<0.042J	<3J	<3J	<3	<3
Glory Hole	GH1-A			25	34.2J			<0.042J	<0.042J			<3	<3
Glory Hole	GH1-B			31.4	52.4J			<0.042J	<0.042J			<3	<3
Glory Hole	GH2-A			21.7	33.6J			<0.042J	<0.042J			<3	<3
Glory Hole	GH2-B			23.4	50.2J			<0.042J	<0.042J			<3	<3
Glory Hole	GH2-C			26.3	64.4J			<0.042J	<0.042J			<3	<3
Glory Hole	GH3-A			21.9	37			<0.042J	<0.042J			<3	<3
Glory Hole	GH3-B			22.5	39.2J			<0.042J	0.23			<3	<3
EFSFSR	EF-7	12.4	7.4J	22.3	35.3J	<0.042J	<0.042J	<0.042J	<0.042J	<3J	<3J	<3	<3
EFSFSR	2040308	15.8	8.9J	24.4	32.8J	<0.042J	<0.042J	<0.042J	<0.042J	<3J	<3J	<3	<3
Hennessey Creek	HC-1A	<0.69	0.7J	<0.81	2.4J	<0.042J	<0.042J	<0.042	<0.042J	<3	<3J	<3	<3
Hennessey Creek	HC-2	<2.4	1.49J	1	2.6J	<0.042J	<0.042J	0.061	<0.042J	<3	<3J	<3	<3
EFSFSR	2040314	7.7	114J	12.5	17.9J	<0.042J	<0.042J	<0.042J	<0.042J	<3J	<3J	<3	<3
Sugar Creek													
Sugar Creek	2040309	0.84	0.98J	1.2	3.2	<0.042J	<0.042J	<0.042J	<0.042J	<3J	<3J	<3	<3
Sugar Creek	SC-3	0.8	0.78J	1.03	3	<0.042J	0.047J	<0.042J	<0.042J	<3J	<3J	<3	<3
Sugar Creek	2040316	1.34	1.05J	1.24	1.83	<0.042J	<0.042J	<0.042J	<0.042J	<3J	<3J	<3	<3

NS = Not sampled.

Table 7-3
Surface Water Quality Results
(1999; Dissolved Metals, µg/L)

	Chemical	Selenium, dissolved				Silver, dissolved				Zinc, dissolved			
	Date	6/10/99 -	6/22/99 -	7/16/99 -	9/14/99 -	6/10/99 -	6/22/99 -	7/16/99 -	9/14/99 -	6/10/99 -	6/22/99 -	7/16/99 -	9/14/99 -
Area/Stream	Station	6/12/99	6/25/99	7/18/99	9/25/99	6/12/99	6/25/99	7/18/99	9/25/99	6/12/99	6/25/99	7/18/99	9/25/99
Meadow Creek													
Meadow Creek	2040320	<1.6J	<1.6	<1.6	<1.6J	<0.066	<0.066J	<0.071J	<0.066	<6.2	4.3	<25J	<4.2
Meadow Creek	MC-1A	<1.6J	<1.6	<1.6	<1.6J	<0.066	<0.066J	<0.066J	<0.066	<4.5	42	<9.6J	<3.6
Meadow Creek	MC-1C	<1.6J	<1.6	<1.6	<1.6J	<0.066	<0.066J	<0.066J	<0.066	<4.5	<3.6	<3.6J	<4.2
Meadow Creek	2040368	<1.6J	<1.6	<1.6	<1.6J	<0.066	<0.066J	<0.066J	<0.066	<4.7	<3.6	<3.6J	<5.7
Meadow Creek	2040322	<1.6J	<1.6	<1.6	<1.6J	<0.066	<0.066J	<0.066J	<0.066	6	<3.6	<11.7J	<3.9
Blowout Creek	BL-1	<1.6J	<3.6	<1.6	<1.6J	<0.066	<0.066J	<0.066J	<0.066	<4.2	<3.6	<3.6J	<3.6
Meadow Creek	MC-2A	<1.6J	<1.6	<1.6	<1.6J	<0.066	<0.066J	<0.066J	<0.066	<3.9	<3.6	<5.9J	<6.6
Meadow Creek	MC-2B	<1.6J	<1.6	<1.6	<1.6J	<0.066	<0.066J	<0.082J	<0.066	<3.6	<3.6	<3.6J	<4.2
Meadow Creek	2040319	<1.6J	<1.6	<1.6	<1.6	<0.066	<0.066J	<0.066J	<0.066	<3.8	<3.6	<3.6J	<4.3
Upper EFSFSR													
EFSFSR	EF-2	<1.6J	<1.6	<1.6	<1.6	<0.066	<0.066J	<0.176J	0.423	<3.6	<3.6	<5.1J	<3.6
EFSFSR	2040313	<1.6J	<1.6	<1.6J	<1.6	<0.066	<0.066J	<0.066J	<0.066	<3.6	<3.6	<3.6	<3.6
EFSFSR	2040324	<1.6J	<1.6	<1.6J	<1.6	<0.066	<0.066J	<0.066J	<0.066	<4.5	16.7	<15.8	<6.7
Midnight Creek	2040321	<1.6J	<1.6	<1.6	<1.6J	<0.066	<0.066J	<0.066J	<0.066	4.4	<3.6	<3.6J	<4.6
Lower EFSFSR													
EFSFSR	2040369	<1.6J	<1.6	<1.6	<1.6	<0.066	<0.066J	<0.066J	<0.066	<4.2	<3.6	<24	<3.6
Glory Hole	GH1-A			<1.6	<1.6			<0.066J	0.088			<5.6	<4.7
Glory Hole	GH1-B			<1.6	<1.6			<0.066J	<0.066			<4.2	<3.6
Glory Hole	GH2-A			<1.6	<1.6			<0.066J	<0.066			<3.8	<3.6
Glory Hole	GH2-B			<1.6	<1.6			<0.066J	<0.066			<5.3	<3.6
Glory Hole	GH2-C			<1.6	<1.6			<0.066J	<0.066			<9.4	<3.6
Glory Hole	GH3-A			<1.6	<1.6			<0.066J	<0.066			<7.5	<5.7
Glory Hole	GH3-B			<1.6	<1.6			<0.066J	<0.066			<11.3	<5.7
EFSFSR	EF-7	<1.6J	<1.6J	<1.6	<1.6	<0.066	<0.066	<0.066J	<0.066	<15.7	<5.3	<5.4	<3.6
EFSFSR	2040308	<1.6J	<1.6J	<1.6	<1.6	<0.066	<0.066	<0.066J	<0.066	<3.6	<4.4	<3.6	<3.6
Hennessey Creek	HC-1A	<1.6J	<1.6J	<1.6	<1.6	<0.066	<0.066	<0.066J	0.097	16	<4.6	32J	<3.6
Hennessey Creek	HC-2	<1.6J	<1.6J	<1.6	<1.6	<0.066	<0.066	<0.066J	<0.066	14.5	<4.5	<3.6J	<3.6
EFSFSR	2040314	<1.6J	<1.6J	<1.6	<1.6	<0.066	<0.118	0.128J	<0.066	<14.1	<3.9	<3.6	<3.6
Sugar Creek													
Sugar Creek	2040309	<1.6J	<1.6J	<1.6J	<1.6	<0.066	<0.066	<0.066J	<0.066	<14.9	<3.9	<3.6	<3.6
Sugar Creek	SC-3	<1.6J	<1.6J	<1.6J	<1.6J	<0.066	<0.066	<0.066J	<0.066J	<16.7	<3.7	<4.4	<3.6
Sugar Creek	2040316	<1.6J	<1.6J	<1.6	<1.6J	<0.066	<0.066	<0.066J	<0.066J	<15.2	<3.6	<26	<3.7

NS = Not sampled.

Table 7-4

Surface Water Quality Results for Stations UW-1, KW-1 and BTO
(1999; Total Metals and Cyanide, µg/L)

Area/Stream	Chemical Station	Date	Aluminum total	Antimony total	Arsenic total	Cadmium total	Chromium total	Copper total	Cyanide total	Cyanide WAD	Iron total
Meadow Creek	UW-1	6/10/99 - 6/12/99	NS	NS	NS	NS	NS	NS	NS	NS	NS
Meadow Creek	UW-1	6/22/99 - 6/25/99	NS	NS	NS	NS	NS	NS	NS	NS	NS
Meadow Creek	UW-1	7/16/99 - 7/18/99	NS	NS	NS	NS	NS	NS	NS	NS	NS
Meadow Creek	UW-1	9/14/99 - 9/25/99	<133	69	316	<0.63	<1.7	4	NS	NS	840
Keyway	KW-1	6/10/99 - 6/12/99	NS	NS	NS	NS	NS	NS	NS	NS	NS
Keyway	KW-1	6/22/99 - 6/25/99	67	127	304	<0.63	<1.7	<1.7	<7.4	<5	650
Keyway	KW-1	7/16/99 - 7/18/99	<240	97	463	<0.63	<1.7	<1.7J	5.6	<1.5	2520
Keyway	KW-1	9/14/99 - 9/25/99	<57	51	276	<0.63	<1.7	<1.7	<1J	<1J	1460
Bailey Tunnel	BTO	6/10/99 - 6/12/99	<52	260	320	<0.63	<1.7	<1.7	NA	NA	1160
Bailey Tunnel	BTO	6/22/99 - 6/25/99	<52J	281	345	<0.63J	<1.7	<1.7	NA	NA	1030
Bailey Tunnel	BTO	7/16/99 - 7/18/99	<52	229	535	<0.63	<1.7	<1.7	NA	NA	1880
Bailey Tunnel	BTO	9/14/99 - 9/25/99	<52	192	491	<0.63	<1.7	<1.7J	NA	NA	1320

NS = Not sampled.
NA = Not analyzed.

Table 7-4

Surface Water Quality Results for Stations UW-1, KW-1 and BTO (1999; Total Metals and Cyanide, μg/L)

Area/Stream	Chemical Station	Date	Lead total	Magnesium total	Manganese total	Mercury total	Nickel total	Selenium total	Silver total	Zinc total	Hardness (mg/L as $CaCO_3$)
Meadow Creek	UW-1	6/10/99 - 6/12/99	NS	NS	NS	NS	NS	NS	NS	NS	NS
Meadow Creek	UW-1	6/22/99 - 6/25/99	NS	NS	NS	NS	NS	NS	NS	NS	NS
Meadow Creek	UW-1	7/16/99 - 7/18/99	NS	NS	NS	NS	NS	NS	NS	NS	NS
Meadow Creek	UW-1	9/14/99 - 9/25/99	5.3	2130	49.1	<0.042	<3J	<1.6	<0.066	<3.6	NA
Keyway	KW-1	6/10/99 - 6/12/99	NS	NS	NS	NS	NS	NS	NS	NS	NS
Keyway	KW-1	6/22/99 - 6/25/99	<0.5	4360	194	<0.042J	<3	<1.6J	<0.066J	<3.6	76.7
Keyway	KW-1	7/16/99 - 7/18/99	<0.5	8770	785	<0.067	<3J	<1.6	<0.066J	4.4	127
Keyway	KW-1	9/14/99 - 9/25/99	<0.5	11800	726	0.118	<3J	<1.6	<0.066	<3.6	178
Bailey Tunnel	BTO	6/10/99 - 6/12/99	6.4	25000	125	<0.042J	<3	<1.6J	<0.066	6.4	306
Bailey Tunnel	BTO	6/22/99 - 6/25/99	<0.5	20500	105	<0.042	<3	<1.6	0.088	6.5	290
Bailey Tunnel	BTO	7/16/99 - 7/18/99	<0.5	22400	181	<0.042J	<3	<1.6	0.106J	<7.2	248
Bailey Tunnel	BTO	9/14/99 - 9/25/99	<0.5	18900	119	<0.042J	<3	<1.6	<0.066	7.5	240

NS = Not sampled.
NA = Not analyzed.

Table 7-5

Surface Water Quality Results for Stations UW-1, KW-1 and BTO (1999; Dissolved Metals, µg/L)

Area/Stream	Chemical Station	Date	Aluminum dissolved	Antimony dissolved	Arsenic dissolved	Cadmium dissolved	Chromium dissolved	Copper dissolved	Iron dissolved	Lead dissolved
Meadow Creek	UW-1	6/10/99 - 6/12/99	NS	NS	NS	NS	NS	NS	NS	NS
Meadow Creek	UW-1	6/22/99 - 6/25/99	NS	NS	NS	NS	NS	NS	NS	NS
Meadow Creek	UW-1	7/16/99 - 7/18/99	NS	NS	NS	NS	NS	NS	NS	NS
Meadow Creek	UW-1	9/14/99 - 9/25/99	<52	70	295	<0.63	<1.7	<4.3	380	2.4
Keyway	KW-1	6/10/99 - 6/12/99	NS	NS	NS	NS	NS	NS	NS	NS
Keyway	KW-1	6/22/99 - 6/25/99	<52	126	224	<0.63	<1.7J	<1.7J	170	<0.5
Keyway	KW-1	7/16/99 - 7/18/99	<52	85	203	<0.63	<1.7	<2.7	450	<0.5
Keyway	KW-1	9/14/99 - 9/25/99	<52	46	136	<0.63	<1.7	<1.7	470	<0.5
Bailey Tunnel	BTO	6/10/99 - 6/12/99	<52	256	48	<0.63	<1.7	<1.7	<16	<0.5
Bailey Tunnel	BTO	6/22/99 - 6/25/99	<52	281	56	<0.63	<1.7J	<1.7	<16	<0.5
Bailey Tunnel	BTO	7/16/99 - 7/18/99	<52	227	42	<0.63	<1.7	<1.7J	<16	<0.5
Bailey Tunnel	BTO	9/14/99 - 9/25/99	<52	182	57	<0.63	<1.7	<1.7	<43J	<0.5

NS = Not sampled.

Table 7-5

Surface Water Quality Results for Stations UW-1, KW-1 and BTO (1999; Dissolved Metals, µg/L)

Area/Stream	Chemical Station	Date	Magnesium dissolved	Manganese dissolved	Mercury dissolved	Nickel dissolved	Selenium dissolved	Silver dissolved	Zinc dissolved
Meadow Creek	UW-1	6/10/99 - 6/12/99	NS	NS	NS	NS	NS	NS	NS
Meadow Creek	UW-1	6/22/99 - 6/25/99	NS	NS	NS	NS	NS	NS	NS
Meadow Creek	UW-1	7/16/99 - 7/18/99	NS	NS	NS	NS	NS	NS	NS
Meadow Creek	UW-1	9/14/99 - 9/25/99	2210	22	<0.042J	NS	<1.6J	3.67	<3.7
Keyway	KW-1	6/10/99 - 6/12/99	NS	NS	NS	NS	NS	NS	NS
Keyway	KW-1	6/22/99 - 6/25/99	5030	201	<0.08J	<3J	<1.6	<0.066J	<3.6
Keyway	KW-1	7/16/99 - 7/18/99	7810	686	<0.042	<3	<1.6	<0.066J	<3.6J
Keyway	KW-1	9/14/99 - 9/25/99	12400	690	<0.042J	<3	<1.6J	<0.066	<7.2
Bailey Tunnel	BTO	6/10/99 - 6/12/99	24500	127	<0.042J	<3J	<1.6J	<0.066	<18.9
Bailey Tunnel	BTO	6/22/99 - 6/25/99	22000	107J	<0.042J	<3J	<1.6J	<0.066	8.6
Bailey Tunnel	BTO	7/16/99 - 7/18/99	22200	113	<0.042J	<3	<1.6J	<0.066J	<8.1
Bailey Tunnel	BTO	9/14/99 - 9/25/99	19300	115	<0.042J	<3	<1.6J	<0.066J	<5.6

NS = Not sampled.

Table 7-6

Physical Aquatic Habitat Characteristics[1]

Station[2]	Average Width (ft)	Average Depth (ft)	Average Gradient (%)[3]	Instream Cover (%)[4]	Habitat Type[5]	Average Embed.(%)[6]	Primary Substrate[7]	Secondary Substrate[7]
Meadow Creek								
2040320 [8]	15	0.3	2.3	10	R-R-P	<12	Sm. Cbl.	Gravel
MC-1C[9]	19	0.3	1.6	<5	R-R	25	Cobble	Gravel
2040322	19	0.5	1.0	6	R-P	<27	Gravel	Cobble
2040319	18	1.1	2.1	8	R-R-P	18	Cobble	Gravel
EFSFSR								
2040315 [8]	15	0.7	9.5	34	Cascade	26	Cbl./Sm. Bldr.	Gravel
2040365	29	0.7	2.6	11	Riffle	21	Cbl./Sm. Bldr.	Gravel
2040310	32	0.6	3.0	23	R-R	<16	Cobble	Gravel
EF-7[9]	27	0.6	1.8	10	R-R-P	<10	Cobble	Gravel
2040308	28	0.7	3.2	20	R-R, S-P	<5	Cbl./Sm. Bldr.	Fine sediment
2040314	35	0.7	1.4	4	R-R	8	Cobble	Gravel
Sugar Creek								
2040309 [8]	23	0.7	5.3	30	R-P	28	Gravel	Cobble
2040316	22	0.7	1.8	9	R-R	36	Cobble	Gravel

[1] Data collected September 9 to 12, 1997; reported in Aquatics Associates (1998) (included in Appendix G of Stibnite Group, 2000).

[2] Stations are listed from upstream to downstream.

[3] Gradient over the 200-foot station.

[4] Percent of station area that provides fish cover (e.g., large woody debris, pools).

[5] Based on Rosgen (1985): R-R-P (riffle-run-pool); R-P (riffle-pool); R-R (riffle-run); S-P (step pool).

[6] Average embeddedness equivalent to percent surface fines.

[7] Substrate: Sm. Cbl. (small cobble); Cbl./Sm. Bldr. (cobble/small boulder).

[8] Reference station.

[9] Data Collected September 14-19, 1999 (reported in Stibnite Group, 2000).

Table 7-7

Water Quality Criteria for Metals and Cyanide (µg/L)

Analytes[1]	Acute Criteria[2]		Chronic Criteria[2]		Notes	
	Idaho[3]	USEPA[4]	Idaho[3]	USEPA[4]	Acute	Chronic
Aluminum	--	750	--	87	--; T	--; T
Antimony[5]	--	88	--	30	--; T	--; T
Arsenic	360	340	190	150	D	D
Cadmium	1.7	1.0	0.5	1.0	D (H)	D (H)
Chromium III	310	300	77	30	D (H)	D (H)
Chromium IV	15	15	11	11	D	D
Copper	7.0	5.0	4.7	4.0	D (H)	D (H)
Iron	--	--	--	1000	--	--; T*
Lead	20	20	0.8	1.0	D (H)	D (H)
Magnesium	--	--	--	--	--	--
Manganese	--	--	--	--	--	--
Mercury[6]	2.1	1.2	0.012	0.77	D	T; D
Nickel	600	200	66	22	D (H)	D (H)
Selenium	20	--	5.0	5.0	T	T
Silver	1.0	1.0	--	--	D (H)	
Zinc	50	50	44	50	D (H)	D (H)
Cyanide, WAD	22	--	5.2	--	--	--
Cyanide, Free	--	22	--	5.2	--	--

[1]Analytes from 1999 Work Plan Addendum (Stibnite Group, 1999).
[2]Water Effect Ratio (WER) of 1.0 assumed for all metals.
[3]Idaho Numeric Criteria (IDHW, 1998; BNA, 1999; USEPA, 1992b).
[4]USEPA Recommended Water Quality Criteria (USEPA, 1976; 1998b; 1999).
[5]Proposed criteria for total antimony (not a standard) (USEPA, 1988; 1991).
[6]Idaho mercury chronic criterion is based on human toxicity from bioaccumulation of mercury in fish tissue and is not based on toxicity to aquatic organisms.
D = Dissolved metal.
H = Criterion is hardness-dependent; calculated for average site-wide hardness of 36 mg/L as $CaCO_3$,
T = Total recoverable metal.
T* = Presumed to be total iron (USEPA, 1976).
WAD = weak acid dissociable.

Tab. . -8

Metal Concentrations Detected in Sediments, Dry Weight (mg/kg)
September 1996[1], October 1997[2], and September 1999[3]

Analyte	Antimony			Arsenic			Cadmium			Chromium			Copper		
	1996	1997	1999	1996	1997	1999	1996	1997	1999	1996	1997	1999	1996	1997	1999
Station[4]															
Meadow Creek															
2040320 [6]	<1.00	NA	NC	4.67	NA	NC	0.097	NA	NC	NA	NA	NC	0.97	NA	NC
MC-1C			20.5			369			<0.07			5.5			6.8
2040322	2.45	1.0	NC	37.9	15	NC	<0.050	<0.1	NC	NA	2.3	NC	4.8	2.2	NC
2040319	2.25	22.5	NC	41	99	NC	1.27	<0.1	NC	NA	1.7	NC	2.53	3	NC
EFSFSR															
2040315 [6]	<1.00	NA	NC	19.6	NA	NC	0.511	NA	NC	NA	NA	NC	1.82	NA	NC
2040365	1.8	15.4	NC	40.6	50	NC	<0.050	<0.1	NC	NA	3	NC	2.18	1.80	NC
2040310	2.67	18.9	NC	40.8	57	NC	1.22	<0.1	NC	NA	2.2	NC	2.07	1.5	NC
GH1			43.7			458			0.16			14.7			15.3
GH2			51.2			612			<0.12			17.5			18.5
GH3			86.6			552			<0.12			19.2			17.1
GH4			128			437			<0.09			10.5			9.6
EF-7			10			1490			<0.36			7.6			7.4
2040308	4.66	35.4	NC	1430	1522	NC	40.4	<0.1	NC	NA	1.8	NC	3.98	4.5	NC
2040314	1.07	34.6	NC	82.7	92	NC	2.54	<0.1	NC	NA	4.1	NC	2.31	6.2	NC
Sugar Creek															
2040309 [6]	<1.00	1.2	NC	38.4	49	NC	1.14	<0.1	NC	NA	4.4	NC	2.57	8.8	NC
2040307	<1.00	NA	NC	37.9	NA	NC	1.13	NA	NC	NA	NA	NC	2.22	NA	NC
2040316	NA	0.59	NC	NA	37	NC	NA	<0.1	NC	NA	4	NC	NA	2	NC
Minimum	<1.00	0.59	--	4.67	15	--	<0.050	<0.1	--	NA	1.7	--	0.97	1.5	--
Maximum	4.66	35.4	--	1430	1522	--	40.4	<0.1	--	NA	4.4	--	4.8	8.8	--

Table 7-8

Metal Concentrations Detected in Sediments, Dry Weight (mg/kg)
September 1996[1], October 1997[2], and September 1999[3]

Analyte:	Iron			Lead			Mercury			Selenium			Zinc		
	1996	1997	1999	1996	1997	1999	1996	1997	1999	1996	1997	1999	1996	1997	1999
Station[4]															
Meadow Creek															
2040320 [6]	3990	NA	NC	NA	NA	NC	0.368	NA	NC	<0.05	NA	NC	7.37	NA	NC
MC-1C			6880			5.7			0.26			<0.13			15.7J
2040322	6660	5552	NC	NA	1.79	NC	0.134	<0.20	NC	1.57	<0.05	NC	9.19	11.6	NC
2040319	5030	5688	NC	NA	3.31	NC	0.086	<0.20	NC	1.69	<0.05	NC	7.5	11.6	NC
EFSFSR															
2040315 [6]	6660	NA	NC	NA	NA	NC	0.215	NA	NC	2.08	NA	NC	13.7	NA	NC
2040365	4500	5892	NC	NA	2.76	NC	0.130	<0.20	NC	2.37	<0.05	NC	7.67	13	NC
2040310	4500	5298	NC	NA	3.45	NC	0.143	<0.20	NC	2.33	<0.05	NC	9.31	12.9	NC
GH1			20800			18.1			1			<0.21J			51.5J
GH2			22200			20.5			1.3			<0.24J			56.9J
GH3			23100			19.3			1.9			0.43J			62.1J
GH4			14300			15.1			1.1			0.21J			38.1J
EF-7			14300			6.9			1.4			<0.14			34.5J
2040308	11300	11698	NC	NA	5.58	NC	0.286	0.45	NC	7.20	<0.05	NC	19.8	26.2	NC
2040314	7200	7766	NC	NA	5.19	NC	2.10	3.14	NC	2.84	<0.05	NC	15.6	19.3	NC
Sugar Creek															
2040309 [6]	8120	9241	NC	NA	5.62	NC	4.20	4.08	NC	1.97	<0.05	NC	15.6	17.7	NC
2040307	7850	NA	NC	NA	NA	NC	9.14	NA	NC	1.80	NA	NC	16.2	NA	NC
2040316	NA	7360	NC	NA	4.52	NC	NA	2.03	NC	NA	<0.05	NC	NA	19.6	NC
Minimum	3990	5298	--	NA	1.79	--	0.086	<0.20	--	<0.05	<0.05	--	7.37	11.6	--
Maximum	11300	11698	--	NA	5.62	--	9.14	4.08	--	7.20	<0.05	--	19.8	26.2	--

[1] 1996 data from Analytical Laboratories, Inc.; submitted to Payette National Forest, Boise, Idaho.

[2] 1997 data from State of Idaho, Dept. of Health and Welfare, Bureau of Laboratories, Boise Laboratory; Submitted to B. Schuld, Idaho Dept. of Environmental Quality.

[3] 1999 data from SVL Laboratories; submitted to Stibnite Group.

[4] Stations are listed from upstream to downstream within each stream.

[5] Referred to in text by the last three digits (e.g., 2040320 is Station 320).

[6] Reference stations.

NA = Data not available.

NC = Sediment samples not collected.

Table 7-9

Survey of Freshwater Sediment Quality Guidelines (SQGs)[1] (mg/kg, dry weight)

Metal	Low SQG	Description	Source	Mid SQG	Description	Source	High SQG	Description	Source
Aluminum	9,400	IN background-lake/stream	1	13,500	EPA GLNPO ERL (amph.)	2	73,000	EPA GLNPO NEC (amph.)	2
Antimony	0.49	IN background-lake/stream	1	2	NOAA NS&T ERL	3	64	WA DOE AET (amph.)	4
Arsenic	3	EPA Reg V non-pol. GLH	5	32	EPA GLNPO ERL (amph.)	2	404	EPA GLNPO NEC (chiro.)	2
Cadmium	0.58	EPA GLNPO TEL (amph.)	2	0.7	EPA GLNPO ERL (amph.)	2	41	EPA GLNPO NEC (chiro.)	2
Chromium	9.8	IL background-streams	6	39	EPA GLNPO ERL (chiro.)	2	360	EPA GLNPO ERM (chiro.)	2
Copper	14.9	IL background-streams	6	96	EPA GLNPO ERL (chiro.)	2	206	EPA GLNPO ERM (chiro.)	2
Iron	13,345	IL background-streams	6	200,000	EPA GLNPO ERL (amph.)	2	280,000	EPA GLNPO ERM (amph.)	2
Lead	23	Ontario background	7	99	EPA GLNPO ERL (chiro.)	2	396	EPA GLNPO ERM (chiro.)	2
Magnesium	NA			NA			6,100	WA DOE AET (amph.)	4
Manganese	736	IL background-streams	6	1,700	EPA GLNPO ERL (chiro.)	2	4,500	EPA GLNPO NEC (chiro.)	2
Mercury	0.04	IL background-streams	6	0.49	Canada ISQG PEL	8	2.7	WA DOE AET (amph.)	4
Nickel	20	IN background-lake/stream	1	40	EPA GLNPO ERL (chiro.)	2	75	Ontario MOE SEL	7
Selenium	0.1	WA DOE AET (amph.)	4	2.5	Predicted Effect Level	9	4	Observed Effect Level	9
Silver	0.5	IN background-lake/stream	1	1	NYDEC SEL	10	4.5	WA DOE AET (amph.)	4
Zinc	50	IL background-streams	6	380	EPA GLNPO ERL (chiro.)	2	550	EPA GLNPO ERM (amph.)	2

[1]Compiled from EVS Environment Consultants, 1998

AET: apparent effects threshold
amph.: amphipod
chiro.: chironomid
DNR: Department of Natural Resources
DOE: Department of Energy
ERL: effects range-low
ERM: effects range-median
GLH: Great Lakes Harbors
GLNPO: Great Lakes National Program Office
IL: Illinois
IN: Indiana
ISQG: interim sediment quality guideline
LEL: low effect level
NA: data not available
NEC: no effect concentration
NS&T: National Status and Trends
NYDEC: New York Department of Environmental Conservation
PEL: probable effect level
WA: Washington
WI: Wisconsin

Primary Sources:
1: IDEM, 1990
2: Ingersoll et al., 1996
3: Long & Morgan, 1990
4: Cubbaage & Breidenbach, 1994
5: USEPA, 1997a
6: IEPA, 1984
7: Persaud et al., 1992
8: Environ. Canada, 1995
9: van Derveer & Canton, 1997
10: NYDEC, 1993

Table 7-10

Consensus-Based Freshwater Sediment Effects Concentrations[1] (mg/kg, dry weight)

Metal	Consensus-Based TEC	Consensus-Based PEC
Arsenic	9.79	33
Cadmium	0.99	4.98
Chromium	43.4	111
Copper	31.6	149
Lead	35.8	128
Mercury	0.18	1.06
Nickel	22.7	48.6
Zinc	121	459

[1]Source: MacDonald et al., 1999.
PEC = probable effect concentration (i.e., above which harmful effects are likely)
TEC = threshold effect concentration (i.e., below which harmful effects are unlikely)

Table 7-11

Benthic Macroinvertebrate Tissue Residue Concentrations, Dry Weight (µg/g)
1995 - 1997 Data[1]

Analyte:	Antimony			Arsenic			Cadmium			Copper			Iron		
Year:	1995	1996	1997	1995	1996	1997	1995	1996	1997	1995	1996	1997	1995	1996	1997
Station[2]															
Meadow Creek															
2040320 [3]	0.5	<0.5	<0.5	2.1	1.28	5.77	0.24	3.24	0.28	16.7	16.7	12.5	758	331	2110
2040322	11	23.3	12	104.7	290.8	45	0.17	<0.15	0.18	18.9	20.2	21.3	2533	14975	1329
2040319	36.8	76.8	13.9	209.1	146.7	63.5	0.119	<0.14	0.11	18.9	16.3	20	3236	1565	1111
EFSFSR															
2040315 [3]	1.59	11.7	<0.5	7.95	<0.65	2.99	0.238	0.51	0.36	18.6	16.1	20.7	402	523	362
2040365	57.4	14.9	12.8	129.8	75.9	44.5	0.21	0.41	0.16	22.8	16.9	23.3	2086	1599	1137
2040310	14.4	27	12	49.7	74.9	23	0.149	<0.1	0.19	16	15.6	18.7	849	1518	744
2040308	21	43.7	16.9	319.8	332.7	79.4	0.21	0.19	<0.1	16.8	22.8	15.3	4048	4211	1211
2040314	4.58	11.2	2.48	43.8	1117	17.9	0.169	0.33	<0.1	13.7	17.1	14.4	1244	3022	490
Sugar Creek															
2040309 [3]	0.7	9.24	<0.5	5.97	1.54	5.52	0.239	0.33	0.22	16.3	13	19.6	407	964	433
2040307	NS[4]	3.59	NS	NS	44.9	NS	NS	0.15	NS	NS	17.3	NS	NS	2017	NS
2040316	1.59	NS	<0.5	47.1	NS	10.9	0.179	NS	<0.1	14.6	NS	12	569	NS	246
Minimum	0.5	<0.5	<0.5	2.1	<0.65	2.99	0.119	<0.1	<0.1	13.7	13	12	402	331	246
Maximum	57.4	76.8	16.9	319.8	1117	79.4	0.24	3.24	0.36	22.8	22.8	23.3	4048	14975	2110

Table 7-11

Benthic Macroinvertebrate Tissue Residue Concentrations, Dry Weight (µg/g)
1995 - 1997 Data [1]

Analyte:	Lead			Mercury			Selenium			Zinc		
Year:	1995	1996	1997	1995	1996	1997	1995	1996	1997	1995	1996	1997
Station[2]												
Meadow Creek												
2040320 [3]	1.2	<0.5	0.6	0.23	NR[5]	NR	1.9	1.77	1.49	191	262	203
2040322	2.99	1.74	5.5	0.44	NR	<0.33	3.79	1.89	2.3	139	212	210
2040319	6.47	1.68	3.27	0.59	NR	<0.25	3.78	1.82	2.88	132	184	212
EFSFSR												
2040315 [3]	0.79	0.78	<0.5	0.25	NR	<0.50	0.99	<0.65	1	180	209	326
2040365	17.5	2.98	3.56	NR	NR	<0.25	2.7	2.03	2.08	172	203	233
2040310	4.47	1.2	3.29	0.4	NR	<0.25	2.29	1.9	2.3	130	190	206
2040308	4.5	3.74	1.39	NR	NR	<0.25	3	2.29	2.28	157	187	179
2040314	1.59	2.3	0.5	0.8	NR	0.24	2.09	<1.64	1.69	145	245	203
Sugar Creek												
2040309 [3]	0.7	<1.1	<0.5	1.05	NR	1.64	1.1	<1.10	0.69	165	235	279
2040307	NS	1.4	NS	NS	NR	NS	NS	0.7	NS	NS	242	NS
2040316	1.19	NS	<0.5	1.09	NS	0.6	1.88	NS	1.29	157	NS	234
Minimum	0.7	<0.5	<0.5	0.23	-	<0.25	0.99	<0.65	0.69	130	184	179
Maximum	17.5	3.74	5.5	1.09	-	1.64	3.79	2.29	2.88	191	262	326

[1] Data from Idaho Dept. of Environmental Quality, B. Schuld.

[2] Stations are listed from upstream to downstream within each stream.

[3] Reference stations.

[4] NS = Station not sampled.

[5] NR = Analysis not reported.

Dash (-) = not calculated.

Table 7-12
Calculated Fish Whole-Body Metal Concentrations (mg/kg), Fresh Weight
August 27, 1997[1]

Analyte:	Aluminum			Antimony			Arsenic			Cadmium		
Sample No.:	1	2	3	1	2	3	1	2	3	1	2	3
Station[2]												
Meadow Creek												
2040322	12	7.7	9.6	0.42	0.13	0.25	3.3	1.5	2.7	< 0.15	< 0.15	< 0.15
EFSFSR												
2040310	4.4	2.2	2.4	0.17	0.10	0.12	1.3	0.71	0.73	< 0.15	< 0.15	< 0.15
2040308	3.0	2.9	2.9	0.15	0.17	0.11	2.4	2.4	1.4	< 0.15	< 0.15	< 0.15
2040314	2.8	4.2	< 1.5	0.11	0.11	0.07	0.84	0.85	0.65	< 0.15	< 0.15	< 0.15
Sugar Creek												
2040309 [3]	< 1.5	12.2	2.5	< 0.05	< 0.05	< 0.05	0.26	0.52	0.5	< 0.15	< 0.15	< 0.15
Overall[4]												
Minimum			< 1.5			0.07			0.65			< 0.15
Maximum			12			0.42			3.3			< 0.15
95th UCL			6.3			0.21			2.0			NA[5]

Analyte:	Chromium			Copper			Iron			Lead		
Sample No.:	1	2	3	1	2	3	1	2	3	1	2	3
Station[2]												
Meadow Creek												
2040322	< 0.50	< 0.50	< 0.50	0.99	0.48	0.57	51	26	33	0.08	0.04	0.08
EFSFSR												
2040310	< 0.50	< 0.50	< 0.50	0.81	1.4	0.80	29	18	14	< 0.05	< 0.05	< 0.05
2040308	< 0.50	< 0.50	< 0.50	1.2	1.3	1.1	33	28	25	< 0.05	0.06	< 0.05
2040314	< 0.50	< 0.50	< 0.50	0.99	1.1	0.99	23	26	18	< 0.05	< 0.05	< 0.05
Sugar Creek												
2040309 [3]	< 0.50	< 0.50	< 0.50	0.81	0.93	1.1	19	32	15	< 0.05	< 0.05	< 0.05
Overall[4]												
Minimum			< 0.5			0.48			14			0.04
Maximum			< 0.5			1.4			51			0.08
95th UCL			NA[5]			1.1			32			0.05

Table 7-12
Calculated Fish Whole-Body Metal Concentrations (mg/kg), Fresh Weight
August 27, 1997[1]

Analyte:	Magnesium			Manganese			Mercury			Nickel		
Sample No.:	1	2	3	1	2	3	1	2	3	1	2	3
Station[2]												
Meadow Creek												
2040322	248	250	274	6.2	2.6	4.0	0.22	0.17	0.17	< 0.50	< 0.50	< 0.50
EFSFSR												
2040310	319	247	213	3.7	1.9	1.4	0.15	0.10	0.08	< 0.50	< 0.50	< 0.50
2040308	219	256	255	2.3	3.1	2.9	0.11	0.06	0.05	< 0.50	< 0.50	< 0.50
2040314	250	266	296	4.2	4.3	3.6	0.06	0.06	0.08	< 0.50	< 0.50	< 0.50
Sugar Creek												
2040309[3]	268	239	246	1.9	1.3	1.4	0.25	0.28	0.35	< 0.50	< 0.50	< 0.50
Overall[4]												
Minimum			213			1.4			0.05			< 0.5
Maximum			319			6.2			0.22			< 0.5
95th UCL			273			4.1			0.14			NA[5]

Analyte:	Selenium			Silver			Zinc		
Sample No.:	1	2	3	1	2	3	1	2	3
Station[2]									
Meadow Creek									
2040322	0.79	0.70	0.84	< 0.25	< 0.25	< 0.25	16.2	12.9	14.0
EFSFSR									
2040310	0.94	0.81	0.67	< 0.25	< 0.25	< 0.25	18.6	14.6	12.4
2040308	0.76	0.89	0.86	< 0.25	< 0.25	< 0.25	19.6	17.7	21.6
2040314	0.66	0.69	0.63	< 0.25	< 0.25	< 0.25	19.8	17.9	22.9
Sugar Creek									
2040309[3]	0.34	0.29	0.32	< 0.25	< 0.25	< 0.25	21.9	16.4	15.8
Overall[4]									
Minimum			0.63			< 0.25			12.4
Maximum			0.94			< 0.25			22.9
95th UCL			0.82			NA[5]			19.1

[1]Whole-body metals concentrations calculated using weight data, fillet concentrations, and body remains concentrations (Tables 8.5-10, 8.5-11, and 8.5-12 in Stibnite Group [1998b]).
Whole-body = $((C_{body\ remains} \times W_{body\ remains}) + (C_{fillet} \times W_{fillet}))/(W_{body\ remains} + W_{fillet})$ where C = wet weight concentration and W = wet weight. When the chemical was not detected in one of the two two tissue components, one-half the method detection limit (MDL) was used as the tissue component concentration to calculate the whole-body concentration. A "<" symbol means that the analyte was not detected in either tissue component, and the higher MDL of the two components is shown as the estimated whole-body concentration.

[2]Stations are listed from upstream to downstream.

[3]Reference station for Sugar Creek (located upstream of West End Creek).

[4]Overall minimum, maximum, and 95th upper confidence limit (UCL) of the mean are calculated using data from Stations 322, 310, 308, and 314 (12 samples). Station 309 is not included in these calculations. One-half the MDL shown for whole-body concentrations with a "<" symbol is used in calculating the 95th UCL.

[5]NA: No[illegible]ble: chemical was not detected in fish tissue.

Table 7-13

1999 Surface Water Exposure Point Concentrations (μg/L) for Exposure Areas[1]

	Meadow Creek			Upper EFSFSR		
Analytes	Max. Detected Conc.	95th UCL[2]	Exposure Point Conc.[3]	Max. Detected Conc.	95th UCL[2]	Exposure Point Conc.[3]
Antimony, total	26	10	10	48	39	39
Arsenic, dissolved	64	29	29	91	54	54
Cadmium, dissolved	ND	ND	ND	ND	ND	ND
Chromium, dissolved (III)	ND	ND	ND	ND	ND	ND
Copper, dissolved	ND	ND	ND	4.7	1.8	1.8
Cyanide, WAD	2.8	1.7	1.7	1.3	2.3	1.3
Lead, dissolved	1.4	0.39	0.39	ND	ND	ND
Mercury, dissolved	0.11	0.040	0.040	ND	ND	ND
Mercury, total	0.054	0.025	0.025	0.13	0.047	0.047
Nickel, dissolved	ND	ND	ND	ND	ND	ND
Selenium, total	ND	ND	ND	ND	ND	ND
Silver, dissolved	ND	ND	ND	ND	ND	ND
Zinc, dissolved	42	5.8	5.8	16.7	6.3	6.3

Table 7-13

1999 Surface Water Exposure Point Concentrations (μg/L) for Exposure Areas[1]

	Lower EFSFSR			Sugar Creek		
Analytes	Max. Detected Conc.	95th UCL[2]	Exposure Point Conc.[3]	Max. Detected Conc.	95th UCL[2]	Exposure Point Conc.[3]
Antimony, total	40	27	27	8.3	4.7	4.7
Arsenic, dissolved	96	53	53	16	11	11
Cadmium, dissolved	ND	ND	ND	ND	ND	ND
Chromium, dissolved (III)	ND	ND	ND	ND	ND	ND
Copper, dissolved	ND	ND	ND	2.9	1.8	1.8
Cyanide, WAD	NA	NA	NA	NA	NA	NA
Lead, dissolved	ND	ND	ND	0.50	0.34	0.34
Mercury, dissolved	0.23	0.039	0.039	0.33	0.21	0.21
Mercury, total	0.39	0.055	0.055	0.047	0.030	0.030
Nickel, dissolved	ND	ND	ND	ND	ND	ND
Selenium, total	ND	ND	ND	ND	ND	ND
Silver, dissolved	0.13	0.044	0.044	ND	ND	ND
Zinc, dissolved	15	4.2	4.2	ND	ND	ND

[1]Sources: Tables A1-1 through A1-4.

[2]95th UCL = The upper 95th confidence limit of the mean. One-half the detection limit is substituted for non-detect results in calculation of 95th UCL.

[3]Exposure Point Concentration = lower of maximum detected concentration or 95th UCL.

WAD = weak acid dissociable.

NA = Not analyzed.

ND = Not detected.

Table 7-14

1999 Surface Water Exposure Point Concentrations (µg/L) for Aquatic Stations[1]

Analytes	Station MC-1C (Meadow Creek in New Diversion) Max. Detected Conc.	Station 2040322 (Meadow Creek below Diversion) Max. Detected Conc.	Station 2040319 (Meadow Creek above EFSFSR) Max. Detected Conc.
Antimony, total	7.1	9.3	26
Arsenic, dissolved	40	46	58
Cadmium, dissolved	ND	ND	ND
Chromium, dissolved (III)	ND	ND	ND
Copper, dissolved	ND	ND	ND
Cyanide, WAD	2.4	2.8	2.8
Lead, dissolved	ND	ND	ND
Mercury, dissolved	ND	ND	ND
Mercury, total	ND	0.054	ND
Nickel, dissolved	ND	ND	ND
Selenium, total	ND	ND	ND
Silver, dissolved	ND	ND	ND
Zinc, dissolved	ND	6.0	ND

Analytes	Station 2040365[2] (EFSFSR below Meadow Creek) Max. Detected Conc.	Station 2040310[2] (EFSFSR at Secondary Camp) Max. Detected Conc.	Station EF-7 (EFSFSR below Glory Hole) Max. Detected Conc.
Antimony, total	20	20	32
Arsenic, dissolved	33	33	68
Cadmium, dissolved	ND	ND	ND
Chromium, dissolved (III)	ND	ND	ND
Cyanide, WAD	1.3	1.3	NA
Copper, dissolved	ND	ND	ND
Lead, dissolved	ND	ND	ND
Mercury, dissolved	ND	ND	ND
Mercury, total	ND	ND	ND
Nickel, dissolved	ND	ND	ND
Selenium, total	ND	ND	ND
Silver, dissolved	ND	ND	ND
Zinc, dissolved	ND	ND	ND

Table 7-14

1999 Surface Water Exposure Point Concentrations (μg/L) for Aquatic Stations[1]

Analytes	Station 2040308 (EFSFSR below NW Bradley Dump) Max. Detected Conc.	Station 2040316 (Sugar Creek above EFSFSR) Max. Detected Conc.
Antimony, total	35	8.3
Arsenic, dissolved	96	16
Cadmium, dissolved	ND	ND
Chromium, dissolved (III)	ND	ND
Copper, dissolved	ND	2.9
Cyanide, WAD	NA	NA
Lead, dissolved	ND	ND
Mercury, dissolved	ND	ND
Mercury, total	ND	0.25
Nickel, dissolved	ND	ND
Selenium, total	ND	ND
Silver, dissolved	ND	ND
Zinc, dissolved	ND	ND

Analytes	Station 2040314 (EFSFSR below Sugar Creek) Max. Detected Conc.	Stations GH1, GH2, GH3, GH4 (Glory Hole) Max. Detected Conc.
Antimony, total	24	33
Arsenic, dissolved	57	85
Cadmium, dissolved	ND	ND
Chromium, dissolved (III)	ND	ND
Cyanide, WAD	NA	NA
Copper, dissolved	ND	ND
Lead, dissolved	ND	ND
Mercury, dissolved	ND	0.23
Mercury, total	0.39	ND
Nickel, dissolved	ND	ND
Selenium, total	ND	ND
Silver, dissolved	0.128	0.088
Zinc, dissolved	ND	ND

[1] Sources: Tables 7-2 (total metals) and 7-3 (dissolved metals)

[2]Based on 1999 results from Station 2040313

ND = Not detected NA = Not analyzed

Table 7-15

Chronic Hazard Quotients for Surface Water in Exposure Areas

	Meadow Creek			Upper EFSFSR		
Analytes	Water Quality Criteria[1] (µg/L)	Expos. Conc.[2] (µg/L)	HQ[3]	Water Quality Criteria[1] (µg/L)	Expos. Conc.[2] (µg/L)	HQ[3]
Antimony, total	30	10	0.33	30	39	1.3
Arsenic, dissolved	150	29	0.19	150	54	0.36
Cadmium, dissolved	0.5	ND	--	0.5	ND	--
Chromium, dissolved (III)	30	ND	--	30	ND	--
Copper, dissolved	4.0	ND	--	4.0	1.8	0.45
Cyanide, WAD	5.2	1.7	0.33	5.2	2.3	0.44
Lead, dissolved	0.8	0.39	0.49	0.8	ND	--
Mercury, dissolved	0.77	0.040	0.052	0.77	ND	--
Mercury, total	0.012	0.025	2.1	0.012	0.047	3.9
Nickel, dissolved	22	ND	--	22	ND	--
Selenium, total	5.0	ND	--	5	ND	--
Silver, dissolved[4]	1.0	ND	--	1.0	ND	--
Zinc, dissolved	44	5.8	0.13	44	6.3	0.14

Table 7-15

Chronic Hazard Quotients for Surface Water in Exposure Areas

Analytes	Lower EFSFSR			Sugar Creek		
	Water Quality Criteria[1] (µg/L)	Expos. Conc.[2] (µg/L)	HQ[3]	Water Quality Criteria[1] (µg/L)	Expos. Conc.[2] (µg/L)	HQ[3]
Antimony, total	30	27	0.90	30	4.7	0.16
Arsenic, dissolved	150	53	0.35	150	11	0.073
Cadmium, dissolved	0.5	ND	--	0.5	ND	--
Chromium, dissolved (III)	30	ND	--	30	ND	--
Copper, dissolved	4.0	ND	--	4.0	1.8	0.45
Cyanide, WAD	5.2	NA	--	5.2	NA	--
Lead, dissolved	0.8	ND	--	0.8	0.34	0.43
Mercury, dissolved	0.77	0.039	0.05	0.77	0.21	0.27
Mercury, total	0.012	0.055	4.6	0.012	0.030	2.5
Nickel, dissolved	22	ND	--	22	ND	--
Selenium, total	5.0	ND	--	5.0	ND	--
Silver, dissolved[4]	1.0	0.044	0.044	1.0	ND	--
Zinc, dissolved	44	4.2	0.095	44	ND	--

[1]Lower of Idaho or USEPA chronic criteria (see Table 7-7) calculated using the average site-wide hardness of 36 mg/L as $CaCO^3$.

[2]Expos. Conc. = Exposure concentration based on 1999 data (lower of maximum detected or 95th UCL) (see Table 7-13).

[3]HQ = Hazard Quotient = (Exposure Concentration, µg/L) / (Water Quality Criterion µg/L).

[4]Acute criterion only available.

-- = No HQ was calculated because the chemical was not detected or not analyzed in surface water.

ND = Not detected.

NA = Not analyzed.

WAD = weak acid dissociable.

Table 7-16
Chronic Hazard Quotients for Surface Water at Aquatic Stations

	Station MC-1C (Meadow Creek in New Diversion)			Station 2040322 (Meadow Creek below diversion)		
Analytes	Water Quality Criteria[1] (ug/L)	Expos. Conc.[2] (ug/L)	HQ[3]	Water Quality Criteria[1] (ug/L)	Expos. Conc.[2] (ug/L)	HQ[3]
Antimony, total	30	7.1	0.24	30	9.3	0.31
Arsenic, dissolved	150	40	0.27	150	46	0.31
Cadmium, dissolved	0.5	ND	--	0.5	ND	--
Chromium, dissolved (III)	30	ND	--	30	ND	--
Copper, dissolved	4.0	ND	--	4.0	ND	--
Cyanide, WAD	5.2	2.4	0.46	5.2	2.8	0.54
Lead, dissolved	0.8	ND	--	0.8	ND	--
Mercury, dissolved	0.77	ND	--	0.77	ND	--
Mercury, total	0.012	ND	--	0.012	0.054	4.5
Nickel, dissolved	22	ND	--	22	ND	--
Selenium, total	5.0	ND	--	5.0	ND	--
Silver, dissolved[4]	1.0	ND	--	1.0	ND	--
Zinc, dissolved	44	ND	--	44	6.0	0.14

	Station 2040319 (Meadow Creek above EFSFSR)			Station 2040365[5] (EFSFSR below Meadow Creek)		
Analytes	Water Quality Criteria[1] (ug/L)	Expos. Conc.[2] (ug/L)	HQ[3]	Water Quality Criteria[1] (ug/L)	Expos. Conc.[2] (ug/L)	HQ[3]
Antimony, total	30	26	0.87	30	20	0.67
Arsenic, dissolved	150	58	0.39	150	33	0.22
Cadmium, dissolved	0.5	ND	--	0.5	ND	--
Chromium, dissolved (III)	30	ND	--	30	ND	--
Copper, dissolved	4.0	ND	--	4.0	ND	--
Cyanide, WAD	5.2	2.8	0.54	5.2	NA	--
Lead, dissolved	0.8	ND	--	0.8	ND	--
Mercury, dissolved	0.77	ND	--	0.77	ND	--
Mercury, total	0.012	ND	--	0.012	ND	--
Nickel, dissolved	22	ND	--	22	ND	--
Selenium, total	5.0	ND	--	5.0	ND	--
Silver, dissolved[4]	1.0	ND	--	1.0	ND	--
Zinc, dissolved	44	ND	--	44	ND	--

Table 7-16
Chronic Hazard Quotients for Surface Water at Aquatic Stations

Analytes	Station 2040310[5] (EFSFSR at Secondary Camp)			Station EF-7 (EFSFSR below Glory Hole)		
	Water Quality Criteria[1] (ug/L)	Expos. Conc.[2] (ug/L)	HQ[3]	Water Quality Criteria[1] (ug/L)	Expos. Conc.[2] (ug/L)	HQ[3]
Antimony, total	30	20	0.67	30	32	1.1
Arsenic, dissolved	150	33	0.22	150	68	0.45
Cadmium, dissolved	0.5	ND	--	0.5	ND	--
Chromium, dissolved (III)	30	ND	--	30	ND	--
Copper, dissolved	4.0	ND	--	4.0	ND	--
Cyanide, WAD	5.2	NA	--	5.2	NA	--
Lead, dissolved	0.8	ND	--	0.8	ND	--
Mercury, dissolved	0.77	ND	--	0.77	ND	--
Mercury, total	0.012	ND	--	0.012	ND	--
Nickel, dissolved	22	ND	--	22	ND	--
Selenium, total	5.0	ND	--	5.0	ND	--
Silver, dissolved[4]	1.0	ND	--	1.0	ND	--
Zinc, dissolved	44	ND	--	44	ND	--

Analytes	Station 2040308 (EFSFSR below NW Bradley Dump)			Station 2040316 (Sugar Creek above EFSFSR)		
	Water Quality Criteria[1] (ug/L)	Expos. Conc.[2] (ug/L)	HQ[3]	Water Quality Criteria[1] (ug/L)	Expos. Conc.[2] (ug/L)	HQ[3]
Antimony, total	30	35	1.2	30	8.3	0.28
Arsenic, dissolved	150	96	0.64	150	16	0.11
Cadmium, dissolved	0.5	ND	--	0.5	ND	--
Chromium, dissolved (III)	30	ND	--	30	ND	--
Copper, dissolved	4.0	ND	--	4.0	2.9	0.73
Cyanide, WAD	5.2	NA	--	5.2	NA	--
Lead, dissolved	0.8	ND	--	0.8	ND	--
Mercury, dissolved	0.77	ND	--	0.77	ND	--
Mercury, total	0.012	ND	--	0.012	0.25	21
Nickel, dissolved	22	ND	--	22	ND	--
Selenium, total	5.0	ND	--	5.0	ND	--
Silver, dissolved[4]	1.0	ND	--	1.0	ND	--
Zinc, dissolved	44	ND	--	44	ND	--

Table 7-16
Chronic Hazard Quotients for Surface Water at Aquatic Stations

Analytes	Station 2040314 (EFSFSR below Sugar Creek)			Stations GH1, GH2, GH3 (Glory Hole)		
	Water Quality Criteria[1] (ug/L)	Expos. Conc.[2] (ug/L)	HQ[3]	Water Quality Criteria[1] (ug/L)	Expos. Conc.[2] (ug/L)	HQ[3]
Antimony, total	30	24	0.80	30	33	1.1
Arsenic, dissolved	150	57	0.38	150	85	0.57
Cadmium, dissolved	0.5	ND	--	0.5	ND	--
Chromium, dissolved (III)	30	ND	--	30	ND	--
Copper, dissolved	4.0	ND	--	4.0	ND	--
Cyanide, WAD	5.2	NA	--	5.2	NA	--
Lead, dissolved	0.8	ND	--	0.8	ND	--
Mercury, dissolved	0.77	ND	--	0.77	0.23	0.30
Mercury, total	0.012	0.39	33	0.012	ND	--
Nickel, dissolved	22	ND	--	22	ND	--
Selenium, total	5.0	ND	--	5.0	ND	--
Silver, dissolved[4]	1.0	0.128	0.13	1.0	0.088	0.088
Zinc, dissolved	44	ND	--	44	ND	--

[1]Lower of Idaho or USEPA chronic criterion (see Table 7-7) calculated using the average site-wide hardness of 36 mg/kg as $CaCO_3$.
[2]Expos. Conc. = Exposure concentration is the maximum detected concentration in 1999 (see Table 7-14).
[3]HQ = Hazard Quotient = (Exposure Concentration, µg/L) / (Water Quality Criterion (µg/L).
[4]Acute criterion only available.
[5]Based on results from Station 313.
-- = No HQ was calculated because the chemical was not analyzed or not measured in surface water.
ND = Not detected.
NA = Not Analyzed.
WAD = weak acid dissociable.

Table 7-17

Hazard Quotients for Sediment at Aquatic Stations

Analytes	Station MC-1C (Meadow Creek in New Diversion)			Station 2040322 (Meadow Creek below diversion)		
	Sediment Screening Values[1] (mg/kg)	Expos. Conc.[2] (mg/kg)	HQ[3]	Sediment Screening Values[1] (mg/kg)	Expos. Conc.[2] (mg/kg)	HQ[3]
Antimony	2	20.5	10	2	1.0	0.50
Arsenic	9.79	369	38	9.79	15	1.5
Cadmium	0.99	ND	--	0.99	ND	--
Chromium	43.4	5.5	0.13	43.4	2.3	0.05
Copper	31.6	6.8	0.22	31.6	2.2	0.07
Lead	35.8	5.7	0.16	35.8	1.79	0.05
Mercury	0.18	0.26	1.4	0.18	ND	--
Selenium	2.5	ND	--	2.5	ND	--
Zinc	121	15.7	0.13	121	11.6	0.10

Analytes	Station 2040319 (Meadow Creek above EFSFSR)			Station 2040365 (EFSFSR below Meadow Creek)		
	Sediment Screening Values[1] (mg/kg)	Expos. Conc.[2] (mg/kg)	HQ[3]	Sediment Screening Values[1] (mg/kg)	Expos. Conc.[2] (mg/kg)	HQ[3]
Antimony	2	22.5	11	2	15.4	7.7
Arsenic	9.79	99	10	9.79	50	5.1
Cadmium	0.99	ND	--	0.99	ND	--
Chromium	43.4	1.7	0.04	43.4	3	0.07
Copper	31.6	3	0.09	31.6	1.80	0.06
Lead	35.8	3.31	0.09	35.8	2.76	0.08
Mercury	0.18	ND	--	0.18	ND	--
Selenium	2.5	ND	--	2.5	ND	--
Zinc	121	11.6	0.10	121	13	0.11

Table 7-17

Hazard Quotients for Sediment at Aquatic Stations

Analytes	Station 2040310 (EFSFSR at Secondary Camp)			Station EF-7 (EFSFSR below Glory Hole)		
	Sediment Screening Values[1] (mg/kg)	Expos. Conc.[2] (mg/kg)	HQ[3]	Sediment Screening Values[1] (mg/kg)	Expos. Conc.[2] (mg/kg)	HQ[3]
Antimony	2	18.9	9.5	2	10	5.0
Arsenic	9.79	57	5.8	9.79	1490	150
Cadmium	0.99	ND	--	0.99	ND	--
Chromium	43.4	2.2	0.05	43.4	7.6	0.18
Copper	31.6	1.5	0.05	31.6	7.4	0.23
Lead	35.8	3.45	0.10	35.8	6.9	0.19
Mercury	0.18	ND	--	0.18	1.4	7.8
Selenium	2.5	ND	--	2.5	ND	--
Zinc	121	12.9	0.11	121	34.5	0.29

Analytes	Station 2040308 (EFSFSR below NW Bradley Dump)			Station 2040316 (Sugar Creek above EFSFSR)		
	Sediment Screening Values[1] (mg/kg)	Expos. Conc.[2] (mg/kg)	HQ[3]	Sediment Screening Values[1] (mg/kg)	Expos. Conc.[2] (mg/kg)	HQ[3]
Antimony	2	35.4	18	2	0.59	0.30
Arsenic	9.79	1522	160	9.79	37	3.8
Cadmium	0.99	ND	--	0.99	ND	--
Chromium	43.4	1.8	0.04	43.4	4	0.09
Copper	31.6	4.5	0.14	31.6	2	0.06
Lead	35.8	5.58	0.16	35.8	4.52	0.13
Mercury	0.18	0.45	2.5	0.18	2.03	11
Selenium	2.5	ND	--	2.5	ND	--
Zinc	121	26.2	0.22	121	19.6	0.16

Table 7-17

Hazard Quotients for Sediment at Aquatic Stations

Analytes	Station 2040314 (EFSFSR below Sugar Creek) Sediment Screening Values[1] (mg/kg)	Station 2040314 Expos. Conc.[2] (mg/kg)	Station 2040314 HQ[3]	Stations GH1, GH2, GH3, GH4 (Glory Hole) Sediment Screening Values[1] (mg/kg)	Stations GH1–GH4 Expos. Conc.[4] (mg/kg)	Stations GH1–GH4 HQ[3]
Antimony	2	34.6	17	2	128	64
Arsenic	9.79	92	9.4	9.79	612	63
Cadmium	0.99	ND	--	0.99	0.16	0.16
Chromium	43.4	4.1	0.09	43.4	19.2	0.44
Copper	31.6	6.2	0.20	31.6	18.5	0.59
Lead	35.8	5.19	0.14	35.8	20.5	0.57
Mercury	0.18	3.14	17	0.18	1.9	11
Selenium	2.5	ND	--	2.5	0.43	0.17
Zinc	121	19.3	0.16	121	62.1	0.51

[1]Source: In priority order: TEC (Table 7-10) if available; or mid SQG (Table 7-9).

[2]Source: Table 7-8: 1997 or 1999 (Stations MC-1C and EF-7).

[3]HQ = Exposure Concentration/Sediment Screening Value.

[4]Source: Maximum from Table 8.5-21 of Stibnite Group (2000).

-- = No HQ was calculated because metal was not detected in sediment.

ND = Not detected.

Table 7-18

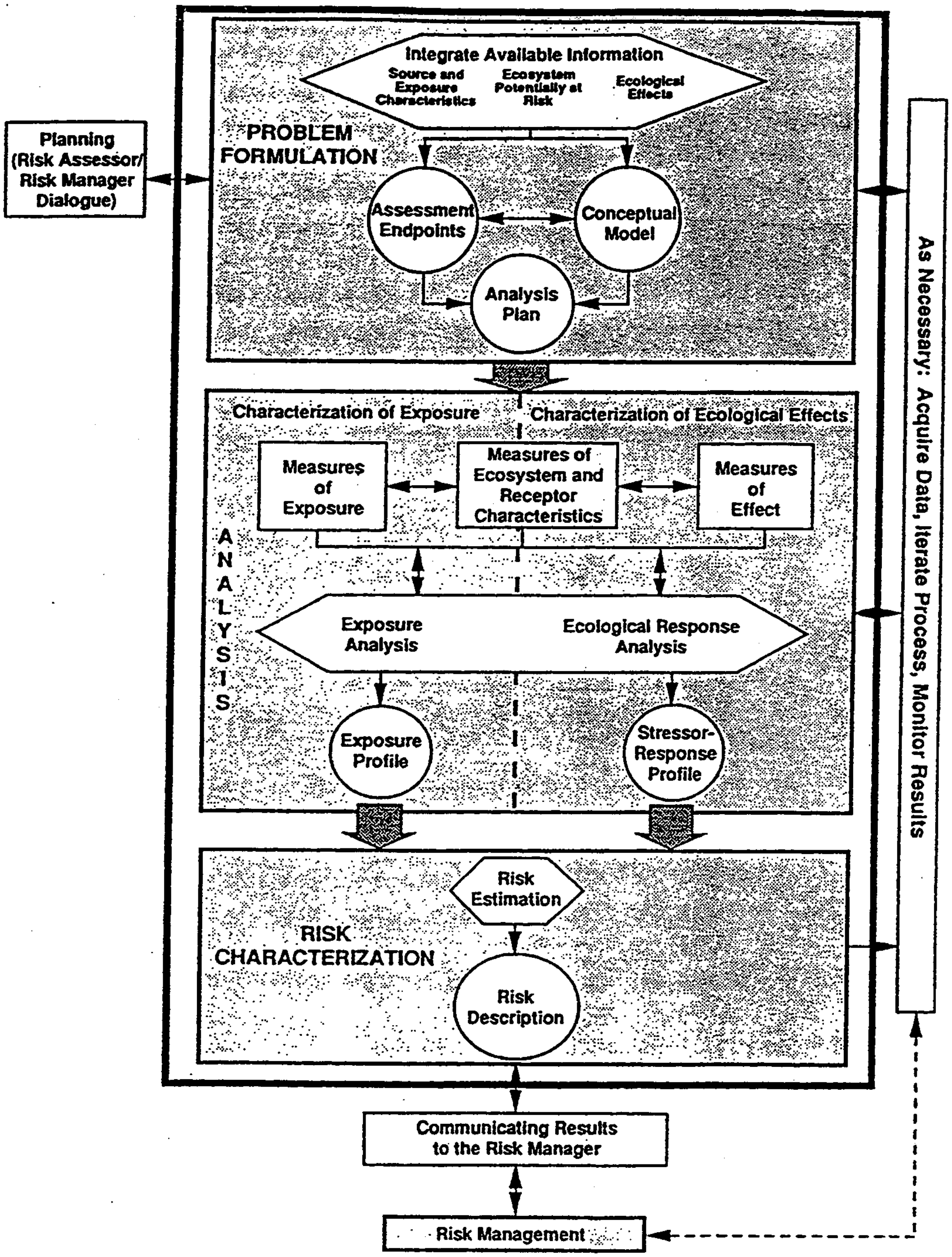
Temperature and Dissolved Oxygen Measured in 1997

Area	Temperature - Seasonal Averages (°C)		
	Site Stations - June Through August	Reference Stations - June Through August	Standards - Maximum June Through August[1]
Area 1	10	9.7	10
Area 2	10	9.7	10
Area 3	9.6	9.9	10

Area	Dissolved Oxygen - Seasonal Averages (mg/L)					
	Site Stations - June Through August	Reference Stations - June Through August	Standards - Minimum June Through August[1]	Site Stations - September and October	Reference Stations - September and October	Standards - Minimum September and October[2]
Area 1	8.6	9.0	7.7	12	14	8.8
Area 2	10	8.1	7.7	14	11	8.4
Area 3	8.5	7.9	7.3	14	15	9.0

[1] Temperature standards for bull trout spawning/rearing from 40 CFR 131.33.

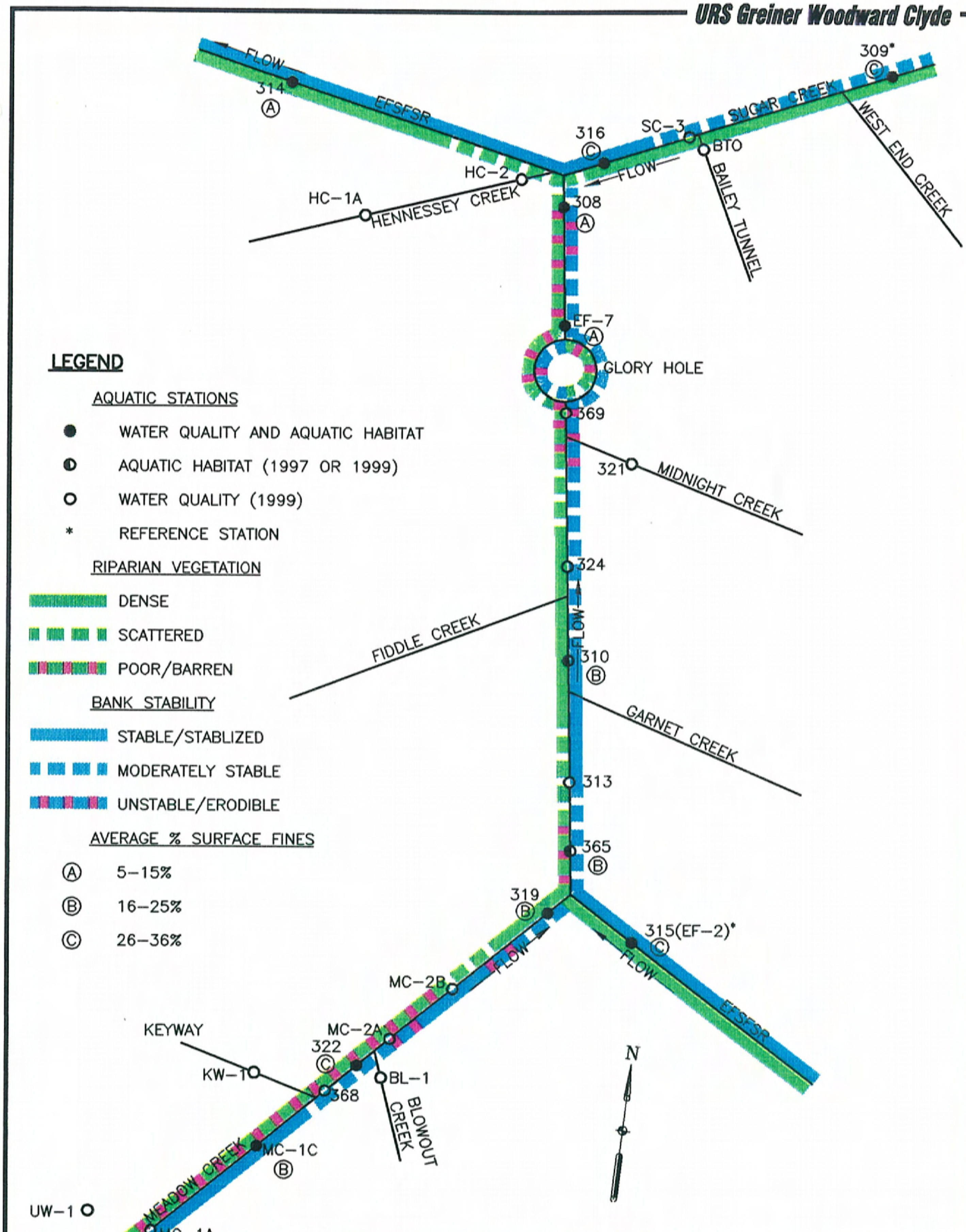
[2] Dissolved oxygen standards for salmonid spawning from IDHW (1998). Standards are based on 90% saturation at the maximum recorded temperature for each area and time period. Saturated values were obtained from Table 21 of Colt (1984).



(SOURCE: USEPA, 1996)

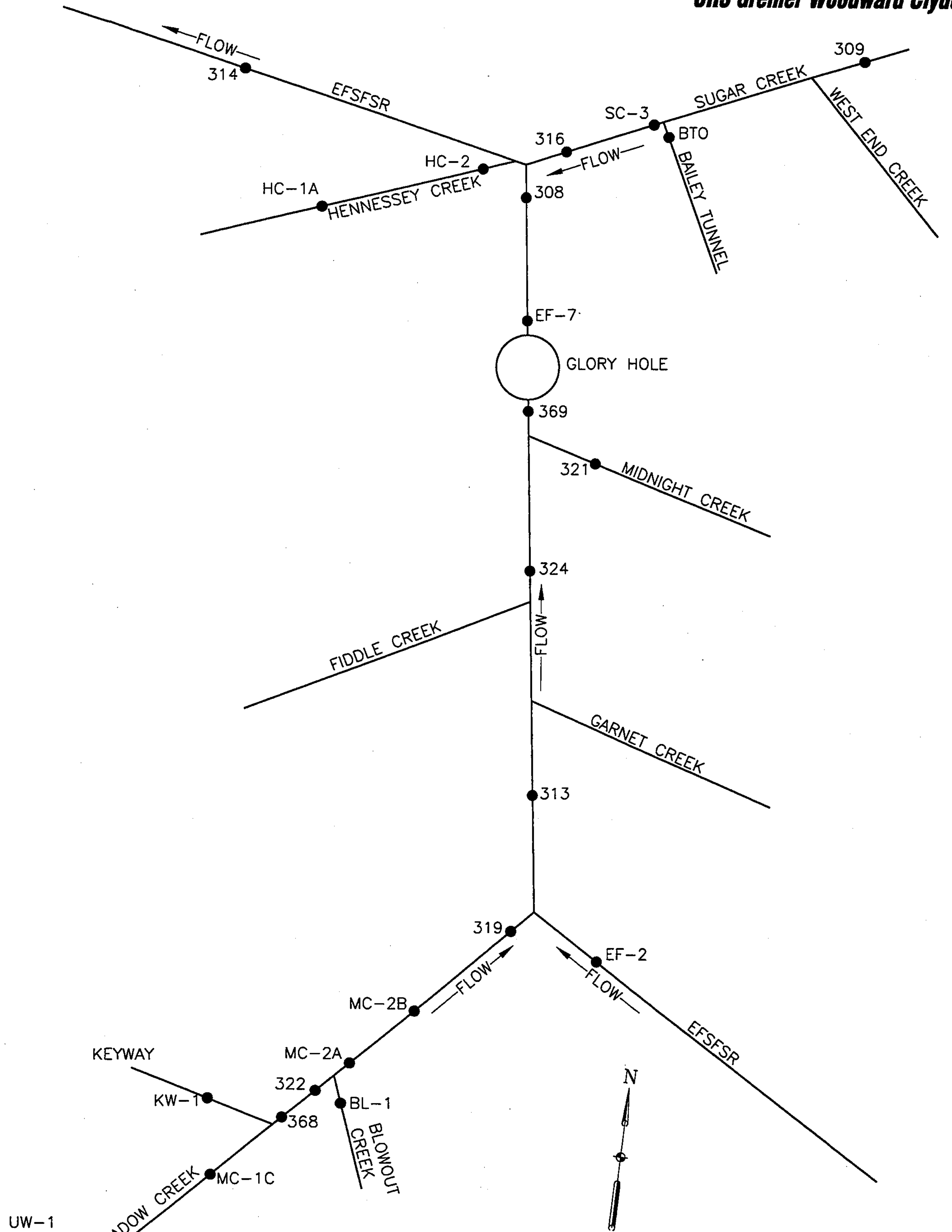
Job No. : 6800024343.00	FIGURE 7-1 ECOLOGICAL RISK ASSESSMENT FRAMEWORK STIBNITE SITE
Prepared By : TGC	
Date : 6/27/00	

TGC18.DWG



Job No. :	6800024343.00
Prepared By : TGC	
Date :	6/27/00

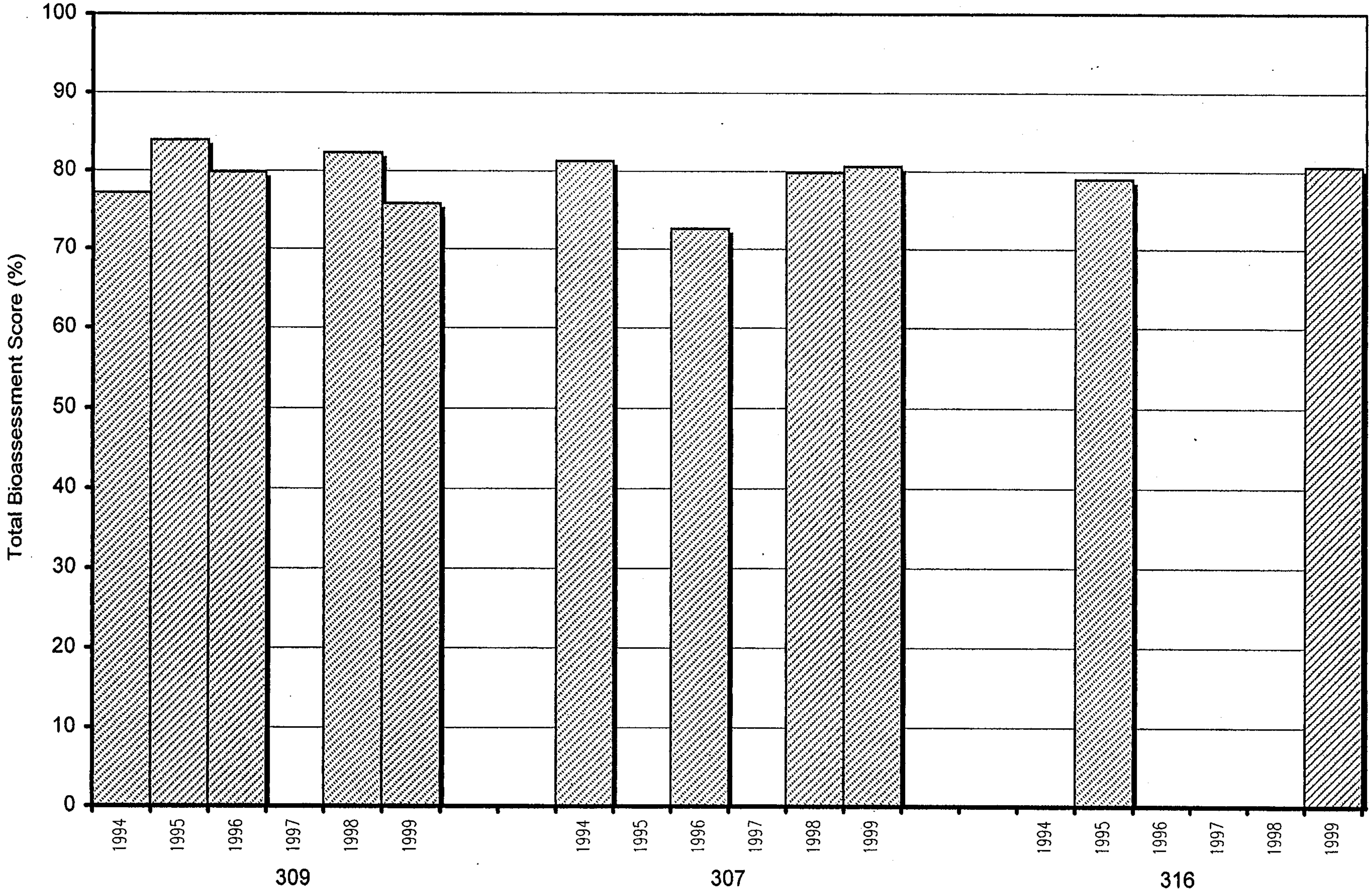
FIGURE 7–2
AQUATIC HABITAT
STIBNITE SITE



Job No. :	6800024343.00
Prepared By : TGC	
Date :	6/27/00

FIGURE 7-3
1999 SURFACE WATER QUALITY SAMPLING STATIONS
STIBNITE SITE

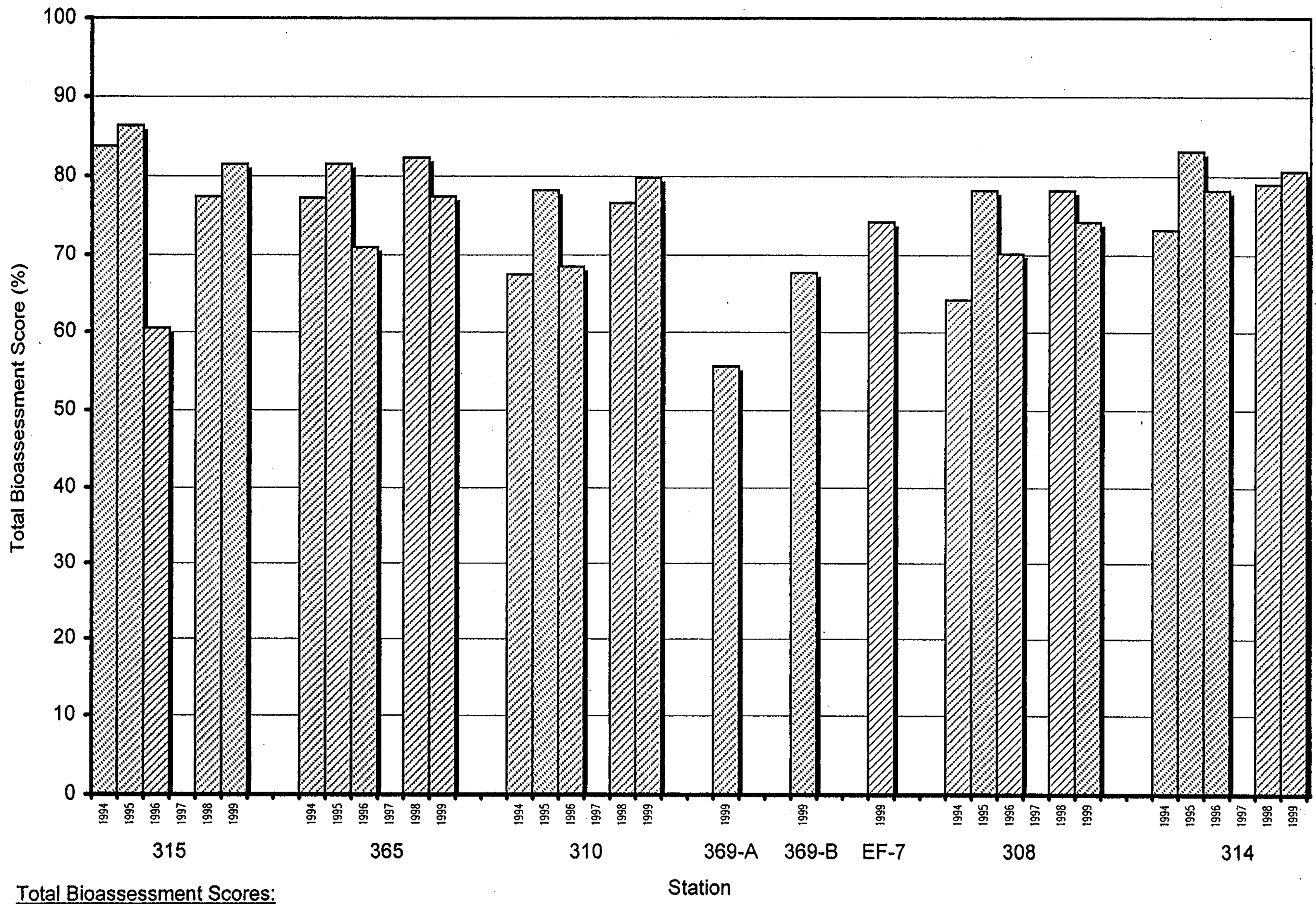
TGC19.DWG



Total Bioassessment Scores:
>90% -- Very High Habitat Complexity and Biotic Integrity
80-89% -- High Habitat Complexity and Biotic Integrity
60-79% -- Moderate Habitat Complexity and Biotic Integrity
40-59% -- Low Habitat Complexity and Biotic Integrity

Source: ABA (2000)

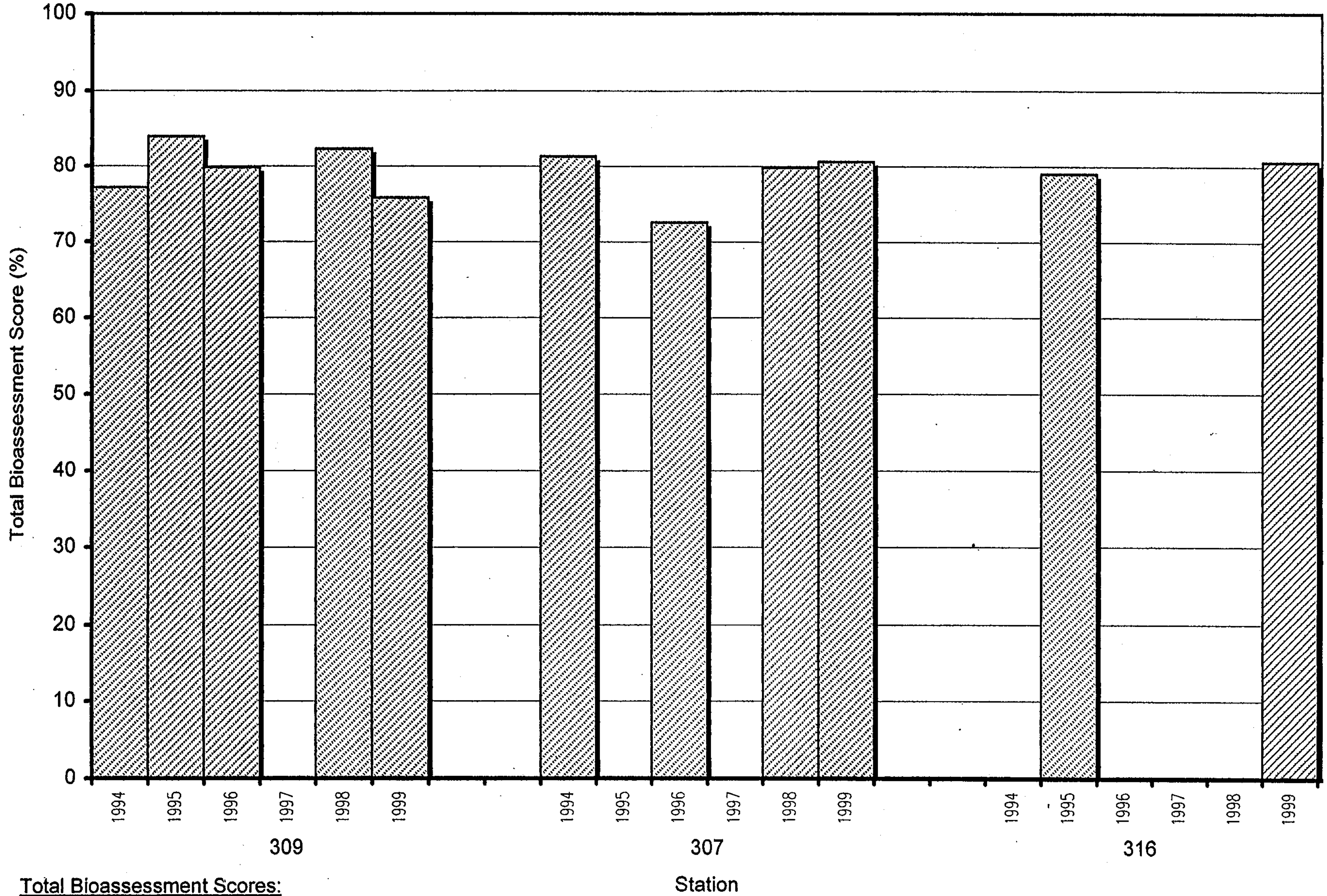
Job No. : 6800024343.00	FIGURE 7–4 TOTAL BIOASSESSMENT SCORES (%) FOR MEADOW CREEK IN 1999 STIBNITE SITE
Prepared by : T.G.C.	
Date : 6/27/00	



Total Bioassessment Scores:
>90% -- Very High Habitat Complexity and Biotic Integrity
80-89% -- High Habitat Complexity and Biotic Integrity
60-79% -- Moderate Habitat Complexity and Biotic Integrity
40-59% -- Low Habitat Complexity and Biotic Integrity

Source: ABA (2000)

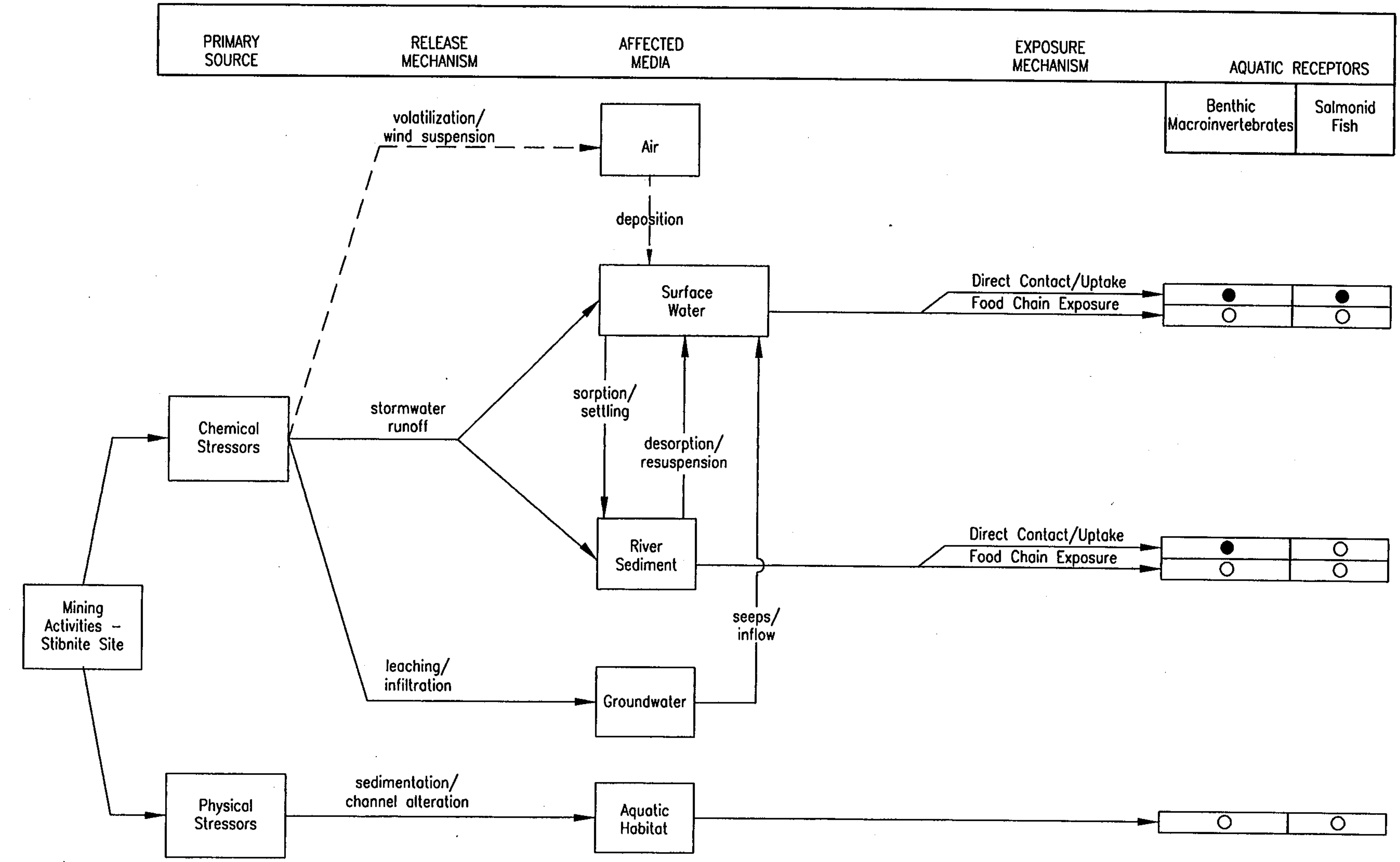
Job No. : 6800024343.00	FIGURE 7-5 TOTAL BIOASSESSMENT SCORES (%) FOR EFSFSR IN 1999 STIBNITE SITE
Prepared by : T.G.C.	
Date : 6/27/00	



Total Bioassessment Scores:
>90% -- Very High Habitat Complexity and Biotic Integrity
80-89% -- High Habitat Complexity and Biotic Integrity
60-79% -- Moderate Habitat Complexity and Biotic Integrity
40-59% -- Low Habitat Complexity and Biotic Integrity

Source: ABA (2000)

Job No. : 6800024343.00	FIGURE 7-6 TOTAL BIOASSESSMENT SCORES (%) FOR SUGAR CREEK IN 1999 STIBNITE SITE
Prepared by : T.G.C.	
Date : 6/27/00	

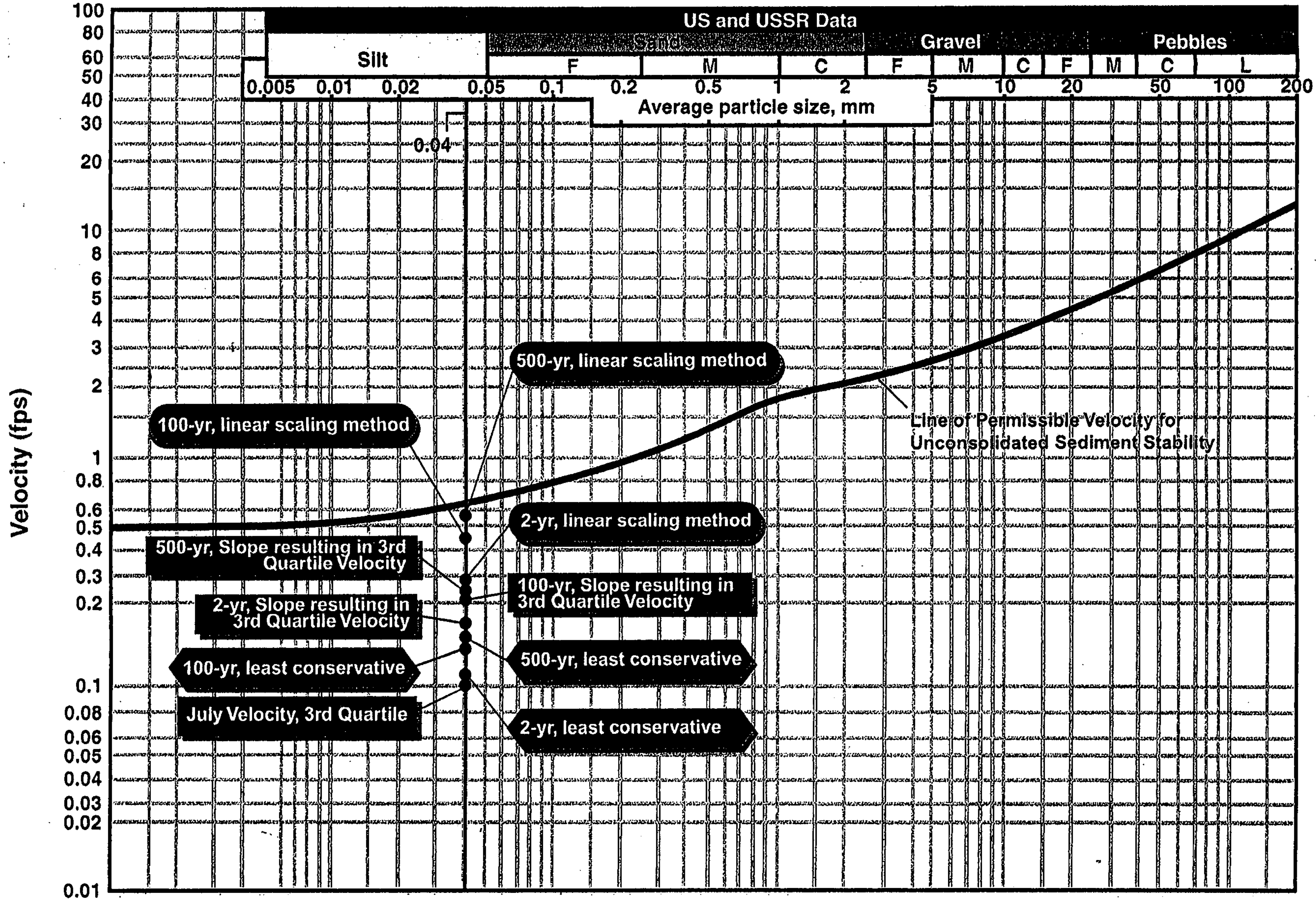


LEGEND

- Potentially Complete Exposure Pathway (solid arrow)
- Potentially Complete but Insignificant Exposure Pathway (dashed arrow)
- ● Potentially Complete Exposure Pathway – Evaluated Quantitatively in Risk Assessment
- ○ Potentially Complete Exposure Pathway – Evaluated Qualitatively in Risk Assessment

Job No. : 6800024343.00	FIGURE 7–7 CONCEPTUAL SITE MODEL (AQUATIC)
Prepared by : T.G.C.	
Date : 6/27/00	STIBNITE SITE

IGC24



NOTE: MEDIAN GLORY HOLE BOTTOM SEDIMENT DIAMETER IS 0.04 mm.
FIGURE MODIFIED FROM CHOW (1959)

Job No. :	24343
Prepared by :	T.G.C.
Date :	7/7/00

FIGURE 7-8
PERMISSIBLE VELOCITY GRAPH WITH PLOTTED VELOCITIES
STIBNITE SITE

4343TB18

8. TERRESTRIAL ECOLOGICAL RISK EVALUATION

Following is the risk evaluation of the terrestrial ecosystem on the Stibnite Site. The terrestrial ecological risk evaluation follows the approach described in the Stibnite Area Risk Evaluation Work Plan (Stibnite Group, 1997) and incorporates revisions based on comments received on the Draft RER (Stibnite Group, 1998) from the involved resource agencies. The risk evaluation also incorporates the results of discussions with IDEQ during a risk evaluation meeting on May 8, 2000.

8.1 APPROACH

The overall approach for the terrestrial ecological risk evaluation of the Stibnite Site is described in Section 2.2. The terrestrial ecological risk evaluation for the Site is performed in accordance with current USEPA guidance for ecological assessments of hazardous waste sites. The principal guidance documents are:

- Guidelines for Ecological Risk Assessment (USEPA, 1998)
- Framework for Ecological Risk Assessment (USEPA, 1992)

Additional detailed guidance and information usable for the terrestrial risk evaluation are presented in: Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (USEPA, 1997a), the series of ECO Updates prepared by the USEPA Office of Solid Waste and Emergency Response, various published ecological risk assessment books, and scientific journal articles.

Based on the paradigm for risk assessments contained in USEPA guidance (1992, 1998), the terrestrial risk evaluation for the Site consists of three principal parts that are illustrated in Figure 7-1.

- Problem Formulation
- Analysis
- Risk Characterization

The Terrestrial Ecological Risk Evaluation (Section 8) is organized into the following major sections:

Section	Title
8.1	Approach
8.2	Nature of the Problem
8.3	Problem Formulation
8.4	Analysis
8.5	Risk Characterization
8.6	Risk Estimation
8.7	Risk Description
8.8	Uncertainty in the Terrestrial Ecological Risk Evaluation
8.9	Terrestrial Ecological Risk Summary

8.2 NATURE OF THE PROBLEM

The purpose of the terrestrial ecological risk evaluation is to produce a scientific evaluation of terrestrial risk that enables managers to make informed decisions regarding whether remediation activities are warranted. The question to be answered by the ecological risk evaluation is: Are there unacceptable risks to the terrestrial environment from historic or recent mining activities? The principal terrestrial ecosystem issue at Stibnite is what constitutes a potentially unacceptable risk to the terrestrial environment (i.e., specific valued ecological resources) such that remedial measures are warranted. The influence of disturbance to terrestrial ecosystems on aquatic ecosystems has been addressed in Section 7 (Aquatic Risk Evaluation).

The terrestrial ecosystem on the Stibnite Site is complex in that it has been affected by various chemical and physical stressors, both naturally occurring and site-related. In order to make informed risk management decisions, it is essential to understand the potential effects of chemical stressors and to be able to separate effects due to physical disturbance from those due to chemical effects. For example, vegetation that appears stressed may be affected by toxic levels of chemicals in soils or by an absence of suitable soils (i.e., lack of nutrients or organic material). Understanding the terrestrial ecosystem on the Site and the various factors that may affect the quality of the system will permit reasonable and focused risk management decisions.

8.3 PROBLEM FORMULATION

Consistent with USEPA guidance, the first part of the risk evaluation, Problem Formulation, integrates available information regarding:

- Characterization of the terrestrial ecosystem
- Identification of stressors (chemical and physical)
- Ecological effects and characteristics of chemical stressors
- Assessment and measurement endpoints
- Conceptual site model for terrestrial receptors and exposure pathways

8.3.1 CHARACTERIZATION OF THE TERRESTRIAL ECOSYSTEM

The physical/chemical habitat of the terrestrial ecosystem on the Stibnite Site is fully characterized in the Draft SCR (Stibnite Group, 2000). The Draft SCR presents a detailed characterization of the site chemical data for soil, sediment, and surface water, and it describes the site natural resources, including vegetation and wildlife (see Table 8-1). The following description is from Sections 3.6 and 9.5 of the Draft SCR (Stibnite Group, 2000). Additional details of the terrestrial ecosystem at the Stibnite Site can be found in Section 6 of Stibnite Group (2000).

The forested slopes of the Stibnite Site are dominated by subalpine fir, lodgepole pine, Douglas-fir, and Englemann spruce. The understory consists of, among other species, grouse whortleberry, globe huckleberry, and elk sedge. Naturally occurring unforested areas are dominated by grasses and forbs and

barren rock outcrops. Areas disturbed by past mining activities are dominated by successional communities. The riparian areas along Meadow Creek and the EFSFSR contain wet meadows and areas dominated by willow and alder shrub.

Many portions of the Stibnite Site have been affected to varying degrees by historic and recent mining activity. Some areas remain largely unvegetated and in poor condition based on vegetation cover and soil stability parameters. Some areas have recovered to some extent, but remain in poor to fair condition; and some have recovered to good condition, where the differences between them and undisturbed areas are not apparent. Many of the areas with poor or fair condition were classified as such based on impacts attributable to physical disturbance from mine exploration and excavation, flood scouring and deposition, and large game traffic and browsing. The surrounding habitats not directly affected by mining activity are in good ecological condition.

In Investigation Area 1 (Meadow Creek drainage), most of the areas affected by mining are riparian (streamside) habitats located in the valley bottom. About 15 acres of lower Meadow Creek Valley have historic tailing deposits on the soil surface, but nearly all of this area is good condition wetlands, meadow and forest, with the exception of about 1 acre of unvegetated tailing. About 360 feet (6 percent) of the right bank of lower Meadow Creek and 230 feet (4 percent) of the left bank are unstable and in tailing, and other discontinuous portions of streambank with tailing are currently stable but susceptible to erosion (Section 8.6 and Plate 11 of the Draft SCR). In the vicinity of the confluence with Blowout Creek, Meadow Creek flows through alluvium deposited by the Blowout Creek dam failure, and there are some areas of bank instability in the alluvium. Most other portions of the valley bottom are permitted reclamation or operational areas. The hillside north of the Hecla and former SMI leach pads, Meadow Creek Mine area, and Smelter Stack area on the north side of the valley are also in poor to fair condition, associated with cuts and fills, steep slopes, erosion, and heavy big game use.

The DMEA dump in Investigation Area 2 (Upper EFSFSR) represents poor-condition habitat (it is steep and barren). This area occupies less than 1 acre. Much of the valley slopes are undisturbed, but some areas along this reach of the EFSFSR are in poor to fair condition due to historic activities such as vegetation clearing for operational areas, cuts and fills, and erosion and deposition in riparian areas along the EFSFSR.

In Investigation Area 3 (Lower EFSFSR and Sugar Creek), the Bradley waste rock dumps and Glory Hole occupy about 110 acres. Soils are mainly derived from mining, including mine excavations, mine waste rock, and reclaimed mine waste rock. Vegetation is sparse or absent in many areas, but reclaimed portions have varying amounts of vegetation cover. About 23 acres have erosive soils and 39 acres have moderately erosive soils. However, as noted previously, steep erosive slopes that are adjacent to the EFSFSR occur only along 800 feet of the west bank of the EFSFSR above the bridge at the main access road, along about 100 feet of shoreline on the southeast side of the Glory Hole, and along 100 feet of shoreline on the east bank and 450 feet on the west bank of the EFSFSR between Midnight Creek and the Glory Hole. In total, the steep erodible slopes immediately adjacent to the EFSFSR occupy about 15 percent of the shoreline from Midnight Creek to Station 314, including the Glory Hole perimeter.

The riparian habitat along the EFSFSR above and below the Bradley dumps and Glory Hole is in poor to fair condition because of past scouring and deposition.

As noted in Section 9.1.4 of the Draft SCR (Stibnite Group, 2000), the shoreline and banks of the Glory Hole are mostly stable, consisting of rock outcrops, wetlands, mostly stable alluvial fans and mine terraces on bedrock, and moderately stable flat to gentle slopes. About 100 feet of shoreline is steep terrain that is only moderately stable.

Over 150 wildlife species (mammals, birds, reptiles and amphibians) are likely to occur at the Stibnite site based on direct observation during site characterization activities in 1997 or as reported in Forest Service (1981), Greystone (1994), and Stoller (1996). Large game mammals that may be present at the Site include mule deer, elk, moose, black bear, and cougar. Mountain goat, bighorn sheep, and white-tailed deer utilize the region for summer range between seasonal snow cover. Small mammals likely to occur at or near the Site include weasel, badger, river otter, mink, striped skunk, bobcat, coyote, red fox, beaver, muskrat, bats, squirrels, and other small rodents. Over 200 bird species are either residents or seasonal visitors. Blue grouse and ruffed grouse are the most important game birds. Spruce grouse and mourning dove are found at lower elevations. Waterfowl that inhabit the area include several species of ducks and shorebirds.

No threatened or endangered species are known or expected to occur, other than an experimental reintroduction population of gray wolf. Suitable habitat is present for nine sensitive (Watch list) animal species. No threatened, endangered, rare or sensitive plant species are known to occur at the Stibnite Site, but some sensitive plant species could potentially be present within natural vegetation types.

For the remainder of Section 8, exposure locations (and primary exposure media) for terrestrial risk evaluation are referred to as:

- BT/NO Disposal Area (soil)
- Meadow Creek Mine Hillside (soil)
- Lower Meadow Creek Valley (soil, sediment, and surface water)
- Upgradient Wetland excluding the UW-1 Hot Spot (UW) (soil and surface water)
- Keyway Wetland (soil and surface water)
- Meadow Creek Forested Wetland (soil)
- SE Bradley Waste Rock Dumps (soil)
- NW Bradley Waste Rock Dumps (soil)
- NE Bradley Waste Rock Dumps (soil)
- UW-1 Hot Spot at the Upgradient Wetland (soil and surface water)
- Smelter Stack Hot Spot (soil)
- DMEA Dump Hot Spot (soil)
- NW Bradley Waste Rock Dump Hot Spot 1997 Antimony Outlier (soil)
- EFSFSR and Midnight Creek (sediment and surface water)
- Glory Hole and EFSFSR (sediment and surface water)

- Sugar Creek (sediment and surface water)
- BTO Hot Spot (surface water)

Five small exposure locations are termed "hot spots" because the results from soil or surface water for that location are not typical or representative of the general area from which other samples were collected.

8.3.2 IDENTIFICATION OF STRESSORS

Much of the modification of the original landscape at the Stibnite Site occurred through physical alteration of the environment associated with historic mining operations. Physical activities that removed or altered habitat include mine excavation (open pit mining), construction and operation of leach pads, placement of waste rock and neutralized ore, road construction, tailing deposition, tree cutting, and construction of other facilities. Indirect results of mining activities include erosion from sparsely vegetated areas. Reclamation actions at the Site have helped restore habitat condition for certain areas in recent years.

Stressors to the terrestrial ecosystem at the Stibnite Site are both physical (e.g., presence of waste rock, tailings, neutralized ore) and chemical (e.g., metals concentrations). Chemical stressors may be present as the result of historic operations, including historic smelter operation; natural presence in soil, tailings, waste rock, or neutralized ore; erosion, wind, or water transport of these materials; wind and water transport of tailing material; and release from shallow groundwater to seeps and surface water. This historic mining area has naturally high metal concentrations (e.g., Meadow Creek fault zone).

The list of chemicals to be evaluated in the terrestrial ecosystem risk evaluation originated with all inorganics detected in soils, wetland sediments, surface water, seeps, and fish tissue, as described in the Draft SCR (Stibnite Group, 2000). Arsenic and antimony were expected to be the principal inorganics because of their elevated concentrations relative to background concentrations in these media and because of the natural mineralization of the area. Chemical stressors in soil then were limited to only those metals that had maximum concentrations exceeding site-specific background concentrations as discussed in Section 6 (see Tables 6-2, 6-3, and 6-4). The number of chemicals evaluated varied between locations as a result of this comparison with background values.

Because of the application of conservative exposure assumptions, use of typical metal soil concentrations in terrestrial risk models often results in conclusions of unacceptable risk to terrestrial receptor populations. Since viable terrestrial ecosystems exist at typical metal soil concentrations, conclusions of unacceptable risk to communities or terrestrial populations at these concentrations is unrealistic and inappropriate. As discussed in Section 8.3.4, the ecologically relevant levels for risk evaluation are the community and population levels, not the individual organism level. To focus the terrestrial risk evaluation on those metals that may potentially pose risks at the community or population levels, only those metals with exposure concentrations greater than regional reference soil concentrations (i.e., average U.S. western soil; Schacklette and Boerngen, 1984) are retained for the quantitative risk evaluation. Results of the comparisons of metals in Site soils with U.S. western soils are provided in Table 8-2 for exposure locations (excluding hot spots), in Table 8-3 for hot spots, and in Table 8-4 for sediments. Sediments are included in this comparison because an exposure pathway of concern in the terrestrial risk assessment is from sediment

to terrestrial populations. Risk to the aquatic ecosystem from metal concentrations in sediments is evaluated separately in Section 7.

For the other media (surface water, seep water, fish tissue), all inorganics that were detected are evaluated. No background comparisons are performed because the principal exposure pathway is from soils and because of a general lack of appropriate background data for the secondary exposure media.

8.3.3 ECOLOGICAL EFFECTS AND CHARACTERISTICS OF CHEMICAL STRESSORS

Discussions of the chemical toxicity of inorganics (metals and cyanide) are provided in Section 8.4.2 (Effects Analysis) for those inorganics that were retained for terrestrial ecological risk characterization (Section 8.5) based on comparisons with Site background concentrations (Section 6) and U.S. western soil reference concentrations (Tables 8-2, 8-3, and 8-4). Discussions for each inorganic include phytotoxic concentrations (mg/kg), toxicity reference values (TRVs) expressed in terms of doses (mg/kg-bw-day) to various receptor groups, and factors (e.g., pH, organic content of soils) that mediate the mobility, bioavailability, and ultimately, the toxicity of the inorganics.

8.3.4 ASSESSMENT AND MEASUREMENT ENDPOINTS

Ecological endpoints to be considered in the terrestrial risk evaluation are generally characterized as assessment endpoints and measurement endpoints (USEPA 1989, 1992a). Assessment endpoints are formal expressions of the environmental values that are to be protected, and measurement endpoints are measurable environmental characteristics that are related to the valued characteristics that are to be protected (Suter, 1993). When an assessment endpoint can be directly measured, the measurement and assessment endpoints are the same. In most cases, however, measurement endpoints are needed because assessment endpoints cannot be directly measured.

For larger sites such as Stibnite, the most ecologically relevant entities are the structural and functional components of the forest ecosystem, rather than the individual plant and animal species present at the site. In order for a chemical or physical stressor to have ecological relevance, the adverse effects should be pervasive enough to result in measurable changes in the structural or functional organization of the ecosystem.

Assessment endpoints are identified based on the following three considerations (USEPA, 1992a):

- Ecological relevance (structure and function of the ecosystem)
- Policy goals and societal values (endangered, threatened, or species of special concern and protection of ecosystem integrity)
- Susceptibility to the stressors of concern (i.e., exposure and sensitivity to chemical and physical stressors)

Protecting the health of the forest ecosystem is a principal resource management goal (i.e., policy goal) for state and federal natural resource agencies. Protection of forest ecosystem health is governed by numerous Federal Acts, including:

- Federal Land Policy and Management Act of 1976,
- National Forest Management Act of 1976,
- Forest and Rangelands Renewable Resources Planning Act of 1974,
- Multiple-Use Sustained Yield Act of 1960, and
- National Environmental Policy Act (NEPA) 1969.

The resource protection goals and adaptive management practices of state and federal natural resource agencies incorporate current ecosystem management principles including the protection of ecosystem integrity, sustainability, and diversity. At mine sites like Stibnite, the USEPA (1998) recommends use of an ecosystem perspective and ecological principles to conduct the risk evaluation. For this reason, protection of ecosystem integrity through maintenance of the ecosystem's structural and functional components was identified as the principal risk management goal for this site.

Potential adverse effects to individual species are addressed only in the case of threatened and endangered species because adverse effects to such individuals can result in significant adverse effects at the population level. No threatened or endangered wildlife or plant species are known or expected to occur in the terrestrial or riparian ecosystem at Stibnite, other than an experimental reintroduction population of gray wolf. Due to the absence of threatened and endangered species, the assessment endpoints address effects to plant communities and wildlife populations and not individual species.

At the Stibnite Site, the primary endpoint can be stated as "protection of ecosystem integrity through maintenance of the ecosystem structural and functional components." Beginning with this primary endpoint, the assessment endpoints to be used for the terrestrial ecological evaluation are as follows:

- Protection of the upland and riparian plant communities
- Protection of populations of wildlife functional groups

Given the size of the Site and the nature of the chemical and physical stressors, basic functional ecosystem categories were identified as the most useful endpoint entities for this risk evaluation. These functional categories (producer, consumer, detritivore) and feeding groups within the consumer category (herbivore, omnivore, carnivore) are ecologically valued for their importance in maintaining a healthy ecosystem. Use of these functional groups and the representative receptor species in the risk model includes consideration of the potential for adverse ecological effects at the population, community, and ecosystem level.

The selection of functional groups as assessment endpoints and receptor groups for this risk evaluation was based on: (1) presence of a complete exposure pathway; (2) nature of the contaminants (i.e., can the contaminant, either directly or indirectly, measurably affect organisms within a designated receptor category); (3) susceptibility to bioaccumulation/biomagnification effects; (4) availability of toxicity data; and (5) presence at the Site.

All functional (receptor) groups are considered ecologically relevant and their interactions are essential for maintaining ecological integrity. Their exposure pathways and other relevant attributes relative to selection as assessment endpoints are described below:

Producers - Vascular Plants

- provide habitat for wildlife
- plant groups sensitive to phytotoxic contaminants
- direct contact with contaminated soils
- widespread and ecologically important (food, habitat, energy and nutrient fixation)
- represent local impacts in a contaminated area

Primary and Secondary Consumers - Terrestrial Insectivores/Invertivores, Small Birds, and Small Mammals

- direct exposure to contaminated soils
- small home range (exposure area)
- low on food chain (prey for higher-level carnivores)
- important in decomposition

Primary Consumers - Herbivores (Avian and Mammalian)

- small to medium home range size
- important intermediate food sources
- direct contact with contaminants in soils as well as exposure through ingestion of plants
- toxicity data available
- known sensitivity to site COPIs

Tertiary and Quaternary Consumers - Carnivores (Avian and Mammalian)

- upper trophic level (greatest potential to be affected by biomagnification)
- large foraging range
- differential sensitivity (bird and mammal)
- ecologically important as "top down" control in terrestrial ecosystems

The detritivore category (soil invertebrates and soil microorganisms) also is included in this risk evaluation even though earthworms, which are the representative example for this category, are generally lacking in these organic-poor forest and mine waste soils. Toxicological benchmarks for soil invertebrates and soil microorganisms generally approximate those for plants. Therefore, protection of vegetation and habitat (landscape) condition as a resource management goal generally also protects the soil organisms and their functioning as detrivores.

The primary measurement endpoints associated with the assessment endpoints and functional groups are:

- Soil and water chemical analyses and comparisons with toxicological endpoints
- Upland and riparian habitat condition (vegetation and soil mapping; soil profiles)

Measures for evaluating effects of each chemical stressor on the receptors are based on No Observed Adverse Effect Level (NOAEL) and Lowest Observed Adverse Effect Level (LOAEL) toxicity benchmarks developed from laboratory studies. Wildlife benchmarks are derived from toxicological data for a limited variety of standard laboratory test organisms (e.g., rat, mouse, duck, chicken). Laboratory toxicity benchmarks are commonly used as surrogate measures of potential adverse effects from a chemical requiring extrapolation of laboratory test organism data to specific species likely to occur onsite, but whose relative sensitivities to site conditions and chemicals are not well known.

Ecological effects of most concern are those that can impact populations or higher levels of ecological organization. Toxicological effects most likely to affect populations are those that affect individual growth, reproduction, and survival. NOAELs and LOAELs for these types of chronic toxic effects were used in this risk analysis to evaluate the potential for adverse effects to terrestrial receptors at a given location. Because the receptors in this evaluation are functional ecological groups rather than individual species, exceedance of a benchmark value for a particular medium (soil, water) presumes that any member of that functional group could be potentially exposed and adversely affected. However, LOAELs based on effects to individual test organisms are expected to be negligible-effects risk levels for wildlife populations (Efroymson et al., 1997a).

The measurement endpoints for chemical stressors are quantitatively evaluated through the calculation of HQs wherein the measured concentrations or the resulting doses to wildlife are divided by the environmental benchmarks (see Section 8.6). The habitat condition and the physical stressors affecting it are evaluated qualitatively.

8.3.5 FOOD WEB

Movement of chemicals through a biotic food chain follows the same basic principles and pathways for any plant and animal community. Figure 8-1 shows a generalized food web for the Site. The food web illustrates the movement of food/nutrition/energy from the decomposing organic material (detritus) through plants, herbivores, and predators. As plants and animals die, their remains ultimately return to the base of the food web (not illustrated). The food web forms the basis for the CSM that shows potential exposure pathways from abiotic media (e.g., soil) through the various trophic levels of the terrestrial/riparian ecosystem. Over 150 wildlife species (mammals, birds, reptiles and amphibians) may potentially occur at the Stibnite Site (Stibnite Group, 2000). These species were categorized into feeding groups for use as wildlife receptors in the CSM and the risk model. Wildlife species observed or potentially occurring at the site and their assigned feeding group are shown in Table 8-1.

8.3.6 CONCEPTUAL SITE MODEL

A general terrestrial ecological CSM diagram is shown in Figure 8-2. This is a refinement of the CSM originally presented in the Draft RER (Stibnite Group, 1998). The CSM is based on the food web, existing site data, selected assessment endpoints, appropriate measurement endpoints, and terrestrial receptor organisms. It summarizes known information and anticipated movements of chemicals between abiotic elements (e.g., groundwater movement to surface water), abiotic-to-biotic movement (e.g., direct contact of plants and animals with chemicals in soils), and between biotic elements (e.g., carnivores preying on small mammals/birds). Location specific CSMs are shown in Figures 8-3 through 8-5. Figure 8-2 also depicts the fact that some mining activities have had physical effects on terrestrial habitats. Physical stressors directly affect ecological resources by burying habitat and creating unfavorable conditions for re-establishment. Recent and ongoing revegetation efforts at the Site are addressing these issues. The physical condition of upland and riparian habitats serves to modify the estimated toxicity of chemical stressors to the plant and animal functional groups and are addressed accordingly in this risk evaluation.

8.4 ANALYSIS

The analysis phase of ecological risk assessment consists of: (1) exposure analysis -- a technical assessment of the potential for and likely magnitude of exposure of terrestrial receptors to the chemical and physical stressors (Section 8.4.1) and (2) ecological response analysis -- an effects assessment (Section 8.4.2).

8.4.1 EXPOSURE ANALYSIS

The most important exposure pathways for terrestrial receptors as illustrated in the CSMs (Figures 8-2 through 8-5) were judged to be:

- Uptake from sediment/soils, surface water, and shallow groundwater by riparian and wetland vegetation
- Direct contact and uptake from soils by upland vegetation
- Direct contact with and/or soil ingestion of invertebrates and herbivores
- Food chain exposure from soils for herbivores, insectivores and carnivores
- Food-chain exposure for fish-eating birds and mammals (piscivores)
- Direct contact with surface water from creeks/rivers or seeps by consumer organisms

The exposure characterization was performed using the functional receptor groups described in Section 8.3.4 and the site-specific data for soil, wetland sediment, surface water, seep water and fish tissue provided in the Site Characterization Report. Representative species of the receptor groups and their exposure pathways are listed in Table 8-5. Based on the exposure estimates for wildlife, plants, and soil organisms, risk was quantitatively estimated using the HQ risk model described below in Section 8.6.

For inorganics in soil, reasonable maximum exposure (RME) concentrations were calculated using the 1997 and 1999 data collected for each exposure location described in Table 5-3. For exposure locations with fewer than four samples, the maximum concentration detected was used as the exposure point

concentration. For locations with four or more samples, the RME concentration was the lower of the 95% UCL or the maximum. The same soil exposure concentrations used in the human health evaluation (see Appendix B) were used in the terrestrial ecological risk model. Exposure locations and concentrations for sediment and surface water likewise were the same as those used in the human health evaluation (Appendix B). Chemical concentrations for each seep were based on the maximum total metals concentrations reported in the Draft SCR Appendix B4 data tables (Stibnite Group, 2000). Exposure concentrations for fish (whole body) are presented in Table 7-12 of the RER.

Calculation of the site-specific exposure using Oak Ridge National Laboratory (ORNL) (Sample et al., 1996) doses for wildlife employed the following generalized equation:

$$\text{Exposure Dose (mg/kg-bw/day)} = (\text{EDI} \times \text{BA} \times \text{F}) / \text{BW}$$

and $$\text{EDI} = [(C_f \times I_f) + (C_s \times I_s)]$$

where:

EDI = the estimated daily ingested amount of the chemical (mg/day).

C_f = the chemical concentration in the food or drinking water (mg/kg wet weight or mg/L).

I_f = the food or drinking water ingestion rate (kg/day wet weight or L/day).

C_s = the chemical exposure concentration in soil, sediment, or water (mg/kg dry weight for soil and sediment and mg/L for water).

I_s = the incidental soil, sediment, or water ingestion rate (kg/day dry weight or L/day).

BA = bioavailability or that fraction of the total concentration which is biologically available. For conservative purposes this value was set at 1.

F = the species area use factor calculated as exposure area/home range. This factor accounts for the proportion of a receptor's time spent exposed to contamination within a particular subsite. The area use factor considers home range size, foraging behavior, and migratory behavior as well as the size of the potentially contaminated habitat available at the subsite. For each receptor and subsite combination, F can have a value equal to or less than 1.0. For conservative purposes this value was set at 1.0 for calculating exposure. Estimates of area use factors for representative receptor species are used in discussions of calculated HQs (Section 8.7).

BW = the body weight of the receptor expressed in kg.

Area use and bioavailability were assumed to be 100 percent (equal to 1). This provides a conservative estimate for larger birds and mammals whose home ranges may encompass several square miles and are thus unlikely to be limited to a specific site location. Actual bioavailability for mining-related chemicals also is probably less than 100 percent, as documented in the scientific literature (USEPA, 1999; 2000).

The chemical concentration in the tissue of food items eaten by wildlife receptors was calculated using the following equation:

$$C_f = BAF \times C_s$$

where:

BAF = chemical-specific bioaccumulation factor

Bioaccumulation factors, which are specified for each food item (i.e., plant, soil, invertebrates, small birds/mammals) and metal are shown in Appendix Table C.A-2.

The wildlife exposure factors used in this risk evaluation (e.g., body weight, food, water, and soil ingestion rates) employed the USEPA (1993b) and Sample et al. (1996) values for representative wildlife species. The representative species used in this evaluation (Table 8-5) and their exposure factors (Table 8-6) are not intended to provide site-specific or realistic estimates of contaminant exposure. Each species is considered to be a representative example of the general diet composition, food and water intake rates, and body weight for that functional receptor group. The functional groups do not have firm boundaries, as individual species can sit astride the border of two or more categories (e.g., omnivore, herbivore, carnivore), depending on the species' diets that vary yearly and seasonally depending on food availability. Use of representative species and exposure factors for those species thus provides a relative means to compare potential risks among functional receptor groups. Exposure through the food web was evaluated by modeling concentrations in food items using Sample et al. (1997) or other USEPA-accepted uptake (bioaccumulation) factors.

8.4.2 ECOLOGICAL RESPONSE ANALYSIS

Following are descriptions of toxic effects and mediating factors for those inorganics (metals and cyanide) that are retained for risk. These descriptions, which follow the ecological response analysis process, are provided to facilitate interpretation of the risk estimates (Section 8.6).

8.4.2.1 Antimony

Uptake and Bioavailability. Antimony in soil is considered to largely be in an immobile form (i.e., unreactive oxides). Mobility of antimony and arsenic largely depends on pH (i.e., greater mobility with lower pH) and on the iron and manganese content of the soils and sediments.

Antimony is non-essential to plants but can be readily absorbed by roots when in soluble forms (Alloway, 1990). Reports are mixed regarding the potential uptake of antimony into plants. Some investigators report that plant roots likely exclude antimony, since the leafy portions of plants grown in pots of uncontaminated soil accumulated as much antimony from air as adjacent plants growing in contaminated soil (Ainsworth et al., 1991). Others report that plants are generally more tolerant of excess antimony than arsenic, and that plants can preferentially translocate (rather than exclude) antimony into older leaves, lower stems, and roots (Alloway, 1990). Coughtrey et al. (1983) have calculated soil/plant ratios of antimony at 0.1, 0.05, and 0.005, respectively, for older leaf, stem, and root tissues, assuming a mean soil concentration of 1 mg/kg. Concentrations between 0.35 and 2.5 mg/kg in trees and shrubs have been found in mineralized areas of Alaska (Schacklette et al., 1978). Clover (a legume) has been shown to be an excluder, with concentrations in plants grown in antimony-containing soil the same as, or less than, concentrations in plants grown in an uncontaminated soil (Alloway, 1990).

Toxicity to Plants and Wildlife. The toxic action of antimony is probably similar for terrestrial and aquatic organisms; that is: 1) toxicity is directly proportional to aqueous solubility; 2) trivalent compounds are more toxic than pentavalent ones; 3) the organic form (antimony potassium tartrate) is the most toxic form; and 4) metallic antimony is more toxic than the oxide and sulfide forms (Seiler and Sigel, 1988).

Phytotoxic levels of antimony have been reported as 5 to 10 mg/kg in plant tissue (Kabata-Pendias and Pendias, 1984). No primary reference data exist that describe toxicity of antimony to plants grown in soil. The 1996 ORNL (Will and Suter, 1995a) soil screening value of 5 mg/kg (Table C.A-3) is based on a report of unspecific, qualitative toxic effects on plants grown in surface soil with the addition of 5 mg/kg antimony (Kabata-Pendias and Pendias, 1984). This is not an appropriate soil screening value for this site, because the average reference soil concentrations exceed this value.

Few data are available regarding the toxicity of antimony to wildlife. Studies on invertebrates and small mammals have shown that invertebrates do not typically concentrate antimony relative to their diet (Ainsworth et al., 1991a), and food chain transfer from detritus and soil litter appears to be limited. Ainsworth et al. (1991b) report that antimony trioxide in a vole diet resulted in elevated organ concentrations; however, an equilibrium between uptake and excretion of antimony seemed to be rapidly established, and progressive increases in organ concentrations did not occur. No genotoxic effects were detected in sheep bred on grounds containing elevated antimony (2 to 15 mg/kg), arsenic (17 to 147 mg/kg), and mercury (1 to 435 mg/kg) (Gebel et al., 1996).

The ORNL (Sample et al., 1996) mammalian LOAEL TRV of 1.25 milligrams per kilogram body weight per day (mg/kg-bw/d) for antimony is based on a chronic drinking water mouse study using 5 mg/L of antimony potassium tartrate. ORNL did not report an antimony TRV for birds.

8.4.2.2 Arsenic

Uptake and Bioavailability. In general, arsenic availability to plants is highest in coarse-textured soils having little colloidal material and little ion exchange capacity, and lowest in fine-textured soils high in clay, organic material, iron, calcium and phosphate (NRCC, 1978). Arsenic in the soil is usually bound to

clay surfaces. Its mobility depends on the pH of the soil, phosphate levels, iron and aluminum content, and soil type (ATSDR, 1999). Chemical and biological transformations can make this cycle very complex.

In a study on the speciation of mobile arsenic in soil samples as a function of pH in most samples (pH of 3 to 9), less than 2 percent of the total arsenic was extracted. This indicates that pH changes in the environment would have to be very dramatic if they were to release high amounts of arsenic bound to the soil (Kallio and Manninen, 1997). Only inorganic species, trivalent arsenic (As^{+3}) and pentavalent arsenic (As^{+5}), were found in the extractions, and much higher concentrations of As^{+5} than As^{+3} were extracted in all cases. The authors also report that a more serious mobilization of arsenic from soil is caused by other mechanisms, for example, ion exchange, than by dissolution as a result of pH changes.

To be absorbed by plants, arsenic compounds must be in a mobile form in the soil solution. Displacement of arsenic by phosphate has been used to ameliorate the toxic effects of arsenic in some soils (Jiang and Singh, 1994). Analogous to phosphorus, total arsenic in soil is a poor indicator of the fraction of arsenic that is plant-available.

Arsenic has generally been found to be nonaccumulative in the plant and water phases of agronomic ecosystems (Eisler, 1994). Arsenic may be bioaccumulated by plants and soil organisms to a limited extent, but arsenic does not biomagnify in the food chain (Eisler, 1994). Plants grown in soils containing up to 80 mg/kg arsenic have been shown to contain up to 5.8 mg/kg (dry weight), but these levels are not considered to be dangerous to grazing ruminants (Merry et al., 1986). Unusually high arsenic concentrations in some plant species are occasionally reported. Levels up to 1430 mg/kg (dry wt) were found, for example, in one plant species (*Bidens cynapiifolia*) at a copper mine site in Peru (Bech et al., 1997). It is more commonly reported that arsenic-tolerant plants effectively restrict arsenic transport to shoots either within or outside the roots, so that herbivorous consumers are generally not affected. Vegetation at the Ester Dome area in Alaska, where bedrock soils contain up to 750 mg/kg arsenic, were not significantly enriched in arsenic (Hawkins et al., 1982).

Toxicity to Plants and Wildlife. Arsenic phytotoxicity of soils is reduced with increasing lime, organic matter, iron, zinc, and phosphates (NRCC, 1978). Displacement of arsenic by phosphate has been used to ameliorate the toxic effects of arsenic in some soils (Jiang and Singh, 1994).

Certain metals, including arsenic, are sufficiently toxic to plants that effects on animal or human health resulting from dietary intakes are not likely (Sheppard, 1992). However, the inability to grow plants is also a rather undesirable impact. The ORNL (Will and Suter, 1995a) soil screening value for plants is 10 mg/kg (Table C.A-3). Commonly reported phytotoxicity thresholds are very close to, or overlap with, commonly reported background levels (Sheppard, 1992). Based on geometric means, inorganic arsenic is 5-fold more toxic in sands than in clay soils, and it is appropriate to set generic regulatory criteria that specify soil texture. Sheppard (1992) reports a geometric mean toxicity threshold of 40 mg/kg, which coincides with the upper bound of typical background level.

Plant uptake and hence, toxicity, is dependent on the plant-available fraction (Deuel and Swoboda, 1972b). Broad ranges in phytotoxicity levels have been reported, even for single crops such as beans or corn

(Sheppard, 1992). This variation is caused by variables such as soil type, soil pH, arsenic source and arsenic speciation. Plant response over a range of inorganic soil-arsenic levels, based on a sampling of the studies, shows how toxic levels approach normal background levels and overlap with stimulatory levels (McKeague et al., 1979).

Cases of chronic arsenosis in animals is rarely encountered, except in humans (Eisler, 1994). The probability of chronic arsenic poisoning from continuous ingestion of small doses is extremely low because detoxification and excretion are rapid (Woolson, 1975). Incidents of acute or subacute arsenic poisoning in wildlife most often result from exposure to arsenical herbicides (Eisler, 1994). Episodes of wildlife poisoning by arsenic have been reported for white-tailed deer that have consumed, by licking, fatal amounts of sodium arsenite (a highly soluble, trivalent form) used to debark trees (Eisler, 1994).

Plants and animals collected from naturally arseniferous areas generally contain elevated levels of arsenic in their tissues, although not always (Bagatto and Alikhan, 1987). Animals are not as sensitive to arsenic as humans, which is partially attributed to differences in gastrointestinal absorption (Naqvi et al., 1994). In rats, the median lethal dose (LD50) (dose which is lethal to 50 percent of the exposed population) ranges from 15 to 193 mg/kg; in other vertebrates it ranges from 10 to 150 mg/kg (IARC, 1987). Because the metabolism of arsenic in rats is unique, rats are not appropriate surrogates for wildlife.

At a dietary concentration of 93 mg/kg (16 milligrams per kilogram body weight [mg/kg-bw]), Stanley Jr. et al. (1994) reported no effects on liver, egg, or body weight of 1-yr old ducklings, or on duckling production in a chronic feeding study using sodium arsenate. A diet of 403 mg/kg (70.5 mg/kg-bw) resulted in decreases in liver weight, duckling weights, duckling production, and whole egg weight. The 1996 ORNL (Sample et al., 1996) dietary arsenic reference values for mammals and birds range from 9.9 mg/kg for small carnivorous mammals to 149 mg/kg for small omnivorous mammals (Table C.A-3).

Because plant phytotoxic levels in tissues are generally well below the calculated LOAEL wildlife TRVs, arsenic is not considered likely to accumulate in food items to the extent that such concentrations would pose a significant dietary concern for terrestrial wildlife.

8.4.2.3 Cadmium

Natural cadmium concentration in phosphorites used to manufacturer phosphate fertilizers range from 3 to 100 mg/kg (ATSDR, 1993). The median concentration of cadmium in U.S. western soils is 0.32 mg/kg (Irwin et al. 1997).

Uptake and Bioavailability. Adsorption of cadmium by soil depends on the pH, the chemical nature of the metal species, the stability of cadmium complexes, the binding power of the functional groups and the ionic strength of solutions and competing ions. Soil pH is the major factor determining the availability of cadmium in the soil, because it affects all adsorption mechanisms and the speciation of metals in the soil solution. The movement of cadmium in soil and potential accumulation in biota is enhanced by low pH, low organic matter content, and large soil particle size (Irwin et al., 1997). The free divalent cadmium ion (Cd^{2+}) is more likely to be adsorbed on the surfaces of soil solids than other species, such as neutral or

anionic species. The free ion Cd^{2+} predominates in polluted soils, with neutral species, such as cadmium sulfate ($CdSO_4$) or cadmium chloride ($CdCl_2$), present in increasing amounts where the pH is greater than 6.5 (Alloway, 1990). In sandy and loamy soils, cadmium adsorption increases by a factor of 3 for every pH unit increase between pH 4 and 7.7 (Alloway, 1990).

Toxicity to Plants and Wildlife. Cadmium has no essential biological function. Although it is highly toxic to plants and animals, the concentrations normally encountered in the environment do not cause acute toxicity. The toxic effects of cadmium are determined more by its form than by its concentration. Strickland et al. (1979) reported that the cadmium concentration required to reduce soybean growth increased from 1.25 mg/kg to 20 mg/kg when organic carbon amendments increased from 0 to 2 percent. ORNL's (Will and Suter, 1995a) plant screening value for cadmium of 4 mg/kg (Table C.A-3) is the 10^{th} percentile of 74 LOECs. These plant experiments were conducted with soluble cadmium salts ($CdCl_2$) as the primary form.

Soil invertebrate and soil microorganism toxicity screening values for cadmium in soil of 20 mg/kg are also 10^{th} percentile LOECs. The primary form of cadmium tested for these soil receptors was the soluble $CdCl_2$ salt. These screening values are typically higher than natural soil levels of cadmium.

ORNL's TRVs (Sample et al. 1996) for mammals and birds are based on the $CdCl_2$ form. Except for small avian and mammalian invertivores, TRVs are typically above natural soil concentrations of cadmium.

8.4.2.4 Copper

Uptake and Bioavailability. Like arsenic, zinc, and lead, copper is not known to biomagnify in terrestrial systems; therefore, the greater risk occurs to the lower trophic level organisms, particularly those with a high soil ingestion rate. In general, copper is strongly absorbed in the top several soil inches to organic matter, carbonates, clays, and hydrous, ferrous, or manganese oxides. Low pH, low organic matter, and an oxidizing environment favor copper mobility. Copper tends to be less mobile than zinc, cadmium and nickel (ATSDR, 1989).

Most studies report total copper concentrations in soil to be an essentially poor indicator of the plant-available fraction.

Toxicity to Plants and Wildlife. Copper is an essential trace element in soils. The toxicity of copper depends upon the chemical form as well as the route of exposure, dose, and duration of exposure. In general, toxicity of copper compounds is proportional to increased solubility. Insufficient dietary copper intake results in deleterious effects in plants and wildlife (e.g., impairment of hemoglobin synthesis).

Soil phytotoxicity threshold concentrations for required nutrients such as copper commonly overlap background levels. ORNL's (Will and Suter, 1995a) copper screening value of 100 mg/kg (Table C.A-3) is based on 68 percent reduction in root and shoot weights of little bluestem grown from seed for 12 weeks in a sandy soil (pH 7.8, 2.5 percent organic matter, cation exchange capacity [CEC] of 12 milliequivalents

[meq]/100 g soil) when 100 mg/kg copper sulfate ($CuSO4$) was added. This was the only concentration tested. Most of Stibnite soils have less than 60 mg/kg of copper.

ORNL's (Sample et al., 1996) TRVs for mammals are based on the copper sulfate form and for birds are based on the copper oxide form, both forms are likely to occur at this Site.

8.4.2.5 Cyanide

<u>Uptake and Bioavailability</u>. Cyanide biomagnification in food webs has not been reported, possibly due to rapid detoxification of sublethal doses by most species and death at higher doses (Eisler, 1991). Most authorities also agree that cyanide has low persistence in the environment and is not accumulated or stored in any mammal studied. Cyanide seldom remains biologically available in soils, because it is either complexed by trace metals, metabolized by various microorganisms, or lost through volatilization. Cyanide is strongly leached into groundwater and not strongly adsorbed or retained on soils.

Cyanide can be found in several forms in water. HCN is one of the most toxic cyanide species. Potassium cyanide (KCN), like sodium cyanide (NaCN), refers to alkali water-soluble salts. In water, NaCN and KCN will completely dissociate to give free cyanide. Free cyanide (CN^{-1}) and metallocyanide complexes are two of the most common forms of cyanide found in the environment. Increased pH will maintain a larger fraction of the cyanide as CN^{-1}, and acidification will cause the reverse (Eisler, 1991).

<u>Toxicity to Plants and Wildlife</u>. Although cyanide at sufficient levels can be toxic or lethal, low levels of cyanide are relatively non-toxic. Most authorities agree that in mammals: (1) despite the high lethality of large single doses, repeated sublethal doses seldom result in cumulative adverse effect; and 2) sublethal intermittent doses can be tolerated by many species for long periods, perhaps indefinitely (Eisler, 1991). The toxicity of simple cyanides will not be affected measurably below pH 8.3 (Eisler, 1991).

Rats, for example, fed diets containing as much as 300 mg/kg in diet for up to 3 years showed little chronic effect, and rats fed diets containing 1,500 mg/kg potassium cyanide or 2,240 mg/kg potassium thiocyananate for 11.5 months neither died nor exhibited clinical signs of toxicity (Philbrick et al., 1979).

At toxic levels, cyanide is a rapid-acting asphyxiant; it induces tissue anoxia through inactivation of cytochrome oxidase (Eisler, 1991). Diagnosis of acute lethal cyanide poisoning is difficult, because signs and symptoms are nonspecific and numerous factors modify its biocidal properties, such as dietary deficiencies in vitamin B12, and sulfur amino acids (Eisler, 1991). Most authorities agree that cyanide has low persistence in the environment and is not accumulated or stored in any mammal studied. Also, cyanide biomagnification in food webs has not been reported, possibly due to rapid detoxification of sublethal doses by most species and death at higher doses (Eisler, 1991).

Many species of migratory birds have been found dead in the immediate vicinity of gold-mine heap-leach extraction facilities and tailings pond, presumably as a result of water containing cyanide concentrations greater than 200 mg/L (total CN) (Eisler, 1991). Some birds may not die immediately after drinking lethal cyanide solutions. This is likely due to the phenomenon of WAD cyanide compounds. Cyanide bound to

certain metals, usually copper, is dissociable in weak acid such as stomach acids. Drinking lethal cyanide solutions by animals may not result in immediate death if the cyanide level is sufficiently low; these animals may die later when additional cyanide is liberated by stomach acid (Eisler, 1994).

8.4.2.6 Lead

There is no significant evidence that lead plays any essential role in metabolism. In general, inorganic lead compounds that result from mining and smelting activities are considerably less toxic than organic lead forms. Near lead-zinc mines, elevated concentrations of lead are often found in mammalian tissues and generally reflect elevated concentrations in soil, vegetation, and invertebrates (Talmage and Walton, 1991; Smith and Rongstad, 1982).

Uptake and Bioavailability. In terrestrial ecosystems, bioavailability of lead in soils to and within plants is generally low due to lead's low solubility and mobility. Lead solubilization and movement in soils is facilitated by acidic pH, which can become a factor in the concentration of lead in plants (Seiler and Sigel, 1988). While lead is potentially toxic to plant life, plant populations near smelter sites seem to be selected for lead tolerance (Seiler and Sigel, 1988). Lead in soils can interfere with manganese uptake, and lead increases the availability of cadmium and other heavy metals (Eisler, 1988). Soil pH and organic matter content combined with total lead concentrations are a better predictor of potential plant toxicity than total metals levels alone.

Lead resulting from mining activities may enter the body directly through ingestion of soil particulates. High concentrations of lead and zinc in soil at mine waste sites are not necessarily hazardous to most wildlife species (Beyer et al., 1985). In general, it is thought that species that decompose organic matter in soils and species whose food chains are dependent on such organisms are the most likely to have higher metal concentrations (Beyer et al., 1985). Herbivorous animals would have less exposure through the food chain. Lead is not considered to biomagnify from diet through either aquatic or terrestrial food webs (DeMayo et al., 1982; Eisler, 1988).

Toxicity to Plants and Wildlife. At concentrations of 450 mg/kg in soil, lead can reduce biological activity (Cole, 1977). Maximum acceptable concentrations in agricultural soils to prevent phytotoxicity are 100 to 400 mg/kg, according to various authors cited in Kabata-Pendias and Pendias (1992). At lesser concentrations, damage to plants is usually negligible, but varies widely among species. The ORNL (Will and Suter, 1995a) soil benchmark for plants is 50 mg/kg (Table C.A-3), based on 17 values from experiments conducted with a range of different plant species. Soil pH and organic matter content combined with total lead concentrations, however, are a better predictor of potential plant toxicity than total metals levels alone. For example, Sauve et al. (1998) report a 50 percent plant growth inhibition level of 177 mg/kg at pH 5.5 versus 2,276 mg/kg at pH 7. In laboratory experiments with oats and red clover, significant yield differences were observed at lead concentrations above 50 mg/kg (Von Hodenberg and Finck, 1975). In all soils except sandy soils, soil lead concentrations of at least 1,000 mg/kg must be present before any lead effects on fruit, such as apples or grapes, can be observed (Tornabene et al., 1977).

Lead has been shown to adversely affect survival, growth, reproduction, development, and metabolism of many species under controlled conditions (Eisler, 1988). Toxic effects from lead, however, are substantially modified by numerous physical, chemical, and biological variables (Eisler, 1988). Diet is often the major modifier of lead absorption and of toxic effects in animals (Eisler, 1988). Other conditions which affect lead toxicity include size of lead particle, type of compound ingested, and presence of other compounds, such as copper or zinc, that act synergistically or antagonistically. In general, it is expected that most of the lead in neutral pH soils would be found in the form of insoluble compounds or complexes that are not bioavailable and therefore have a low wildlife toxicity potential (relative to laboratory toxicity values). While most plants are likely to exclude lead in the root zone, plants which can accumulate lead, such as certain species of submerged aquatic macrophytes (Scheuhammer, 1991), are capable of exerting toxic effects when ingested.

ORNL (Sample et al., 1996) provides no LOAEL or NOAEL based TRVs for mammals for metallic lead. ORNL's lead benchmarks for mammals are based on the highly soluble lead acetate form. ORNL's avian NOAEL reference values for metallic lead range from 3.0 to 128 mg/kg-bw/day (Sample et al., 1996). Using ORNL's dietary uptake factors, the LOAEL soil reference values range from 40.5 mg/kg for small carnivorous birds and 740 mg/kg for small carnivorous mammals, to 55,000 mg/kg for large carnivorous birds and 18,600 mg/kg for large herbivorous mammals (Table C.A-3).

Various countries have recommended levels for lead concentrations in the drinking water of farm animals. The NAS and the U.S. National Academy of Engineering recommend a maximum concentration of 0.1 mg/L (DeMayo et al., 1982). The ORNL (Sample et al., 1996) NOAEL and LOAEL drinking water benchmarks for wildlife (birds and mammals) are all greater than 1 mg/L.

8.4.2.7 Manganese

Uptake and Bioavailability. Manganese is an essential nutrient for plants and animals and is one of the most abundant trace elements. In soils manganese commonly occurs as oxide mineral forms, birnessite and vernadite, but manganese is a component of over 100 other minerals including sulfides, oxides, carbonates, silicates, and borates (ATSDR, 1998). The complex mineralogical and chemical behavior of manganese is largely governed by pH-Eh conditions (Kabata-Pendias and Pendias, 1992). Bioavailability and uptake of manganese into plants is reported to increase as pH decrease with plant toxicity commonly associated with acidic soils in warm climes (Alloway, 1990). However, a complete understanding of the processes that directly affect manganese behavior does not exist (Alloway, 1990).

Toxicity to Plants and Wildlife. The ORNL soil screening value for plants of 500 mg/kg (Table C.A-3) was based on a single experiment. Stem weights of bush beans were reported to be reduced 29 percent by 500 mg/kg manganese, added as manganese sulfate (Sample et al., 1996). Plant toxicity has been reported at soil manganese concentrations of 80 to 5,000 mg/kg where manganese is in a highly available form (Alloway, 1990). Manganese toxicity more commonly occurs in well-drained soils at pH levels below 5.5, in poorly aerated soils at pH above 6.0, and in highly alkaline soils with a pH above 8.0.

For soil microorganisms the ORNL (Will and Suter, 1995b) soil screening value of 100 mg/kg (Table C.A-3) is the lowest of four values. Nitrogen fixation by native soil microflora was reported to be severally inhibited at 100 mg/kg manganese added as manganese sulfate, in a sandy loam (Will and Suter, 1995b). There is no ORNL soil screening value for soil invertebrates (Table C.A-3).

ORNL (Sample et al., 1996) TRVs for mammals and birds are based on experiments conducted with manganese oxide (Mn_3O_4), a form potentially present at the site. Except for small mammal invertivores soil reference values derived from these values are above typical soil concentrations. For the small mammal invertivore, NOAEL (120 mg/kg), and LOAEL (390 mg/kg) reference values are below typical U.S. western soil concentrations of 480 mg/kg (Shacklette and Boerngen, 1984).

8.4.2.8 Mercury

Uptake and Bioavailability. Mercury is one of the few metals which strongly bioconcentrates and biomagnifies, has only harmful effects with no useful physiological functions when present in fish and wildlife, and can be transformed from a less toxic inorganic form to a more toxic organic form in fish and wildlife tissues (Irwin et al., 1997). Mercury is most toxic to aquatic organisms and has a strong tendency to biomagnify in piscivorous (fish-eating) birds and mammals.

Inorganic mercury sorbed to particulate material is not readily desorbed. Leaching is a relatively insignificant transport process in soils. Adsorption of mercury in soil is decreased with increasing pH and/or chloride ion concentrations (ATSDR, 1994). The organic matter content is an important determinant of mercury concentrations, with organic soils commonly having higher average mercury content than mineral soils (Alloway, 1990). Due to its strong ability to form complexes, mercury rarely occurs in the free ionic form under natural conditions. Metallic mercury (Hg^0) and mercuric ion (Hg^{2+}) are the states normally encountered in soils, with pH and chloride ion (Cl^-) being the key parameters determining the speciation of mercury in the soil solution. An important property of mercury is the ability to bind strongly to the sulfide ion (Alloway, 1990). Only a very minute fraction of Hg^{2+} occurs in soil solution, the major fraction being either bound in soil minerals or adsorbed on inorganic and organic solid surfaces.

In general, the availability of soil mercury to plants is low, and roots serve as an effective barrier to mercury uptake (Alloway, 1990). Mercury levels in plant tissues are generally less than 0.5 mg/kg (dry weight). There are some exceptions, however, as a few species have been shown to exhibit tolerance and show some translocation to aboveground portions, particularly for the organic forms. Roots and green tissues of plants found growing in soil over a cinnabar vein (concentrations up to 40 mg/kg) yielded mercury concentrations of 1 to 3.5 mg/kg (Munshower, 1994). Investigation of plant uptake from agricultural soils near a mercury mine found that the relative mercury content in roots was closely related to the ammonium acetate (NH_4OAc)-extractable mercury in soils, while the mercury concentration in aboveground parts of the plants, appeared to be largely dependent on foliar uptake of Hg^0 volatilized from soil (Alloway, 1990).

Toxicity to Plants and Wildlife. Mercury usually does not present a major problem with respect to phytotoxicity (Alloway, 1990). In general, the availability of soil mercury to plants is low, and roots serve as an effective barrier to mercury uptake (Alloway, 1990). For mercury, the ORNL soil screening value for plants is 0.3 mg/kg in soil, based on unspecified effects (Table C.A-3).

Mercury is both acutely and chronically toxic to animals in any of its three forms: elemental mercury, inorganic salts, and organic mercury compounds. The suggested maximum tolerable dietary level for domestic animals is 2 mg/kg for both the organic and inorganic forms, with some species showing higher tolerance of the inorganic form (NAS, 1980). ORNL (Sample et al., 1996) provides several TRVs for mercury based on inorganic or organic forms.

ORNL (Sample et al., 1996) reported inorganic and organic-based TRVs. The ORNL (Sample et al., 1996) TRV for mammals is based on a dietary NOAEL of 1.01 mg/kg-bw/d using $HgCl_2$ in a chronic reproduction study with mink. The second ORNL (Stephen et al., 1996) TRV for mammals is based on a NOAEL dose of 13.2 mg/kg-bw/d for mercuric sulfide in a chronic reproduction study with mice. Two TRVs are also provided for methyl mercury chloride (CH_3HgCl). The first reference value is based on a dietary NOAEL of 0.015 mg/kg-bw/d and a LOAEL of 0.247 mg/kg-bw/d for mink. The second reference value is based on a dietary NOAEL of 0.032 mg/kg-bw/d and a LOAEL of 0.16 mg/kg-bw/d for rats.

The first ORNL (Sample et al., 1996) TRV for birds is based on a dietary NOAEL of 0.45 mg/kg-bw/d and a LOAEL of 0.9 mg/kg-bw/d using mercuric chloride ($HgCl_2$) in a chronic reproduction study with Japanese quail. The second ORNL TRV for birds is based on a NOAEL dose of 0.064 mg/kg-bw/d for methyl mercury dicyandiamide in a chronic reproduction study with mallards.

8.4.2.9 Nickel

Uptake and Bioavailability. Nickel is found primarily as oxides or sulfides in the environment (ATSDR, 1996) but is additionally found in ores as arsenides, antimonides, or silicates (Irwin et al., 1997). Nickel is the 24^{th} most abundant element and is an essential element for plants and animals.

Soil properties such as texture, bulk density, pH. organic matter, the type and amount of clay minerals, and certain hydroxides influence the retention and release of nickel from soils (ATSDR, 1996). Nickel adsorption is highly pH dependent, with increased soil acidity decreasing adsorption (ATSDR, 1996). In alkaline soils, nickel adsorption may be irreversible which limits nickel's availability and mobility in these soils (ATSDR, 1996).

Toxicity to Plants and Wildlife. For plants, the ORNL soil screening value for nickel is 30 mg/kg (Table C.A-3). The ORNL screening value is the 10^{th} percentile of 14 LOEC values, nickel was applied primarily as either nickel sulfate or nickel chloride. LOEC values for phytotoxicity ranged from 25 mg/kg to 294 mg/kg. Barley seedlings grown in a loam soil at pH 5.8 exhibited an 88 percent reduction in shoot growth at 25 mg/kg nickel (Will and Suter, 1995a).

Limited soil invertebrate data were available for ORNL to develop a screening value for nickel (Will and Suter, 1995b) -- only four results. Therefore, ORNL's nickel screening value of 200 mg/kg for soil invertebrates was based on the lowest LOEC value available from the four available results. Toxicity of nickel to soil invertebrates ranged from 200 mg/kg to 1000 mg/kg (Will and Suter, 1995b).

The soil microorganism ORNL (Will and Suter, 1995b) soil screening value of 90 mg/kg is the 10th percentile of LOEC values from 56 reported experiments (Table C.A-3). About half the experiments applied nickel as nickel sulfate and the other half as nickel chloride.

Relatively high levels of nickel are required to produce toxicosis in mammals and birds. NOAEL TRVs for birds and mammals range from 8 to 13 mg/kg-bw/day for mammals and 77 mg/kg-bw/day for birds (Tables C.A-4 and C.A-5). These values translate to 54 to 8100 mg/kg of nickel in soil for mammals and 450 mg/kg of nickel in soil for birds. ORNL's (Sample et al., 1996) soil screening values and the mammal and bird TRVs are above average soil concentrations of nickel in U.S. western soils of 19 mg/kg (Shacklette and Boerngen, 1984).

8.4.2.10 Selenium

Uptake and Bioavailability. Selenium is a chalcophile element, and as such is associated with sulfide ore deposits (Alloway, 1990). Selenium exists in soils as basic ferric selenite, calcium selenate, elemental selenium, and organic compounds derived from plant tissue (NAS, 1980).

The uptake and accumulation of selenium by plants may be influenced by a number of environmental factors, the most significant of which include concentration, speciation, pH, soil mineralogical composition, and plant species (Alloway, 1990). Sodium and potassium selenates dominate in neutral, well-drained mineral soils (HSDB, 2000). Therefore, in acidic to neutral soils, the amount of biologically available selenium declines (Eisler, 1985). In contrast, dry alkaline soils under oxidizing conditions maintains the availability of selenium. Selenate, which prevails under alkaline toxic conditions, is more mobile, soluble, but is less well adsorbed than selenite. In acidic soils, the presence of clay, iron oxides, and organic matter affect availability to a greater extent than in soils where selenate is the predominant species (Alloway, 1990). Heavy metal selenides which are insoluble and immobile, predominant in acidic soils with high amounts of organic matter (HSDB, 2000). Changing pH and the presence of other anions, such as phosphate and sulfate, affects apparent selenium accumulation by plants.

Toxicity to Plants and Wildlife. Phytotoxicity occurs as a result of the incorporation of selenium analogs of essential sulfur compounds in plant tissues, and the ability of different plant species to incorporate and tolerate selenium varies widely. The ORNL (Will and Suter, 1995a) soil screening value for plants is 1 mg/kg (Table C.A-3), based on 14 available literature values.

Selenium is an essential trace element with dietary requirements ranging from 0.1 to 0.3 mg/kg in dry matter (NAS, 1980). In short-term feeding studies, signs of toxicity were observed in some domestic species at dietary levels of 5 mg/kg (NAS, 1980). A dietary level of 4 mg/kg was toxic to rats fed

semipurified diets (NAS, 1980). NAS (1980) recommends 2 mg/kg as the maximum tolerable level for all species.

The metabolism and dose-effect relationship of selenium compounds is influenced by interactions with other nutrients and/or exposure to other metals. In particular, where intake of vitamin E is low, susceptibility to the effects of selenium poisoning and selenium deficiency increases in rats and chicks. In vivo, selenium is bound into insoluble compounds with silver, copper, cadmium and mercury. Selenium has been shown to prevent the damaging effects of cadmium and mercury. Arsenic has been shown to have a protective effect against selenosis (Seiler and Sigel, 1988). Plant and animal metabolism of selenium converts selenium to inert and insoluble forms (Eisler, 1985).

Chronic poisoning due to long-term exposure, or "alkali disease," has been observed in several animals in areas where plants contain 5-25 mg/kg selenium. In livestock, the "blind stagger" syndrome, a subacute selenium intoxication, may result from the consumption of selenium in accumulator plants. Many selenium compounds (e.g., selenite, selenate, and selenocysteine) are very toxic and lethal to lab animals in single doses from 1.5 to 6 mg/kg (Seiler and Sigel, 1988). Chronic selenosis may be induced by exposure to dietary selenium at 1 (rat) to 44 (horse) mg/kg or from water containing 0.5 to 2.0 mg/L (Oehme, 1978).

8.4.2.11 Silver

Uptake and Bioavailability. Silver can occur as native silver, in mineral form, and as complex sulfides, primarily occurring as sulfides in association with iron (pyrite), lead (galena), tellurides, and gold (ATSDR, 1990). Silver has no known biological function in plants or animals (NAS, 1980).

The behavior of silver in soils is strongly influenced by the prevailing pH and redox conditions, and by interaction with soil organic matter. Humic acid and organic matter likely limit adsorption and retention of silver, so that an excess of silver in soils of low organic matter is potentially more toxic than in soils of higher organic matter (Kabata-Pendias and Pendias, 1992). There is little evidence indicating silver is likely to bioaccumulate to any significant extent in plants, nor is silver thought likely to biomagnify in terrestrial food webs.

Toxicity to Plants and Wildlife. The ORNL (Will and Suter, 1995a) plant screening value for silver of 2 mg/kg (Table C.A-3) is based on a report of unspecified toxic effects on plants grown in surface soil with the addition of 2 mg/kg. Humic acid and organic matter likely limit adsorption and retention of silver, so that an excess of silver in soils of low organic matter is potentially more toxic than in soils of higher organic matter (Kabata-Pendias and Pendias, 1992).

8.4.2.12 Zinc

Uptake and Bioavailability. Total zinc contents in soil can seldom be used as an appropriate criterion for evaluating plant availability; the zinc fraction incorporated in unweathered minerals has no direct biological significance (Alloway, 1990). The factors affecting zinc availability in soils are mainly soil parameters, such as pH, organic matter, adsorption sites, microbial activity, moisture regime, and

interactions with other macro- and micronutrients (Alloway, 1990). The availability of zinc decreases at increasing pH values of the soils, due to lower solubility of zinc minerals and increasing adsorption of zinc (Alloway, 1990). High soil phosphorus levels decrease zinc availability and plant uptake (Alloway, 1990). Interactions with other nutrients -- mainly zinc-iron antagonism, but also zinc-copper, zinc-nitrogen, and zinc-calcium interactions -- may decrease zinc availability (Alloway, 1990).

Toxicity to Plants and Wildlife. Zinc is an essential nutrient for plants and animals. The soil NOAEL reference value for zinc (Sample et al., 1996) translates to 32 mg/kg for the small avian invertivore and 38 mg/kg for the medium mammal carnivore. These soil NOAEL benchmarks are below the average zinc soil concentration for the U.S. and are therefore considered inappropriate.

8.5 RISK CHARACTERIZATION

Within the Risk Characterization, the likelihood of adverse toxicological effects to ecological receptors based on soil, sediment, seep, and surface water quality results from 1997 and 1999 is evaluated. The potential for unacceptable risk is calculated in Section 8.6 for ten receptor groups exposed to chemicals through direct contact with soil, sediment, and surface water, and through uptake and ingestion of prey organisms. In Section 8.7, results of the risk estimates (i.e., HQs and HIs) are interpreted through examination of the terrestrial habitat and vegetation conditions as reported in the Draft SCR (Stibnite Group, 2000).

8.6 RISK ESTIMATION

The potential for ecological effects is traditionally characterized through the risk estimates calculated using the HQ model. For each inorganic chemical and environmental medium (e.g., soil, water, sediment, fish), the HQ is expressed as the ratio of a potential exposure level to a toxicity benchmark as follows:

$$HQ = \frac{\text{Exposure Concentration or Dose}}{\text{Toxicity Benchmark}}$$

For terrestrial plants and soil organisms, the HQ is based on a comparison of the chemical concentration in soil or wetland sediments (mg/kg), with a toxicity benchmark for that medium (mg/kg). For mammals and birds, the HQ is based on a comparison of chemical doses (mg/kg-bw/day). For this evaluation, HQs for wildlife exposed chemicals in soil, sediment, and creek/river surface water are calculated using both NOAEL and LOAEL (dose) toxicity benchmarks. Both LOAEL and NOAEL benchmarks are used in order to "bracket" the HQ-estimated threshold for adverse effects. However, as described previously, LOAELs based on effects to individual test organisms are expected to be negligible-effect risk levels for wildlife populations (Efroymson et al., 1997a). Literature sources for the toxicity benchmarks are provided in Appendix C (Tables C.A-3 through C.A-7).

The wildlife toxicity benchmarks used in this evaluation are based primarily on the wildlife TRVs published by Sample et al. (1996). See Section 8.4.2 for additional discussions of toxic effects. TRVs from Sample et al. (1996) and other published literature are conservatively adjusted to receptor-specific

(wildlife) toxicity benchmarks using one uncertainty factor from each of three categories: intertaxon extrapolation (f_i), study duration (f_d), and toxicity test endpoint (f_t). These three categories of uncertainty factors are multiplicative:

$$\text{Total Uncertainty Factor} = f_i \times f_d \times f_t$$

The total uncertainty factor is used in the denominator to adjust the TRV to the wildlife toxicity benchmark:

$$\text{Wildlife Toxicity Benchmark} = \frac{\text{TRV}}{\text{Total Uncertainty Factor}}$$

The intertaxon uncertainty factors (f_i), recommended by USEPA Region VIII are used to adjust mammalian TRVs to benchmarks as follows.

- Same species 1
- Same genus, different species 2
- Same family, different genus 3
- Same order, different family 4
- Same class, different order 5
- Same phylum, different class 6

No intertaxon uncertainty factors (i.e., intertaxon uncertainty factor = 1) are used to adjust avian TRVs because no pattern has been found in contaminant sensitivity due to differences in taxon (USEPA, 1996).

Uncertainty factors for toxicity test endpoint and study duration also are used to adjust the wildlife TRVs to the wildlife non-lethal NOAEL benchmarks as follows:

The following study duration extrapolation factors (f_d) are used:

- Chronic 1
- Subchronic to Chronic Exposure 3
- Acute to Chronic Exposure 10

The following test endpoint extrapolation factors (f_t) are used:

- Nonlethal no observed effect 1
- Lethal NOAEL to non-lethal NOAEL 3
- Lethal LOAEL to non-lethal LOAEL 3
- Non-lethal LOAEL to non-lethal NOAEL 3
- Lethal LOAEL to non-lethal NOAEL 10
- Frank effect (death) to non-lethal NOAEL 15

The TRVs, uncertainty factors, and benchmark derivations are documented in Appendix C (Tables C.A-4 through C.A-7). TRVs and benchmarks for birds are generally less available than those for mammals. Avian benchmarks for some inorganics for which there were no avian toxicity data were extrapolated from mammalian data. Because extrapolation across classes of organisms is considered less than optimum, the toxicity benchmarks and HQ results for avian receptors may contain a greater level of uncertainty than those for mammalian receptors. Allometric body-scaling is not used in this risk model.

The potential for adverse ecological effects to wildlife drinking seep water is characterized using risk-based concentrations (RBCs) for each functional group rather than through calculation of HQ estimates based on doses. RBCs are the NOAEL or LOAEL-based concentrations for chemicals in specific environmental media (i.e., seep water) that are anticipated to be protective of the ecological receptors. RBCs for water are back-calculated from the chemical toxicity benchmark using the same HQ equation for drinking water and specific exposure factors for each representative wildlife receptor. Since RBCs are medium-specific, they provide a more direct means to compare chemical concentrations in a medium to threshold effects levels for that medium.

The HQ results presented in this evaluation provide a relative measure of potential risk to the receptor groups through the various exposure pathways. Although the HQ model is designed to provide conservative risk estimates, considerable uncertainty and error are inherent in this model. Section 8.8 further discusses these uncertainties and the direction of their potential effect on the risk estimates and their interpretation.

Ecological HQ and HI results are generally interpreted as follows:

- If the value of the LOAEL-based HQ or HI is less than or equal to 1.0, it is generally expected that no unacceptable impacts will occur in the exposed population of receptors and no further consideration of ecological risk is warranted.
- If the HQ or HI based on the LOAEL exceeds a value of one, adverse effects to populations or communities is possible. Further consideration of risk management goals, decisions, data needs, or remedial options are warranted under these circumstances.

Both exposure and toxicity assumptions are generally 'worst-case', and represent the upperbound of potential risks to ecological receptors. HQ models do not account for implausibility, variability, error, or uncertainty in the exposure and effects estimates, and thus do not provide a statistical probability of occurrence of adverse ecological effects. The significance of the HQ or HI exceeding the target value (traditionally 1.0) depends on the perceived 'value' (ecological, social, political) of the receptor, the nature of the endpoint measured, and the degree of uncertainty associated with the process as a whole. The decision to take no further action, consider remedial action, or identify additional decisions and data needs is therefore approached on a location, chemical, and species-specific basis.

One of the major components in the HQ risk equation is the modeling of concentrations of chemicals in the tissue of food items (e.g., BAF x C_s; see Section 8.4.1) eaten by wildlife receptors. Typically, risk assessments have not evaluated if these predicted tissue concentrations are attainable. Two reasons a

predicted tissue concentration may not be attained include: 1) there is an upper boundary for the amount of chemical that can physically be stored in tissue, and 2) the predicted tissue concentration is above critical lethal tissue limits. Tissue concentrations (i.e., tissue residues) that correlate with toxic effects on the plant or animal itself have been reported and reviewed in the literature (Kabata-Pendias and Pendias, 1992; Braune et al., 1999; Eisler, 1997). These critical tissue limits allow predicted tissue concentrations from BAF models to be evaluated in terms of the likelihood that the food-web would be interrupted (i.e., concentration predicted in the food item is above that concentration reported to harm it) by setting an upper boundary for tissue concentrations. In this risk evaluation, predicted tissue concentrations in food items in the soil and sediment exposure pathways are compared with critical tissue limits to evaluate if the food web is interrupted, resulting in reduced exposure to consumers/predators.

For the soil exposure pathways, HQs are calculated for plants, soil invertebrates (earthworms serve as surrogates for invertebrates), and primary/secondary consumers. The soil screening values used to evaluate risk to plants and soil invertebrates are based on LOECs. LOEC risks have been recommended for evaluating effects to populations rather than individuals. Except for antimony, food web interruption for the herbivore is interpreted as likely to occur where both the plant HQ is >1 and the predicted plant tissue concentration is above the critical plant tissue limit (Table C.A-8). Except for antimony, food web interruption for the invertivores is interpreted as likely to occur where both the earthworm HQ is >1 and the predicted earthworm tissue concentration is above the critical animal tissue limit (Table C.A-9). Because there are no antimony soil TRVs for plants or earthworms, antimony food web interruption for herbivores or invertivores is interpreted as likely to occur where the predicted plant tissue concentration or earthworm tissue concentrations are above their respective antimony critical tissue limits. For carnivores, food web interruption is interpreted as likely to occur where LOAEL HQs for at least two of the three small mammals or birds are >1 and the predicted tissue concentrations in small mammals and birds also are above animal critical tissue limits.

For the sediment exposure pathway, food web interruption is interpreted as likely to occur for herbivores where the predicted plant tissue concentration is above the critical plant tissue limit. Food web interruption for invertivores was interpreted to likely occur where the predicted earthworm tissue concentration is above the critical animal tissue limit. For carnivores, food web interruption was interpreted as likely to occur where LOAEL HQs for at least two of the three small mammals or birds are >1 and the predicted tissue concentrations in small mammals and birds also are above animal critical tissue limits.

Many of the high HQ results for wildlife exposure to arsenic and antimony in soil are considered implausible because modeled chemical concentrations in the wildlife receptor's dietary items (plants, prey) exceed critical tissue residue levels for those dietary items and/or LOAEL HQs for the dietary items are >1 as described above. Thus, the exposure pathway is partially incomplete and risk is substantially reduced. The implausible results are shown in brackets on the overview soil HQ summary (Table 8-7) and the sediment HQ summary (Table 8-8). Soil RBCs for metals are commonly below mineralized and non-mineralized background levels and/or the nutritionally required levels for plants and wildlife due to the conservative factors used in the risk model. USEPA guidance (1997a, 1998) cautions that any exceedance

of a wildlife toxicity benchmark, and especially in these cases, should not be construed as evidence of ecological harm.

HQ and RBC (seep) results are summarized in the tables presented in this section and in Appendix C. Tables 8-7, 8-8, and 8-9 provide overview summaries of the HQ results for soil, sediment, and surface water, respectively. Tables 8-10 and 8-11 summarize the comparison of wildlife drinking water RBCs to chemical concentrations at seeps. In view of the small size of the seeps and the intermittent flows, HQs greater than 1 are not expected to represent any unacceptable risk to terrestrial receptors. Table 8-12 provides a summary of HQ results for pisciverous wildlife (i.e., belted kingfisher and mink feeding exclusively on fish). Location-specific summaries of the HQ-NOAEL and HQ-LOAEL results for soil, sediment, and stream surface water are provided in Appendix C.D. These HQ summary tables also show the HIs (cumulative risk = sum of individual HQs for a location) for each receptor and location. The detailed risk model input parameters (toxicity benchmarks, wildlife exposure factors, bioaccumulation factors), and HQ calculations are provided in Appendix C.A, C.B, and C.C tables.

The level of detail provided in the terrestrial ecological risk evaluation tables increases in the following order: (1) Overview tables (Tables 8-7 through 8-12), (2) Summary tables (Tables C.D-1 through C.D-34), and (3) Detailed tables (Appendices C.A, C.B, and C.C).

8.7 RISK DESCRIPTION

The HQ values calculated for terrestrial receptors exposed to inorganics in soil, sediment, and surface waters plus determinations of reduced risk (i.e., bracketed HQs) due to interruption of the food web (Section 8.6) provide the starting point for descriptions of potential risk to the plant community and wildlife populations exposed to chemicals at each of the exposure locations. However, in order to gain a more realistic estimate of the exposure and potential risk of each receptor group at each of the exposure locations, the habitat condition, soil characteristics, and exposure location size are combined with the risk estimates.

The compilation of habitats and risk descriptions is provided in Table 8-13 for each exposure location. Potential for risks to habitat (including soil invertebrates) or plant community and the wildlife populations (e.g., small avian invertivore, medium mammal carnivore) are described as "unlikely" or "possible" for current and future conditions at each exposure location. Risk was considered "unlikely" if expected exposure and resulting HQs were less than 1 and "possible" if the HQs were greater than 1. Stressors described as representing a "possible" risk may occur but are not expected to have any significant effects on the assessment endpoints. Measurement endpoints described as "unlikely" are not expected to have any measurable effect on the assessment endpoints.

Each of these assessments in Table 8-13 is followed by a description of the HQs from Tables 8-7, 8-8, and 8-9 and the risk mitigating factors at the exposure location. Many of the risk estimates for higher-level receptors are judged to be overestimates of risk because the presumed exposure through the food web is not complete. Interruption of the food web is due to the assumed prey organisms (plants, invertebrates, or small birds and mammals) being affected by the metals concentrations in soils prior to affecting the higher-

level organisms. The rationale for this process is described in Section 8.6. The bioavailability of metals in soils (assumed to be 100 percent in the exposure analysis) is influenced by location-specific soil pH and soil organic matter. These mediating factors are considered in the evaluation of risk probabilities as is the applicability of selected TRVs when evaluated against reference metals concentrations in U.S. western soils.

To focus on those exposure locations where terrestrial ecological risk is "possible," the risk evaluations (e.g., "unlikely" risk) from Table 8-13 are compiled into Table 8-14. In this table, the greatest risk (termed "possible" risk) is shown for terrestrial habitat or plant communities at four exposure locations: BT/NO Disposal Area, Southeast Bradley Waste Rock Dump, Northwest Bradley Waste Rock Dump, and Northeast Bradley Waste Rock Dump. Risk to the plant community at three locations is due primarily to exposure to high arsenic and mercury concentrations in soils. In addition, plants in the BT/NO Disposal Area are exposed to high antimony concentrations in soil. Risk to the soil invertebrate community also is due primarily to exposure to high arsenic concentrations in soil. Chemical risks to habitats or the plant communities at all other exposure locations are evaluated as being either "unlikely" or " unlikely or possible". No habitat or plant community is evaluated as having "likely" risk.

Risk to the wildlife populations at nine exposure locations is judged to be "unlikely or possible." These judgements are based on possible risks from exposure to high antimony, arsenic, and/or mercury concentrations in soil that is reduced by the small areas involved and the sparse vegetation/habitat available at the locations. Risk to wildlife populations at all other locations also is evaluated as "unlikely" (Table 8-14). No wildlife populations are evaluated as having "possible" or "likely" risk.

8.8 UNCERTAINTY IN THE TERRESTRIAL ECOLOGICAL RISK EVALUATION

In conformance with USEPA (1997a) guidance, the terrestrial ecological risk evaluation includes a discussion of uncertainties that influence the interpretation of the results. The HQ values presented should not be interpreted as precise estimates of actual risk. Quantitative evaluation of ecological risks is limited by uncertainty (lack of data or knowledge) regarding a number of important Site data, exposure, toxicity, and risk factors. This lack of knowledge is usually circumvented by making estimates based on whatever limited data are available, or by making assumptions based on professional judgement when no reliable data are available. The approach taken in this risk evaluation was to employ conservative assumptions to ensure that potential risk was not underestimated.

A summary of the principal sources of uncertainty and the direction of their effect on potential risk is presented in Table 8-15. Because assumptions of a conservative nature are made throughout the risk analysis, especially the exposure assessment, the final risk results are likely overly conservative.

8.9 TERRESTRIAL ECOLOGICAL RISK SUMMARY

A risk evaluation of the terrestrial ecosystem on the Site was performed in accordance with current USEPA guidance for ecological risk assessments. Using the results of soil, sediment, surface water, seep, and fish

tissue sampling from 1997 and 1999, potential risk to terrestrial populations or communities was evaluated for 17 exposure locations (including five small "hot spot" locations).

Two terrestrial assessment endpoints were evaluated: 1) protection of the upland and riparian plant communities and 2) protection of populations of wildlife functional groups. The measurement endpoints considered in the evaluation of assessment endpoints were: 1) upland and riparian habitat condition (vegetation and soil mapping; soil profiles) and 2) soil, sediment, and water chemical analyses and comparisons with toxicological endpoints.

The overall potential for unacceptable risks to plant communities and wildlife populations was described as "unlikely" or "possible." Risk was considered "unlikely" if expected exposure and resulting HQs were less than 1 and "possible" if the HQs were greater than 1. Stressors described as representing a "possible" risk may occur but are not expected to have any significant effects on the assessment endpoints. Measurement endpoints described as "unlikely" are not expected to have any measurable effect on the assessment endpoints.

Risks to habitat, plant communities, and wildlife populations based on the two terrestrial measurement endpoints considered in each of the exposure locations were described in detail in Table 8-12 and are summarized in Table 8-13.

Possible risk is shown for terrestrial habitat or plant communities at four exposure locations: BT/NO Disposal Area, Southeast Bradley Waste Rock Dump, Northwest Bradley Waste Rock Dump, and Northeast Bradley Waste Rock Dump. Risk to the plant community at these locations is due primarily to exposure to high arsenic and mercury concentrations in soils. In addition, plants in the BT/NO Disposal Area are exposed to high antimony concentrations in soil. Risk to the soil invertebrate community also is due primarily to exposure to high arsenic in soil. Chemical risks to habitats or the plant communities at all other exposure locations are evaluated as being either "unlikely" or " unlikely or possible. No habitat or plant community is evaluated as having "likely" risk.

Risk to the wildlife populations at nine exposure locations is judged to be "unlikely or possible." These judgements are based on possible risks from exposure to high antimony, arsenic, and/or mercury concentrations in soil that is reduced by the small areas involved and the sparse vegetation/habitat available at the locations. Risk to wildlife populations at all other locations also is evaluated as "unlikely" (Table 8-14). No wildlife populations are evaluated as having "possible" or "likely" risk.

Table 8-1

Potential Wildlife Species Within the Stibnite Mine Area
By Size and Food Guild

Mammals

Guild: Insectivore/Invertivore

Size: Small

Common Name	Scientific Name
Vagrant Shrew	*Sorex vagrans*
Dusky Shrew	*Sorex monticolus*
Water Shrew	*Sorex palustris*
Little Brown Myotis	*Myotis lucifugus*
Yuma Myotis	*Myotis yumanensis*
Long-eared Myotis	*Myotis evotis*
Long-legged Myotis	*Myotis volans*
Silver-haired Bat	*Lasionycteris noctivagans*
Big Brown Bat	*Eptesicus fuscus*
Hoary Bat	*Lasiurus cinereus*

Guild: Omnivore

Size: Small

Common Name	Scientific Name
Deer Mouse	*Peromyscus maniculatus*

Size: Medium

Common Name	Scientific Name
Masked Shrew	*Sorex cinereus*
Western Jumping Mouse	*Zapus princeps*

Guild: Piscivore

Size: Medium

Common Name	Scientific Name
Northern River Otter	*Lutra canadensis*

Guild: Herbivore

Size: Small

Common Name	Scientific Name
Southern Red-backed Vole	*Clethrionomys gapperi*
Heather Vole	*Phenacomys intermedius*
Meadow Vole	*Microtus pennsylvanicus*
Long-tailed Vole	*Microtus longicaudus*
Water Vole	*Microtus richardsoni*
Northern Pocket Gopher	*Thomomys talpoides*
Least chipmunk	*Tamias minimus*

Size: Large

Common Name	Scientific Name
Rocky Mtn. Elk	*Cervus elaphus*
Mule Deer	*Odocoileus hemionus*
White-tailed Deer	*Odocoileus virginianus*
Moose	*Alces alces*
Mountain Goat	*Oreamnos americanus*
Bighorn Sheep	*Ovis canadenis*

Size: Medium

Common Name	Scientific Name
Common porcupine	*Erethizon dorsatum*
Muskrat	*Ondatra zibethicus*
Bushy-tailed Woodrat	*Neotoma cinerea*
American Beaver	*Castor canadensis*
Northern Flying Squirrel	*Glaucormus sabrinus*
Red Squirrel	*Taniasciurus hudsonicus*
Golden-mantled Ground Squirrel	*Spermophilus lateralis*
Columbian Ground Squirrel	*Spermophilus columbianus*
Hoary Marmot	*Marmota caligata*
Yellow-bellied Marmot	*Moarmota flaviventris*
Yellow Pine Chipmunk	*Tamias amoenus*
White-tailed Jackrabbit	*Lepus townsendii*
Snowshoe Hare	*Lepus americanus*
American Pika	*Ochotona princeps*

Table 8-1

Potential Wildlife Species Within the Stibnite Mine Area
By Size and Food Guild

Guild: Carnivore

Size: Small

Common Name	Scientific Name
Ermine	*Mustela erminea*
Mink	*Mustela vison*
Long-tailed Weasel	*Mustela frenata*
American Marten	*Martes americana*

Size: Medium

Common Name	Scientific Name
Coyote	*Canis latrans*
Gray Wolf	*Canis lupus*
Bobcat	*Felis rufus*
Wolverine	*Gulo gulo*

Size: Large

Common Name	Scientific Name
Mountain Lion	*Felis concolor*
Black Bear	*Ursus americanus*

Amphibians/Reptiles

Guild: Insectivore/Invertivore

Size: Small

Common Name	Scientific Name
Long-toed Salamander	*Ambystoma macrodactylum*
Tailed Frog	Ascaphus truei
Western Toad	*Bufo boreas*
Pacific Chorus Frog	*Pseudacris regilla*
Spotted Frog	*Rana pretiosa*

Guild: Carnivore

Size: Small

Common Name	Scientific Name
Idaho Giant Salamander	*Dicamptodon aterrimus*
Common Garter Snake	*Thamnophis sirtalis*

Birds

Guild: Insectivore/Invertivore

Size: Small

Common Name	Scientific Name
Spotted Sandpiper	*Actitis macularia*
Common Snipe	*Gallinago gallinago*
Vaux's Swift	*Chaetura vauxi*
Downy Woodpecker	*Picoides pubescens*
Three-toed Woodpecker	*Picoides tridactylus*
Olive-Sided Flycatcher	*Contopus borealis*

Size: Medium

Common Name	Scientific Name
Common Nighthawk	*Chordeiles minor*
Williamson's Sapsucker	*Sphyrapicus thyroideus*
Hairy Woodpecker	*Picoides villosus*
Black-backed Woodpecker	*Picoides arcticus*
Northern Flicker	*Colaptes auratus*
American Dipper	*Cinclus mexicanus*

Table 8-1

Potential Wildlife Species Within the Stibnite Mine Area By Size and Food Guild

Guild: Insectivore/Invertivore (continued)

Size: Small		***Size: Medium***	
Common Name	Scientific Name	Common Name	Scientific Name
Western Wood-pewee	*Contopus sordidulus*	Townsend's Solitaire	*Myadestes townsendi*
Willow Flycatcher	*Empidonax traillii*	Veery	*Catharus fuscescens*
Hammonds Flycatcher	*Empidonax hammondii*	Swainson's Thrush	*Catharus ustulatus*
Dusky Flycatcher	*Empidonax oberholseri*	Hermit Thrush	*Catharus guttatus*
Cordilleran Flycatcher	*Empidonax occidentalis*	American Robin	*Turdus migratorius*
Tree Swallow	*Tachycineta bicolor*	Varied Thrush	*Ixoreus naevius*
Violet-green Swallow	*Tachycineta thalassina*	Gray Catbird	*Dumetella carolinensis*
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	Black-headed Grosbeak	*Pheucticus melanocephalus*
Black-capped Chickadee	*Parus atricapillus*	Bullock's Oriole	*Icterus bullockii*
Mountain Chickadee	*Parus gambeli*	Yellow-breasted Chat	*Icteria virens*
Red-breasted Nuthatch	*Sitta canadesis*		
White-breasted Nuthatch	*Sitta carolinensis*		
Brown Creeper	*Certhia americana*		
Winter Wren	*Troglodytes troglodytes*		
Golden-crowned Kinglet	*Regulus satrapa*		
Ruby-crowned Kinglet	*Regulus calendula*		
Mountain Bluebird	*Sialia currucoides*		
Plumbeus Vireo	*Vireo plumbeus*		
Warbling Vireo	*Vireo gilvus*		
Red-eyed Vireo	*Vireo olivaceus*		
Orange-crowned Warbler	*Vermivora celata*		
Nashville Warbler	*Vermivora ruficapilla*		
Yellow-rumped Warbler	*Dendroica coronata*		
Yellow Warbler	*Dendroica petechia*		
Townsend's Warbler	*Dendroica townsendi*		
American Redstart	*Setophaga ruticilla*		
MacGillivray's Warbler	*Oporornis tolmiei*		
Wilson's Warbler	*Wilsonia pusilla*		
Western Tanager	*Piranga ludoviciana*		

Table 8-1

Potential Wildlife Species Within the Stibnite Mine Area By Size and Food Guild

Guild: Herbivore

Size: Small

Common Name	Scientific Name
Cinnamon Teal	*Anus cyanoptera*
Red-naped Sapsucker	*Sphyrapicus nuchalis*
Song Sparrow	*Melospiza melodia*
Lincoln's Sparrow	*Melospiza lincolnii*
Dark-eyed Junco	*Junco hyemalis*
Cassin's Finch	*Carpodacus cassinii*
Red Crossbill	*Loxia curvirostra*
Pine Siskin	*Carduelis pinus*

Size: Medium

Common Name	Scientific Name
Mallard	*Anus platyrhynchos*
Spruce Grouse	*Dendragapus canadensis*
Blue Grouse	*Dendragapus obscurus*
Fox Sparrow	*Passerella iliaca*
Evening Grosbeak	*Coccothroustes vespertinus*
Pine Grosbeak	*Pinicola enucleator*

Guild: Omnivore

Size: Small

Common Name	Scientific Name
Calliope Hummingbird	*Stellula calliope*
Rufous Hummingbird	*Selasphorus rufus*
Chipping Sparrow	*Spizella passerina*
White-crowned Sparrow	*Zonotrichia leucophrys*

Size: Medium

Common Name	Scientific Name
Gray Jay	*Perisoreus canadensis*
Steller's Jay	*Cyanocitta stelleri*
Clark's Nutcracker	*Nucifraga columbiana*
Black-billed Magpie	*Pica pica*
Spotted Towhee	*Pipilo maculatus*
Red-winged Blackbird	*Agelaius phoeniceus*
Ruffed Grouse	*Bonasa umbellus*

Size: Large

Common Name	Scientific Name
Pileated Woodpecker	*Dryocopus pileatus*
Common Raven	*Corvus corax*

Table 8-1

Potential Wildlife Species Within the Stibnite Mine Area
By Size and Food Guild

Guild: Carnivore

Size: Small

Common Name	Scientific Name
Sharp-Shinned Hawk	*Accipiter striatus*
Coopers Hawk	*Accipiter cooperii*
Flammulated Owl	*Otus flammeolus*
Northern Pygmy Owl	*Glaucidium gnoma*

Size: Medium

Common Name	Scientific Name
Northern Goshawk	*Accipiter gentilis*
Western Screech Owl	*Otus kennicottii*
Barred Owl	*Strix varia*
Boreal Owl	*Aegolius funereus*
Northern Saw-whet Owl	*Aegolius acadicus*

Size: Large

Common Name	Scientific Name
Great Blue Heron	*Ardea herodias*
Red-tailed Hawk	*Buteo jamaicensis*
Golden Eagle	*Aquila chrysaetos*
Great Horned Owl	*Bubo virginianus*
Great Grey Owl	*Strix nebulosa*
Long-eared Owl	*Asio otus*

Guild: Piscivore

Size: Medium

Common Name	Scientific Name
Common Merganser	*Mergus merganser*
Belted Kingfisher	*Ceryle alcyon*

Size: Large

Common Name	Scientific Name
Osprey	*Pandion haliaetus*

Compiled from Greystone (1994); Forest Service (1981); Stoller (1996); or observed by Woodward-Clyde in 1997.

Table 8-2

Comparison of Soil Metal Exposure Concentrations in Exposure Locations (Excluding Hot Spots) to U.S. Western Soils

Analyte	Estimated Arithmetic Mean for U.S. Western Soils[1]	BT/NO Disposal Area (RME)	Retained for Risk Evaluation ?	Meadow Creek Mine Hillside (RME)	Retained for Risk Evaluation ?	Lower Meadow Creek Valley (RME)	Retained for Risk Evaluation ?	Upgradient Wetland, excl. hot spot at UW-1 (Max)	Retained for Risk Evaluation ?	Keyway Wetland (Max)	Retained for Risk Evaluation ?	Meadow Creek Forested Wetland (Max)	Retained for Risk Evaluation ?	SE Bradley Waste Rock Dumps (RME)	Retained for Risk Evaluation ?	NW Bradley Waste Rock Dumps (RME)	Retained for Risk Evaluation ?	NE Bradley Waste Rock Dumps (RME)	Retained for Risk Evaluation ?
Aluminum	74000	<bkg	NR	13319	NR	<bkg	NR	43300	NR	<bkg	NR	34200	NR	<bkg	NR	<bkg	NR	<bkg	NR
Antimony	0.62	133	R	15.6	R	1324	R	nd	NR	333	R	1550	R	<bkg	NR	368	R	<bkg	NR
Arsenic	7.0	1620	R	1460	R	955	R	24.4	R	634	R	1230	R	4970	R	2717	R	5630	R
Cadmium[2]	0.32	1.3	R	nd	NR	nd	NR	nd	NR	nd	NR	0.13	NR	nd	NR	nd	NR	nd	NR
Chromium	56	17.7	NR	<bkg	NR	7.78	NR	39.9	NR	7.1	NR	14.3	NR	<bkg	NR	<bkg	NR	<bkg	NR
Copper	27	19.3	NR	<bkg	NR	33.1	Y	12.1	NR	19.6	NR	68.8	R	<bkg	NR	<bkg	NR	<bkg	NR
Cyanide	na	1.03	na	na	na	na	na	nd	na	0.27	na	nd	na	na	na	na	na	na	na
Lead	20	15.6	NR	4.5	NR	34.7	R	9.4	NR	47.8	R	160	R	<bkg	NR	<bkg	NR	<bkg	NR
Manganese	480	<bkg	NR	1583	R	<bkg	NR	<bkg	NR	<bkg	NR	<bkg	NR	<bkg	NR	<bkg	NR	<bkg	NR
Mercury	0.065	2.62	R	0.42	R	0.72	R	0.11	R	0.89	R	3.1	R	2.5	R	1.39	R	1.52	R
Nickel	19	35.2	R	3.83	NR	9.8	NR	21	Y	5.9	NR	8	NR	<bkg	NR	<bkg	NR	<bkg	NR
Selenium	0.34	nd	NR	nd	NR	0.48	R	<bkg	NR	0.52	R	5.3	R	nd	NR	0.32	NR	0.25	NR
Silver[3]	0.3	0.81	R	0.15	NR	2.52	R	0.1	NR	2.8	R	19.6	R	0.54	R	2.52	R	1.95	R
Zinc	65	<bkg	NR	45.3	NR	58.2	NR	67.7	Y	<bkg	NR	70.9	Y	<bkg	NR	<bkg	NR	<bkg	NR

(1) Except as noted, average U.S. western soil concentrations are from Shacklette and Boerngen (1984).
(2) Median U.S. western soil concentration from Irwin et al. (1997).
(3) Upper range of typical average soil concentrations (0.07 to 0.3) from Irwin et al. (1997).
na = not analyzed
nd = not detected
<bkg = maximum concentration at an exposure location is below the Site-specific nonmineralized background screening concentration (see Section 6.2).
R = Exposure location receptor exposure concentration is greater than the average U.S. western soil concentration (retained for evaluation).
NR = Exposure location receptor exposure concentration is comparable (i.e., less than or within +10 percent) of average U.S. western soil concentration (not retained for evaluation).
RME = reasonable maximum exposure concentration
Max = maximum concentration

Table 8-3

Comparison of Soil Metal Exposure Concentrations in Hot Spots to U.S. Western Soils

Analyte	Estimated Arithmetic Mean for U.S. Western Soils[1]	Upgradient Wetland, UW1 (Max)	Retained for Risk Evaluation?	Smelter Stack (Max)	Retained for Risk Evaluation?	DMEA Dump (Max)	Retained for Risk Evaluation?	1997 Antimony Outlier, NW Bradley Waste Rock Dump (Max)	Retained for Risk Evaluation?
Aluminum	74000	<bkg	NR	<bkg	NR	<bkg	NR	<bkg	NR
Antimony	0.62	689	R	292	R	<bkg	NR	16400	R
Arsenic	7.0	983	R	3750	R	9460	R	4790	R
Cadmium[2]	0.32	nd	NR	<bkg	NR	nd	NR	<bkg	NR
Chromium	56	<bkg	NR	<bkg	NR	<bkg	NR	<bkg	NR
Copper	27	286	R	<bkg	NR	<bkg	NR	26.5	NR
Cyanide	na	nd	na	na	na	na	na	na	na
Lead	20	754	R	16.6	NR	<bkg	NR	34.7	R
Manganese	480	<bkg	NR	<bkg	NR	<bkg	NR	<bkg	NR
Mercury	0.065	2.3	R	471	R	9.9	R	13.6	R
Nickel	19	<bkg	NR	<bkg	NR	nd	NR	<bkg	NR
Selenium	0.34	1.1	R	66.7	R	0.35	Y	7.7	R
Silver[3]	0.3	2.2	R	4.1	R	3.4	R	6.79	R
Zinc	65	<bkg	NR	<bkg	NR	<bkg	NR	150	R

(1) Except as noted, average U.S. western soil concentrations are from Shacklette and Boerngen (1984).

(2) Median U.S. western soil concentration from Irwin et al. (1997).

(3) Upper range of typical average soil concentrations (0.07 to 0.3) from Irwin et al. (1997).

<bkg = maximum concentration at an exposure location is below the Site-specific nonmineralized background screening concentration (see Section 6.2).

na = not analyzed

nd = not detected

R = Exposure location receptor exposure concentration is greater than the average U.S. western soil concentration (retained for evaluation).

NR = Exposure location receptor exposure concentration is comparable (i.e., less than or within +10 percent) of average U.S. western soil concentration (not retained for evaluation).

RME = reasonable maximum exposure concentration

Max = maximum concentration

Table 8-4

Comparison of Soil Metal Exposure Concentrations in Sediment to U.S. Western Soils

Analyte	Estimated Arithmetic Mean for U.S. Western Soils[1]	Lower Meadow Creek Valley (RME)	Retained for Risk Evaluation?	EFSFSR and Midnight Creek (RME)	Retained for Risk Evaluation?	Glory Hole and EFSFSR (RME)	Retained for Risk Evaluation?	Sugar Creek (Max)	Retained for Risk Evaluation?
Aluminum	74000	na	na	na	na	8850	NR	na	na
Antimony	0.62	19.2	R	18.9	R	128	R	0.59	NR
Arsenic	7.0	90.3	R	56.4	R	1522	R	37.9	R
Cadmium[2]	0.32	1.07	R	1.03	R	40.4	R	1.13	R
Chromium	56	2.3	NR	3	NR	9.2	NR	4.0	NR
Copper	27	4.5	NR	2.18	NR	7.3	NR	2.22	NR
Cyanide	na	na	na	na	na	na	na	na	na
Lead	20	3.31	NR	3.45	NR	10.6	NR	4.52	NR
Manganese	480	na	na	na	na	562	R	na	na
Mercury	0.065	0.129	R	0.143	R	1.83	R	9.14	R
Nickel	19	na	na	na	na	7.06	NR	na	na
Selenium	0.34	1.69	R	2.37	R	3.45	R	1.8	R
Silver[3]	0.3	na	na	na	na	1.56	R	na	na
Zinc	65	11.6	NR	13	NR	31.6	NR	19.6	NR

(1) Except as noted, average U.S. western soil concentrations are from Shacklette and Boerngen (1984).
(2) Median U.S. western soil concentration from Irwin et al. (1997).
(3) Upper range of typical average soil concentrations (0.07 to 0.3) from Irwin et al. (1997).
na = not analyzed
nd = not detected
R = Exposure location receptor exposure concentration is greater than the average U.S. western soil concentration (retained for evaluation).
NR = Exposure location receptor exposure concentration is comparable (i.e., less than or within +10 percent) of average U.S. western soil concentration (not retained for evaluation).
RME = reasonable maximum exposure concentration
Max = maximum concentration

Ta[illegible]-5

Terrestrial Wildlife Exposure Pathways

Exposure Medium	Exposure Location	Pathway	Soil microorganisms	Terrestrial Plants	Soil Invertebrates	Small Avian Invertivore (Snipe)	Small Mammal Herbivore (Meadow vole)	Small Mammal Invertivore (Short-tailed shrew)	Medium Mammal Carnivore (Red fox)	Large Mammal Herbivore (White-tailed deer)	Small Avian Piscivore (Belted Kingfisher)	Median Mammal Piscivore (Mink)
Surface Soil	Bradley Impoundment and Neutralization Ore (BT/NO) Disposal Area	Dermal	NA	NA	NA	--	--	--	--	--	NA	NA
	Meadow Creek Mine Hillside	Direct Contact/Ingestion	●	●	●	●	●	●	●	●	NA	NA
	Lower Meadow Creek Valley	Indirect Ingestion	NA	NA	NA	●	●	●	●	●	NA	NA
	Upgradient Wetland											
	Keyway Wetland											
	Meadow Creek Forested Wetland											
	Southeast Bradley Waste Rock Dumps											
	Northwest Bradley Waste Rock Dumps											
	Northeast Bradley Waste Rock Dumps											
	Hotspots (Upgradient Wetland, Smelter Stack, DMEA Dump)											
	1997 Outlier, Northwest Bradley Waste Rock Dump											
Surface water/ Seeps	Lower Meadow Creek Valley	Dermal	NA	NA	NA	--	--	--	--	--	--	--
	Keyway Wetland	Direct Ingestion	NA	NA	NA	●	●	●	●	●	●	●
	Upgradient Wetland	Indirect Ingestion	NA	NA	NA	NA	NA	NA	NA	NA	●*	●*
	EFSFSR and Midnight Creek											
	Glory Hole and EFSFSR											
	Bailey Tunnel Outlet											
	Upgradient Wetland-Hotspot											
	Sugar Creek											
	Seeps at Areas 1, 2, and 3											
Sediment	Lower Meadow Creek	Dermal	NA	NA	NA	--	--	--	--	--	--	--
	EFSFSR and Midnight Creek	Direct Ingestion	NA	NA	NA	●	●	●	●	●	--	--
	Glory Hole and EFSFS	Indirect Ingestion	NA	NA	NA	●	●	●	●	●	●*	●*
	Sugar Creek											

NA = Not applicable pathway
l = Potentially complete pathway addressed in this risk evaluation.
-- = Potentially complete pathway not addressed in this risk evaluation.
*Whole body fish tissue concentration was used for piscivores instead of indirect ingestion of surface water and sediment.

Table 8-6

Wildlife Exposure Factors

Representative Species			Body Weight		Food Ingestion Rate			Composition of Diet (%)					Soil Ingestion Rate			Water Intake		
Food-web classification	Common Name	Scientific Name	kg wet wt.	Reference	kg wet wt./day[(a)]	Comment	Reference	Plants	Inverte-brates	Small Mammals	Fish	Reference	kg dry wt./day	Comment	Reference	L/d	Comment	Reference
Birds																		
avian, small invertivore	Snipe	*Capella gallinago*	0.134	Terres 1991	0.102	based on woodcock = 76% of BW	Sample et al. 1996	0%	100%	0%	0%	(assumed)	0.011	based on woodcock = 10.4% of FI rate wet weight	EPA 1993	0.015	WI (L/day)= $0.059*BW^{0.67}$ (BW in wet wt. kg)	USEPA 1993
avian, small piscivore	Belted kingfisher	*Ceryle alcyon*	0.148	Sample et al. 1996	0.075		Sample et al. 1996	0%	0%	0%	100%	(assumed)	0		Sample et al. 1997	0.016		Sample et al. 1996
Mammals																		
mammal, small herbivore	Meadow vole	*Microtus pennsylvanicus*	0.044	Sample et al. 1996	0.005		Sample et al. 1996	100%	0%	0%	0%	Sample et al. 1996	0.000024	2.4% of dry weight FI, assuming 80% diet moisture content[(c)]	Beyer et al. 1994	0.006		Sample et al. 1996
mammal, medium piscivore	Mink	*Mustela vison*	1.0	Sample et al. 1996	0.137		Sample et al. 1996	0%	0%	0%	100%		0	negligible	Sample et al. 1997	0.099		Sample et al. 1996
mammal, medium carnivore	Red fox	*Vulpes vulpes*	3.94	EPA 1993	0.66	Dry weight - FI [(b)] (kg/day) = $0.0687BW^{0.822}$ (kg) = 0.21	EPA 1993	0%	0%	100%	0%	USEPA 1993	0.00588	2.8% of dry weight food ingestion rate (0.21 kg/day)	EPA 1993	0.34	WI (L/day) = $0.099 BW^{0.90}$ (BW in kg wet wt.)	EPA 1993
mammal, small invertivore	Short-tailed shrew	*Blarina brevicauda*	0.015	Sample et al. 1996	0.009		Sample et al. 1996	0%	100%	0%	0%	Efroymson et al. 1997	0.00117		Efroymson et al. 1997	0.0033		Sample et al. 1996
mammal, large herbivore	White-tailed deer	*Odocoileus virginianus*	56.5	Sample et al. 1996	1.74		Sample et al. 1996	100%	0%	0%	0%	Efroymson et al. 1997	0.0348		Efroymson et al. 1997	3.7		Sample et al. 1996

(a) kg wet wt/day = (kg dry wt/day) /(fraction solids)
(b)Assumed small mammals are 68% moisture (EPA 1993, p.4-13)
(c) Assumed plants are 80% moisture (EPA 1993, p.4-14)
FI = food ingestion rate
BW=body weight
WI=water intake
wt.=weight

Table 8-7

Overview of Soil Hazard Quotients for Terrestrial Risk Evaluation

Area	Analyte	Exposure Concentration[(a)] (mg/kg)	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe) NOAEL	Small Avian Invertivore (Snipe) LOAEL	Small Mammal Herbivore (Meadow Vole) NOAEL	Small Mammal Herbivore (Meadow Vole) LOAEL	Small Mammal Invertivore (Short-tailed Shrew) NOAEL	Small Mammal Invertivore (Short-tailed Shrew) LOAEL	Medium Mammal Carnivore (Red Fox) NOAEL	Medium Mammal Carnivore (Red Fox) LOAEL	Large Mammal Herbivore (White-tailed Deer) NOAEL	Large Mammal Herbivore (White-tailed Deer) LOAEL
BT/NO Disposal Area															
	Antimony	133	27	nc	tiss.	[904]	[292]	4.8	1.6	[619]	[200]	[16]	[5.1]	2.9	0.95
	Arsenic	1620	162	16	27	[266]	[105]	[18]	[5.5]	[4786]	[1473]	[369]	[114]	[17]	[5.4]
	Cadmium	2.7	0.90	0.14	0.14	2.0	0.15	0.11	0.01	12	1.2	0.08	0.01	0.05	0.01
	Cyanide	1.03	nc	nc	nc	0.04	0.01	0.03	0.01	0.03	0.01	0.05	0.02	0.01	<0.01
	Mercury	2.62	8.7	0.09	26	1.7	0.85	5.5	3.4	64	40	[439]	[285]	1.6	1.0
	Nickel	35.2	1.2	0.39	0.18	0.08	0.06	0.01	<0.01	0.66	0.33	0.23	0.11	<0.01	<0.01
	Silver	0.81	0.41	0.02	nc	0.01	<0.01	<0.01	<0.01	0.02	0.01	<0.01	<0.01	<0.01	<0.01
Meadow Creek Mine Hillside															
	Antimony	15.6	3.1	nc	tiss.	[106]	[34]	0.57	0.18	[73]	[23]	1.8	0.59	0.34	0.11
	Arsenic	1460	146	15	24	[240]	[95]	[16]	[5]	[4313]	[1327]	[333]	[102]	[16]	[4.8]
	Manganese	1583	3.2	16	nc	0.27	0.09	0.34	0.10	13	4.1	0.43	0.13	0.19	0.06
	Mercury	0.416	1.4	0.01	4.2	0.27	0.13	0.87	0.55	10	6.4	70	45	0.26	0.16
Lower Meadow Creek Valley															
	Antimony	1324	265	nc	tiss.	[8998]	[2907]	[48]	[16]	[6166]	[1992]	[156]	[50]	[29]	[9.4]
	Arsenic	955	96	9.6	16	[157]	[62]	[11]	[3]	[2821]	[868]	[218]	[67]	[10]	[3.2]
	Lead	34.7	0.69	0.04	0.07	5.6	0.56	0.02	<0.01	3.4	0.34	0.09	0.01	0.02	<0.01
	Mercury	0.72	2.4	0.02	7.2	0.46	0.23	1.5	0.94	18	11	[120]	78	0.44	0.28
	Selenium	0.48	0.48	<0.01	<0.01	0.57	0.29	0.01	<0.01	4.7	2.9	1.5	0.92	0.01	0.01
	Silver	2.52	1.3	0.05	nc	0.02	0.01	<0.01	<0.01	0.07	0.02	<0.01	<0.01	<0.01	<0.01
Upgradient Wetland (excluding UW-1 Hot Spot)															
	Arsenic	24.4	2.4	0.24	0.41	4	1.6	0.27	0.08	72	22	5.6	1.7	0.26	0.08
	Mercury	0.11	0.37	<0.01	1.1	0.07	0.04	0.23	0.14	2.7	1.7	18	12	0.07	0.04
	Nickel	21	0.70	0.23	0.11	0.05	0.03	<0.01	<0.01	0.39	0.20	0.14	0.07	<0.01	<0.01
	Silver	0.1	0.05	<0.01	nc	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Keyway Wetland															
	Antimony	333	67	nc	tiss.	[2263]	[731]	12	3.9	[1551]	[501]	[39]	[13]	7.3	2.4
	Arsenic	634	63	6.3	11	[104]	[41]	[7.1]	[2.1]	[1873]	[576]	[145]	[44]	[6.83]	[2.1]
	Cyanide	0.27	nc	nc	nc	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01
	Lead	47.8	0.96	0.05	0.10	7.7	0.77	0.03	<0.01	4.7	0.47	0.12	0.01	0.03	<0.01
	Mercury	0.89	3.0	0.03	8.9	0.57	0.29	1.9	1.2	22	14	[149]	[97]	0.55	0.34
	Selenium	0.52	0.52	<0.01	<0.01	0.62	0.31	0.01	0.01	5.1	3.1	1.7	1.0	0.01	0.01
	Silver	2.8	1.4	0.06	nc	0.02	0.01	<0.01	<0.01	0.07	0.02	<0.01	<0.01	<0.01	<0.01
Meadow Creek Forested Wetland															
	Antimony	1550	310	nc	tiss.	[10534]	[3403]	[56]	[18]	[7219]	[2332]	[182]	[59]	[34]	[11]
	Arsenic	1230	123	12	21	[202]	[80]	[14]	[4.2]	[3634]	[1118]	[281]	[86]	[13]	[4.1]
	Copper	68.8	0.69	0.69	1.4	0.83	0.63	0.28	0.22	[4.8]	[3.9]	2	1.5	0.09	0.07
	Lead	160	3.2	0.18	0.32	26	2.6	0.09	0.01	16	1.6	0.4	0.04	0.09	0.01
	Mercury	3.1	10	0.10	31	2.0	1.0	6.5	4.1	76	47	[520]	[338]	1.9	1.2
	Selenium	5.3	5.3	0.05	0.08	6.3	3.2	0.09	0.05	52	31	17	10	0.10	0.06
	Silver	19.6	9.8	0.39	nc	0.17	0.06	0.01	<0.01	0.51	0.17	0.03	0.01	<0.01	<0.01
SE Bradley Waste Rock Dumps															
	Arsenic	4970	497	50	83	[817]	[323]	[56]	[17]	[14683]	[4518]	[1133]	[349]	[54]	[16]
	Mercury	2.51	8.4	0.08	25	1.6	0.81	5.3	3.3	62	38	[421]	[273]	1.6	0.97
	Silver	0.54	0.27	0.01	nc	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
NW Bradley Waste Rock Dumps															
	Antimony	368	74	nc	tiss.	[2501]	[808]	13	4.4	[1714]	[554]	[43]	[14]	8.1	2.6
	Arsenic	2717	272	27	45	[447]	[177]	[30]	[9.2]	[8027]	[2470]	[620]	[191]	[29]	[9]
	Mercury	1.39	4.6	0.05	14	0.90	0.45	2.9	1.8	34	21	[233]	[151]	0.86	0.54
	Silver	2.52	1.3	0.05	nc	0.02	0.01	<0.01	<0.01	0.07	0.02	<0.01	<0.01	<0.01	<0.01
NE Bradley Waste Rock Dumps															
	Arsenic	5630	563	56	94	[926]	[366]	[63]	[19]	[16632]	[5118]	[1284]	[395]	[61]	[19]
	Mercury	1.52	5.1	0.05	15	0.98	0.49	3.2	2.0	37	23	[255]	[166]	0.94	0.59
	Silver	1.95	0.98	0.04	nc	0.02	0.01	<0.01	<0.01	0.05	0.02	<0.01	<0.01	<0.01	<0.01
UW1 Hot Spot															
	Antimony	689	138	nc	tiss.	[4683]	[1513]	25	8.2	[3209]	[1037]	[81]	[26]	15	4.9
	Arsenic	983	98	9.8	16	[162]	[64]	[11]	[3.3]	[2904]	[894]	[224]	[69]	[11]	[3]
	Copper	286	2.9	2.9	5.7	[3.5]	[2.6]	[1.2]	0.92	[20]	[16]	[8]	[6.4]	0.37	0.29
	Mercury	2.3	7.7	0.08	23	1.5	0.74	4.8	3.0	56	35	[386]	[251]	1.4	0.89
	Selenium	1.1	1.1	0.01	0.02	1.3	0.65	0.02	0.01	11	7	3.5	2.12	0.02	0.01
	Silver	2.2	1.1	0.04	nc	0.02	0.01	<0.01	<0.01	0.06	0.02	<0.01	<0.01	<0.01	<0.01
Smelter Stack Hot Spot															
	Antimony	292	58	nc	tiss.	[1984]	[641]	11	3.5	[1360]	[439]	[34]	[11]	6.4	2.1
	Arsenic	3750	375	38	63	[617]	[244]	[42]	[13]	[11078]	[3409]	[855]	[263]	[40]	[12]
	Mercury	471	1570	16	4710	[304]	[152]	[989]	[618]	[11541]	[7213]	[78953]	[51319]	[290]	[181]
	Selenium	66.7	67	0.67	0.95	[79]	[40]	1.1	0.68	[652]	[395]	[34]	[128]	1.3	0.78
	Silver	4.1	2.1	0.08	nc	0.04	0.01	<0.01	<0.01	0.11	0.04	0.01	<0.01	<0.01	<0.01
DMEA Dump Hot Spot															
	Arsenic	9460	946	95	158	[1556]	[615]	[106]	[32]	[27947]	[8599]	[2157]	[664]	[102]	[31]
	Mercury	9.9	33	0.33	99	[6.4]	[3.2]	[21]	[13]	[243]	[152]	[1660]	[1079]	[6.1]	[3.8]
	Silver	3.4	1.7	0.07	nc	0.03	0.01	<0.01	<0.01	0.09	0.03	0.01	<0.01	<0.01	<0.01
1997 Antimony Outlier, NW Bradley Waste Rock Dump Hot Spot															
	Antimony	16400	3280	nc	tiss.	[111457]	[36009]	[596]	[194]	[76377]	[24676]	[1927]	[622]	[361]	[117]
	Arsenic	4790	479	48	80	[788]	[311]	[54]	[16]	[14151]	[4354]	[1092]	[336]	[52]	[16]
	Lead	34.7	0.69	0.04	0.07	5.6	0.56	0.02	<0.01	3.4	0.34	0.09	0.01	0.02	<0.01
	Mercury	13.6	45	0.45	136	[8.8]	[4.4]	[29]	[18]	[333]	[208]	[2280]	[1482]	[8.4]	[5.2]
	Selenium	7.7	7.7	0.08	0.11	9.2	4.6	0.13	0.08	75	46	24	15	0.15	0.09
	Silver	6.79	3.4	0.14	nc	0.06	0.02	<0.01	<0.01	0.18	0.06	0.01	<0.01	<0.01	<0.01
	Zinc	150	3.0	1.5	0.75	4.8	0.54	0.1	0.05	1.8	0.92	[3.9]	[2]	0.05	0.02

(a)Except for sites with one to three samples, the reasonable maximum exposure concentration, which is the lower of the maximum and 95 percent upper confidence limit of the mean, is used as the site exposure concentration. For sites with one to three samples, the maximum concentration is used as the exposure concentration.

nc = no toxicity reference value for soil and no critical tissue limits are available.

tiss. = no toxicity reference value for soil but critical tissue limit is available.

29 =Bolded and shaded hazard quotient (HQ) values are greater than 1

[29] = Bolded and shaded HQ values are greater than 1 but the bracket indicates food web is likely to be interupted and therefore, the herbivores, invertivores, or carnivores would have reduced exposure (i.e., no exposure, therefore HQ inappropriate or a lower HQ than shown). Except for antimony, food web interuption for herbivores was interpreted to likely occur where the HQ of plants is >1 and the predicted plant tissue concentration is above critical plant tissue limits. Except for antimony, food web interuption for invertivores was interpreted to likely occur where the HQ of earthworms is >1 and the predicted earthworm concentration is above critical animal tissue limits. Because there are no antimony soil toxicity reference values for plants or earthworms, food web interuption for herbivores or invertivores was interpreted as likely to occur where the predicted plant tissue concentration or earthworm tissue concentration were above their respective critical tissue limits (see Appendix C Tables). For carnivores, food web interuption was interpreted as likely to occur where HQs for small mammals or avians were >1 and the predicted tissue concentration in small mammals and birds was also above critical tissue limits (see Appendix C Tables).

Table 8-8

Overview of Sediment Hazard Quotients for Terrestrial Risk Evaluation

Area	Analyte	Exposure Concentration[a] (mg/kg)	Small Avian Invertivore (Snipe)		Small Mammal Herbivore (Meadow Vole)		Small Mammal Invertivore (Short-tailed Shrew)		Medium Mammal Carnivore (Red Fox)		Large Mammal Herbivore (White-tailed Deer)	
			NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Lower Meadow Creek Valley												
	Antimony	19.2	[130]	[42]	0.70	0.23	[89]	[29]	**2.3**	0.73	0.42	0.14
	Arsenic	90.3	[15]	[5.9]	1.0	0.31	[267]	[82]	[21]	[6.3]	0.97	0.30
	Cadmium	1.07	0.78	0.06	0.04	<0.01	**4.7**	0.47	0.03	<0.01	0.02	<0.01
	Lead	3.31	0.54	0.05	<0.01	<0.01	0.32	0.03	0.01	<0.01	<0.01	<0.01
	Mercury	0.129	0.08	0.04	0.27	0.17	**3.2**	**2.0**	[22]	[14]	0.08	0.05
	Selenium	1.69	**2.0**	1.0	0.03	0.02	**17**	**10**	**5.4**	**3.3**	0.03	0.02
EFSFSR and Midnight Creek												
	Antimony	18.9	[128]	[42]	0.69	0.22	[88]	[28]	**2.2**	0.72	0.42	0.13
	Arsenic	56.4	[9.3]	[3.7]	0.63	0.19	[167]	[51]	[13]	[4]	0.61	0.19
	Cadmium	1.03	0.75	0.06	0.04	<0.01	**4.52**	0.45	0.03	<0.01	0.02	<0.01
	Mercury	0.143	0.09	0.05	0.30	0.19	**3.5**	**2.2**	[24]	[16]	0.09	0.06
	Selenium	2.37	**2.8**	**1.4**	0.04	0.02	**23**	**14**	**7.5**	**4.6**	0.05	0.03
Glory Hole and EFSFSR												
	Antimony	128	[870]	[281]	**4.7**	**1.5**	[596]	[193]	[15]	[4.9]	**2.8**	0.91
	Arsenic	1522	[250]	[99]	[17]	[5.2]	[4496]	[1384]	[347]	[107]	[16]	[5.1]
	Cadmium	40.4	[29]	[2.2]	**1.6**	0.16	[177]	[18]	**1.3**	0.12	0.81	0.08
	Manganese	562	0.09	0.03	0.12	0.04	**4.6**	**1.5**	0.15	0.05	0.07	0.02
	Mercury	1.83	**1.2**	0.59	**3.8**	**2.4**	**45**	**28**	[307]	[199]	**1.1**	0.70
	Selenium	3.45	**4.1**	**2.1**	0.06	0.03	**34**	**20**	**11**	**6.7**	0.07	0.04
	Silver	1.56	0.01	<0.01	<0.01	<0.01	0.04	0.01	<0.01	<0.01	<0.01	<0.01
Sugar Creek												
	Antimony	0.59	**4.0**	**1.3**	0.02	0.01	**2.8**	0.89	0.07	0.02	0.01	<0.01
	Arsenic	37.9	[6.2]	[2.5]	0.42	0.13	[112]	[34]	[8.6]	[2.7]	0.41	0.13
	Cadmium	1.13	0.82	0.06	0.04	<0.01	**5.0**	0.50	0.03	<0.01	0.02	<0.01
	Mercury	9.14	[5.9]	[3]	[19]	[12]	[224]	[140]	[1532]	[996]	[5.6]	[3.5]
	Selenium	1.8	**2.1**	**1.1**	0.03	0.02	**18**	**11**	**5.7**	**3.5**	0.03	0.02

(a)Except for sites with one to three samples, the reasonable maximum exposure concentration, which is the lower of the maximum and 95 percent upper confidence limit of the mean, is used as the site exposure concentration. For sites with one to three samples, the maximum concentration is used as the exposure concentration.

29 =Bold and shaded HQ values are greater than 1

[29] = Bolded and shaded HQ values are greater than 1 but the bracket indicates food web is likely to be interupted and therefore, the herbivores, invertivores, or carnivores would have reduced exposure (i.e., no exposure therefore HQ inappropriate or a lower HQ than shown). Food web interuption for herbivores was interpreted to likely occur where the predicted plant tissue concentration is above the critical plant tissue limit. Food web interuption for invertivores was interpreted to likely occur where the predicted earthworm tissue concentration is above the critical animal tissue limit. For carnivores, food web interuption was interpreted as likely to occur where HQs for small animals are >1 and the predicted animal tissue concentration is above the critical animal tissue limit.

Overview of Surface Water Hazard Quotients for Terrestrial Risk Evaluation

Area	Analyte	Exposure Concentration[a] (mg/L)	Small Avian Invertivore (Snipe)		Small Avian Piscivore (Belted Kingfisher)		Small Mammal Herbivore (Meadow Vole)		Small Mammal Invertivore (Short-tailed Shrew)		Medium Mammal Carnivore (Red Fox)		Medium Mammal Piscivore (Mink)		Large Mammal Herbivore (White-tailed Deer)	
			NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL	NOAEL	LOAEL
Lower Meadow Creek Valley																
	Aluminum	0.0831	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01
	Antimony	0.0112	0.02	0.01	0.02	0.01	0.01	<0.01	0.03	0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01
	Arsenic	0.0323	<0.01	<0.01	<0.01	<0.01	0.03	0.01	0.09	0.03	0.03	0.01	0.04	0.01	0.03	0.01
	Copper	0.002	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Cyanide	0.0023	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Lead	0.00143	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Manganese	0.0314	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Mercury	0.000054	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Zinc	0.00252	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Upgradient Wetland (excluding UW-1 Hot Spot)																
	Aluminum	0.153	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.03	0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01
	Copper	0.0017	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Cyanide	0.0021	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Lead	0.001	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Manganese	0.0072	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Keyway Wetland																
	Aluminum	0.12	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.02	0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01
	Antimony	0.127	0.20	0.07	0.20	0.06	0.12	0.04	0.33	0.11	0.13	0.04	0.15	0.05	0.12	0.04
	Arsenic	0.463	0.03	0.01	0.03	0.01	0.49	0.15	**1.3**	0.39	0.50	0.15	0.57	0.18	0.02	0.01
	Cyanide	0.0056	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Manganese	0.785	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Mercury	0.000118	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Zinc	0.0044	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
EFSFSR and Midnight Creek																
	Aluminum	0.079	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01
	Antimony	0.0392	0.06	0.02	0.06	0.02	0.04	0.01	0.10	0.03	0.04	0.01	0.05	0.01	0.03	0.01
	Arsenic	0.0577	<0.01	<0.01	<0.01	<0.01	0.06	0.02	0.16	0.05	0.06	0.02	0.07	0.02	0.05	0.01
	Cyanide	0.0021	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Lead	0.0046	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Manganese	0.0154	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Mercury	0.000131	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Zinc	0.0159	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Glory Hole and EFSFSR																
	Aluminum	0.047	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Antimony	0.0267	0.04	0.01	0.04	0.01	0.03	0.01	0.07	0.02	0.03	0.01	0.03	0.01	0.02	0.01
	Arsenic	0.059	<0.01	<0.01	<0.01	<0.01	0.06	0.02	0.16	0.05	0.06	0.02	0.07	0.02	0.05	0.01
	Lead	0.00032	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Manganese	0.0282	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Mercury	0.00039	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Nickel	0.0144	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Silver	0.000129	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Zinc	0.00385	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sugar Creek																
	Aluminum	0.137	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.02	0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01
	Antimony	0.0083	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.02	0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01
	Arsenic	0.012	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.03	0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01
	Manganese	0.005	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Mercury	0.000255	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Zinc	0.008	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
UW-1 Hot Spot																
	Antimony	0.069	0.11	0.04	0.11	0.03	0.07	0.02	0.18	0.06	0.07	0.02	0.08	0.03	0.05	0.02
	Arsenic	0.316	0.02	0.01	0.02	0.01	0.33	0.10	0.87	0.27	0.34	0.10	0.39	0.12	0.26	0.08
	Copper	0.004	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Lead	0.0053	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Manganese	0.0491	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
BTO Hot Spot																
	Antimony	0.281	0.45	0.15	0.43	0.14	0.27	0.09	0.74	0.24	0.29	0.09	0.33	0.11	0.26	0.08
	Arsenic	0.535	0.04	0.01	0.03	0.01	0.56	0.17	**1.5**	0.45	0.58	0.18	0.66	0.20	0.02	0.01
	Lead	0.0064	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Manganese	0.181	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Silver	0.000106	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Zinc	0.0075	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

(a)Except for sites with one to three samples, the reasonable maximum exposure concentration, which is the lower of the maximum and 95 percent upper confidence limit of the mean, is used as the site exposure concentration. For sites with one to three samples, the maximum concentration is used as the exposure concentration.

1.5 =Bold and shaded HQ values are greater than 1

T ; 8-10

Comparison of Wildlife Drinking Water RBCs (NOAELs and LOAELs) to Maximum Seep Water Concentrations (All Seeps)

Comparison to NOAELs	Reference	Non-Impacted Seeps[a]		Potentially Impacted Seeps Seeps at Areas 1 and 3[b]		RBCs Based on NOAELs (mg/L)							
Analyte	Maximum Concentration[c] (mg/L)	Maximum Concentration (mg/L)	Location of Maximum Concentration	Maximum Concentration (mg/L)	Location of Maximum Concentration	Small Avian Invertivore (Snipe)	Small Avian Piscivore (Belted Kingfisher)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Medium Mammal Piscivore (Mink)	Large Mammal Herbivore (White-tailed Deer)	Minimum RBC (mg/L)
Aluminum	3.83	79.3	SPHP-1	2.43	SPMC-9	40	42	15	**5.91**	15	13	20	5.9
Antimony	0.08	0.18	SPGH-9	2.55	SPMC-8	0.63	0.65	1.0	**0.38**	0.97	0.85	1.3	0.38
Arsenic	0.09	2.7	SPMC-5	10.9	SPMC-8	15	16	1	**0.36**	0.93	0.81	1.2	0.36
Chromium	0.002	0.09	SPHP-1	0.003	SPMC-9	**8.9**	9.3	6688	2486	6339	5525	8353	9
Copper	0.21	0.08	SPHP-1	0.03	SPMC-8	143	148	18	**11**	35	121	37	11
Cyanide	0.003	0.003	SPGH-7	0.02	SPGH-6	103	106	169	**64**	162	141	214	64
Lead	0.002	0.02	SPGH-7	0.003	SPGH-6	10	10	20	**7.3**	19	16	24	7
Manganese	0.09	20	SPHP-1	2.00	SPMC-8	8907	9222	213	**82**	209	182	275	82
Mercury	ND	0.002	SPMC-5	0.0005	SPMC-9	4.0	4.2	0.07	**0.05**	0.15	0.51	0.15	0.045
Nickel	ND	0.10	SPHG-3	0.01	SPGH-5	688	712	95	**36**	93	81	122	36
Selenium	ND	ND	SPGH-8	0.003	SPMC-9	3.6	3.7	0.49	**0.18**	0.46	0.40	0.61	0.18
Silver	ND	0.0013	SPHP-2	0.0001	SPGH-6	491	509	183	**68**	174	152	229	68
Zinc	0.01	0.52	SPHP-1	0.039	SPNW-1	**134**	139	389	145	371	323	489	134

Comparison to LOAELs	Reference	Non-Impacted Seeps[a]		Potentially Impacted Seeps Seeps at Areas 1 and 3[b]		RBCs Based on LOAELs (mg/L)							
Analyte	Maximum Concentration[c] (mg/L)	Maximum Concentration (mg/L)	Location of Maximum Concentration	Maximum Concentration (mg/L)	Location of Maximum Concentration	Small Avian Invertivore (Snipe)	Small Avian Piscivore (Belted Kingfisher)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Medium Mammal Piscivore (Mink)	Large Mammal Herbivore (White-tailed Deer)	Minimum RBC (mg/L)
Aluminum	3.83	79.3	SPHP-1	2.43	SPMC-9	134	139	46	**17**	44	38	58	17
Antimony	0.08	0.18	SPGH-9	2.55	SPMC-8	1.9	2.0	3.2	**1.2**	3.0	2.6	4.0	1.2
Arsenic	0.09	2.7	SPMC-5	10.9	SPMC-8	38.4	40	3.2	**1.2**	3.0	2.6	4.0	1.2
Chromium	0.002	0.09	SPHP-1	0.003	SPMC-9	**44.7**	46	20093	7455	19005	16566	25043	44.7
Copper	0.21	0.08	SPHP-1	0.03	SPMC-8	188	194	22.0	**13.6**	44.0	151.5	45.8	13.6
Cyanide	0.003	0.003	SPGH-7	0.02	SPGH-6	307	318	506.0	**186**	475	414	626	186
Lead	0.002	0.02	SPGH-7	0.003	SPGH-6	98	102	198.0	**72.7**	185	162	244	73
Manganese	0.09	20	SPHP-1	2.00	SPMC-8	26720	27667	696.7	**259**	661	576	870	259
Mercury	ND	0.002	SPMC-5	0.0005	SPMC-9	8.0	8.3	0.12	**0.07**	0.23	0.81	0.24	0.07
Nickel	ND	0.10	SPHG-3	0.01	SPGH-5	956	990	198	**73**	185	162	244	73
Selenium	ND	ND	SPGH-8	0.003	SPMC-9	7.1	7.4	0.81	**0.30**	0.76	0.67	1.0	0.30
Silver	ND	0.0013	SPHP-2	0.0001	SPGH-6	1483	1536	543	**200**	510	444	672	200
Zinc	0.01	0.52	SPHP-1	0.039	SPNW-1	1170	1212	785	**291**	742	646	977	291

ND = not detected
mg/L = milligrams per liter.
RBC = Risk Based Concentration.

(a) Non-Impacted Seeps are those unlikely to be mining impacted through groundwater transport pathway (includes SPEF-3, SPGC-1, SPGH-2, SPGH-3, SPGH-4, SPGH-7, SPGH-8, SPGH-9, SPHP-1, SPMC-10, SPMC-3, SPMC-4, SPMC-5, SPMC-7). All seeps in Area 2 (SPEf-3, SPGC-1) are considered as non-impacted seeps.
(b) Includes seeps from Area 1 (SPMC-2, SPMC-8, and SPMC-9) and Area 3 (SPGH-5, SPGH-6, SPNW-1, and SPNW-2).
(c) Maximum of reference locations (SPMC-1 and SPGH-1) indicated.

T 8-11

Comparison of Wildlife Drinking Water RBCs (NOAELs and LOAELs) to Maximum Seep Water Concentrations (Specific Seeps)

Comparison to RBCs Based on NOAELs

Analyte	Area 1 Seep Water Concentration (mg/L) (Ref) SPMC-1	SPMC-2	SPMC-8	SPMC-9	Area 3 Seep Water Concentration (mg/L) (Ref) SPGH-1	SPGH-5	SPGH-6	SPNW-1	SPNW-2	RBCs Based on NOAELs (mg/L) Small Avian Invertivore (Snipe)	Small Avian Piscivore (Belted Kingfisher)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Medium Mammal Piscivore (Mink)	Large Mammal Herbivore (White-tailed Deer)
Antimony	0.08	0.38	**2.55 (a)**	**1.66**	0.05	0.27	0.24	0.26	0.20	0.63	0.65	1.0	**0.38 (b)**	0.97	0.85	1.3
Arsenic	0.02	**2.39**	**10.9**	**1.86**	0.09	0.02	0.29	0.31	0.67	15	16	1.0	**0.36**	0.93	0.81	1.2

Comparison to RBCs Based on LOAELs

Analyte	Area 1 Seep Water Concentration (mg/L) (Ref) SPMC-1	SPMC-2	SPMC-8	SPMC-9	Area 3 Seep Water Concentration (mg/L) (Ref) SPGH-1	SPGH-5	SPGH-6	SPNW-1	SPNW-2	RBCs Based on LOAELs (mg/L) Small Avian Invertivore (Snipe)	Small Avian Piscivore (Belted Kingfisher)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Medium Mammal Piscivore (Mink)	Large Mammal Herbivore (White-tailed Deer)
Antimony	0.08	0.38	**2.55 (a)**	**1.66**	0.05	0.27	0.24	0.26	0.20	1.9	2.0	3.2	**1.18 (b)**	3.0	2.6	4.0
Arsenic	0.02	**2.39**	**10.9**	**1.86**	0.09	0.02	0.29	0.31	0.67	38	39.8	3.2	**1.2**	3.0	2.6	4.0

Concentration of Other Analytes In Seeps

Analyte	Area 1 Seep Water Concentration (mg/L) (Ref) SPMC-1	SPMC-2	SPMC-8	SPMC-9	Area 3 Seep Water Concentration (mg/L) (Ref) SPGH-1	SPGH-5	SPGH-6	SPNW-1	SPNW-2
Alkalinity	19.4	ND	50.0	62.7	37	ND	ND	ND	ND
Chloride	0.23	3.1	0.45	6.0	0.22	ND	ND	ND	ND
Magnesium	0.83	5.7	4.4	8.1	3.1	7.9	9.1	7.6	8.5
Sodium	4.7	5.1	10.3	33.4	4.8	ND	ND	ND	ND
Sulfate	2.5	18.1	53.3	278	6.1	120	128	85	ND
TDS	49.0	205	175	492	74	223	220	160	180
TOC	ND	ND	3.8	ND	ND	ND	ND	ND	ND
TSS	14	12	56	54	33	ND	ND	ND	ND
min pH	6.78	7.83	6.52	7.56	7.14	7.02	7.03	6.34	6.34
max pH	7.23	7.93	7.03	9.21	7.80	7.15	7.10	7.20	6.34

Alkalinity (total) as $CaCO_3$. When adjusted to pH 4.5 and 8.5, alkalinity was generally not detected
mg/L = milligrams per liter.
ND = not detected
RBC = Risk Based Concentration.
TDS = Total Dissolved Solids
TOC = Total Organic Carbon
TSS = Total Suspended Solids
(a)**2.55** = Bolded and highlighted concentration values in Areas 1 and 3 exceed the minimum RBC concentration.
(b)**1.18** = Bolded RBC concentration indicates minimum RBC value.

Table 8-12
Overview of Piscivore (Fish) Hazard Quotients

Comparison with NOAELs

Analyte	Site: RME Whole-body Concentration[2] (mg/kg wet wt.)	Site: Small Avian Piscivore (Belted Kingfisher)	Site: Medium Mammal Piscivore (Mink)	Background: RME Whole-body Concentration[2] (mg/kg wet wt.)	Background: Small Avian Piscivore (Belted Kingfisher)	Background: Medium Mammal Piscivore (Mink)
Aluminum	6.3	0.71	0.66	12.2	**1.4**	**1.3**
Antimony	0.21	**1.5**	0.34	ND(<0.05)	0.36	0.08
Arsenic	2	0.60	**3.4**	0.52	0.16	0.89
Copper	1.1	0.03	0.01	1.1	0.03	0.01
Lead	0.05	0.02	<0.01	ND(<0.05)	0.02	<0.01
Manganese	4.1	<0.01	0.03	1.9	<0.01	0.01
Mercury	0.14	0.16	0.38	0.35	0.39	0.96
Selenium	0.82	1.0	**2.8**	0.34	0.43	**1.2**
Zinc	19.1	0.65	0.08	21.9	0.74	0.09

Comparison with LOAELs

Analyte	Site: RME Whole-body Concentration (mg/kg wet wt.)	Site: Small Avian Piscivore (Belted Kingfisher)	Site: Medium Mammal Piscivore (Mink)	Background: RME Whole-body Concentration (mg/kg wet wt.)	Background: Small Avian Piscivore (Belted Kingfisher)	Background: Medium Mammal Piscivore (Mink)
Aluminum	6.3	0.21	0.23	12.2	0.41	0.44
Antimony	0.21	0.49	0.11	ND(<0.05)	0.12	0.03
Arsenic	2.0	0.24	**1.1**	0.52	0.06	0.27
Copper	1.1	0.03	0.01	1.1	0.03	0.01
Lead	0.05	<0.01	<0.01	ND(<0.05)	<0.01	<0.01
Manganese	4.1	<0.01	0.01	1.9	<0.01	<0.01
Mercury	0.14	0.08	0.24	0.35	0.20	0.60
Selenium	0.82	0.52	**1.7**	0.34	0.22	0.71
Zinc	19.1	0.07	0.04	21.9	0.08	0.05

mg/kg = milligrams per kilogram

fish concentration in wet weight

ND = not detected. Detection limit is provided in brackets.

1.7 = bolded and shaded HQ values are greater than 1.

(1) HQs only reported for those metals detected in site fish tissue. Cadmium, chromium, nickel, and silver were not detected in fish tissue. Used the detection limit to calculate HQs for antimony and lead in background fish tissue.

(2) The lower of the maximum or 95 percent upper confidence limit of the mean value.

Table 8-13
Terrestrial Exposure Locations: Habitat and Risk Overview

Exposure Location*	Habitat Types	Soil Types	Approx. Size (acres)	Current Habitat Condition	Soil pH	Risk to Habitat or Plant Community	Risk to Wildlife Populations	Risk to Habitat and Plant Community	Risk to Wildlife Populations
	Habitat Type and Condition					Current Ecological Risk		Future Ecological Risk	
BT/NO Disposal Area (Soil samples SOD 1 - 3, STP 1 - 14)									
	Reclamation area. Upland soils with sparse vegetation, talus slopes, rock outcrops	Neutralized ore	103	Graded, amended with high phosphate fertilizer, potassium chloride and organic matter. Seeded with grasses and forbes in 1998.	6.4 - 9.0	**Risk Possible**: Scant terrestrial habitat due to physical limitations. Reclaimed area in process of revegetation. HQs for plants range from 1.2 (nickel) to 162 (arsenic); HQs for soil microorganisms <1 for all metals except arsenic (16); soil invertebrate HQs are <1 except for mercury (26) and arsenic (27). Soil amendments designed to reduce potential toxicity (i.e., bioavailability) of arsenic to plants and neutral to alkaline pH is also expected to reduce bioavailability of metals to plants and soil invertebrates. **Erosion potential:** Low to moderate.	**Risk Unlikely**: Scant habitat (i.e., none to limited exposure of wildlife receptors). Soil amendments designed to reduce bioavailability of arsenic to plants (i.e., reduce toxicity and bioaccumulation) and therefore should also reduce bioavailability to wildlife ingesting plants. LOAEL HQs for wildlife receptors >1 for arsenic, antimony, and mercury. Risk from arsenic and antimony to receptors is unlikely because plant and soil invertebrate community is expected to be affected first (i.e., food web exposure is reduced). Mercury HQs for the mammalian carnivore are inappropriate because benchmark is below U.S. western soil mercury concentrations (reference concentrations).	**Risk Unlikely**: Expect development of meadow and wooded habitat with organic soil layer decreasing bioavailability of arsenic and antimony to plants and animals. Expect bioavailability of metals to be low because of neutral to alkaline soil pH conditions.	**Risk Unlikely:** As habitat improves, wildlife use will increase, but metals are expected to have lower bioavailability because of binding in organic soil layer and the neutral to alkaline pH.
Meadow Creek Mine Hillside (Soil sample MCM 1 - 10)									
	Steep hillside meadow with douglas fir.	Granite colluvial	119	Poor to fair: erosion, steepness, heavy big game traffic, disturbed area (cuts and fills) at Meadow Cr. Mine. Little to no difference in habitat condition among mineralized and non-mineralized areas.	6.2 - 7.3	**Risk Unlikely:** Slope, game traffic, and soil types are naturally occurring. Area is low to sparsely vegetated due primarily to slope, aspect, and high trampling from game traffic. Plant HQs range from 1.4 (mercury) to 146 (arsenic). Arsenic and manganese have soil microorganism HQs >1 (15 and 16) and arsenic and mercury have soil invertebrate HQs >1 (24 and 4.2). **Erosion potential:** Moderate; does not affect aquatic system, limited to base of slope.	**Risk Unlikely**: Due to neutral pH, metal bioavailability, uptake and toxicity is expected to be limited as demonstrated by the presence of plant communities in mineralized areas and the lack of difference in plant communities between the mineralized and non-mineralized areas of this exposure location. All LOAEL HQs for wildlife receptors are >1 for arsenic. Antimony LOAEL HQs are 34 and 23 for the avian and mammalian invertivores, respectively. Mammal invertivore LOAEL HQs are 4.1 (manganese) and 6.4 (mercury). The arsenic LOAEL HQs (all wildlife) are considered unlikely because modeled toxicity would affect prey items first, and the mercury benchmark is inappropriate (benchmark < western soils).	**Risk Unlikely:** Risk unchanged from current assessment.	**Risk Unlikely**: Risk unchanged from current assessment.

Table 8-13
Terrestrial Exposure Locations: Habitat and Risk Overview

Exposure Location*	Habitat Types	Soil Types	Approx. Size (acres)	Current Habitat Condition	Soil pH	Current Ecological Risk: Risk to Habitat or Plant Community	Current Ecological Risk: Risk to Wildlife Populations	Future Ecological Risk: Risk to Habitat and Plant Community	Future Ecological Risk: Risk to Wildlife Populations
Lower Meadow Creek Valley and area below EFSFSR confluence (Soil samples MCV 1-19; Water samples: 7 locations; Sediment samples: 2; Fish samples: 6)									
	Mixture of habitats and habitat quality (see details below)	Mixture of soil types (see details below)	39.9	Poor to good. Some areas have been reseeded (see details below)	3.9 - 8.8	**Risk Unlikely or Possible:** Habitat quality differs from poor to good. Plant HQs are >1 for antimony (265), arsenic (96), mercury (2.4) and silver (1.3). Soil microorganism HQs are all <1 except for arsenic (9.6). Soil invertebrates HQs are all <1 except for arsenic (16) and mercury (7.2). Expected effects to the plant and soil community are dependent on the quality of the soil. **See discussions below** for how soil quality is expected to be affect conclusions about HQs for each major habitat.	**Risk Unlikely or Possible:** Wildlife drinking water NOAEL and LOAEL HQs are all <0.1 indicating no risk to terrestrial wildlife. Avian piscivore LOAEL HQs are all <1 indicating no unacceptable risk to bird populations feeding on fish in the valley. Mammalian piscivore LOAEL HQs are <1 for all metals except arsenic (1.1) and selenium (1.7) suggesting a possible risk to terrestrial mammals feeding on fish. Antimony and arsenic LOAEL HQs for all wildlife receptors are >1. However, estimated risk is less than calculated because food web exposure is reduced. Except for antimony and arsenic, LOAEL HQs for the small avian invertivore and small and large mammal herbivores are <1. The LOAEL HQ for the small mammal invertivore is 11(mercury) and 2.9 (selenium). The LOAEL HQ for the medium mammal carnivore is 78 (mercury). The model used to evaluate risk to the carnivore from mercury is inappropriate (benchmark < western soils). **See discussions below** for how soil quality is expected to affect conclusions about HQs for each major habitat. **For sediment exposure:** LOAEL HQs for the small avian invertivore and small mammal invertivore and >1 for antimony and arsenic. The LOAEL HQ for medium mammal carnivore is 6.3 for arsenic. Mercury and selenium LOAEL HQs for small mammal invertivore and medium mammal carnivore are >1. Each of these sediment LOAEL HQs are considered unlikely because modeled toxicity would affect prey items first.	**Risk Unlikely or Possible:** (see details for each habitat below)	**Risk Unlikely or Possible:** (see details for each habitat below)
	Reclaimed areas below Keyway and north of Meadow Creek (samples MCV 1-7, 11-13).	Waste rock, neutralized ore, and other fill over tailing	26	Graded and seeded with grasses and forbs in 1992, 1993, 1996. Mostly moderate condition except about 1 acre of compacted fill with sparse vegetation.	6.0 - 8.8	**Risk Possible** **Erosion potential:** Low, due to vegetation and flat grade.	**Risk Unlikely or Possible:** Soil has low organic content.	**Risk Unlikely or Possible:** Vegetation cover, biomass, and diversity should increase; soil is expected to develop more favorable characteristics.	**Risk Unlikely:** Similar to current. Expect reduced risk as soil develops.
	Meadow, wet meadow, willow and alder shrub, lodgepole pine (samples MCV 8 - 10). Includes Blowout Creek debris fan.	Valley bottom soils (alluvium from blowout).	9	Good, heavy big game browsing.	6.6	**Risk Unlikely:** Good habitat with high vegetation cover. **Erosion potential:** Low, due to vegetation and flat grade.	**Risk Unlikely:** Habitat appears to have low bioavailability of metals due to neutral pH and existence of normal plant diversity.	**Risk Unlikely:** Risk unchanged from current assessment.	**Risk Unlikely:** Risk unchanged from current assessment.

Table 8-13
Terrestrial Exposure Locations: Habitat and Risk Overview

Exposure Location*	Habitat Types	Soil Types	Approx. Size (acres)	Current Habitat Condition	Soil pH	Risk to Habitat or Plant Community	Risk to Wildlife Populations	Risk to Habitat and Plant Community	Risk to Wildlife Populations
	Habitat Type and Condition					Current Ecological Risk		Future Ecological Risk	
	Sparsely vegetated with exposed tailing on valley floor (samples MCV 14 - 16).	Tailing	1.1	Poor; no soil development.	3.9 - 7.0	**Risk Possible:** However, only a small area (1.1 acres) involved. **Erosion potential:** Erodible material but not currently adjacent to creek.	**Risk Unlikely:** Limited habitat (1.1 acres) and sparse vegetation -- limited exposure of populations. Alternative habitat is available.	**Risk Unlikely to Likely:** Floods and/or streambank erosion could potentially re-route stream channel to erode tailing deposit.	**Risk Unlikely:** Without reclamation the location is expected to remain sparsely vegetated with poor soil development. Therefore, exposure of wildlife populations is expected to be limited. Alternative habitat is available.
	Valley meadow and willow/alder shrubland (MCV 17 - 19). Contains historic Bradley tailing below confluence with EFSFSR.	Tailing, valley bottom soils	3.8	Good; big game browsing. May have been reseeded in past.	7.2 - 7.7	**Risk Unlikely:** Existing high plant cover and diversity indicates metal bioavailability is limited. Neutral pH and high organic matter content is expected to limit metal bioavailability, uptake, and toxicity. **Erosion potential:** Low due to stable stream banks and mostly low relief.	**Risk Unlikely:** Bioavailability, uptake, and toxicity are expected to be low due to neutral pH and high soil organic content.	**Risk Unlikely:** Risk unchanged from current assessment.	**Risk Unlikely:** Risk unchanged from current assessment.
Upgradient Wetland (Soil samples SOD 5, UW 1 - 3; Water samples UW-1, MC-1A)									
	Emergent wetland, fir and spruce (Soil samples UW 2 and 3 and water sample MC-1A)	Valley bottom soil	12	Good; recovering from 1997 flooding in lower portion.	6.7 - 6.8	**Risk Unlikely:** Good habitat (well vegetated); mostly native soils with high organic content and neutral pH. HQs for plants, soil microorganisms, and soil invertebrates are all <1 except for arsenic (plant HQ = 2.4) and mercury (soil invertebrate HQ = 1.1). High organic content and neutral pH is expected to limit bioavailability/toxicity of metals to the soil community. **Erosion potential**: Low.	**Risk Unlikely:** NOAEL and LOAEL HQs for drinking water are all <1. Soil LOAEL HQs for herbivores are <1. Arsenic LOAEL soil HQs are >1 for avian and mammalian invertivores (1.6 and 22) and mammalian carnivore (1.7). But neutral pH and high organic content is expected to limit arsenic bioavailability/toxicity. Mercury soil LOAEL HQ for the mammalian carnivore (12) is inappropriate because benchmark is below U.S. western soil mercury concentrations.	**Risk Unlikely:** Risk unchanged from current assessment; high potential for recovery from previous flooding, based on current observations.	**Risk Unlikely**: Risk unchanged from current assessment.

Table 8-13
Terrestrial Exposure Locations: Habitat and Risk Overview

	Habitat Type and Condition					Current Ecological Risk		Future Ecological Risk	
Exposure Location*	Habitat Types	Soil Types	Approx. Size (acres)	Current Habitat Condition	Soil pH	Risk to Habitat or Plant Community	Risk to Wildlife Populations	Risk to Habitat and Plant Community	Risk to Wildlife Populations
Upgradient Wetland Hot Spot (Soil samples SOD 5, UW 1 - 3; Water samples UW-1, MC-1A)									
	Exposed tailing (soil sample UW-1 and water sample UW-1)	Tailing	<0.005	Barren	6.7	**Risk Unlikely**: Very small area related to hot spot. Effects to plants and soil invertebrates are expected to be localized to small area. HQs for plants are 1.1 (selenium and silver) to 138 (antimony). HQs for soil microorganisms are <1 except for arsenic (9.8) and copper (2.9). Soil invertebrate HQs are <1 (selenium) to 23 (mercury). **Erosion potential:** Material is erodible but unlikely to reach main stream due to low topography gradient.	**Risk Unlikely**: Very small area makes potential risk to populations unlikely; also there is no habitat and therefore to exposure. All wildlife receptor drinking water NOAELs and LOAELs are <1. All wildlife receptors have LOAEL HQs >1 for most metals except silver, but effects on plants and prey limit food web exposure for wildlife.	**Risk Unlikely:** Risk unchanged from current assessment.	**Risk Unlikely**: Even if vegetated, the extremely small size of area makes any potential risk to populations unlikely.
Keyway Wetland (Soil sample KW 1 - 3; Water sample KW-1)									
	Emergent wetland.	Valley bottom soil	2.9	Good. Big game browsing. Buried tailing present at KW-2.	7	**Risk Unlikely**: Good habitat; abundant and similar vegetation in areas with and without buried tailing. Plant HQs for antimony (67), arsenic (63), mercury (3.0) and silver (1.4) are >1. HQs for soil microorganisms are <1 for all metals except arsenic (6.3). Soil invertebrate HQs are <1 for all metals except arsenic (11) and mercury (8.9). High organic content of soil and neutral pH is expected to limit bioavailability/toxicity. **Erosion potential:** Low.	**Risk Unlikely**: Drinking water LOAEL HQs for all wildlife are <1; therefore no unacceptable risk from surface water. Abundant vegetation and a soil profile high in organic matter content demonstrates that soil is not toxic to plants and soil community therefore not likely to be toxic to wildlife. Wildlife LOAEL HQs are >1 for antimony and arsenic, but presence of organic matter and neutral pH is expected to limit bioavailability, uptake, and toxicity of these metals. The selenium LOAEL HQ for the small mammal invertivore (3.1) likely overestimates risk to populations as the benchmark translates to a concentration below site-specific nonmineralized (background) concentrations. Mercury LOAEL HQs for the small mammal herbivore (1.2), and mammal invertivore (14) and carnivore (97) are greater than 1. The carnivore HQs for antimony, arsenic, and mercury are considered unrealistic because effects on prey organisms limit food web exposure for the carnivore.	**Risk Unlikely**: Risk unchanged from current assessment.	**Risk Unlikely**: Risk unchanged from current assessment.

Table 8-13
Terrestrial Exposure Locations: Habitat and Risk Overview

Exposure Location*	Habitat Types	Soil Types	Approx. Size (acres)	Current Habitat Condition	Soil pH	Current Ecological Risk: Risk to Habitat or Plant Community	Current Ecological Risk: Risk to Wildlife Populations	Future Ecological Risk: Risk to Habitat and Plant Community	Future Ecological Risk: Risk to Wildlife Populations
Meadow Creek Forested Wetland (Soil samples MCW 1 - 3)									
	Meadow, wet meadow, forest (vegetated tailing mostly south of Meadow Creek)	Tailing, organic layers	10	Good. Surface tailing deposits with 2- to 3-inch organic layer on top. Heavy game browsing.	4.2 - 6.4	**Risk Unlikely or Possible:** Most of the area is well vegetated. Limited areas have sparse vegetation and potentially signs of chemical stress and/or fluctuating water levels. Upland terrestrial plants were observed directly adjacent to plants more adapted to saturated soil conditions.	**Risk Unlikely or Possible:** Area with low pH, exhibits very high use by wildlife. Vegetated areas have a good organic layer, reducing metals mobility and exposure potential. LOAEL HQs for wildlife populations >1 for antimony, arsenic, cyanide, mercury, and selenium. However, risk from arsenic, antimony, and mercury less likely than calculated because food web exposure is reduced.	**Risk Unlikely or Possible:** Risk unchanged from current assessment.	**Risk Unlikely or Possible:** Risk unchanged from current assessment.
Southeast Bradley Waste Rock Dump (Soil samples SE 1 - 4; Surface water: 3 locations; Sediment samples: 2; Fish samples: 6)									
	Barren, sparse upland vegetation (see Plate 14 in Draft Site Characterization Report (SCR) [Stibnite Group, 2000])	Waste rock	3	Poor. No soil development, steep slopes, soils are eroded and eroding.	4.2-7.0	**Risk Possible:** Acidic to neutral pH along with poor soil characteristics (limited organics) contribute to sparse vegetation. Expect arsenic and other metals to be bioavailable.	**Risk Unlikely or Possible:** Very small area lacks vegetation to attract wildlife. Risk to wildlife from arsenic and mercury is unlikely because plants, invertebrates, and small prey are affected first. LOAEL HQs for all plant, invertebrate, and wildlife communities/populations exposed to arsenic are >1. However, risk to wildlife is considered unlikely because the plants and soil invertebrates are affected first, reducing exposure. LOAEL HQ for the carnivore exposed to mercury (273) also is unlikely since the prey are affected first.	**Risk Possible:** Risk unchanged from current assessment.	**Risk Unlikely or Possible:** If vegetation becomes present at low pH, metals would be expected to be bioavailable to vegetation and then wildlife.
Northwest Bradley Waste Rock Dump and Glory Hole/EFSFSR (Soil samples BD 1 - 5, 7 - 10, NW 1 - 14; Surface water: 12 locations; Sediment samples: 6; Fish samples: 6)									
	Barren to sparse upland vegetation, see Plate 14 in SCR	Waste rock	29 total with 8 revegetated	Poor. No soil development, steep slopes, erosion.	4.1-6.7	**Risk Possible:** Acidic to neutral pH along with poor soil characteristics. Expect arsenic and other metals to be bioavailable. Antimony, arsenic, and mercury all have LOAEL HQs >1 for plants and invertebrates.	**Risk Unlikely or Possible:** Lacks native vegetation to attract wildlife. However, revegetation may attract some herbivores. LOAEL HQs for small/medium wildlife exposed to antimony, arsenic, mercury, all are >1, but are considered unlikely since vegetation and invertebrates are affected first. LOAEL HQ for large herbivore exposed to arsenic also >1, but risk unlikely because plant community affected first. Mercury LOAEL HQ for the mammalian carnivore population is inappropriate because the benchmark is below western soil concentrations.	**Risk Possible or Likely:** Risk unchanged from current assessment.	**Risk Unlikely or Possible:** If vegetation becomes present in low pH areas, metals would be expected to be bioavailable to vegetation and then wildlife.

Table 8-13
Terrestrial Exposure Locations: Habitat and Risk Overview

Exposure Location*	Habitat Types	Soil Types	Approx. Size (acres)	Current Habitat Condition	Soil pH	Risk to Habitat or Plant Community	Risk to Wildlife Populations	Risk to Habitat and Plant Community	Risk to Wildlife Populations
	Habitat Type and Condition					Current Ecological Risk		Future Ecological Risk	
Northeast Bradley Waste Rock Dump and Sugar Creek (Soil samples NE 1 - 8, BT 1 - 2; Surface water and sediment: 2 locations in Sugar Creek)									
	Barren, sparse upland vegetation, see Plate 14 in SCR	Waste rock	6 with approx. 0.5 of this revegetated	Poor. No soil development, steep slopes, erosion.	3.5-8.0	**Risk Possible:** Acidic to neutral pH along with poor soil characteristics contribute to sparse vegetation. Expect arsenic and other metals to be bioavailable.	**Risk Unlikely or Possible:** Lacks vegetation to attract wildlife. LOAEL HQs for small wildlife exposed to arsenic is unlikely because vegetation and invertebrates are affected first. LOAEL HQ for the carnivore exposed to mercury (166) also is unlikely because the benchmark is below western soil concentrations.	**Risk Possible:** Risk unchanged from current assessment.	**Risk Unlikely or Possible:** If vegetation becomes present in low pH areas, metals would be expected to be bioavailable to vegetation and then wildlife.
SMALL AREAS OF CONCERN									
Smelter Stack Soil (Soil samples SMST 1-3, 5)									
	Sparse to normal upland successional vegetation	Granite colluvial, forested	0.3	Fair. Presence of cuts and fills, ash, wood, and debris.	3.5-5.8	**Risk Unlikely:** Acidic pH contributes to bioavailability of metals. However, very small area limits effects to plant and invertebrate communities. **Erosion Potential:** Moderate.	**Risk Unlikely:** Very small area limits exposure and risk to populations. LOAEL HQs for wildlife exposed to antimony, arsenic, mercury, and selenium all are >1. But risks are unlikely because plants and prey are affected first. Mercury risk for mammal carnivore population is unlikely because benchmark is below western soil concentrations.	**Risk Unlikely:** Risk unchanged from current assessment.	**Risk Unlikely:** Risk unchanged from current assessment.
DMEA Dump (Soil samples DMEA 1 - 3)									
	Barren to sparse upland vegetation	Waste rock	0.7	Poor. Poor soil development, steep, erosion.	3.1 - 7.4	**Risk Unlikely:** Acidic to neutral pH along with poor soil characteristics. Expect arsenic and other metals to be bioavailable in the rock dump. Very small area contributes to unlikely risk to plant community. **Erosion potential:** Moderate to high.	**Risk Unlikely:** Limited aerial extent and sparse vegetation limit exposure of wildlife populations. HQs for wildlife exposed to arsenic and mercury are all >1. But risk is unlikely because plants and prey are affected first. Mercury risk for mammal carnivore population is unlikely because benchmark is below western soil concentrations.	**Risk Unlikely:** Risk unchanged from current assessment.	**Risk Unlikely:** Risk unchanged from current assessment.
UW-1 (see Upgradient Wetland)									

Table 8-13
Terrestrial Exposure Locations: Habitat and Risk Overview

Exposure Location*	Habitat Types	Soil Types	Approx. Size (acres)	Current Habitat Condition	Soil pH	Current Ecological Risk: Risk to Habitat or Plant Community	Current Ecological Risk: Risk to Wildlife Populations	Future Ecological Risk: Risk to Habitat and Plant Community	Future Ecological Risk: Risk to Wildlife Populations
BD-6 (antimony outlier in Northwest Bradley Waste Rock Dump).									
	Barren	Waste rock	<0.5	Poor. Poor soil development.	4.03	**Risk Unlikely or Possible:** Very small exposure area. Low pH and lack of organic material allow metals to be bioavailable to plants and invertebrates. Poor soil limits plant community development.	**Risk Unlikely:** Lack of organic material and low pH allow metals to be bioavailable to plants and then to animals. LOAEL HQs for most metals (antimony, arsenic, mercury, and selenium) and wildlife receptors (small and medium invertivores, herbivores, and carnivores) >1. But most HQs are unlikely since the plant and animal food base is affected first. LOAEL HQ for the carnivore exposed to mercury (1482) is inappropriate because the benchmark is below western soil concentrations. Therefore, wildlife population effects unlikely.	**Risk Possible:** Risk unchanged from current assessment.	**Risk Unlikely**: Risk unchanged from current assessment.
BTO									
	NA	NA	NA	NA	NA	NA	**Risk Unlikely:** Drinking water LOAEL HQs for all wildlife receptors are <1 (except for small mammal invertivore and arsenic [HQ = 1.5]) indicating unlikely risk to wildlife populations drinking from the BTO. Also, low flows limit wildlife exposure.		**Risk Unlikely:** Risk unchanged from current assessment.
Potentially Impacted Seeps at Areas 1 and 3									
	NA	NA	NA	NA	NA	NA	**Risk Unlikely:** Drinking water benchmarks for all wildlife receptors are higher than measured concentrations, indicating risk is unlikely for wildlife populations drinking from the seeps at Areas 1 and 3.		**Risk Unlikely:** Risk unchanged from current assessment.
EFSFSR and Midnight Creek (Water samples: 3; Sediment samples: 2; Fish samples: 6)									
	NA	NA	NA	NA	NA	NA	**Risks Unlikely to Possible:** Wildlife drinking water NOAEL and LOAEL HQs are all <0.2 indicating no risk to terrestrial wildlife. Avian piscivore LOAEL HQs are all <1 indicating no risk to birds feeding on fish in the EFSFSR and Midnight Creek. Mammalian piscivore LOAEL HQs are <1 for all metals except arsenic (1.1) and selenium (1.7) suggesting possible risk for terrestrial mammals feeding on fish in the EFSFSR and Midnight Creek. Antimony LOAEL HQs are >1 for small avian invertivore and small mammal invertivore. Arsenic LOAEL HQs are >1 for small avian invertivore, small mammal invertivore, and medium mammal carnivore. Risk from antimony and arsenic to receptors is unlikely because plant, soil invertebrate, and small bird/mammal communities are expected to be affected first.		**Risk Unlikely:** Risk unchanged from current assessment.

Table 8-13
Terrestrial Exposure Locations: Habitat and Risk Overview

	Habitat Type and Condition					Current Ecological Risk		Future Ecological Risk	
Exposure Location*	Habitat Types	Soil Types	Approx. Size (acres)	Current Habitat Condition	Soil pH	Risk to Habitat or Plant Community	Risk to Wildlife Populations	Risk to Habitat and Plant Community	Risk to Wildlife Populations
EFSFSR and Midnight Creek (continued)							LOAEL HQs for small mammal invertivore and medium mammal carnivore are >1 for mercury; however, risk from mercury to medium mammal carnivores is unlikely because modeled toxicity would affect prey items first. Selenium LOAEL HQs are >1 for small avian invertivore, small mammal invertivore, and medium mammal carnivore.		
Glory Hole and EFSFSR (Water samples: 12; Sediment samples: 6; Fish samples: 6)									
	NA	NA	NA	NA	NA	NA	**Risks Unlikely to Possible:** Wildlife drinking water NOAEL and LOAEL HQs are all ≤0.5 indicating no unacceptable risk to terrestrial wildlife. Avian piscivore LOAEL HQs are all <1 indicating no unacceptable risk to birds feeding on fish in the Glory Hole and EFSFSR. Mammalian piscivore LOAEL HQs are <1 for all metals except arsenic (1.1) and selenium (1.7) indicating a possibility of risk for terrestrial mammals feeding on fish in the Glory Hole and EFSFSR. All arsenic LOAEL HQs are >1. Cadmium LOAEL HQs are >1 for small avian invertivore and small mammal invertivore. However, risk from arsenic and cadmium to these animals is unlikely because modeled toxicity would affect prey items first. Antimony LOAEL HQs for sediment are >1 for small avian invertivore, small mammal herbivore, small mammal invertivore, and medium mammal carnivore. But risk is considered unlikely for invertivores and carnivores because prey populations are expected to be affected first. Wildlife LOAEL HQs for mercury are >1; however, small bird/plant communities are expected to be affected first and therefore herbivore, invertivore, and carnivore population HQs are considered unlikely. Selenium LOAEL HQs are >1 for invertivore and carnivore populations.		**Risk Unlikely:** Risk unchanged from current assessment.

Table 8-13
Terrestrial Exposure Locations: Habitat and Risk Overview

Exposure Location*	Habitat Types	Soil Types	Approx. Size (acres)	Current Habitat Condition	Soil pH	Risk to Habitat or Plant Community	Risk to Wildlife Populations	Risk to Habitat and Plant Community	Risk to Wildlife Populations
	Habitat Type and Condition					Current Ecological Risk		Future Ecological Risk	
Sugar Creek (Water samples: 2; Sediment samples: 2)									
	NA	NA	NA	NA	NA	NA	**Risks Unlikely to Possible:** Wildlife drinking water NOAEL and LOAEL HQs are all ≤0.1 indicating unlikely risk to terrestrial wildlife. Wildlife LOAEL HQs >1 for mercury in sediment. But mercury in Sugar Creek is from upstream offsite sources. Arsenic LOAEL HQs are >1 for invertivores and medium mammal carnivore. These arsenic LOAEL HQs are considered overestimates because modeled concentrations would affect prey items first. Antimony LOAEL HQ for small avian invertivore is only slightly >1 (1.3). Wildlife LOAEL HQs for selenium are >1 for invertivores and medium mammal carnivore.		**Risk Unlikely:** Risk unchanged from current assessment.

* For exposure location descriptions see Table 5-3, Section 5.3, and Plate 1.

Table 8-14

Compilation of Current Terrestrial Ecological Risk Evaluations for Exposure Locations[1]

Risk Classification	Exposure Location	Risk to Habitat or Plant Community	Risk to Wildlife Populations
Unlikely Risk			
	BT/NO Disposal Area		X
	Meadow Creek Hillside	X	X
	Upgradient Wetland	X	X
	Upgradient Wetland Hot Spot	X	X
	Keyway Wetland	X	X
	Smelter Stack	X	X
	DMEA Dump	X	X
	BD-6 (antimony outlier in NW Bradley Dump)		X
Unlikely or Possible Risk			
	Lower Meadow Creek Valley[2]	X	X
	Meadow Creek Forested Wetland	X	X
	Southeast Bradley Waste Rock Dump		X
	Northwest Bradley Waste Rock Dump		X
	Northeast Bradley Waste Rock Dump		X
	BD-6 (antimony outlier in NW Bradley Dump)	X	
	EFSFSR and Midnight Creek		X
	EFSFSR and Glory Hole		X
	Sugar Creek		X
	Seeps in Areas 1 and 3		X
Possible Risk			
	BT/NO Disposal Area	X	
	Southeast Bradley Waste Rock Dump	X	
	Northwest Bradley Waste Rock Dump	X	
	Northeast Bradley Waste Rock Dump	X	

[1]See Table 8-12 for areal extent of exposure locations and descriptions of habitats, plant communities, and wildlife populations

[2]Includes four sub-locations

BT/NO = Bailey tailing and neutralized ore

Table 8-15

Sources of Uncertainty

Potential Source	Direction of Effect on Potential Risk	Discussion
Uncertainties Associated with Problem Formulation		
Use of limited media sampling for screening process	Unknown	The use of limited site information to characterize the site may not accurately describe media conditions.
Food web assumed to occur at site	Unknown	Validity of the food web used in the models at the sites is unknown.
Over-simplification of dietary composition in the food web models	Unknown	Assumptions are made regarding primary prey items for the receptor. In reality, other prey items may be consumed on a regular or seasonal basis.
Development of Conceptual Site Model	Unknown	Large potential source for uncertainty due to limited or incorrect knowledge about exposure pathways, ecological receptors, and spatial and temporal limits.
Uncertain occurrence of receptors at sites	Unknown	The actual occurrence at the site by receptor groups considered in the food chain models is uncertain.
Overall Effect	***Unknown***	
Uncertainties Associated with Exposure Assessment		
Food chain model exposure parameter assumptions	Unknown	Exposure parameters are from the literature. Efforts are made to select exposure parameters representative of different foraging types, so that exposure estimates would be representative of more than a single species.
Assumption that receptor species will spend equal time at all habitats within home range	Unknown	Organisms will spend varying amounts of time in different habitats, thus affecting their exposure at each habitat type.
Extrapolation from test species to representative wildlife species	Unknown	Species differ with respect to absorption, metabolism, distribution, and excretion of chemicals. The magnitude and direction of the different will vary with each chemical.

Table 8-15

Sources of Uncertainty

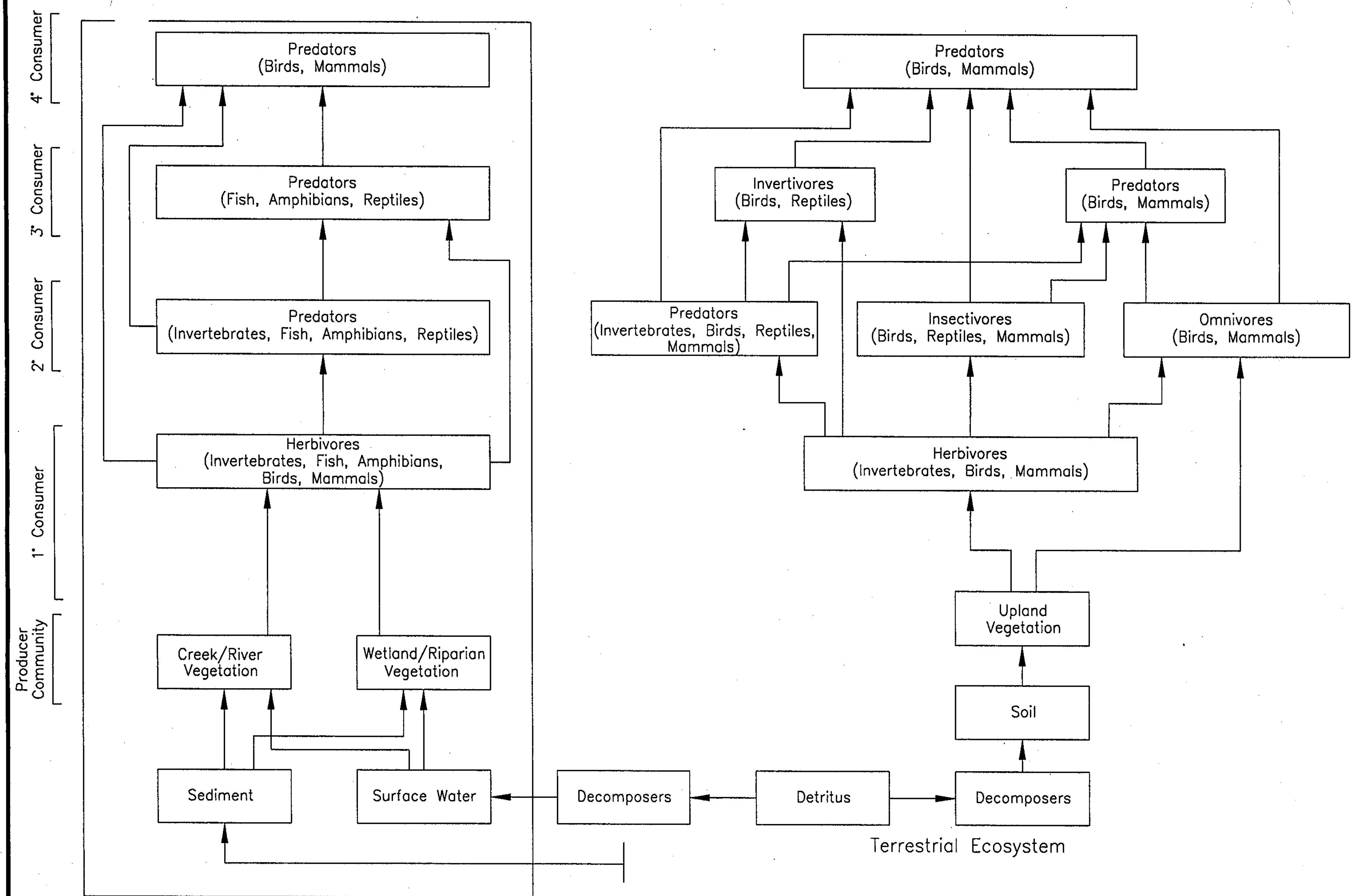
Potential Source	Direction of Effect on Potential Risk	Discussion
Consumption of contaminated prey	Unknown or Overestimate	Toxicity to prey receptors may result in sickness or mortality. Fewer prey items would be available for predators. Predators may stop foraging in areas with reduced densities of food/prey populations, or discriminate against sick prey. Food web may shift as a result of adverse effects on prey.
Exposure point concentration	Overestimate	It is unlikely any receptor would be exposed concurrently to maximum or 95th UCL concentrations of all chemicals in each area or in all media.
Uptake factor for prey items	Overestimate	An uptake factor is typically derived using literature-derived assumptions or regressions. It does not consider that only a finite mass of each chemical is available on-site.
Exposure duration	Overestimate	The assumption is that exposure conditions for prey items and receptors are in equilibrium.
Incidental soil ingestion	Unknown	HQs incorporate the incidental soil ingestion pathway; organisms in the wild may ingest more or less soil than considered in the exposure estimates.
Safety factors	Overestimate	Assumptions regarding the use of multiple uncertainty factors are based on precedent, rather than scientific data.
Bioavailability equal to one (1)	Overestimate	Assumption that all of the measured chemical is available for uptake overestimates exposure.
Receptor area use factors equal to one (1)	Overestimate	For the larger receptors (snip, mink, red fox, white-tailed deer), the ranges are greater than many of the exposure areas.
Use of NOAELs	Overestimate	Use of NOAELs likely overestimates effects to populations or communities since this measurement endpoint does not reflect any observed impacts. LOAELs which may be an order of magnitude above literature-based NOAELs are more appropriate benchmarks for estimating risk to higher components of the terrestrial ecosystem.

Table 8-15

Sources of Uncertainty

Potential Source	Direction of Effect on Potential Risk	Discussion
Overall Effect	*Overestimate*	
Uncertainties Associated with Risk Characterization		
Use of measurement endpoints	Overestimate	Use of ecotoxicological literature for measurement endpoints may overestimate risk to assessment endpoints.
Use of toxicity reference values that are lower than typical widespread concentrations	Overestimate/Unrealistic	Cumulative impact of conservative model assumptions and/or use of bioavailable forms used in toxicity tests may result in toxicity reference values for media lower than what actually occurs in uncontaminated media. HQs and HIs derived using these values are poor measures of risk.
Risk evaluated for individual receptors	Overestimate	Effects on individual organisms may occur with little population or community level effects. However, as the number of affected individuals increases, the likelihood of population-level effects increases.
Lack of predictive capability and ecological relevance	Unknown	The HQ/HI approach provides a conservative estimate of risk based on a "snapshot" of site conditions; the HQ approach has no predictive capability.
Lack of boundaries on tissue concentrations in prey items	Overestimate	The assumption that chemicals can accumulate in tissue to any mass may overestimate risk.
Effect of decreased prey item populations on predatory receptors	Unknown	Adverse population effects to prey items may reduce the foraging population for predatory receptors, but may not necessarily adversely impact the population of predatory species.
Multiple conservative assumptions	Overestimate	Cumulative impact of multiple conservative assumptions yields high risk to ecological receptors.
Summation of effects	Unknown	The assumption that effects are additive (i.e., $\Sigma HQ = HI$) ignores potential synergistic or antagonistic effects. It assumes similarity in mechanism of action, which is not the case for many chemicals. Various metals may induce toxic effects in different organs or systems.
Overall Effect	*Overestimate*	

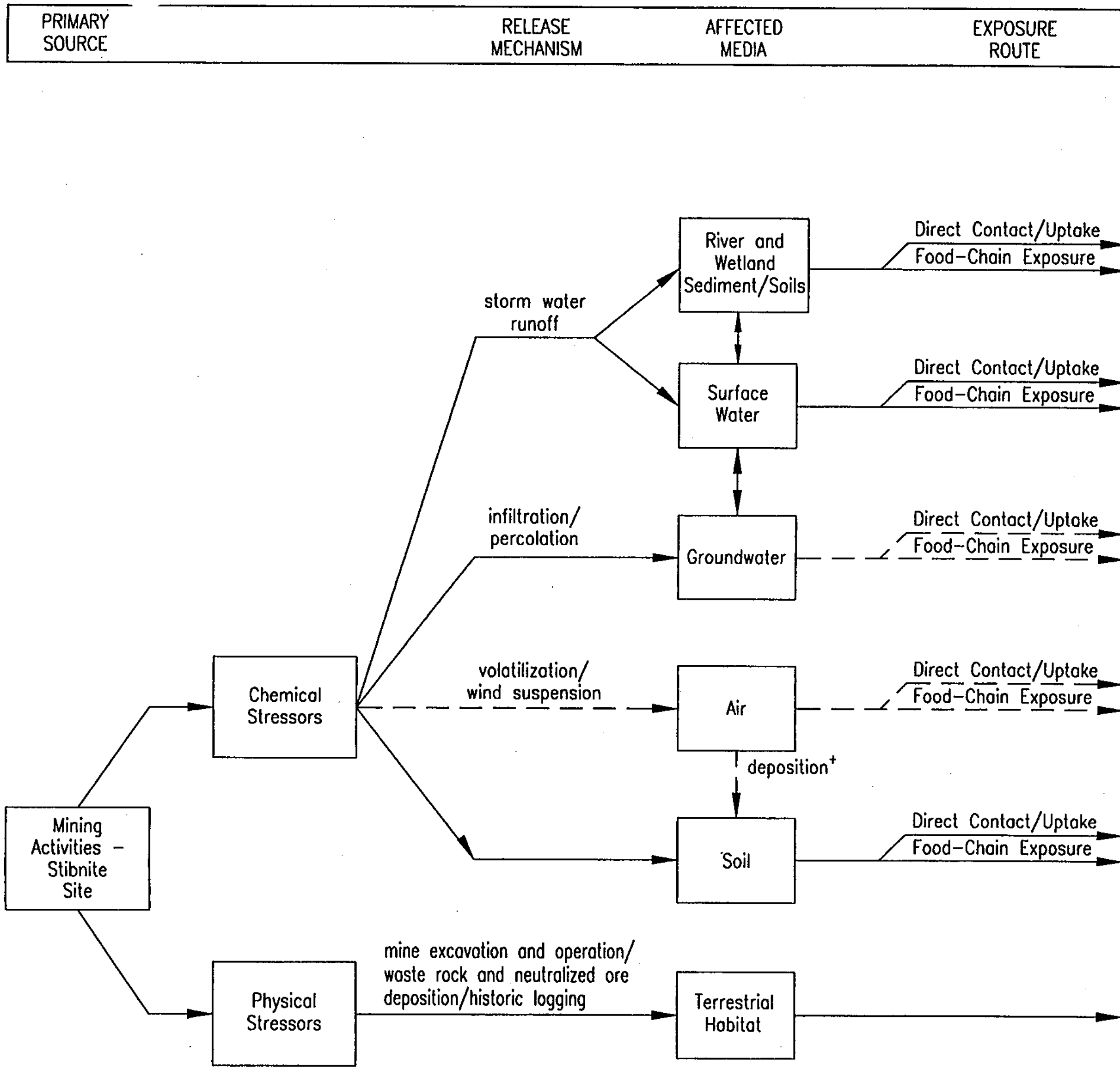
URS Greiner Woodward-Clyde



* Meant only to illustrate major food web pathways

Job No. : 6800024343	FIGURE 8-1 GENERALIZED SITE-WIDE FOOD WEB* STIBNITE SITE
Prepared by : L.H.P.	
Date : 7/21/00	

24343082



TERRESTRIAL ECOLOGICAL RECEPTORS

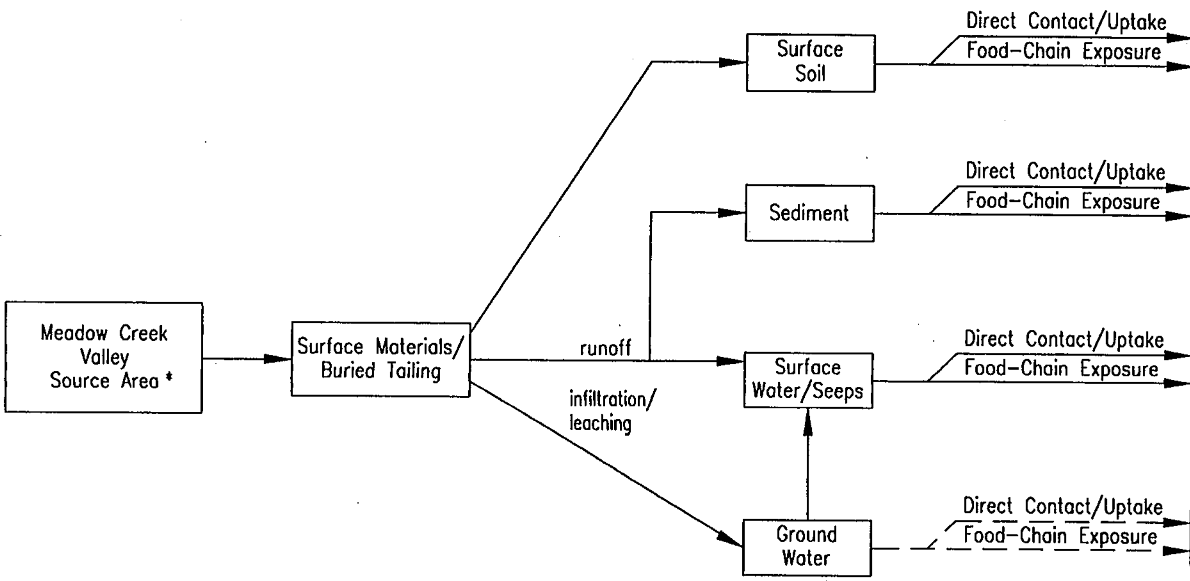
Affected Media / Exposure Route	Terrestrial Ecosystem: Producers: Upland Vegetation	Terrestrial Ecosystem: Producers: Riparian/ Wetland Vegetation	Terrestrial Ecosystem: Detritivores: Soil Organisms	Terrestrial Ecosystem: Consumers: Herbivores	Terrestrial Ecosystem: Consumers: Insectivores	Terrestrial Ecosystem: Consumers: Carnivores	Aquatic Ecosystem: Consumer: Aquatic Birds & Mammals (Piscivores)
River and Wetland Sediment/Soils – Direct Contact/Uptake	–	●	–	●	●	●	●
River and Wetland Sediment/Soils – Food-Chain Exposure	–	–	–	●	●	●	●
Surface Water – Direct Contact/Uptake	–	○	–	●	●	●	●
Surface Water – Food-Chain Exposure	–	–	–	–	–	–	●
Groundwater – Direct Contact/Uptake	○	○	–	–	–	–	–
Groundwater – Food-Chain Exposure	–	–	–	○	○	○	–
Air – Direct Contact/Uptake	○	○	–	○	○	○	○
Air – Food-Chain Exposure	–	–	○	○	○	○	–
Soil – Direct Contact/Uptake	●	–	●	●	●	●	○
Soil – Food-Chain Exposure	–	–	●	●	●	●	○
Terrestrial Habitat	○	○	○	○	○	○	○

LEGEND

- ——► Potentially Complete Exposure Pathway
- – –► Potentially Complete but Insignificant Exposure Pathway
- ● Potentially Complete Exposure Pathway
- ○ Potentially Complete but Insignificant Exposure Pathway
- – Not Applicable

Job No. :	6800024343
Prepared by :	D.M.R.
Date :	7/21/00

FIGURE 8–2
CONCEPTUAL SITE MODEL (TERRESTRIAL)
STIBNITE SITE



Exposure Media	Exposure Route	Terrestrial Ecosystem – Producers – Upland Vegetation	Terrestrial Ecosystem – Producers – Riparian/Wetland Vegetation	Terrestrial Ecosystem – Detritivores – Soil Organisms	Terrestrial Ecosystem – Consumers – Herbivores	Terrestrial Ecosystem – Consumers – Insectivores	Terrestrial Ecosystem – Consumers – Carnivores	Aquatic Ecosystem – Consumer – Aquatic Birds & Mammals (Piscivores)
Surface Soil	Direct Contact/Uptake	●	–	●	●	●	●	○
Surface Soil	Food-Chain Exposure	–	–	●	●	●	●	○
Sediment	Direct Contact/Uptake	–	●	–	●	●	●	●
Sediment	Food-Chain Exposure	–	–	–	●	●	●	●
Surface Water/Seeps	Direct Contact/Uptake	–	○	–	●	●	●	●
Surface Water/Seeps	Food-Chain Exposure	–	–	–	–	–	–	●
Ground Water	Direct Contact/Uptake	○	○	–	–	–	–	–
Ground Water	Food-Chain Exposure	–	–	–	○	○	○	–

TERRESTRIAL ECOLOGICAL RECEPTORS

* BT/NO Disposal Area
* Meadow Creek Mine Hillside
* Lower Meadow Creek Valley
* Upgradient Wetland (Excluding UW-1)
* Meadow Creek Forested Wetland
* Keyway Wetland

LEGEND

—→ Potentially Complete Exposure Pathway

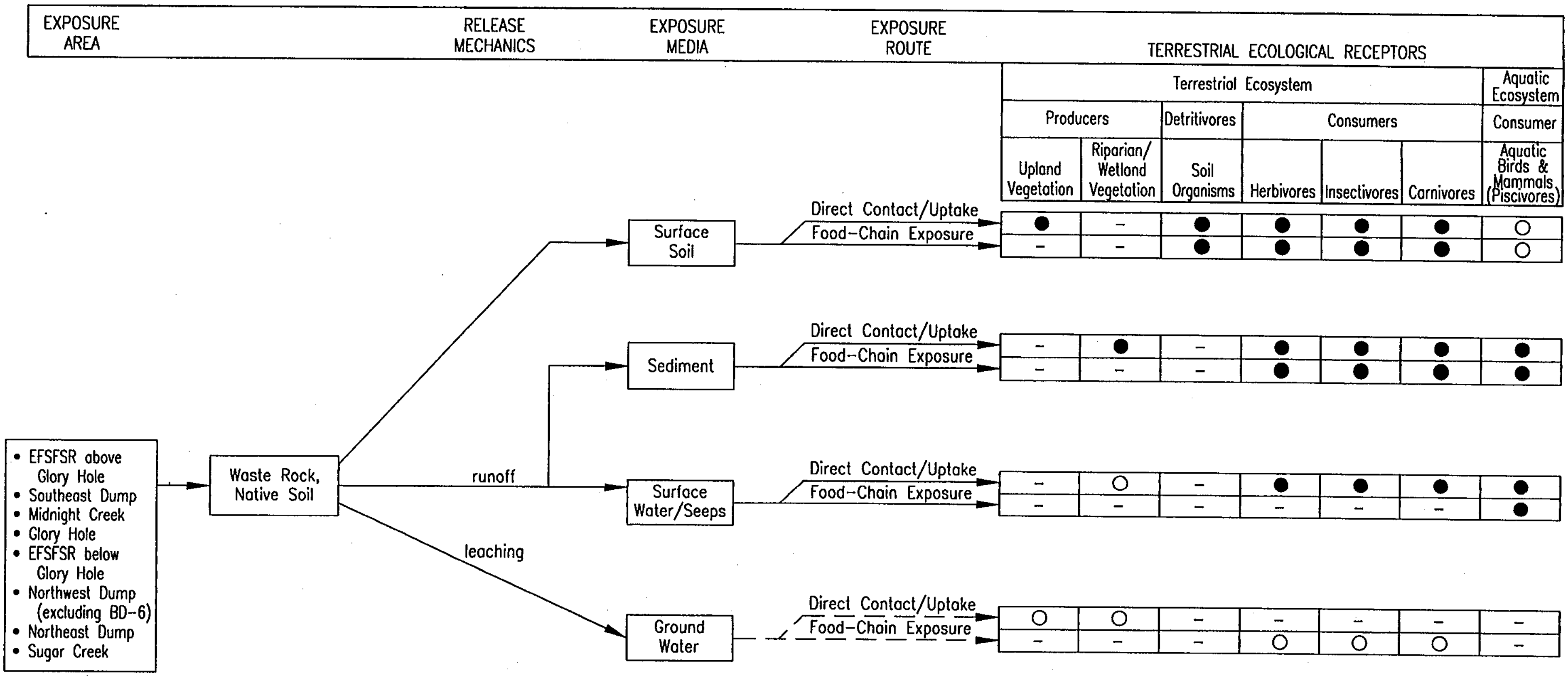
– –→ Potentially Complete but Insignificant Exposure Pathway

● Potentially Complete Exposure Pathway

○ Potentially Complete but Insignificant Exposure Pathway

– Not Applicable

Job No. : 6800024343	FIGURE 8-3 CONCEPTUAL SITE MODEL FOR MEADOW CREEK VALLEY STIBNITE SITE
Prepared by : D.M.R.	
Date : 7/21/00	

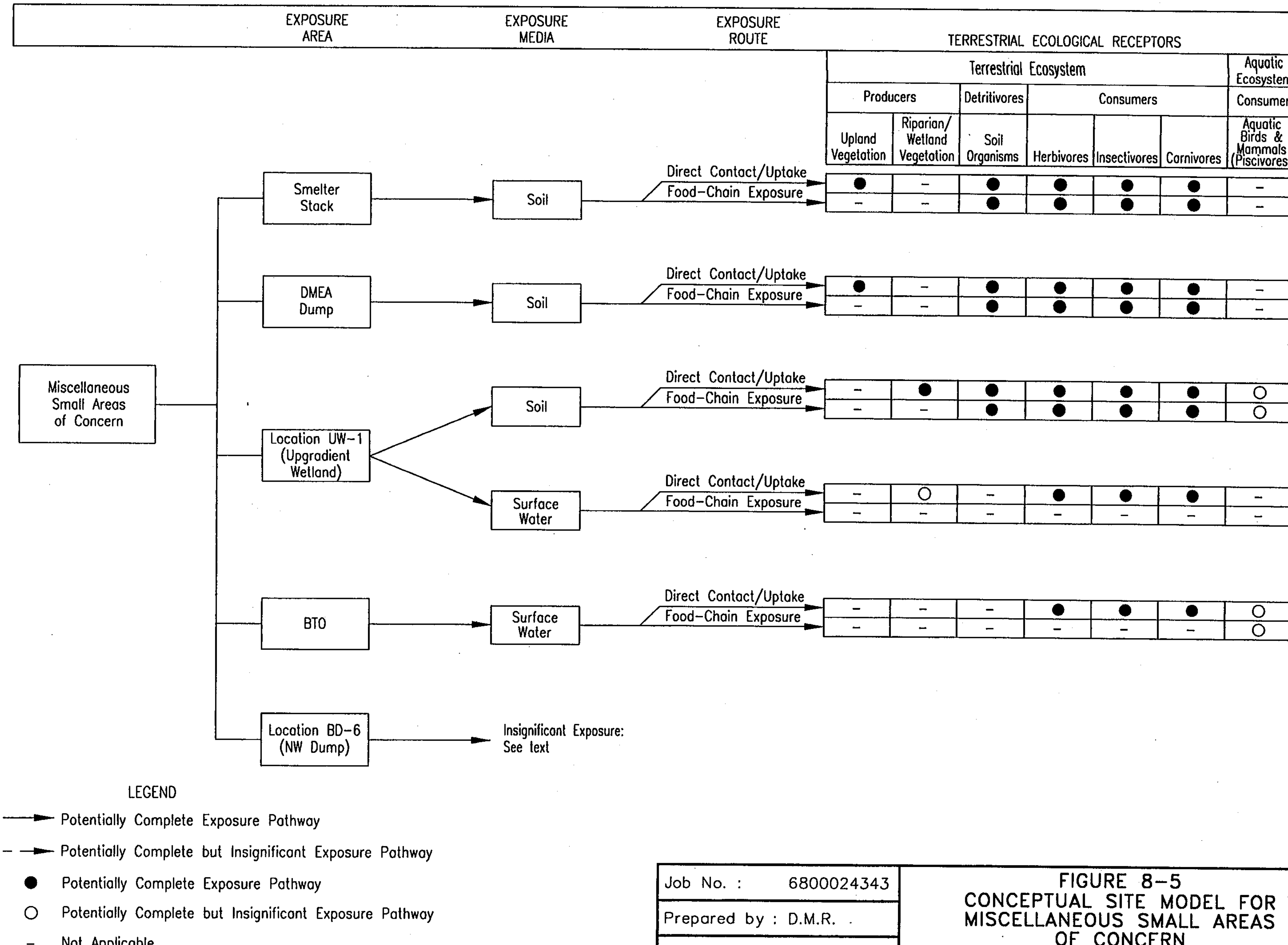


Exposure Media	Exposure Route	Terrestrial Ecosystem: Producers – Upland Vegetation	Terrestrial Ecosystem: Producers – Riparian/Wetland Vegetation	Terrestrial Ecosystem: Detritivores – Soil Organisms	Terrestrial Ecosystem: Consumers – Herbivores	Terrestrial Ecosystem: Consumers – Insectivores	Terrestrial Ecosystem: Consumers – Carnivores	Aquatic Ecosystem: Consumer – Aquatic Birds & Mammals (Piscivores)
Surface Soil	Direct Contact/Uptake	●	–	●	●	●	●	○
Surface Soil	Food-Chain Exposure	–	–	●	●	●	●	○
Sediment	Direct Contact/Uptake	–	●	–	●	●	●	●
Sediment	Food-Chain Exposure	–	–	–	●	●	●	●
Surface Water/Seeps	Direct Contact/Uptake	–	○	–	●	●	●	●
Surface Water/Seeps	Food-Chain Exposure	–	–	–	–	–	–	●
Ground Water	Direct Contact/Uptake	○	○	–	–	–	–	–
Ground Water	Food-Chain Exposure	–	–	–	○	○	○	–

LEGEND

- ——▶ Potentially Complete Exposure Pathway
- – –▶ Potentially Complete but Insignificant Exposure Pathway
- ● Potentially Complete Exposure Pathway
- ○ Potentially Complete but Insignificant Exposure Pathway
- – Not Applicable

Job No. : 6800024343	FIGURE 8–4 CONCEPTUAL SITE MODEL FOR EFSFSR, GLORY HOLE, SUGAR CREEK, AND DUMP AREAS STIBNITE SITE
Prepared by : D.M.R.	
Date : 7/21/00	



Exposure Area	Exposure Media	Exposure Route	Terrestrial Ecosystem: Producers: Upland Vegetation	Producers: Riparian/Wetland Vegetation	Detritivores: Soil Organisms	Consumers: Herbivores	Consumers: Insectivores	Consumers: Carnivores	Aquatic Ecosystem: Consumer: Aquatic Birds & Mammals (Piscivores)
Smelter Stack	Soil	Direct Contact/Uptake	●	–	●	●	●	●	–
		Food-Chain Exposure	–	–	●	●	●	●	–
DMEA Dump	Soil	Direct Contact/Uptake	●	–	●	●	●	●	–
		Food-Chain Exposure	–	–	●	●	●	●	–
Location UW-1 (Upgradient Wetland)	Soil	Direct Contact/Uptake	–	●	●	●	●	●	○
		Food-Chain Exposure	–	–	●	●	●	●	○
	Surface Water	Direct Contact/Uptake	–	○	–	●	●	●	–
		Food-Chain Exposure	–	–	–	–	–	–	–
BTO	Surface Water	Direct Contact/Uptake	–	–	–	●	●	●	○
		Food-Chain Exposure	–	–	–	–	–	–	○
Location BD-6 (NW Dump)	Insignificant Exposure: See text								

Job No. : 6800024343
Prepared by : D.M.R.
Date : 7/21/00

FIGURE 8-5
CONCEPTUAL SITE MODEL FOR MISCELLANEOUS SMALL AREAS OF CONCERN
STIBNITE SITE

9. HEALTH RISK EVALUATION

This section estimates potential human health risk at the Stibnite Site via exposure to surface soil, surface water, sediment, and fish ingestion. Groundwater is not used as a water supply (no supply wells are on site), but groundwater was evaluated qualitatively for its suitability as an untreated source of drinking water. Likewise, seep water was evaluated qualitatively, since most seeps are seasonal, have low flow, are not readily accessible, and are unlikely sources of drinking water compared to the EFSFSR.

The overall approach used to evaluate health risk is consistent with USEPA guidance in Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (USEPA, 1989a). USEPA Region X guidance was referred to for dermal exposure assessment (USEPA Region X, 1998). The risk evaluation was performed in accordance with the Stibnite Area Risk Evaluation Work Plan (Stibnite Group, 1997), with the exceptions noted below under Land Use and Receptors (Section 9.1).

The human health risk evaluation includes the following topics.

- Current and future land use and identification of potential receptors
- Exposure areas and media evaluated
- Exposure pathway assessment
- Exposure assumptions
- Constituents evaluated
- Calculation of exposure point concentrations
- Toxicity information used in the risk evaluation
- Characterization of risk
- Lead Exposure Assessment
- Qualitative Evaluation of Surface Water, Groundwater, Seep Water, and Subsurface Soil
- Uncertainty evaluation
- Summary and conclusions

9.1 LAND USE AND RECEPTORS

The Site is largely inactive, except for intermittent monitoring and closure activities. In 1998 and 1999, the SMI facilities, camps, and roads (except for the main access road and the Thunder Mountain Road) were demolished and reclaimed by IDEQ and the Idaho Department of Lands. Closure of the Hecla heap is in process. Monitoring of groundwater and surface water near the former SMI leach pads and Hecla heap is conducted in accordance with approved reclamation plans. Environmental monitoring at the BT/NO disposal area was conducted according to the AOC between Mobil, USEPA, and the Forest Service. The Forest Service also conducts periodic monitoring of surface water, sediment, and benthic communities.

Mining operations are not planned or anticipated in the foreseeable future. Both Hecla and IDEQ expect that future activities other than monitoring (such as final closure or focussed reclamation work) will be limited to one season.

Within the Site boundaries, recreational uses such as hunting, fishing, or camping are minimal due to past mining operations, the small size of the tributaries to the EFSFSR which render them less attractive or unsuitable for fishing, and the fact that large portions of the Site are privately owned (Figure 3-1). However, recreational use could increase in the future as remediation, reclamation, and closure programs reach completion.

Based on current and probable future land use, the following receptors were evaluated in the risk assessment.

- Reclamation workers
- Future recreational users

Because current land use has changed since the submittal of the Risk Evaluation Work Plan (Stibnite Group, 1997) in August, 1997 (i.e., mining operations have ceased), two other receptors that were identified in the Work Plan are no longer present at the site and were therefore not evaluated in the risk assessment. These are the "Current Part-time Resident" and the "Current Recreational User"; these receptors were members of mine employees or contract workers' families that resided seasonally in the camps for the duration of employment of the mine worker.

Exposure conditions for workers are also different than described in the Work Plan (Stibnite Group, 1997). Since mining operations have ceased, workers no longer reside at the site, and estimated duration of employment at the site is one season to complete closure activities or perform focussed reclamation work. Exposure frequency and duration for the previously defined current worker have been adjusted accordingly for a reclamation worker.

9.2 EXPOSURE AREAS AND MEDIA

The 1997 Risk Evaluation Work Plan described three general exposure areas referred to as Area 1 (Meadow Creek Valley), Area 2 (EFSFSR between Meadow Creek and Midnight Creek), and Area 3 (Glory Hole to site boundary). These areas had been designated for site characterization based on the different types of mining-related sources in each area. For example, Area 1 contained the BT/NO disposal area, Bradley tailing deposits, other historic features related to mining or processing ores from the Meadow Creek Mine and Yellow Pine Mine, and Hecla and SMI leach pads and related facilities. Area 2 contained the EFSFSR between Meadow Creek and Midnight Creek, Garnet Creek and Garnet Creek Pit, the former camps, and auxiliary features recent mining operations (such as the contractor shop and crusher site). Area 3 contained the Glory Hole, historic Bradley waste rock dumps, other historic features (Monday Camp, Bailey Tunnel), recent mining pits (now reclaimed), and various tributaries to the EFSFSR (Midnight Creek, West End Creek, Sugar Creek, and Hennessey Creek) (Stibnite Group, 1997).

Sampling was performed in 1999 at several additional investigation areas, namely, three wetlands in Meadow Creek Valley, the Northeast and Southeast Bradley waste rock dumps, the Glory Hole, and several miscellaneous small areas of concern (former Bradley smelter stack, the DMEA Dump, and the BTO).

Because of the additional site characterization performed in 1999, the exposure areas for terrestrial and human health risk assessment were modified to reflect the diversity of areas investigated. These areas were indicated in Section 5.3 and Table 5-3, and are listed below for convenience, along with the media evaluated. The reader is referred to Table 5-3 for a list of samples evaluated in each exposure area.

Meadow Creek Valley

- Bradley Tailing Impoundment and Neutralized Ore Disposal Area (soil)
- Meadow Creek Mine Hillside (soil)
- Lower Meadow Creek Valley (soil, surface water, sediment, fish)
- Meadow Creek Upgradient Wetland (excluding location UW-1) (soil, surface water)
- Keyway Wetland (soil, surface water)
- Meadow Creek Forested Wetland (soil)

EFSFSR

- EFSFSR, Southeast Bradley Waste Rock Dump, and Midnight Creek (soil, surface water, sediment, fish)
- Glory Hole, EFSFSR, Northwest Bradley Waste Rock Dump, and Hennessey Creek (soil, surface water, sediment, fish)
- Northeast Bradley Waste Rock Dump and Sugar Creek (soil, surface water, sediment)

Miscellaneous Small Areas of Concern

- Smelter Stack (soil, ash, wood)
- DMEA Dump (soil)
- BTO (surface water)
- Location UW-1, Upgradient Wetland (soil, surface water)
- Location BD-6, Northwest Dump (soil)

In addition, surface water and groundwater were evaluated qualitatively as drinking water, by comparison to drinking water standards or water quality criteria protective of lifetime consumption. A screening-level evaluation of seep water ingestion also was performed.

9.3 EXPOSURE PATHWAY ASSESSMENT

CSMs for human exposure to potentially affected media in (1) the Meadow Creek Valley Floor, (2) Meadow Creek Upland Areas, (3) Bradley Waste Rock and Glory Hole Area, and (4) Miscellaneous Small Sources are shown in Figures 9-1 through 9-4. A CSM is a schematic representation of the constituent source areas, chemical release mechanisms, environmental transport media, potential exposure routes, and potential receptors. The purpose of the CSM is to represent chemical sources and exposure pathways that may result in human health risks, to aid in developing a sampling plan to address significant chemical release and migration pathways, and to aid in identifying effective remedial alternatives, if necessary, that

are targeted at significant chemical sources and exposure pathways that contribute to unacceptable risk levels.

Only complete exposure pathways are evaluated in the risk assessment. A complete exposure pathway includes all of the following elements.

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

The absence of any one of these elements results in an incomplete exposure pathway. Where there is no potential human exposure, there is no potential human health risk. The CSMs show potentially complete, potentially complete but relatively insignificant, and incomplete pathways. The exposure pathways for each receptor are described in the following sections, along with the rationale for pathways not quantified in the health risk evaluation.

9.3.1 POTENTIALLY COMPLETE PATHWAYS EVALUATED QUANTITATIVELY

As indicated in the CSMs, potentially affected environmental media in each area include surface water, sediment, and surface soil. In addition, ash and wood are potential exposure media in the Smelter Stack exposure area. Game animals could also be indirectly affected via ingestion of plants, and fish by exposure to surface water, prey organisms, and sediments. Subsurface soil or other materials that have been capped are not an exposure medium of concern except for potential leaching to groundwater, which was evaluated in the Site Characterization by direct sampling of groundwater and seeps.

Pathways by which reclamation workers could be exposed to site-related constituents and which were evaluated quantitatively in risk assessment were:

- ingestion and dermal exposure to surface material;
- inhalation of airborne particulates released by wind erosion from surface material;
- incidental ingestion and dermal exposure to surface water; and
- ingestion of sediment.

Pathways by which future recreational users might be exposed to site-related constituents and which were evaluated quantitatively in risk assessment include:

- ingestion and dermal exposure to surface material;
- inhalation of airborne particulates released by wind erosion from surface material;
- ingestion of sediment (presumed to occur while fishing);
- ingestion of surface water as a drinking water source;
- dermal exposure to surface water; and
- ingestion of fish (whitefish only; others are catch and release).

9.3.2 INSIGNIFICANT OR INCOMPLETE PATHWAYS

Other potential human exposure pathways are shown in the CSMs as incomplete or as potentially complete but relatively insignificant, based on the factors listed below.

- Dermal absorption from stream sediment is not evaluated because the sediments are not cohesive and would not adhere to skin, particularly in a flowing stream. Note, however, that dermal absorption from tailing-affected surface soil and wetland soil is evaluated quantitatively.
- Volatilization (and inhalation of volatile compounds) is an incomplete pathway because the only volatile analyte was cyanide, which disperses rapidly upon release to air and is a negligible inhalation hazard. Therefore, this pathway and exposure route are not evaluated further in the risk evaluation.
- Direct exposure to groundwater at the Stibnite Site is incomplete because there are no drinking water supply wells and none is anticipated in future. However, groundwater is evaluated qualitatively for its suitability as an untreated source of drinking water.
- Human exposure to site-related constituents via ingestion of game animals is considered potentially complete but insignificant because the areas of concern that were investigated in the Site Characterization represent only a small fraction of game animals' relatively large foraging area, most metals have limited bioaccumulation potential in plants and shrubs, and game would comprise a relatively small portion of the human diet.

9.4 EXPOSURE FACTORS FOR ESTIMATING CONSTITUENT INTAKE

Exposure factors (e.g., soil or surface water ingestion rates, exposure frequency and duration, and body weight) are used to estimate constituent intake by each exposure pathway for each receptor discussed in the previous section. The estimates of constituent intake are then combined with toxicity information to yield estimates of potential health risk. Constituent intake is expressed in terms of mg/kg-day. The general equation for calculating constituent intake in terms of mg/kg-day is:

$$\text{Intake} = \frac{\text{chemical conc. x contact rate x exposure frequency x exposure duration}}{\text{body weight x averaging time}}$$

Omitting constituent concentration from the intake equation yields a pathway-specific "intake factor." The intake factor (kg soil/kg body weight-day; L water/kg-day; m^3 air/kg-day; or kg fish/kg-day) can then be multiplied by the exposure point concentration of each constituent in soil, water, or fish to obtain the pathway-specific intake for that constituent.

A constituent intake factor is calculated using estimates of body weight, ingestion and inhalation rates, and frequency and duration of exposure. RME is estimated by selecting values for exposure variables so that the combination of all variables results in the maximum exposure that can reasonably be expected to occur at the site. Central tendency exposure and risk are not estimated because the reclamation worker and recreational user exposure scenarios are site-specific, the RME assumptions are considered protective, and there is little empirical basis for developing central tendency exposure factors for these scenarios.

The exposure factors used to estimate intake for the receptors and pathways evaluated in the health risk evaluation are summarized in Tables 9-1 through 9-5. The values are considered reasonable but conservative and are likely to overestimate actual exposure potential at the Site, because they assume (1) daily contact of reclamation workers with the sampled media in each investigation area, and (2) recreational users spend their time at locations investigated in the Site Characterization. However, these values are adopted in order not to underestimate potential risk and to support development of risk management decisions for the Site.

The exposure factors are developed using various guidance documents, which are cited in the footnotes to Tables 9-1 through 9-5. The chief guidance documents used are the Exposure Factors Handbook (USEPA, 1989b); Risk Assessment Guidance for Superfund, Parts A and B (USEPA, 1989a,c); "Standard Default Exposure Factors" (USEPA, 1991a); "Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure" (USEPA, 1993a), and Exposure Factors Handbook (USEPA, 1997a). Professional judgment and site information are used where published guidance is not available. The source or rationale for the various exposure factors identified in Tables 9-1 through 9-5 are discussed in more detail in the following sections. Intake factors for all receptors and pathways are summarized in Table 9-6.

9.4.1 RECLAMATION WORKER EXPOSURE FACTORS

Tables 9-1 and 9-4 summarize the exposure factors for estimating constituent intake by an on-site reclamation worker from: 1) oral exposure to surface soil, sediments, and surface water, 2) dermal exposure to surface soil and surface water, and 3) from inhalation of airborne particulates. Equations for calculating intake by each exposure route are shown on the tables. The guidance documents and assumptions used in selecting the exposure factors are summarized in footnotes to the table and discussed in more detail below.

Soil Ingestion Rate (IS): Few data are available to support an estimate of adult soil ingestion rates. However, it is recognized that soil ingestion rates are activity-dependent, and it is assumed that work performed at the Site is "contact intensive" with soil. Hawley (1985) proposed a high-end soil ingestion rate of 480 mg/day for contact-intensive activities such as yard work, assuming dermal adherence of soil to hands of 3.5 mg/cm^2 and ingestion of all soil adhered to a certain portion of the hand. New data from USEPA-sponsored studies reported by Kissel et al. (1996) show that even for contact-intensive activities, adherence of soil to hands is substantially less than 1 mg/cm^2. For example, measured dermal adherence of soil to hands while farming is an average of 0.44 mg/cm^2 and is even lower for other parts of the body exposed during work (Kissel et al., 1996). USEPA's Exposure Factors Handbook (USEPA, 1997a) recommends using the Kissel data to estimate soil adherence to skin. Following this recommendation, a soil ingestion value of 60 mg/day can be estimated by adjusting the Hawley data using the experimentally determined dermal adherence factor for farmer's hands of 0.44 mg/cm^2 (480 mg/day x 0.44/3.5 = 60 mg/day). This value is lower than, but of similar magnitude to, the 100 mg/day suggested by USEPA for high-end adult residential (24-hour) exposure (USEPA, 1991a). In addition, this 60 mg/day value is higher than the high-end soil ingestion estimate of 50 mg/day recommended by USEPA for adults in the typical occupational

setting or industrial workplace (USEPA, 1991a). The USEPA Technical Review Workgroup (TRW) for lead recently recommended a default soil ingestion value for contact intensive scenarios of 100 mg/day (USEPA, 1999). Therefore, a high-end soil ingestion rate of 100 mg/day is used to estimate exposure for the reclamation worker with high contact with soil. This soil ingestion rate is also applied to incidental ingestion of other types of surface material (e.g., ash and wood at the smelter stack).

Sediment Ingestion Rate (ISD): The sediment ingestion rate is 10 mg/hour, based on the reclamation worker soil ingestion rate of 100 mg/day divided by 10 working hours/day.

Relative Bioavailability Factor for Arsenic: Arsenic ingested in soil is considered to be less toxic than soluble arsenic ingested in drinking water or food, because arsenic forms in soil are often insoluble and arsenic adsorbs to soil. Both of these factors would make arsenic less available for absorption, and therefore, less toxic per mg ingested compared to soluble arsenic in water. It is common practice in risk assessment to derive relative bioavailability factors to account for lower availability (and toxicity) of arsenic in soil (USEPA, 1993b; 1996c; 1997d; and Walker and Griffin, 1998). Good correlations between arsenic in soil and urinary arsenic levels in human receptors are reported at a site where site-specific relative bioavailability factors (0.18 to 0.25) are used to account for lower bioavailability of arsenic in soil (Walker and Griffin, 1998). In the absence of site-specific data, USEPA Region X recommends using a default relative bioavailability factor of 0.6 to account for the decreased absorption of ingested arsenic in soil relative to the absorption of soluble arsenic ingested in water (personal communication, Roseanne Lorenzana, 1998, U.S. EPA Region X).

Surface Water Ingestion Rate (ISW): Exposure of workers to surface water is assumed to consist of wading across streams and occasional construction of sediment control or other structures. USEPA (1989a) recommends a 50-mL/hour ingestion rate for swimmers. Recognizing that accidental splashing or hand-to-face contact while working might result in a very small amount of water in or near the mouth, but that most would be removed by wiping or spitting, 1 mL/hour is assumed for the amount actually ingested.

Inhalation Rate (IN): USEPA's Exposure Factors Handbook (USEPA, 1997a) recommends an RME value of 3.5 m^3/hour for outdoor workers.

Particulate Emission Factor (PEF): The PEF relates the constituent concentration in soil with the concentration of respirable particles (PM_{10}) in the air due to wind erosion of surface soil. The derivation of PEF is explained in Cowherd et al. (1985) and discussed in USEPA's Soil Screening Guidance: Technical Background Document (USEPA, 1996b). The PEF is a function of mean annual wind speed, threshold friction velocity needed to raise dust particles, fraction vegetative cover, soil particle size, surface roughness coefficient, mixing height, size of source area, and a normalized annual average concentration (or dispersion coefficient) that is estimated using a standard box model.

The USEPA default value for PEF of 1.32 E+09 m^3/kg (USEPA, 1996b) is used for the Stibnite Site. This value is appropriate and conservative because:

- The mean annual wind speed (4.69 m/sec) used to calculate the default PEF is the 90th percentile value from data collected at 29 cities in the United States. This velocity is from data for Minneapolis, MN. For comparison, the mean annual windspeed for Boise, ID, is reported as 4.0 m/sec (Cowherd, 1985, Table 4-1).
- The dispersion coefficient (C/Q; kg/m^3 per g/m^2-sec) is based on the 90th percentile mean annual windspeed and the most conservative source area size (0.5 acre). The inverse of the dispersion coefficient is used in the PEF calculation. The USEPA default value for Q/C is 90.80 (USEPA, 1996b, Table 3, 0.5-acre source in Minneapolis, MN). For comparison, the Q/C for Boise, ID, is 69.41. Therefore, the default value is conservative compared to a value for Boise.
- The particle size (500 μm) and surface roughness height (0.5 cm) used to calculate the threshold friction velocity are conservative values because they are near the low end of the ranges considered. For example, the particle size is representative of loamy soil, and the roughness height falls between a field of snow and a plowed agricultural field (Cowherd et al., 1985, Figure 3-6). Therefore, these values are considered suitable for estimating particulate emissions from wind erosion at the Site.
- The fraction vegetative cover (0.5) used to calculate the default USEPA PEF is considered reasonable or conservative for most soil locations being evaluated in the Stibnite Site, such as the Meadow Creek Mine Hillside, Meadow Creek Valley, and unvegetated areas such as the iste rock dumps, which are primarily cobbles, small boulders, and gravel that are not readily subject to wind erosion. Changing the fraction vegetated from 0.5 to 0.2, for example, increases the PEF by a factor of 2.5, from about 1.3E+09 to 3.2E+09 m^3/kg, which would have an insignificant effect on the estimate of intake by the air pathway. Therefore, the default PEF is still considered conservative for the Site.

Skin Surface Area (SA): Skin surface areas of 5000 cm^2/day and 5000 cm^2 are used for dermal exposure to soil and surface water, respectively, based on the USEPA default central tendency value for adults for outdoor activities (assumes 25 percent of surface area is exposed) (USEPA, 1997a).

Adherence Factor (AF): An adherence factor of 0.1 mg/cm^2 is used, based on an USEPA default value for contact intensive exposure to soil by gardeners (USEPA Region X, 1998).

Absorption Factor (AB): Dermal absorption factors for metals in soil are taken from USEPA guidance, i.e., 0.03 for arsenic and 0.01 for other inorganics (USEPA, 1998b).

Aqueous Permeability Constant (PC): Permeability constants for metals in water are chemical-specific, and range from about 0.0001 to 0.001 cm/hour (USEPA, 1998b).

Exposure Time (ET): Reclamation workers may work up to 10 hours/day outdoors. Exposure time to surface water and sediment is assumed to be 4 hours/day.

Exposure Frequency (EF): Reclamation workers are assumed to work for 4 months (mid-June through mid-October) for 5 days/week, for a total of 80 days. Reclamation and monitoring programs are likely to be conducted during a 5-day work week (or less frequently). This exposure frequency is an alteration from

the Work Plan, which included a mine worker active 7 days per week. Mining operations ceased in 1997 and are not expected to resume in the foreseeable future.

A shorter exposure frequency of 10 days is used for the miscellaneous small areas such as the smelter stack and location UW-1 in the Upgradient Wetland, assuming that, at most, 10 days would be required for any reclamation activity in these areas.

Exposure Duration (ED): An exposure duration of 1 year is adopted as the expected duration of employment because it is estimated that reclamation will be completed in one season (mid June through mid October). These durations are an alteration from the Work Plan, which included a mine worker employed for up to 10 years (Stibnite Group, 1997). Mining operations have ceased and are not expected to resume in the foreseeable future.

CFs and CFw: Unit conversion factors are 1E-06 kg per mg soil and 1E-03 L per mL or cm^3 of water.

Body Weight (BW): The standard default body weight for adults is 70 kg (USEPA, 1989a).

Averaging Time (AT): Averaging times are used to estimate the average daily intake of constituent over the exposure duration (for noncarcinogens) or over a 70-year lifetime (for carcinogens) (USEPA, 1989a). The averaging times used in this assessment are equal to the ED in days (for noncarcinogens) or 70 years in days (for carcinogens). For miscellaneous small areas of concern, the averaging time for noncarcinogens equals the exposure frequency.

9.4.2 FUTURE RECREATIONAL USER EXPOSURE FACTORS

Tables 9-2 and 9-5 summarize the exposure factors for estimating constituent intake by the future recreational user from oral exposure to soil, surface water, and sediments, dermal exposure to soil and surface water, and inhalation of airborne particulates. Table 9-3 shows exposure factors for fish ingestion. Guidance documents and assumptions used in selecting the values for the future recreational user are summarized in the tables. Factors specific to this receptor are discussed below. Other terms are as previously defined.

Soil and Sediment Ingestion Rate (IS): The soil and sediment ingestion rates for the recreational user are calculated to be 6.25 mg/hour, based on the USEPA TRW default soil ingestion rate for contact intensive scenarios of 100 mg/day (USEPA, 1999), divided by 16 waking hours per day (i.e., 100/16 = 6.25).

Surface Water Ingestion Rate (ISW): It is conservatively assumed that the future recreational user will use unfiltered surface water from on-site creeks as a drinking water source. Therefore, the ingestion rate is 2 L/day (USEPA, 1989a). The ingestion rate for surface water at the BTO and stagnant water at location UW-1 is assumed to be a worst-case value of 0.1 L/day.

Inhalation Rate (IN): A 1.0 m^3/hour inhalation rate is used based on "typical" outdoor activities requiring 7% heavy activity (1.9 m^3/hour), 37% moderate activity (1.2 m^3/hour), 28% light activity (1.0 m^3/hour), and 28% resting (0.3 m^3/hour) (USEPA, 1989b).

Skin Surface Area: Skin surface areas of 5000 cm^2/day and 5000 cm^2 are used for dermal exposure to soil and surface water, respectively, based on the USEPA default central tendency value for adults for outdoor activities (assumes 25% of surface area is exposed) (USEPA, 1997a).

Exposure Time (ET): Future recreational users are assumed to spend 2 hours/day in contact with soil in the investigation areas (which constitute only a small fraction of the total area to which a hunter, hiker, or fisherman would be exposed). Future recreational users are assumed to spend 4 hours/day in contact with potentially affected surface water and sediment. Future recreational users are assumed to be in contact with potentially affected media in miscellaneous small areas for 2 hours/day.

Exposure Frequency (EF): An EF value of 12 days/year is used for the Site based on United States Department of the Interior (USDOI) data for Idaho (average of 12 days/year for fishing or hunting) (USDOI, 1993). A shorter exposure frequency of 1 day/year is used for miscellaneous small areas, such as the smelter stack and BTO, assuming that a future recreational user would visit the area only once. (At the miscellaneous small areas of concern, averaging time for noncarcinogens equals exposure frequency, and EF and AT cancel out in the calculation of intake. Therefore, the calculation of HQs is independent of the number of visits.)

Exposure Duration (ED): The ED for future recreational use of the site is 30 years based on the standard default value for residents (USEPA, 1989a). For miscellaneous small areas, the ED is 1 year.

9.4.3 FISH INGESTION EXPOSURE FACTORS

Table 9-3 shows exposure factors applied to estimate constituent intake via fish ingestion. The guidance documents and assumptions used in selecting values for exposure factors are summarized in the table. Factors specific to this receptor are discussed below. Other factors are previously defined.

Fish Ingestion Rate (IF): An RME fish ingestion rate of 200 g/day is estimated from data reported for owners of fishing licenses in the Lake Coeur d'Alene area (ATSDR, 1989, Table 9 and page 8). This estimate is based on eating two fish per meal, one meal per day, at 3.5 oz per dressed fish, and 28.35 g/oz. Because the EFSFSR is designated as catch and release, only whitefish can be consumed under current regulations. The estimated fish ingestion rate probably considerably overstates likely consumption of whitefish from the Stibnite Site.

Exposure Frequency (EF): The exposure frequency for fish ingestion is set equal to the exposure frequency for future recreational users (12 days/year).

Exposure Duration (ED): The ED for fish intake is 30 years based on the standard default value for residents (USEPA, 1989a).

CFf: The unit conversion factor for fish is 1E-03 kg/g fish.

9.5 CONSTITUENTS EVALUATED

Constituents that are evaluated quantitatively in the human health risk evaluation are aluminum, antimony, arsenic, cadmium, chromium III, copper, lead, manganese, mercury, nickel, selenium, silver, and zinc. Cyanide also is included for surface water. Many of these constituents do not exceed background ranges in some or all of the exposure areas (see Section 6.2 and Tables 6-2 through 6-4). However, in most cases inorganic constituents that are within background ranges do not contribute significantly to overall health risk estimates, and excluding those metals prior to risk calculations often does not have a measurable effect on the results or conclusions of the health risk assessment. Therefore, they are retained in the human health risk calculations for simplicity.

Other analytes that are included in the site characterization program but are not included in the risk evaluation are iron, major cations (calcium, magnesium, potassium, and sodium), and anions (sulfate, nitrate/nitrite, ammonia, phosphate, and chloride).

Chromium at the site is assumed to be trivalent chromium (chromium III), rather than hexavalent chromium (chromium VI), because there is no source of chromium VI at the Site, chromium III is predominant form in most soils, and chromium VI is unstable in the environment and quickly reduces to chromium III under ambient conditions. In most soils, chromium VI represents at most a small percentage of total chromium (less than 5 percent and typically undetectable) (McGrath and Smith, 1990).

9.6 EXPOSURE POINT CONCENTRATIONS

This section describes the approach for calculating exposure point concentrations for use in the risk evaluation. Tables of data and summary statistics are included in Appendix B.

9.6.1 CONCENTRATION TERMS FOR SOIL, SEDIMENT, AND WATER

Exposure point concentrations for constituents in soil, sediment, and surface water are estimated based on the most current analytical results available for the sampled media (Table 5-3). Analytical results from both 1999 and 1997 are used to calculate soil and sediment exposure point concentrations. Surface water exposure point concentrations are determined from the 1999 analytical results. The concentration terms are either the 95% UCL on the mean concentration or the maximum concentration, whichever is lower, following recommendations in Risk Assessment Guidance for Superfund (USEPA, 1989a) and "Supplemental Guidance to RAGS: Calculating the Concentration Term" (USEPA, 1992a). For exposure areas with fewer than four samples, the maximum concentration detected is used as the exposure point concentration.

Prior to calculating the 95% UCL, the distribution of the data is tested for normality or lognormality (substituting one-half the detection limit for non-detect results), and the 95% UCL is calculated using the appropriate equation and student's t or H statistic (USEPA, 1992a). For data sets that fit neither a normal or lognormal distribution (e.g., bimodal distribution) and for data sets with less than 50 percent detection

frequency, the arithmetic mean and t statistic are used to provide a reasonable estimate of the 95% UCL (Singh et al., 1997).

Air particulate matter concentrations are estimated using the concentration term for soil and USEPA's screening-level particulate emission factor described in Section 9.4.1.

9.6.2 FISH TISSUE CONCENTRATIONS

The most current analytical results for fish are from the fish sampling conducted by the Forest Service in August 1997. Metal concentrations are determined for both whole fish bodies and fish fillets. Only the fish fillet results are used to evaluate potential human health effects from COPIs identified in fish, because this is the part of the fish most likely to be consumed by humans. The 1997 data include results for cutthroat trout collected at Station 322 in Meadow Creek, cutthroat trout collected at Station 310 in the EFSFSR, and steelhead caught at Stations 308 and 314 in the EFSFSR downstream of the Glory Hole. Three fish are collected at each station. Sampling results from six fish collected in Meadow Creek and the EFSFSR are used to calculate exposure point concentrations for evaluating fish ingestion in the lower Meadow Creek Valley and the Southeast Dump and Midnight Creek Exposure Area (which includes the EFSFSR). These fish are probably from the same population because there is no barrier to movement of fish between Meadow Creek and the EFSFSR. Sampling results from six fish collected in the EFSFSR downstream of the Glory Hole are used to calculate exposure point concentrations for fish in Glory Hole/Northwest Dump/EFSFSR area. The concentration terms are either the 95% UCL on the arithmetic mean concentration or the maximum concentration, whichever is lower.

Fish tissue is analyzed for total arsenic. However, most arsenic in fish is present as non-toxic organic forms (arsenobetaine and arsenocholine) (ATSDR, 1993a). USEPA (1988) reported that 10 percent of total arsenic in freshwater fish is in the inorganic form. In estimating a level of concern for arsenic in shellfish, FDA (1993) assumes that 10 percent of total arsenic in shellfish is in the inorganic form. Therefore, for the risk evaluation it is assumed that 10 percent of total arsenic in fish is the potentially toxic inorganic form. For quantifying hazard/risk from ingestion of inorganic arsenic in fish by the future recreational user, the concentration of total arsenic in fish is multiplied by a factor of 0.1 to yield the concentration of inorganic arsenic.

The 1997 fish samples are analyzed for 15 metals: aluminum, antimony, arsenic, cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, selenium, silver, and zinc. Results are reported as mg/kg (fresh weight). Of analytes measured, all but iron and magnesium (essential nutrients) are evaluated for potential human health effects.

The Work Plan for the human health risk evaluation (Stibnite Group, 1997) indicated that 1996 fish tissue data would be included in the data set for the fish ingestion scenario. However, as indicated in the Draft SCR (Section 8.5.6; Stibnite Group, 2000) the only 1996 data reported (Rich, 1997) are from four mountain whitefish collected from an unidentified station in the EFSFSR downstream of Sugar Creek; analyses are performed on whole fish (not fish fillet and body remains), and concentrations are reported on

a dry weight basis. Therefore, the data are not comparable to the 1997 site-specific sampling and are not used in the risk evaluation.

9.7 TOXICITY ASSESSMENT

Toxicity values for use in the health risk evaluation are presented in Table 9-7. The table contains slope factors (SFs) for carcinogenic effects, cancer weight of evidence classifications for constituents with carcinogenic effects, and chronic reference doses (RfDs) for constituents with noncarcinogenic effects.

The USEPA SFs are 95% UCLs of the probability of response per unit intake of constituent (by oral or inhalation routes) over a lifetime. SFs are based on mathematical extrapolation from experimental animal data and epidemiological studies, when available. SFs are expressed in units of risk per mg constituent intake per mg/kg-day or $(mg/kg\text{-}day)^{-1}$. Because SFs are upperbound estimates, actual cancer potency of constituents may be lower than estimated and some may approach zero.

The chronic RfD is a pathway-specific (e.g., oral or inhalation) estimate of a daily constituent intake per kg body weight below which it is unlikely that adverse health effects will occur over a lifetime of exposure (USEPA, 1989a). The USEPA derives RfDs to protect sensitive populations such as children. The USEPA has developed chronic RfDs to evaluate long-term exposures (7 years to a lifetime), and subchronic RfDs to evaluate exposures of shorter duration (2 weeks to 7 years).

Toxicity values specific to the oral and inhalation pathways are obtained from the sources listed below in the following hierarchy.

- Integrated Risk Information System (IRIS) on-line database (USEPA, 2000)
- Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997b)
- Provisional toxicity values as cited in USEPA Region IX Preliminary Remediation Goals tables (USEPA Region IX, 2000)

The oral RfD for "mercuric chloride" is used to evaluate mercury in soil (ingestion only), sediments, and surface water at the Site, while the inhalation RfD for "elemental mercury" is used to evaluate mercury by the soil (particulate) inhalation route (USEPA, 2000). The oral RfD for methyl mercury is used to evaluate mercury in fish at the Site (USEPA, 2000). For nickel, the oral RfD for "nickel soluble salts" is used for soil (ingestion), sediments, and surface water and the inhalation SF for "nickel refinery dust" is used for inhalation of soil particulates (USEPA, 2000). RfDs and SFs for inorganic arsenic are used to evaluate arsenic for all exposure media at the Site.

Oral RfDs are available for all constituents evaluated except lead (see lead discussion below). Route-to-route extrapolation from oral to inhalation toxicity values is not undertaken, and potential risk from the inhalation exposure route is not evaluated for constituents that did not have published inhalation RfDs. This approach is not expected to have any material effect on the risk results because the contribution of the inhalation route to overall exposure is negligible. For example, the inhalation intake factors for exposure to soil ranged from approximately 2E-13 kg soil/kg bw-day to 4E-10 kg soil/kg bw-day, compared with

intake from the soil ingestion or dermal absorption routes on the order of 6E-09 to 7E-06 kg soil/kg bw-day (Table 9-6). Therefore, intake via inhalation is orders of magnitude below intake from the ingestion or dermal routes, and the absence of toxicity values for the inhalation route of exposure will not affect overall estimates of health hazards at the site.

There are no toxicity values specific to dermal exposure. Therefore, oral toxicity values are typically used to assess risks from dermal exposure. The oral toxicity factor relates toxic response to an administered dose of chemical, only some of which may be absorbed by the body, whereas chemical intake from dermal contact is estimated as an absorbed dose using chemical-specific permeability constants for absorption from water and dermal absorbed fraction from soil (USEPA, 1998b).

To ensure that dermal toxicity is not underestimated, USEPA recommends adjusting oral toxicity factors by chemical-specific gastrointestinal absorption fractions to evaluate toxic effects of a dermally absorbed dose (USEPA Region X, 1998). A default gastrointestinal absorption factor of 20 percent recommended for inorganics by USEPA Region X is used, with the following exceptions. Arsenic ingested in water is almost completely absorbed. Therefore, the gastrointestinal absorption factor of 95 percent recommended by USEPA (1998b) is used for arsenic in water. Cadmium is detected in soil, sediment, and wood at the site, but is not detected in surface water. Therefore, the gastrointestinal absorption factor for cadmium from food of 2.5 percent reported by USEPA (2000) is used to adjust the oral RfD to evaluate dermal toxicity of cadmium.

There are no toxicity values for lead. Therefore, potential hazards from exposure to lead in soil, surface water, sediments, and fish is assessed by comparing observed concentrations to federal action levels or other health-based criteria.

Chemical-specific toxic effects are an important consideration when evaluating risk from exposure to multiple chemicals. Risk from exposure to chemicals with similar non-cancer effects are considered additive, whereas risks from exposure to chemicals with different effects are not considered additive. However, USEPA (1989a) considers risks from exposure to carcinogens to be additive, regardless of the type of cancer potentially induced by each chemical.

Arsenic, antimony, and mercury, which are expected to contribute most to overall risk estimates at the site, have different non-cancer (toxic) effects. The oral RfD for arsenic is based on a vascular condition known as "blackfoot disease." This disease is associated with hyperpigmentation and hyperkeratosis, and is observed in a Taiwanese population that ingested elevated levels of arsenic in drinking water (USEPA, 2000). The oral RfD for antimony is based on changes in blood chemistry, including decreases in nonfasting blood glucose levels and increased cholesterol levels, and decreased longevity in rats administered antimony in drinking water for life (USEPA, 2000). The most sensitive adverse effect for mercuric chloride is reported to be formation of mercuric-mercury-induced autoimmune glomerulonephritis (USEPA, 2000).

There is no evidence that antimony, arsenic, or mercury affect the same toxic endpoint. Therefore, the effects of these metals may be evaluated separately from each other when estimating non-cancer hazards for the site.

Toxicological profiles have been developed for arsenic and antimony based on their contribution to overall hazard or risk. The toxicological profiles are in Appendix E.

9.8 RISK CHARACTERIZATION METHODOLOGY

In the risk characterization step, the toxicity factors (RfDs and SFs) are applied in conjunction with exposure point concentrations and intake assumptions to estimate noncarcinogenic and carcinogenic health risk. This section describes how the risk calculations are performed, explains how lead is evaluated, and presents risk results. All risk calculations are shown in Appendix D.

9.8.1 HAZARD INDEX FOR NONCARCINOGENIC EFFECTS

For both chronic and subchronic scenarios, the potential for noncarcinogenic effects is characterized by comparing estimated constituent intakes with chemical-specific RfDs. The resulting ratio is the HQ. It is derived in the following manner.

$$\text{Non-cancer HQ} = \frac{\text{Constituent Intake (mg/kg-day)}}{\text{RfD (mg/kg-day)}}$$

The chronic RfD represents a level of intake (the RfD) below which it is unlikely that even sensitive individuals such as children will experience adverse health effects over the period of exposure. If the average daily intake exceeds the RfD (that is, if the HQ exceeds 1), there may be cause for concern for non-cancer health effects (USEPA, 1989a). It should be noted, however, that the level of concern does not increase linearly as the RfD is approached or exceeded. This is because different RfDs are based on different toxic endpoints in different species and types of studies and, therefore, they incorporate different uncertainty factors. Since the HQ does not define a dose-response relationship, its numerical value cannot be construed as a direct estimate of risk (USEPA, 1986). Rather, a HQ above 1 indicates a potential cause for concern for non-cancer health effects, which might indicate the need for reevaluating actual exposure conditions, concentrations, or toxicity, or consideration of risk management alternatives.

To assess exposures to multiple constituents, the HQs for each constituent are summed to yield a HI. The assumption of additive effects reflected in the HI is most properly applied to substances that induce the same effect by the same biological mechanism (USEPA, 1986). Consequently, summing HQs for substances that are not expected to induce the same type of toxic effect will overestimate the potential for adverse health effects. The HI provides a measure of the potential for adverse effects, but it is conservative and dependent on the quality of experimental evidence.

For receptors exposed by multiple pathways, the HIs from all relevant pathways are summed to obtain the total HI for that receptor. When the total HI is less than or equal to 1, multiple-pathway exposures to

constituents at the site are judged unlikely to result in an adverse effect. If the sum is greater than 1, further evaluation of exposure assumptions and toxicity, including consideration of specific target organs affected and mechanisms of toxic action, may be warranted to ascertain if the cumulative exposure would in fact be likely to harm exposed individuals.

9.8.2 CARCINOGENIC RISK

Potential carcinogenic effects are characterized in terms of the incremental probability of an individual developing cancer as a result of exposure to a potential carcinogen. Excess lifetime cancer risk is estimated from the projected lifetime daily average intake and the cancer SF, which represents an upperbound estimate of the dose-response relationship. Excess lifetime cancer risk is calculated by multiplying the average daily constituent intake by the cancer SF, as follows:

$$\text{Cancer Risk} = \text{Constituent Intake (mg/kg-day)} \times \text{SF (mg/kg-day)}^{-1}$$

The risks resulting from exposure to multiple carcinogens are assumed to be additive. The total cancer risk is estimated by summing the risks estimated for each constituent and for each pathway. This is approach results in an artificially elevated estimate of cancer risk, especially if several carcinogens are present, because the 95th percentile estimates are not strictly additive (USEPA, 1989a).

USEPA policy is considered when interpreting the significance of the cancer risk estimates. In the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (USEPA, 1990), USEPA states that: "For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper-bound lifetime cancer risk of between 1E-04 and 1E-06. Additionally, where cumulative carcinogenic risk to an individual based on RME exposure is less than 1E-04 and the total HI does not exceed 1, action is generally not warranted for protection of public health (USEPA, 1991b).

9.8.3 RISK QUANTIFICATION

The potential for noncarcinogenic health effects due to exposure to a constituent, expressed as the HQ, is calculated using the following format:

(1)	(2)	(3) (1) x (2)	(4)	(5) (3) ÷ (4)
Constituent Concentration (mg/kg or mg/L)	Intake Factor (kg/kg-day or L/kg-day)	Daily Intake (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient

The concentration of each noncarcinogenic constituent (column 1) is multiplied by the pathway-specific RME intake factor (column 2) to yield a RME daily constituent intake (column 3). The daily intake is then divided by the chronic or subchronic RfD (column 4) to obtain the RME HQ. Individual HQs are summed for all constituents in an exposure pathway to provide a pathway-specific HI. Pathway-specific HIs are summed to obtain the total HI for all exposure pathways applicable to a given receptor.

The potential for carcinogenic effects, expressed as excess cancer risk, are calculated in a similar manner:

(1)	(2)	(3) (1) x (2)	(4)	(5) (3) x (4)
Constituent Concentration (mg/kg or mg/L)	Lifetime Intake Factor (kg/kg-day or L/kg-day)	Lifetime Daily Intake (mg/kg-day)	Slope Factor $(mg/kg\text{-}day)^{-1}$	Excess Cancer Risk

The concentration of each carcinogen (column 1) is multiplied by pathway-specific intake factors (column 2) to yield the lifetime daily intake (column 3). The daily intake is then multiplied by the SF to obtain a numerical estimate of excess cancer risk. The cancer risks are then summed for all of the carcinogenic constituents and exposure pathways for each receptor evaluated

Spreadsheets showing noncarcinogenic hazard and cancer risk calculations in a format like those shown above are in Appendix D.

9.9 RISK RESULTS

Cumulative hazard indices and cancer risks for each receptor and exposure area are summarized in Table 9-8, along with the constituents and pathways that contributed to the overall risk estimates. Pathway-specific risk estimates for receptors in each area are shown in Tables 9-9 through 9-22. Chemical-specific risk calculations are in Appendix D. This section reports the results of the risk calculations and discusses their significance.

9.9.1 EXCESS CANCER RISK RESULTS

With one exception, excess cancer risk results are within or below USEPA's generally acceptable cancer risk range of 1E-06 to 1E-04 (Table 9-8). The only result above this range is for the future recreational user exposed to arsenic via ingestion of surface water in the Keyway Wetland (CR = 3E-04). The RME concentration of arsenic in Keyway Wetland surface water is 0.463 mg/L (1999 data), and the recreational user is assumed to drink 2 L/day, 12 days/year, for 30 years. These assumptions are likely to overestimate actual exposure and risk (see discussion of risk results, below).

9.9.2 CUMULATIVE HAZARD INDEXES FOR NON-CANCER EFFECTS

HIs exceed 1 for the reclamation worker and recreational user in the exposure areas listed below (Table 9-8). Arsenic, antimony, and mercury are the only constituents that contributed significantly to HIs above 1. Chemical-specific HQs for constituents other than arsenic, antimony, and mercury are well below 1 for all receptors, indicating that other constituents at the Site do not pose a threat of non-cancer effects. Non-cancer effects of arsenic, antimony, and mercury are not additive because their toxic endpoints differ (see Section 9.7, Toxicity Assessment). Table 9-8 and the following list summarize the maximum chemical-specific HIs for total (multiple-chemical) HIs that exceed 1.

Reclamation Worker Exposure Areas with Chemical-Specific HIs >1

- Meadow Creek Forested Wetland (maximum HI = 2 [antimony]),
- Southeast Bradley iste rock dump/Midnight Creek (maximum HI = 4 [arsenic]),
- Glory Hole, Northwest Bradley iste rock dump, EFSFSR (maximum HI = 3 [arsenic]),
- Northeast Bradley iste rock dump, Sugar Creek (maximum HI = 4 [arsenic])

Small areas of concern:

- Location UW-1 (antimony HI = 4, arsenic HI = 4),
- DMEA Dump (arsenic HI = 34),
- Location BD-6 (antimony HI = 73, arsenic HI = 17),
- BTO (antimony HI = 3, arsenic HI = 2), and
- Smelter Stack wood (antimony HI = 3, arsenic HI = 8); soil (arsenic HI = 14, mercury HI = 3), and ash (antimony HI = 28, arsenic HI = 736, mercury HI = 18).

Future Recreational User Exposure Areas with Chemical-Specific HIs >1

Five miscellaneous small areas of concern:

- Location UW-1 (arsenic HI = 3),
- DMEA Dump (arsenic HI = 10),
- Location BD-6 (antimony HI = 22, arsenic HI = 5),
- BTO (antimony HI = 2, arsenic HI = 3), and
- Smelter Stack wood (arsenic HI = 2); soil (arsenic HI = 4), and ash (antimony HI = 8, arsenic HI = 226, mercury HI = 6).

Note that under the exposure conditions evaluated, HIs for the recreational user exceed 1 only at the miscellaneous small areas of concern.

At most exposure areas, soil ingestion and dermal absorption are the exposure routes associated with HIs above 1. At the BTO and Keyway Wetland, ingestion and/or dermal contact with surface water are the primary exposure routes associated with HIs above 1. At Location UW-1 in the Upgradient Wetland, exposure to both soil and surface water are associated with HIs above 1.

9.9.3 DISCUSSION OF RISK RESULTS

This section discusses the significance of the risk results reported above.

Excess Cancer Risk at Keyway Wetland: The only cancer risk estimate that exceeds USEPA's generally acceptable risk range of 1E-06 to 1E-04 is for the future recreational user exposed to arsenic via ingestion of surface water in the Keyway Wetland (CR = 3E-04). The RME concentration of arsenic in Keyway Wetland surface water is 0.463 mg/L (1999 data), and the recreational user is assumed to drink 2 L/day, 12 days/year, for 30 years. These assumptions are likely to overestimate actual exposure and risk because the flow through the wetland is very low, and the wetland is not a likely source of daily water supply for

recreational visitors. Considering a lower, but still protective, rate of exposure (for example, ingestion of 1 L/day, and exposure frequency for ingestion and dermal contact of 5 days/year, for 30 years), the excess cancer risk would be 6E-05, which is within EPA's generally acceptable range.

In conclusion, the surface water exposure assumptions applied for the recreational user at other water bodies, such as Meadow Creek or the Glory Hole, are considered overly conservative for evaluating potential ingestion of water in wetlands. Ingestion of water in the Keyway Wetland does not pose an unacceptable cancer risk if a somewhat lower, but still conservative, exposure level is assumed (ingesting 1 L/day for 5 days/year for 30 years).

Non-cancer HIs Between 2 and 4: For the reclamation worker, maximum chemical-specific HIs range from 2 to 4 at four exposure areas and two miscellaneous small areas of concern: Meadow Creek Forested Wetland, the three Bradley iste rock areas, Location UW-1 in the Upgradient Wetland, and BTO. For the recreational user, maximum chemical-specific HIs range from 2 to 4 at three miscellaneous small areas of concern: Location UW-1, BTO, and smelter stack soil and wood (smelter stack ash presented a higher hazard level).

HIs of 5 or less are considered to represent a low potential of actual health threat because:

a. HIs above 1 do not indicate that an adverse effect will occur but only indicate potential cause for concern (USEPA, 1989a).

b. Chronic RfDs protective of lifetime exposure of sensitive individuals are used to assess risk from short-term and acute exposures in the miscellaneous small areas. Because higher doses can usually be tolerated for short-term exposure the likelihood of actual non-cancer effects occurring is expected to be minimal (see Section 9.12.2, Qualitative Uncertainty Analysis, Toxicity Factors Used to Evaluate Short-Term Exposures).

c. The exposure assumptions for the reclamation worker are likely to overestimate actual magnitude of exposure. For example, the reclamation worker is assumed to spend 80 days (about 4 months or one field season) in one exposure area and 10 days at a miscellaneous small area of concern. Three of these areas are so small (Meadow Creek Forested Wetland, BTO, and Location UW-1) that exposure magnitude is probably overestimated by a factor of 10 or more.

d. Recreational users are assumed to have a one-time exposure at the miscellaneous small areas of concern. Modest HIs between 2 and 4, calculated using chronic RfDs, probably do not indicate an unacceptable hazard from acute exposure.

In conclusion, none of the exposure areas evaluated (excluding three small areas of concern) are deemed to pose an unacceptable health threat under the exposure conditions evaluated.

HIs of 10 or Above: Three small areas of concern (DMEA Dump, Location BD-6, and the Smelter Stack ash, soil, and wood) have HIs ranging from 2 to 736 (Table 9-8). The DMEA Dump and Smelter Stack

media (ash in particular) may pose an unacceptable non-cancer hazard for one or both receptors under the exposure conditions evaluated.

It is unlikely that Location BD-6 poses an actual threat to human health because exposure potential is minimal. BD-6 is one of 24 soil samples collected at the Northwest Bradley iste rock dump. It had an unusually high level of antimony (16,400 mg/kg, compared to a maximum of 915 mg/kg and a 95% UCL concentration of 368 mg/kg for the other 23 samples). The arsenic level in this sample (4,790 mg/kg) is also twice as high as the 95% UCL concentration of 2,720 mg/kg for the other 23 samples. Because this location appears unique and only represents a very small fraction of the total area of the Northwest iste rock pile, the potential for exposure during reclamation or recreational activities at the northwest rock pile is extremely limited, and therefore the potential for unacceptable health hazards is also low.

9.10 LEAD EXPOSURE ASSESSMENT

There are no USEPA toxicity values for lead, so lead cannot be evaluated quantitatively in the same way as the other constituents (USEPA, 2000). Therefore, lead is evaluated by comparing to action levels or other health-protective criteria. Based on this evaluation (presented below), lead at the Site does not pose an unacceptable risk to human health.

Sampling results and exposure point concentrations for lead in soil, surface water, sediments, and fish are presented in Appendix B. Exposure point concentrations of lead in surface water in each exposure area are well below the federal action level for tap water level of 15 μg/L (USEPA, 1998a) and below the ambient water quality criteria (AWQC) level for protection of human health of 50 μg/L (USEPA, 1991c), indicating that lead is not a concern in surface water even if used as a drinking water source. Lead concentrations in soil, smelter stack ash and wood, and sediments are well below the USEPA default residential soil screening level of 400 mg/kg for protection of children (USEPA, 1994), with one exception: lead in soil in Location UW-1 (Upgradient Wetland) is 754 mg/kg.

USEPA (1996d) recommends using the Adult Lead Exposure Model for assessing lead risks and establishing cleanup goals that will protect the developing fetus of adult workers from adverse effects of exposure to lead in soil. The exposure frequency for miscellaneous small areas is 10 days for the reclamation worker and 1 day for the future recreational worker. The Adult Lead Exposure Model should not be used to evaluate exposure frequencies of less than 1 day/week or exposure durations of less than 90 days (USEPA, 1996d). Action levels derived using the model for lead in soil for adult commercial/industrial workers exposed for 219 days/year typically range from approximately 1200 to 1800 mg/kg. The USEPA Region IX Preliminary Remediation Goal for industrial workers exposed for 250 days/year to lead in soil is 1000 mg/kg. Exposure to 754 mg/kg lead in soil for 1 day, 10 days, or 250 days/year for a working lifetime is not expected to pose an unacceptable threat to adults or fetuses of adults exposed at the Site.

Lead is detected at a concentration of 0.06 mg/kg in one of six fish collected in the Northwest Dump, Glory Hole and EFSFSR area. Using the exposure point concentration for lead in fish in the Northwest Dump, Glory Hole and EFSFSR area of 0.042 mg/kg with the RME ingestion rate of 0.200 kg fish/day for the future recreational user, daily intake of lead from fish ingestion is predicted to be 0.0084 mg/day (0.200 kg fish/day x

0.042 mg lead/kg fish = 0.0084 mg lead/day), which is well below the Food and Drug Administration's (FDA's) provisional tolerable total intake level for adults of 0.075 mg lead per day (Carrington et al., 1993).

In conclusion, lead in soil, surface water, sediments, and fish at the Site does not pose an unacceptable risk to human health based on comparison with health-based criteria.

9.11 QUALITATIVE EVALUATION OF SURFACE WATER, GROUNDWATER, SEEP WATER, AND SUBSURFACE SOIL

This section compares concentrations of trace metals in surface water and groundwater to water quality criteria protective of public health (lifetime exposure). A screening-level risk evaluation for ingestion of seep water also is discussed.

9.11.1 SURFACE WATER COMPARED TO WATER QUALITY CRITERIA FOR PROTECTION OF HUMAN HEALTH

Table 9-23 compares surface water concentrations in the various surface water exposure areas to Idaho water quality standards for protection of human health (for consumption of water and fish and of fish only) (IDHW, 1998) and to federal MCLs for drinking water (USEPA 1998a). These criteria apply to lifetime exposure and to public water supplies. Therefore, results of the comparison must be interpreted with caution because these exposure conditions do not apply to the Stibnite Site.

In most surface water exposure areas evaluated, RME concentrations of antimony (8 to 127 µg/L) and arsenic (12 to 463 µg/L) exceed MCLs (6 µg/L antimony, 50 µg/L arsenic) and water quality criteria for consumption of water and fish (14 µg/L antimony, 0.018 µg/L arsenic). Antimony levels are below the Idaho numeric criterion for consumption of fish only (4300 µg/L); arsenic levels are above the Idaho numeric criterion for consumption of fish only (0.14 µg/L). Note that the RME surface water concentrations, except in the Keyway Wetland, are below federal water quality criteria for protection of freshwater aquatic life of 150 µg/L arsenic (recommended) (see Tables 7-4, 7-5, and 7-7).

Surface water is not a source of drinking water at the Stibnite Site or in the immediate vicinity downgradient of the Site. Therefore, although MCLs and ambient water quality criteria considered protective of lifetime consumption by humans were exceeded in 1999, the likelihood of an actual threat to health is low because the likelihood of long-term ingestion of the water is negligible.

9.11.2 GROUNDWATER COMPARED TO MCLs FOR DRINKING WATER

Table 9-24 compares concentrations of arsenic and antimony in groundwater to federal MCLs (USEPA 1998a) for drinking water (50 and 6 µg/L, respectively). Concentrations in most wells, whether in mining-impacted areas or not, exceed one or both federal MCLs for drinking water. These results indicate that the quality of untreated groundwater does not meet standards for an approved source of public water supply. However, groundwater at the Stibnite Site is not a source of drinking water, and therefore the exceedances

of arsenic and antimony MCLs do not represent an actual threat to health. (Note that the former camp well water is treated with carbon adsorption prior to use.)

9.11.3 RISK EVALUATION FOR SEEPS

Ingestion of seep water by humans is unlikely. Most seeps are seasonal, with low to moderate flows in spring, and many dry up by late summer. Many are not readily accessible, and the numerous creeks and streams on site provide more accessible, attractive, and plentiful water than do the seeps. Nevertheless, a screening-level risk evaluation is performed, as an indication of potential health effects associated with one-time ingestion of 500 mL of seep water (acute exposure). Arsenic is selected as the indicator for potential risk. Antimony is the other chief constituent observed in seep water samples (Draft SCR, Section 8.3). However, antimony is not included in the evaluation because its maximum concentration in most seeps is lower than or comparable to arsenic concentrations, the RfD for antimony is of similar magnitude to arsenic, the non-cancer effects of arsenic and antimony are not additive (see Section 9.7), and antimony is not a known or suspected carcinogen. Therefore, the health risks estimated for arsenic provide an adequate indication of overall risk from ingestion of seep water.

Table 9-25 shows HIs and cancer risk estimates for maximum concentrations of total arsenic observed in seep samples, assuming one-time ingestion of 500 mL of seep water. The table also compares the arsenic intake to the oral dose at which no adverse effects have been observed in humans (0.01 mg/kg-day) and the lowest short-term dose at which mild effects have been observed in sensitive individuals (0.02 mg/kg-day, mild gastrointestinal effects) (ATSDR, 1993a; 1993b).

Table 9-25 shows that in seeps in Meadow Creek Valley estimated cancer risk levels are between 6E-08 to 5E-06 (associated with maximum detected concentrations at SPMC-8, which emerges in an area of historic Bradley tailing deposits). Elsewhere, estimated excess cancer risks are below 6E-07. All excess cancer risk estimates are within or below USEPA's target acceptable risk range of 1E-06 to 1E-04.

Hazard indices range from 3 to 7 at most seeps. Exceptions are seeps affected by Bradley tailing (SPMC-2, -8, and -9, HIs between 44 and 259), SPMC-5, which emerges at the surface expression of the Meadow Creek Fault Zone (HI = 64), seeps at the Northwest Bradley iste rock dump (HI = 16), and seep SPHP-1 (Homestake Pit, HI = 32). All HIs are based on maximum observed concentrations and chronic RfDs.

HIs between 3 and 7, which apply to most seeps, are not considered to represent an actual threat to human health because (a) maximum observed concentrations are used in the calculation (HIs for average concentrations would be lower), (b) chronic RfDs protective of lifetime exposure are used (higher doses can probably be safely tolerated for short exposure durations, and (c) HIs do not indicate that an adverse effect will necessarily occur but only indicate potential cause for concern (USEPA 1989a). Furthermore, arsenic intake from these seeps is equal to or below the lowest levels reported to be associated with mild effects from short term exposure, as discussed in the next paragraph.

As shown in Table 9-25, except for certain seeps in Meadow Creek Valley, maximum intake of arsenic from ingestion of 500 mL of water does not exceed the dose of 0.01 mg/kg-day at which <u>no effects</u> have

been reported for short term exposures. At seep SPMC-5 (surface expression of the Meadow Creek Fault Zone), the maximum estimated arsenic dose exceeds the "no-effects" dose of 0.01 mg/kg-day but is lower than the dose of 0.02 mg/kg-day at which mild gastrointestinal effects have been reported. At the Bradley tailing seeps SPMC-2, -8, and -9, the highest concentrations are associated with doses above 0.02 mg/kg-day. These results suggest that occasional ingestion of as much as 0.5 L of seep water is not likely to be associated with significant adverse health effects, except for the maximum observed concentrations in seeps impacted by Bradley tailing.

9.11.4 EVALUATION OF SUBSURFACE SOIL EXPOSURE

Lower Meadow Creek Valley subsurface materials are mainly comprised of soil and tailings (0.5 to 10 ft below ground surface) at the Bradley Tailing Impoundment and in the Bradley Tailing Deposition Mapping Area (see Plate 1 and Figures 3-2 and 3-3). The tailings have been covered with neutralized ore, iste rock, Blowout Creek debris, and other fill materials. Human exposure to subsurface soil and tailings could only occur by digging activities, such as during construction, or in residential scenarios. Neither construction or residential homes are expected in the Lower Meadow Creek Valley in the foreseeable future for the following reasons.

- Because of the presence of the buried tailings, the Lower Meadow Creek Valley is not structurally sound for commercial and residential building.
- Because of the presence of the buried tailings, the Lower Meadow Creek Valley would pose an unacceptable risk to commercial and residential users, and is therefore unsuitable for commercial and residential purposes.
- Mining activities are in the process of closing down because economic feasibility is not expected to return in the foreseeable future.

Therefore, no human exposure to Lower Meadow Creek Valley subsurface soil is expected.

Subsurface soils in the Bradley iste rock dumps do not differ from surface soils because the Bradley iste rock dumps contain iste rock from the surface to the bottom of the dumps. Therefore, it is not necessary to evaluate Bradley iste rock dump subsurface soils separately.

9.12 QUALITATIVE UNCERTAINTY ANALYSIS

This section identifies the key uncertainties that may affect the numerical risk estimates and assesses their impact on the results and conclusions of the risk evaluation. The three chief areas of uncertainty with the potential to affect risk estimates and conclusions are:

- the exposure assumptions used in the evaluation;
- using chronic RfDs to characterize potential health effects from short-term exposures of 1 to 10 days; and
- using chronic exposure scenarios to characterize risk from main exposure areas to the future recreational user.

These are discussed below.

9.12.1 EXPOSURE ASSUMPTIONS

Exposure assumptions used in this evaluation may over- or underestimate actual exposure and risk for the receptors evaluated. However, conservative assumptions are made that are likely to overestimate actual exposure for the reclamation worker (80 days in the main exposure areas and wetlands; 10 days in miscellaneous small areas of concern) and for the recreational user in the main exposure areas and wetlands (12 days/year for 30 years; ingestion of 2L/day of surface water as drinking water). Recreational exposure to miscellaneous small areas of concern is assumed to occur on a one-time (or once-a-year) basis, to provide a guide to potential hazard from occasional contact. Therefore, the risk results are considered protective and suitable for supporting risk management decisions.

9.12.2 TOXICITY FACTORS USED TO EVALUATE SHORT-TERM EXPOSURE

RfDs for long-term (lifetime daily) exposure are used to characterize risk of short-term or acute exposure (1 to 10 days) at the small areas of concern because subchronic RfDs are not available for the principal site constituents. Consequently, actual non-cancer hazards at the miscellaneous small areas of concern where HIs ranged from 2 to 73 (and up to 736 at Smelter Stack ash) are probably overestimated by factors of 10 to 100, because doses substantially higher than chronic RfDs may have no harmful effect under short-term exposure conditions.

For example, except for Smelter Stack ash, the maximum oral dose of arsenic in any area was 0.008 mg/kg-day (reclamation worker ingestion of DMEA Dump soil). An intake of 0.008 mg/kg-day is 27 times higher than the chronic RfD of 0.0003 mg/kg-day (HI = 27). However, it is lower than the oral dose at which no adverse effects have been observed in humans with short-term exposure (0.01 mg/kg-day) and the dose for which mild gastrointestinal effects have been reported for sensitive individuals (0.02 mg/kg-day) (ATSDR, 1993a, 1993b). Therefore, risk from short-term exposure at the miscellaneous small areas of concern is likely to be substantially lower than implied by the magnitude of the HIs. While the likelihood of lower risk does not obviate a potential cause for concern, it may affect the consideration of risk management options at the miscellaneous small areas of concern.

9.12.3 FUTURE RECREATIONAL USER ONE-TIME EXPOSURE IN MAIN EXPOSURE AREAS AND WETLANDS

Non-cancer risk to the future recreational user did not account for an acute one-time exposure (1 day) to the main exposure areas and wetlands. An acute one-time exposure (ED=1 year, EF=1 day/year, and AT=1 day) would result in a non-cancer risk approximately 30 to 50 times greater than the non-cancer risk calculated for the chronic risk scenario (ED=30 years, EF=12 days/year, AT=10950 days). However, acute one-time exposures for the future recreational user are not expected to have harmful effects.

For example, the maximum acute oral arsenic doses in any of the main exposure areas and wetlands are 0.013 mg/kg-day ([0.463 mg/L arsenic x 2 L surface water/day x 1 day/year x 1 year]/[1 day x 70 kg]) for

future recreational user ingestion of keyway wetland surface water and 0.001 mg/kg-day ([5630 mg/kg arsenic x 6.25 mg soil/hour x 2 hour/day x 1 day/year x 1 year x 1E-06 kg/mg]/[1 day x 70 kg]) for future recreational user ingestion of Northeast Bradley iste rock soil. Both these doses are lower than the oral dose for which only mild gastrointestinal effects have been reported for sensitive individuals (0.02 mg/kg-day). The soil dose also is lower than the oral dose at which no adverse effects have been observed in humans with acute exposure (0.01 mg/kg-day) (ATSDR, 1993a; 1993b). Therefore, one-time exposures for the future recreational user in the main exposure areas and wetlands are not expected to have harmful effects.

9.13 SUMMARY AND CONCLUSIONS

The human health risk assessment evaluated potential human health risk for reclamation workers and recreational users assumed to be exposed to multiple media (soil, sediment, surface water, and fish) in nine exposure areas and five miscellaneous small areas of concern. The exposure areas include several subareas and wetlands within Meadow Creek Valley, the EFSFSR, (including tributaries), the Glory Hole, and the Bradley iste rock dumps. Miscellaneous small areas of concern include the smelter stack, DMEA Dump, BTO, and two sample locations with unique characteristics (i.e., UW-1 in the Meadow Creek Upgradient Wetland and sample location BD-6 in the Northwest Bradley iste rock dump).

Groundwater, surface water, and seep water are evaluated qualitatively for suitability as drinking water sources. Subsurface materials (e.g., tailing deposits) related to historic mining and milling operations in Meadow Creek Valley are also evaluated qualitatively for potential human exposure.

Reclamation workers are assumed to work for 80 days (one season) at any one of the nine exposure areas and for 10 days at the miscellaneous small areas of concern. Recreational users are assumed to visit for 12 days/year for 30 years at any one of the nine exposure areas and to have one-time contact at the small areas of concern. Exposure routes evaluated are soil ingestion, dermal contact, and inhalation; sediment ingestion; surface water ingestion and dermal contact; and fish ingestion.

9.13.1 SUMMARY OF HEALTH RISK RESULTS

Cancer risk and non-cancer HIs are calculated for each inorganic, receptor, and exposure area using standard USEPA methodologies. Results are compared to USEPA's generally acceptable cancer risk range of 1E-06 to 1E-04 and to an HI of 1. HIs above 1 indicate a potential cause for concern for non-cancer effects but do not indicate that an adverse effect will necessarily occur.

The only constituents that contributed significantly to overall health risk estimates are antimony, arsenic, and, at the Smelter Stack area, mercury. Because the toxic effects of these chemicals are different, that is, they affect different endpoints in the body, the non-cancer effects are not additive (USEPA 1989a). Therefore, HIs are reported for each constituent separately, and maximum HIs are listed in this summary.

Human health risk results are shown in Table 9-8 and summarized below.

- Cancer risk estimates are within or less than USEPA's acceptable cancer risk range of 1E-06 to 1E-04, for all scenarios evaluated, except for the recreational user at the Keyway Wetland (CR = 3E-04).
- It is unlikely that recreational exposure at the Keyway Wetland poses an unacceptable risk of cancer under realistic exposure conditions. The cancer risk estimate of 3E-04 assumed ingestion of wetland water at a rate of 2 L/day, 12 days/year, for 30 years, which is unrealistically conservative for this exposure area. Considering a lower, but still conservative, rate of exposure (for example, ingestion of 1 L/day for 5 days/year for 30 years), the excess cancer risk would be 6E-05, which is within EPA's generally acceptable range.
- HIs ranged from less than 1 to 4 in all exposure areas, except for three miscellaneous small areas of concern. There is a low probability of unacceptable health hazard at exposure areas with HIs of 5 or less due to the conservative estimates of exposure frequency and duration and chronic toxicity values (applicable to lifetime exposure) that are used in estimating non-cancer hazard.
- Maximum constituent-specific HIs are 10 or above for one or both receptors at three miscellaneous small areas of concern:
  - DMEA Dump (reclamation worker HI = 34; recreational user HI = 10), primarily due to ingestion and dermal absorption of arsenic in the dump material. The DMEA Dump poses a potential non-cancer health hazard under the exposure assumptions evaluated.
  - The smelter stack ash (reclamation worker HI = 736, recreational user HI = 226), soil at the smelter stack (reclamation worker HI = 14; recreational user HI = 4); and flume wood (reclamation worker HI = 8, recreational user HI = 2). Antimony, arsenic, and mercury contributed to HIs above 1 at this area. The smelter stack materials pose a potential non-cancer health hazard under the exposure assumptions evaluated.
  - Location BD-6 at the Northwest Bradley iste rock (reclamation worker HI = 73, recreational visitor HI = 22), due to ingestion and dermal absorption of antimony and arsenic at this sample location. In spite of the magnitude of the HIs, there is a low probability of actual health risk because exposure potential is minimal (the maximum HI for the rest of the Northwest Bradley iste rock dump area is 3).

Table 9-26 summarizes the exposure areas ranked by relative risk levels. Areas with very low to no potential for unacceptable health risk under the exposure conditions evaluated are:

- BT/NO Disposal Area
- Meadow Creek Mine Hillside
- Upgradient Wetland, including Location UW-1
- Lower Meadow Creek Valley
- Keyway Wetland
- Meadow Creek Forested Wetland
- EFSFSR, Southeast Bradley iste rock, and Midnight Creek
- Glory Hole, EFSFSR, Northwest Bradley waste rock, and Hennessey Creek
- Northeast Bradley iste rock and Sugar Creek
- Bailey Tunnel Outlet (incidental ingestion of surface water)

- Location BD-6 (Northwest Bradley waste rock sample location)

Two miscellaneous small areas of concern pose a potential for unacceptable non-cancer health effects under the exposure conditions evaluated:

- DMEA Dump (both receptors) and
- Smelter Stack ash (both receptors); Smelter Stack soil and flume wood (reclamation worker)

9.13.2 SURFACE WATER AND GROUNDWATER AS DRINKING WATER

In most surface water exposure areas evaluated (Table 9-23), concentrations of antimony (8 to 127 μg/L) and arsenic (12 to 463 μg/L) exceeded MCLs for drinking water and water quality criteria for consumption of water and fish. Levels of arsenic, but not antimony, also exceeded the Idaho numeric criterion for consumption of fish only.

These exceedances of water quality criteria applicable to lifetime consumption by humans do not represent an actual threat to health at the Stibnite Site because:

- no unacceptable health risk is estimated in the risk assessment for incidental ingestion of surface water, for ingestion of surface water as drinking water by recreational users (except for drinking 2 L/day at Keyway Wetland), or for fish ingestion, and
- the likelihood of lifetime or long-term consumption is negligible.

In groundwater (Table 9-24), concentrations of antimony and arsenic in most wells, whether in mining-impacted areas or not, exceeded one or both federal MCLs for drinking water. These results indicate that the quality of untreated groundwater does not meet standards for an approved source of public water supply. However, groundwater at the Stibnite Site is not a source of drinking water, and therefore, exceedances of arsenic and antimony MCLs do not represent an actual threat to health under current conditions.

9.13.3 SEEPS

A screening-level evaluation of arsenic in seep water ingestion is performed as a guide to potential health concerns, if small amounts of seep water are ingested on a one-time basis.

At most seeps, no significant health hazards are identified for ingestion of 500 mL of seep water because maximum estimated arsenic doses are equal to or below a dose at which no effects have been reported in humans from short term exposures (Table 9-25). At seeps impacted by Bradley tailing, maximum estimated arsenic does are up to 4 times higher than the dose at which mild gastrointestinal effects have been reported in humans (0.02 mg/kg-day). Cancer risk estimates at all seeps are within or below USEPA's generally acceptable risk range of 1E-06 to 1E-04.

9.13.4 SUBSURFACE SOIL IN MEADOW CREEK VALLEY

Human exposure to subsurface soil in the Lower Meadow Creek Valley could occur through construction activities and in residential scenarios. However, construction activities and residential activities are not expected in the Lower Meadow Creek Valley for the following reasons:

- The presence of buried tailings make the Lower Meadow Creek Valley unsuitable, both structurally and from a risk perspective, for commercial and residential buildings.
- Mining activities are not expected to occur in the foreseeable future.

Therefore, no human exposure to Lower Meadow Creek Valley subsurface soil is expected.

9.13.5 HEALTH RISK CONCLUSIONS

The human health risk assessment identified very low to no potential for unacceptable health risk at all main exposure areas and wetlands and most miscellaneous small areas of concern under the exposure conditions evaluated. This conclusion is based on HIs and excess cancer risk levels within USEPA acceptable ranges, or consideration of conservative assumptions that affect the interpretation of the numerical risk results if results somewhat exceeded the targets (e.g., HIs <5).

Two miscellaneous small areas of concern (the DMEA Dump and smelter stack) pose a potential for unacceptable non-cancer health effects under the exposure conditions evaluated, based on HIs of 10 or above for the soil ingestion and dermal absorption pathways.

Surface water and groundwater concentrations of arsenic and antimony exceed drinking water MCLs or other quality criteria protective of lifetime consumption of water and or fish. However, the risk assessment calculations show no unacceptable health risk for ingestion of surface water or fish under the exposure conditions evaluated (with the possible exception of Keyway Wetland water ingested at a rate of 2 L/day in the recreational scenario). Furthermore, neither surface water nor groundwater is used as a source of water at the site.

There appears to be no significant health hazards associated with short-term ingestion exposure to seeps, except possibly for seeps emerging from Bradley tailing deposits in lower Meadow Creek Valley where mild effects may be experienced.

There is no health hazard associated with Lower Meadow Creek Valley subsurface soil because no human exposure is expected.

Table 9-1

Intake Assumptions
Reclamation Worker

Soil Intake Factors (kg soil/kg BW-day)

Ingestion = (IS x EF x ED x CFs) / (AT x BW)
Dermal Contact = (SA x AF x AB x EF x ED x CFs)/(AT x BW)

Air Particulate Intake Factor (kg soil/kg BW-day)

Inhalation = (IN x ETair x EF x ED)/ (AT x BW x PEF)

Sediment Intake Factors (kg sediment/kg BW-day)

Ingestion = (ISD x ETsed x EF x ED x CFs) / (AT x BW)

Surface Water Intake Factors (L water/kg BW-day)

Ingestion = (ISW x ETsw x EF x ED x CFw) / (AT x BW)
Dermal Contact = (SA x PC x ETsw x EF x ED x CFw)/(AT x BW)

	Intake Parameter	RME
IS:	Ingestion Rate, soil (mg/day) (1)	100
ISD:	Ingestion Rate, sediments (mg/hour) (2)	10
ISW:	Ingestion Rate, surface water (mL/hour) (3)	1
IN	Inhalation Rate, air (m^3/hr) (4)	3.5
PEF:	Particulate Emission Factor (m^3/kg) (5)	1.32E+09
SA:	Skin Surface Area (cm^2/day for soil, cm^2 for water) (6)	5000
AF:	Adherence Factor, soil (mg/cm^2) (7)	0.1
AB:.	Absorption Factor (unitless) (8)	chem-specific
PC:	Aqueous Permeability Constant (cm/hour) (9)	chem-specific
ETair:	Exposure Time (hours/day) (10)	10
ETsw:	Exposure Time, surface water (hours/day) (11)	4
ETsed:	Exposure Time, sediment (hours/day) (11)	4
EF:	Exposure Frequency (days/year) (12)	80
ED:	Exposure Duration (years) (13)	1
CFs:	Conversion Factor, soil and sediment (kg/mg)	1E-06
CFw:	Conversion Factor, water (L/ml or cm^3)	1E-03
BW:	Body Weight (kg) (14)	70
AT:	Averaging Time (days) (15)	
	Noncarcinogenic	365
	Carcinogenic	25,550

RME = Reasonable Maximum Exposure

(1) Soil Ingestion Rate: The 100 mg/day RME value was derived using data from Hawley (1985) and a site-specific dermal adherence factor (see text).

(2) Sediment Ingestion Rate: The sediment ingestion rate of 10 mg/hour is based on a worker soil ingestion rate of 100 mg/day, divided by 10 working hours/day.

(3) Surface Water Ingestion Rate: USEPA (1989a) recommends a 50-mL/hour ingestion rate for swimmers. Reclamation workers are assumed to be exposed to surface water only while wading across or constructing in streams at the site. Therefore, a 1-mL/hour ingestion rate is estimated, assuming that accidental splashing or hand-to-face contact will result in ingestion of a small amount of water that is not removed by wiping or spitting.

(4) Inhalation Rate: 3.5 m^3/hour for outdoor workers (USEPA, 1997a).

(5) Particulate Emission Factor: USEPA default value for 90th percentile (high end) wind erosion and particulate dispersion (USEPA, 1996b; EQM, 1994).

(6) Skin Surface Area: Central tendency value for outdoor activities (25% of body surface area exposed); Table 6-16 of Exposure Factors Handbook, Volume 1 (USEPA 1997a).

Table 9-1

Intake Assumptions
Reclamation Worker

(7) Adherence Factor, soil: USEPA default value for gardeners (USEPA Region X, 1998).

(8) Absorption Factor: Chemical-specific values are in Table 4-5 of Region X guidance (USEPA Region X, 1998).

(9) Aqueous Permeability Constant: Chemical-specific values are in Table 2 of EPA Dermal Risk Assessment Guidance (USEPA 1998b).

(10) Exposure Time, air: Assumes a 10-hour workday.

(11) Exposure Time, surface water and sediment: Assumes 4 working hours/day are spent in surface water/sediments.

(12) Exposure Frequency: Based on 5 days/ week for 4 weeks for 4 months (1 season to accomplish reclamation work).

(13) Exposure Duration: Reclamation work is assumed to be completed in one season (mid June - mid Oct).

(14) Body Weight: Average adult body weight (USEPA, 1989a).

(15) Averaging Time: Noncarcinogens = ED expressed in days. Carcinogens = 70-year lifetime expressed in days.

Table 9-2

Intake Assumptions
Future Recreational User

Soil Intake Factor (kg soil/kg BW-day)

Ingestion = (IS x ETsoil x EF x ED x CFs) / (AT x BW)
Dermal Contact = (SA x AF x AB x EF x ED x CFs)/(AT x BW)

Air Particulate Intake Factor (kg soil/kg BW-day)

Inhalation = (IN x ETsoil x EF x ED)/ (AT x BW x PEF)

Sediment Intake Factors (kg sediment/kg BW-day)

Ingestion = (IS x ETsed x EF x ED x CFs) / (AT x BW)

Surface Water Intake Factors (L water/kg BW-day)

Ingestion = (ISW x EF x ED) / (AT x BW)
Dermal Contact = (SA x PC x ETsw x EF x ED x CFw)/(AT x BW)

	Intake Parameter	RME
IS:	Ingestion Rate, soil or sediments (mg/hour)(1)	6.25
ISW:	Ingestion Rate, surface water (L/day) (2)	2
IN:	Inhalation Rate, air (m^3/hour) (3)	1
PEF:	Particulate Emission Factor (m^3/kg) (4)	1.32E+09
SA:	Skin Surface Area (cm^2/day for soil, cm^2 for water) (5)	5000
AF:	Adherence Factor, soil (mg/cm^2) (6)	0.1
AB:.	Absorption Factor (unitless) (7)	chem-specific
PC:	Aqueous Permeability Constant (cm/hour) (8)	chem-specific
ETsoil:	Exposure Time, soil (hours/day) (9)	2
ETsw:	Exposure Time, surface water (hours/day) (10)	4
ETsed:	Exposure Time, sediments (hours/day) (10)	4
EF:	Exposure Frequency (days/years) (11)	12
ED:	Exposure Duration (years) (12)	30
CFs:	Conversion Factor, soil and sediments (kg/mg)	1E-06
CFw:	Conversion Factor, water (L/ml or cm^3)	1E-03
BW:	Body Weight (kg) (13)	70
AT:	Averaging Time (days) (14)	
	Noncarcinogenic	10,950
	Carcinogenic	25,550

RME = Reasonable Maximum Exposure

(1) Ingestion Rate, soil or sediments: Based on USEPA default soil ingestion rate of 100 mg/day for adult residents, divided by 16 waking hours.

(2) Ingestion Rate, surface water: USEPA standard default values for RME residential water ingestion, assuming that untreated surface water is the sole source of drinking water.

(3) Inhalation Rate: Inhalation rate assumes "typical" outdoor activity with 7% heavy activity at 1.9 m^3/hour, 37% moderate activity at 1.2 m^3/hour, 28% light activity at 1.0 m^3/hour, and 28% resting at 0.3 m^3/hour for an adult (Exposure Factors Handbook, USEPA, 1989b; Review Draft Exposure Factors Handbook, USEPA, 1996a).

(4) Particulate Emission Factor: USEPA default value for 90th percentile (high end) wind erosion and particulate dispersion (USEPA, 1996b; EQM, 1994).

(5) Skin Surface Area: Central tendency value for outdoor activities (25% of body surface area exposed); Table 6-16 of Exposure Factors Handbook, Volume 1 (USEPA 1997a).

(6) Adherence Factor, soil: USEPA default value for gardeners (USEPA Region X, 1998).

Table 9-2

Intake Assumptions
Future Recreational User

(7) Absorption Factor: Chemical-specific values are in Table 4-5 of Region X guidance (USEPA Region X, 1998).

(8) Aqueous Permeability Constant: Chemical-specific values are in Table 2 of EPA Dermal Risk Assessment Guidance (USEPA 1998b).

(9) Exposure Time, soil: Assumes 2 hours/day are spent in contact with soil in investigation areas at the Site. This rate is considered reasonable because the areas being evaluated constitute only a small fraction of the area that a hunter, hiker, or fisherman would be exposed to during recreational pursuits.

(10) Exposure Time, sediments/surface water: Assumes 4 hours/day are spent at activities in or around surface water bodies (e.g., wading, fishing).

(11) Exposure Frequency: Based on the U.S. Department of the Interior's (USDOI) National Survey of Fishing, Hunting, and Wildlife-Associated Recreation of 1991 for Idaho (average of 12 days/year for hunting and 11 days/year for fishing) (USDOI, 1993, Table 3).

(12) Exposure Duration: USEPA standard default RME value for residents (USEPA, 1989a, 1993a).

(13) Body Weight: Average adult body weight (USEPA, 1989a).

(14) Averaging Time: Noncarcinogens = ED expressed in days. Carcinogens = 70-year lifetime expressed in days.

Table 9-3

Intake Assumptions
Recreational User Consumption of Fish

Fish Intake Factor (kg fish/kg BW-day)

Ingestion = (IF x DF x EF x ED x CFf) / (AT x BW)

	Intake Parameter	RME
IF:	Fish Ingestion Rate (g/day) (1)	200
DF:	Diet Fraction from contaminated source (unitless) (2)	1
EF:	Exposure Frequency, Future Recreational User (days/years) (3)	12
ED:	Exposure Duration (years) (4)	30
CFf:	Conversion Factor, fish (kg/g)	1E-03
BW:	Body Weight (kg) (5)	70
AT:	Averaging Time (days) (6)	
	Noncarcinogenic	10,950
	Carcinogenic	25,550

RME = Reasonable Maximum Exposure

(1) RME fish ingestion rate assumes eating two fish caught at the site per meal, at 3.5 oz per dressed fish, and 28.35 g/oz (ATSDR 1989, Table 9 and page 8).

(2) Diet fraction: FC = 1 assumes that all fish consumed are caught within the Stibnite site.

(3) Exposure frequency: Based on the Department of the Interior's (DOI) National Survey of Fishing, Hunting, and Wildl Associated Recreation of 1991 for Idaho (average of 12 days/year for hunting and 11 days/year for fishing) (USDOI, 1993, Table 3).

(4) Exposure duration: USEPA standard default RME value for residents (USEPA, 1989a, 1993b).

(5) Body weight: Average adult body weight (USEPA, 1989a).

(6) Averaging time: Noncarcinogens = ED expressed in days. Carcinogens = 70-year lifetime expressed in days.

Table 9-4

Intake Assumptions
Reclamation Worker at Miscellaneous Small Areas

Soil Intake Factors (kg soil/kg BW-day)

Ingestion = (IS x EF x ED x CFs) / (AT x BW)
Dermal Contact = (SA x AF x AB x EF x ED x CFs)/(AT x BW)

Air Particulate Intake Factor (kg soil/kg BW-day)

Inhalation = (IN x ET x EF x ED)/ (AT x BW x PEF)

Surface Water Intake Factors (L water/kg BW-day)

Ingestion = (ISW x ET x EF x ED x CFw) / (AT x BW)
Dermal Contact = (SA x PC x ET x EF x ED x CFw)/(AT x BW)

	Intake Parameter	RME
IS:	Ingestion Rate, soil (mg/day) (1)	100
ISW:	Ingestion Rate, surface water (mL/hour) (2)	1
IN	Inhalation Rate, air (m^3/hr) (3)	3.5
PEF:	Particulate Emission Factor (m^3/kg) (4)	1.32E+09
SA:	Skin Surface Area (cm^2/day for soil, cm^2 for water) (5)	5000
AF:	Adherence Factor, soil (mg/cm^2) (6)	0.1
AB:.	Absorption Factor (unitless) (7)	chem-specific
PC:	Aqueous Permeability Constant (cm/hour) (8)	chem-specific
ET	Exposure Time (hours/day) (9)	10
EF:	Exposure Frequency (days/year) (10)	10
ED:	Exposure Duration (years) (11)	1
CFs:	Conversion Factor, soil (kg/mg)	1E-06
CFw:	Conversion Factor, water (L/ml or cm^3)	1E-03
BW:	Body Weight (kg) (12)	70
AT:	Averaging Time (days) (13)	
	Noncarcinogenic	10
	Carcinogenic	25,550

RME = Reasonable Maximum Exposure

(1) Soil Ingestion Rate: The 100 mg/day RME value was derived using data from Hawley (1985) and a site-specific dermal adherence factor (see text).

(2) Surface Water Ingestion Rate: USEPA (1989a) recommends a 50-mL/hour ingestion rate for swimmers. Reclamation workers are assumed to be exposed to surface water only while wading across or constructing in streams at the site. Therefore, a 1-mL/hour ingestion rate is estimated, assuming that accidental splashing or hand-to-face contact will result in ingestion of a small amount of water that is not removed by wiping or spitting.

(3) Inhalation Rate: 3.5 m^3/hour for outdoor workers (USEPA, 1997a).

(4) Particulate Emission Factor: USEPA default value for 90th percentile (high end) wind erosion and particulate dispersion (USEPA, 1996b; EQM, 1994).

(5) Skin Surface Area: Based on central tendency value for outdoor activities (25% of body surface area exposed); Table 6-16 of Exposure Factors Handbook, Volume 1 (USEPA 1997a).

(6) Adherence Factor, soil: USEPA default value for gardeners (USEPA Region X, 1998).

(7) Absorption Factor: Chemical-specific values are in Table 4-5 of Region X guidance (USEPA Region X, 1998).

(8) Aqueous Permeability Constant: Chemical-specific values are in Table 2 of EPA Dermal Risk Assessment guidance (USEPA 1998b).

(9) Exposure Time: Assumes a 10-hour workday.

(10) Exposure Frequency: EF assumes 10 days of reclamation activity at the miscellaneous small area of concern.

(11) Exposure Duration: Reclamation work is assumed to be completed in one season (mid June - mid Oct).

(12) Body Weight: Average adult body weight (USEPA, 1989a).

(13) Averaging Time: Noncarcinogens = EF. Carcinogens = 70-year lifetime expressed in days.

Table 9-5

Intake Assumptions
Future Recreational Exposure at Miscellaneous Small Areas

Soil Intake Factor (kg soil/kg BW-day)

Ingestion = (IS x ET x EF x ED x CFs) / (AT x BW)
Dermal Contact = (SA x AF x AB x EF x ED x CFs)/(AT x BW)

Air Particulate Intake Factor (kg soil/kg BW-day)

Inhalation = (IN x ET x EF x ED)/ (AT x BW x PEF)

Surface Water Intake Factors (L water/kg BW-day)

Ingestion = (ISW x EF x ED) / (AT x BW)
Dermal Contact = (SA x PC x ETsw x EF x ED x CFw)/(AT x BW)

	Intake Parameter	RME
IS:	Ingestion Rate, soil (mg/hour)(1)	6.25
ISW:	Ingestion Rate, surface water (L/day) (2)	0.1
IN:	Inhalation Rate, air (m^3/hour) (3)	1
PEF:	Particulate Emission Factor (m^3/kg) (4)	1.32E+09
SA:	Skin Surface Area (cm^2/day for soil, cm^2 for water) (5)	5000
AF:	Adherence Factor, soil (mg/cm^2) (6)	0.1
AB:.	Absorption Factor (unitless) (7)	chem-specific
PC:	Aqueous Permeability Constant (cm/hour) (8)	chem-specific
ET	Exposure Time (hours/day) (9)	2
EF:	Exposure Frequency (days/years) (10)	1
ED:	Exposure Duration (years) (10)	1
CFs:	Conversion Factor, soil and sediments (kg/mg)	1E-06
CFw:	Conversion Factor, water (L/ml or cm^3)	1E-03
BW:	Body Weight (kg) (11)	70
AT:	Averaging Time (days) (12)	
	Noncarcinogenic	1
	Carcinogenic	25,550

RME = Reasonable Maximum Exposure

(1) Ingestion Rate, soil : Based on USEPA default soil ingestion rate of 100 mg/day for adult residents, divided by 16 waking hours.

(2) Ingestion Rate, surface water: 100 mL/day is a worst-case assumption for consuming water at Bailey Tunnel Outlet and stagnant water at location UW-1.

(3) Inhalation Rate: Inhalation rate assumes "typical" outdoor activity with 7% heavy activity at 1.9 m^3/hour, 37% moderate activity at 1.2 m^3/hour, 28% light activity at 1.0 m^3/hour, and 28% resting at 0.3 m^3/hour for an adult (Exposure Factors Handbook, USEPA, 1989b; Review Draft Exposure Factors Handbook, USEPA, 1996a).

(4) Particulate Emission Factor: USEPA default value for 90th percentile (high end) wind erosion and particulate dispersion (USEPA, 1996b; EQM, 1994).

(5) Skin Surface Area: Based on central tendency value for outdoor activities (25% of body surface area exposed); Table 6-16 of Exposure Factors Handbook, Volume 1 (USEPA 1997a).

(6) Adherence Factor, soil: USEPA default value for gardeners (USEPA Region X, 1998).

(7) Absorption Factor: Chemical-specific values are in Table 4-5 of Region X guidance (USEPA Region X, 1998).

(8) Aqueous Permeability Constant: Chemical-specific values are in Table 2 of EPA Dermal Risk Assessment guidance (USEPA 1998b).

(9) Exposure Time: Assumes 2 hours/day are spent at the miscellaneous small area of concern.

(10) Exposure Frequency and Exposure Duration: Assumes the recreational user visits the miscellaneous small area of concern once. See risk characterization text for discussion of more frequent exposures.

(11) Body Weight: Average adult body weight (USEPA, 1989a)

(12) Averaging Time: Noncarcinogens = EF. Carcinogens = 70-year lifetime expressed in days.

Table 9-6

Intake Factor Values for Human Health Risk Assessment

Receptor	Pathway	Intake Factor (Non-Carcinogens) RME	Intake Factor (Carcinogens) RME
Reclamation Worker (1)	Soil Ingestion	3.13E-07	4.47E-09
	Soil Dermal Contact	1.57E-06	2.24E-08
	Inhalation (Particulate Matter)	8.30E-11	1.19E-12
	Sediment Ingestion	1.25E-07	1.79E-09
	Surface Water Dermal Contact	6.26E-02	8.95E-04
	Surface Water Ingestion	1.25E-05	1.79E-07
Reclamation Worker at Miscellaneous Small Areas (2)	Soil Ingestion	1.43E-06	5.59E-10
	Soil Dermal Contact	7.14E-06	2.80E-09
	Inhalation (Particulate Matter)	3.79E-10	1.48E-13
	Surface Water Dermal Contact	7.14E-01	2.80E-04
	Surface Water Ingestion	1.43E-04	5.59E-08
Future Recreational User (3)	Soil Ingestion	5.87E-09	2.52E-09
	Soil Dermal Contact	2.35E-07	1.01E-07
	Inhalation (Particulate Matter)	7.12E-13	3.05E-13
	Sediment Ingestion	1.17E-08	5.03E-09
	Surface Water Dermal Contact	9.39E-03	4.03E-03
	Surface Water Ingestion	9.39E-04	4.03E-04
	Fish Ingestion	9.39E-05	4.03E-05
Future Recreational User at Miscellaneous Small Areas (4)	Soil Ingestion	1.79E-07	6.99E-12
	Soil Dermal Contact	7.14E-06	2.80E-10
	Inhalation (Particulate Matter)	2.16E-11	8.47E-16
	Surface Water Dermal Contact	1.43E-01	5.59E-05
	Surface Water Ingestion	1.43E-03	5.59E-08

(1)Intake factor values calculated using equations and parameter values on Table 9-2.
(2)Intake factor values calculated using equations and parameter values on Table 9-5.
(3)Intake factor values calculated using equations and parameter values on Tables 9-3 and 9-4.
(4)Intake factor values calculated using equations and parameter values on Table 9-6.

Table 9-7

Toxicity Factors for Human Health Risk Assessment

Chemical	RfDo	Source	Oral GI Absorption Factor	Source	RfDd[7]	RfDi	Source	SFo	Source	SFd[8]	SFi	Source	Weight--Of-Evidence Cancer Classification	Source
Aluminum	1.00E+00	NCEA[1]	2.00E-01	Region 10	2.00E-01	1.40E-03	NCEA	-	-	-	-	-	-	-
Antimony	4.00E-04	IRIS	2.00E-01	Region 10	8.60E-05	-	-	-	-	-	-	-	-	-
Arsenic	3.00E-04	IRIS	9.50E-01	EPA	2.85E-04	-	-	1.50E+00	IRIS	3.66E+00	1.50E+01	IRIS	A; human carcinogen	IRIS
Cadmium	1.00E-03	IRIS	2.50E-02	IRIS	2.50E-05	-	-	-	-	-	6.30E+00	IRIS	B1; probable human carcinogen	IRIS
Chromium III	1.50E+00	IRIS	2.00E-01	Region 10	3.00E-01	-	-	-	-	-	-	-	-	-
Copper	3.70E-02	HEAST	2.00E-01	Region 10	7.40E-03	-	-	-	-	-	-	-	D; not classifiable	IRIS
Cyanide	2.00E-02	IRIS[2]	2.00E-01	Region 10	4.00E-03	-	-	-	-	-	-	-	D; not classifiable	IRIS
Lead	-	-	-	-	-	-	-	-	-	-	-	-	B2; probable human carcinogen	IRIS
Manganese (water)	4.70E-02	IRIS	2.00E-01	Region 10	9.40E-03					-			D; not classifiable	IRIS
Manganese (soil and sediment)	1.40E-01	IRIS	2.00E-01	Region 10	2.80E-02	1.40E-05	IRIS	-	-	-	-	-	D; not classifiable	IRIS
Mercury	3.00E-04	IRIS[3]	2.00E-01	Region 10	6.00E-05	8.60E-05	IRIS[4]	-	-	-	-	-	C; possible human carcinogen	IRIS
Methyl mercury	1.00E-04	IRIS	9.00E-01	Region 10	9.00E-05	-	-	-	-	-	-	-	C; possible human carcinogen	IRIS
Nickel	2.00E-02	IRIS[5]	2.00E-01	Region 10	4.00E-03	-	-	-	-	-	8.40E-01	IRIS[6]	A; human carcinogen	IRIS
Selenium	5.00E-03	IRIS	2.00E-01	Region 10	1.00E-03	-	-	-	-	-	-	-	D; not classifiable	IRIS
Silver	5.00E-03	IRIS	2.00E-01	Region 10	1.00E-03	-	-	-	-	-	-	-	D; not classifiable	IRIS
Zinc	3.00E-01	IRIS	2.00E-01	Region 10	6.00E-02	-	-	-	-	-	-	-	D; not classifiable	IRIS

IRIS - Integrated Risk Information System, on-line database (USEPA, 2000)
HEAST - Health Effects Assessment Summary Tables (USEPA, 1997b)
NCEA - National Center for Environmental Assessment
(1)Provisional RfDo for aluminum obtained from the NCEA (USEPA, 1992b)
(2)RfDo value for free cyanide
(3)RfDo value for mercuric chloride
(4)RfDi value for elemental mercury
(5)RfDo value for nickel, soluble salts
(6)SFi value for nickel refinery dust
(7)RfDd calculated by multiplying oral GI absorption factor by RFDs.
(8)Sfd calculated by dividing Sfo by oral GI absorption factor.
- = not available

Region X - Default values for metals from Interim Final Guidance; Developing Risk-Based Cleanup Levels at Resource Conservation and Recovery Act Sites in Region 10 (USEPA Region X, 1998).
EPA - Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual Supplemental Guidance Dermal Risk Assessment Interim Guidance (USEPA, 1998b).

Table 9-8

Human Health Risk Results Summary

Exposure Area	Reclamation Worker HI (1)	Reclamation Worker CR	Recreational User HI (1)	Recreational User CR	Risk Drivers
Meadow Creek Valley					
BT/NO Disposal Area	1	8E-06	0.07	1E-05	
Meadow Creek Mine Hillside	1	7E-06	0.05	1E-05	
Lower Meadow Creek Valley	Sb = 1 As = 0.8	5E-06	0.5	3E-05	Antimony, arsenic (nc): Soil ingestion and dermal absorption.
Upgradient Wetland	0.04	1E-07	0.002	2E-07	
Keyway Wetland	1	4E-06	As = 1	**3E-04**	Arsenic (nc, c): Surface water ingestion
Meadow Creek Forested Wetland	**Sb = 2** **As = 1**	6E-06	0.10	9E-06	Antimony, arsenic (nc): Soil ingestion and dermal absorption.
EFSFSR and Tributaries					
EFSFSR, SE Dump, and Midnight Cr.	**As = 4**	3E-05	0.7	7E-05	Arsenic (nc): Soil ingestion and dermal absorption.
Glory Hole, EFSFSR, NW Dump, Hennessey Cr	**As = 3**	2E-05	0.6	7E-05	Arsenic (nc): Soil ingestion, dermal absorption, sediment ingestion.
NE Dump, Sugar Creek	**As = 4**	3E-05	0.30	5E-05	Arsenic: Soil ingestion and dermal absorption
Miscellaneous Small Areas of Concern					
Location UW-1 (Upgradient Wetland)	**Sb = 4** **As = 4**	8E-07	**Sb = 1** **As = 3**	5E-08	Antimony, arsenic (nc): Soil and surface water: ingestion, dermal absorption.
DMEA Dump	**As = 34**	6E-06	**As = 10**	2E-07	Arsenic: Soil ingestion and dermal absorption.
Location BD-6 (NW Waste Rock)	**Sb = 73** **As = 17**	3E-06	**Sb = 22** **As = 5**	9E-08	Antimony and arsenic (nc): Soil ingestion and dermal absorption.
BTO	**Sb = 3** **As = 2**	3E-07	**Sb = 2** **As = 3**	5E-08	Antimony and arsenic (nc): Surface water ingestion and dermal absorption.
Smelter Stack Soil	**As = 14** **Hg = 3**	2E-06	**As = 4**	7E-08	Arsenic (nc), mercury: Soil ingestion and dermal absorption
Smelter Stack Ash	**Sb = 28** **As = 736** **Hg = 18**	1E-04	**Sb = 8** **As = 226** **Hg = 6**	4E-06	Antimony, arsenic (nc), mercury: Ash ingestion and dermal absorption.
Smelter Stack Wood	**Sb = 3** **As = 8**	1E-06	**Sb = 0.9** **As = 2**	4E-08	Antimony and arsenic (nc): Wood ingestion and dermal absorption.

(1) Noncancer effects of arsenic, antimony, and mercury are not additive. Therefore, HIs for each are shown separately if they exceeded 1.

HI = Hazard Index for noncancer effects. CR = Cancer risk.

nc = noncancer effects c = cancer effects.

Sb = antimony. As = arsenic. Hg = mercury.

Table 9-9

Summary of Human Health Non-Cancer Hazard and Cancer Risk
Bradley Tailings Impoundment and Neutralized Ore Disposal Area

Receptor/Pathway	RME	
	HI	CR
Reclamation Worker		
Worker Soil Ingestion	1.13E+00	6.52E-06
Worker Soil Dermal	2.96E-01	1.72E-06
Worker Inhalation of Particulates	2.71E-03	2.89E-08
Reclamation Worker Total(1)	1E+00	9E-06
Future Recreational User		
Soil Ingestion	2.11E-02	3.67E-06
Soil Dermal	4.44E-02	7.72E-06
Inhalation of Particulates	2.32E-05	7.43E-09
Future Recreational User Total(1)	6E-02	1E-05

RME = Reasonable Maximum Exposure
HI = Hazard Index
CR = Cancer Risk

(1) Total HIs and CRs are expressed with one significant figure, in accordance with USEPA guidelines (USEPA, 1989a).

Table 9-10

Summary of Health Risks
Non-Cancer Hazard and Cancer Risk
Meadow Creek Mine Hillside

Receptor/Pathway	RME	
	HI	CR
Reclamation Worker		
Worker Soil Ingestion	9.35E-01	5.88E-06
Worker Soil Dermal	2.46E-01	1.55E-06
Worker Inhalation of Particulates	1.02E-02	2.60E-08
Reclamation Worker Total[(1)]	1E+00	7E-06
Future Recreational User		
Soil Ingestion	1.75E-02	3.31E-06
Soil Dermal	3.69E-02	6.96E-06
Inhalation of Particulates	8.72E-05	6.68E-09
Future Recreational User Total[(1)]	5E-02	1E-05

RME = Reasonable Maximum Exposure
HI = Hazard Index
CR = Cancer Risk
(1) Total HIs and CRs are expressed with one significant figure, in accordance with USEPA guidelines (USEPA, 1989a).

Table 9-11

Summary of Health Risks
Non-Cancer Hazard and Cancer Risk
Lower Meadow Creek Valley

Receptor/Pathway	RME	
	HI	CR
Reclamation Worker		
Worker Soil Ingestion	1.64E+00	3.84E-06
Worker Soil Dermal	4.18E-01	1.01E-06
Worker Inhalation of Particulates	2.04E-03	1.70E-08
Worker Sediment Ingestion	2.89E-02	1.45E-07
Woker Surface Water Ingestion	1.71E-03	8.67E-09
Worker Surface Water Dermal	1.62E-02	4.56E-08
Reclamation Worker Total(1)	2E+00	5E-06
Reclamation Worker Chemical-Specific HI(2)		
Antimony	1E+00	
Arsenic	8E-01	
Future Recreational User		
Soil Ingestion	3.07E-02	2.16E-06
Soil Dermal	6.26E-02	4.55E-06
Inhalation of Particulates	1.74E-05	4.37E-09
Sediment Ingestion	2.71E-03	4.09E-07
Surface Water Ingestion	1.28E-01	1.95E-05
Surface Water Dermal	2.43E-03	2.05E-07
Fish Ingestion	2.43E-01	4.40E-06
Future Recreational User Total(1)	5E-01	3E-05

RME = Reasonable Maximum Exposure
HI = Hazard Index
CR = Cancer Risk

(1) Total HIs and CRs are expressed with one significant figure, in accordance with USEPA guidelines (USEPA, 1989a).

(2) Non-cancer effects of antimony, arsenic, and mercury are not additive (Section 9.7, Toxicity Assessment)

Table 9-12

Summary of Health Risks
Non-Cancer Hazard and Cancer Risk
Meadow Creek Upgradient Wetland

Receptor/Pathway	RME	
	HI	CR
Reclamation Worker		
Worker Soil Ingestion	2.99E-02	9.82E-08
Worker Soil Dermal	7.69E-03	2.58E-08
Worker Inhalation of Particulates	3.79E-03	4.55E-10
Woker Surface Water Ingestion	5.73E-06	0.00E+00
Worker Surface Water Dermal	1.43E-04	0.00E+00
Reclamation Worker Total(1)	4E-02	1E-07
Future Recreational User		
Soil Ingestion	5.61E-04	5.53-08
Soil Dermal	1.15E-03	1.16E-07
Inhalation of Particulates	3.25E-05	1.17E-10
Surface Water Ingestion	4.29E-04	0.00E+00
Surface Water Dermal	2.15E-05	0.00E+00
Future Recreational User Total(1)	2E-03	2E-07

RME = Reasonable Maximum Exposure
HI = Hazard Index
CR = Cancer Risk
(1) Total HIs and CRs are expressed with one significant figure, in accordance with USEPA guidelines (USEPA, 1989a).

Table 9-13

Summary of Health Risks
Non-Cancer Hazard and Cancer Risk
Keyway Wetland

Receptor/Pathway	RME	
	HI	CR
Reclamation Worker		
Worker Soil Ingestion	6.64E-01	2.55E-06
Worker Soil Dermal	1.71E-01	6.72E-07
Worker Inhalation of Particulates	2.15E-03	1.13E-08
Woker Surface Water Ingestion	2.35E-02	1.24E-07
Worker Surface Water Dermal	2.07E-01	6.54E-07
Reclamation Worker Total[(1)]	1E+00	4E-06
Future Recreational User		
Soil Ingestion	1.24E-02	1.44E-06
Soil Dermal	2.57E-02	3.02E-06
Inhalation of Particulates	1.85E-05	2.90E-09
Surface Water Ingestion	1.76E+00	2.80E-04
Surface Water Dermal	3.10E-02	2.94E-06
Future Recreational User Total[(1)]	2E+00	3E-04
Future Recreational UserChemical-Specific HI[(2)]		
Arsenic	1.00E+00	

RME = Reasonable Maximum Exposure
HI = Hazard Index
CR = Cancer Risk

(1) Total HIs and CRs are expressed with one significant figure, in accordance with USEPA guidelines (USEPA, 1989a).

(2) Non-cancer effects of antimony, arsenic, and mercury are not additive (Section 9.7, Toxicity Assessment)

Table 9-14

Summary of Health Risks
Non-Cancer Hazard and Cancer Risk
Meadow Creek Forested Wetland

Receptor/Pathway	RME	
	HI	CR
Reclamation Worker		
Worker Soil Ingestion	2.00E+00	4.95E-06
Worker Soil Dermal	5.10E-01	1.30E-06
Worker Inhalation of Particulates	3.21E-03	2.19E-08
Reclamation Worker Total[(1)]	3E+00	6E-06
Reclamation Worker Chemical-Specific HI[(2)]		
Antimony	2E+00	
Arsenic	1E+00	
Future Recreational User		
Soil Ingestion	3.75E-02	2.79E-06
Soil Dermal	7.65E-02	5.86E-06
Inhalation of Particulates	2.75E-05	5.63E-09
Future Recreational User Total[(1)]	1E-01	9E-06

RME = Reasonable Maximum Exposure
HI = Hazard Index
CR = Cancer Risk

(1) Total HIs and CRs are expressed with one significant figure, in accordance with USEPA guidelines (USEPA, 1989a).

(2) Non-cancer effects of antimony, arsenic, and mercury are not additive (Section 9.7, Toxicity Assessment)

Table 9-15

Summary of Health Risks
Non-Cancer Hazard and Cancer Risk
EFSFSR Above Midnight Creek and Southeast Dump

Receptor/Pathway	RME	
	HI	CR
Reclamation Worker		
Worker Soil Ingestion	3.12E+00	2.00E-05
Worker Soil Dermal	8.21E-01	5.27E-06
Worker Inhalation of Particulates	3.61E-03	8.84E-08
Worker Sediment Ingestion	2.03E-02	9.08E-08
Woker Surface Water Ingestion	3.65E-03	1.55E-08
Worker Surface Water Dermal	4.37E-02	8.15E-08
Reclamation Worker Total[(1)]	4E+00	3E-05
Reclamation Worker Chemical-Specific HI[(2)]		
Arsenic	4E+00	
Future Recreational User		
Soil Ingestion	5.85E-02	1.13E-05
Soil Dermal	1.23E-01	2.37E-05
Inhalation of Particulates	3.09E-05	2.27E-08
Sediment Ingestion	1.90E-03	2.55E-07
Surface Water Ingestion	2.74E-01	3.48E-05
Surface Water Dermal	6.55E-03	3.67E-07
Fish Ingestion	2.43E-01	4.40E-06
Future Recreational User Total[(1)]	7E-01	7E-05

RME = Reasonable Maximum Exposure
HI = Hazard Index
CR = Cancer Risk

(1) Total HIs and CRs are expressed with one significant figure, in accordance with USEPA guidelines (USEPA, 1989a).

(2) Non-cancer effects of antimony, arsenic, and mercury are not additive (Section 9.7, Toxicity Assessment)

Table 9-16

Summary of Health Risks
Non-Cancer Hazard and Cancer Risk
EFSFSR Below Midnight Creek, Glory Hole, and Northwest Dump

Receptor/Pathway	RME	
	HI	CR
Reclamation Worker		
Worker Soil Ingestion	1.99E+00	1.09E-05
Worker Soil Dermal	5.21E-01	2.88E-06
Worker Inhalation of Particulates	1.97E-03	4.83E-08
Worker Sediment Ingestion	4.29E-01	2.45E-06
Woker Surface Water Ingestion	3.33E-03	1.58E-08
Worker Surface Water Dermal	3.45E-02	8.33E-08
Reclamation Worker Total[1]	3E+00	2E-05
Reclamation Worker Chemical-Specific HI[2]		
Arsenic	3E+00	
Future Recreational User		
Soil Ingestion	3.74E-02	6.15E-06
Soil Dermal	7.81E-02	1.30E-05
Inhalation of Particulates	1.69E-05	1.24E-08
Sediment Ingestion	4.02E-02	6.89E-06
Surface Water Ingestion	2.50E-01	3.56E-05
Surface Water Dermal	5.18E-03	3.75E-07
Fish Ingestion	1.47E-01	4.46E-06
Future Recreational User Total[1]	6E-01	7E-05

RME = Reasonable Maximum Exposure
HI = Hazard Index
CR = Cancer Risk

(1) Total HIs and CRs are expressed with one significant figure, in accordance with USEPA guidelines (USEPA, 1989a).

(2) Non-cancer effects of antimony, arsenic, and mercury are not additive (Section 9.7, Toxicity Assessment)

Table 9-17

Summary of Health Risks
Non-Cancer Hazard and Cancer Risk
Northeast Dump and Sugar Creek

Receptor/Pathway	RME	
	HI	CR
Reclamation Worker		
Worker Soil Ingestion	3.55E+00	2.27E-05
Worker Soil Dermal	9.33E-01	5.96E-06
Worker Inhalation of Particulates	2.78E-03	1.00E-07
Worker Sediment Ingestion	1.37E-02	6.10E-08
Woker Surface Water Ingestion	7.75E-04	3.22E-09
Worker Surface Water Dermal	9.48E-03	1.70E-08
Reclamation Worker Total[1]	5E+00	3E-05
Reclamation Worker Chemical-Specific HI[2]		
Arsenic	4E+00	
Future Recreational User		
Soil Ingestion	6.65E-02	1.27E-05
Soil Dermal	1.40E-01	2.68E-05
Inhalation of Particulates	2.39E-05	2.58E-08
Sediment Ingestion	1.28E-03	1.72E-07
Surface Water Ingestion	5.81E-02	7.25E-06
Surface Water Der mal	1.42E-03	7.63E-08
Future Recreational User Total[1]	3E-01	5E-05

RME = Reasonable Maximum Exposure
HI = Hazard Index
CR = Cancer Risk

(1) Total HIs and CRs are expressed with one significant figure, in accordance with USEPA guidelines (USEPA, 1989a).

(2) Non-cancer effects of antimony, arsenic, and mercury are not additive (Section 9.7, Toxicity Assessment)

Table 9-18

Summary of Health Risks
Non-Cancer Hazard and Cancer Risk
Location UW-1 (Meadow Creek Upgradient Wetland)

Receptor/Pathway	RME	
	HI	CR
Reclamation Worker		
Worker Soil Ingestion	5.32E+00	4.95E-07
Worker Soil Dermal	1.37E+00	1.30E-07
Worker Inhalation of Particulates	9.45E-03	2.19E-09
Woker Surface Water Ingestion	1.75E-01	2.65E-08
Worker Surface Water Dermal	1.41E+00	1.37E-07
Reclamation Worker Total(1)	8E+00	8E-07
Reclamation Worker Chemical-Specific HI(2)		
Antimony	4E+00	
Arsenic	4E+00	
Future Recreational User		
Soil Ingestion	6.65E-01	6.18E-09
Soil Dermal	1.37E+00	1.30E-08
Inhalation of Particulates	5.40E-04	1.25E-11
Surface Water Ingestion	1.75E+00	2.65E-08
Surface Water Dermal	2.82E-01	2.79E-08
Future Recreational User Total(1)	4E+00	5E-08
Future Recreational User Chemical-Specific HI(2)		
Antimony	1E+00	
Arsenic	3E+00	

RME = Reasonable Maximum Exposure
HI = Hazard Index
CR = Cancer Risk

(1) Total HIs and CRs are expressed with one significant figure, in accordance with USEPA guidelines (USEPA, 1989a).

(2) Non-cancer effects of antimony, arsenic, and mercury are not additive (Section 9.7, Toxicity Assessment)

Table 9-19

Summary of Health Risks
Non-Cancer Hazard and Cancer Risk
Smelter Stack

Receptor/Pathway	RME	
	HI	CR
Reclamation Worker (Soil)		
Worker Soil Ingestion	1.40E+01	1.89E-06
Worker Soil Dermal	3.65E+00	4.97E-07
Worker Inhalation of Soil Particulates	1.57E-02	8.34E-09
Reclamation Worker Total (Soil)(1)	2E+01	2E-06
Reclamation Worker Chemical-Specific Soil(2)		
Arsenic	1.40E+01	--
Mercury	3.00E+00	--
Reclamation Worker (Ash)		
Worker Ash Ingestion	6.20E+02	1.03E-04
Worker Ash Dermal	1.63E+02	2.70E-05
Worker Inhalation of Ash Particulates	1.41E-02	4.54E-07
Reclamation Worker Total (Ash)(1)	8E+02	1E-04
Reclamation Worker Chemical-Specific Ash(2)		
Antimony	2.80E+01	--
Arsenic	7.36E+02	--
Mercury	1.80E+01	--
Reclamation Worker (Wood)		
Worker Wood Ingestion	8.71E+00	1.11E-06
Worker Wood Dermal	2.26E+00	2.91E-07
Worker Inhalation of Wood Particulates	6.21E-04	4.89E-09
Reclamation Worker Total (Wood)(1)	1E+01	1E-06
Reclamation Worker Chemical-Specific Wood(2)		
Antimony	3.00E+00	--
Arsenic	8.00E+00	--
Reclamation Worker Total(1)	8E+02	1E-04
Future Recreational User (Soil)		
Soil Ingestion	1.76E+00	2.36E-08
Soil Dermal	3.65E+00	4.97E-08
Inhalation of Soil Particulates	8.99E-04	4.77E-11
Future Recreational User Total (Soil)(1)	5E+00	7E-08
Future Recreational User Chemical-Specific Soil(2)		
Arsenic	4.00E+00	--
Mercury	1.00E+00	--
Future Recreational User (Ash)		
Ash Ingestion	7.75E+01	1.28E-06
Ash Dermal	1.63E+02	2.70E-06
Inhalation of Ash Particulates	8.07E-04	2.59E-09
Future Recreational User Total (Ash)(1)	2E+02	4E-06

Table 9-20

Summary of Health Risks
Non-Cancer Hazard and Cancer Risk
DMEA Dump

Receptor/Pathway	RME	
	HI	CR
Reclamation Worker		
Worker Soil Ingestion	2.71E+01	4.67E-06
Worker Soil Dermal	7.14E+00	1.25E-06
Worker Inhalation of Particulates	2.52E-02	2.10E-08
Reclamation Worker Total[1]	3E+01	6E-06
Reclamation Worker Chemical-Specific HI[2]		
Arsenic	3.4E+01	--
Future Recreational User		
Soil Ingestion	3.39E+00	5.95E-08
Soil Dermal	7.14E+00	1.25E-06
Inhalation of Particulates	1.44E-03	1.20E-10
Future Recreational User Total[1]	1E+01	2E-07
Future Recreational User Chemical-Specific HI[2]		
Arsenic	1.00E+01	--

RME = Reasonable Maximum Exposure
HI = Hazard Index
CR = Cancer Risk

(1) Total HIs and CRs are expressed with one significant figure, in accordance with USEPA guidelines (USEPA, 1989a).

(2) Non-cancer effects of antimony, arsenic, and mercury are not additive (Section 9.7, Toxicity Assessment)

Table 9-21

Summary of Health Risks
Non-Cancer Hazard and Cancer Risk
Location BD-6 (Northwest Dump)

Receptor/Pathway	RME	
	HI	CR
Reclamation Worker		
Worker Soil Ingestion	7.23E+01	2.41E-06
Worker Soil Dermal	1.83E+01	6.34E-07
Worker Inhalation of Particulates	5.43E-03	1.07E-08
Reclamation Worker Total[1]	9E+01	3E-06
Reclamation Worker Chemical-Specific HI[2]		
Antimony	7.3E+01	--
Arsenic	1.7E+01	--
Future Recreational User		
Soil Ingestion	9.04E+00	3.01E-08
Soil Dermal	1.83E+01	6.34E-08
Inhalation of Particulates	3.10E-04	6.09E-11
Future Recreational User Total[1]	3E+01	9E-08
Future Recreational User Chemical-Specific HI[2]		
Antimony	2.2E+01	--
Arsenic	5.00E+00	--

RME = Reasonable Maximum Exposure
HI = Hazard Index
CR = Cancer Risk

(1) Total HIs and CRs are expressed with one significant figure, in accordance with USEPA guidelines (USEPA, 1989a).

(2) Non-cancer effects of antimony, arsenic, and mercury are not additive (Section 9.7, Toxicity Assessment)

Table 9-22

Summary of Health Risks
Non-Cancer Hazard and Cancer Risk
Bailey Tunnel Outlet

Receptor/Pathway	RME	
	HI	CR
Reclamation Worker		
Worker Surface Water Ingestion	3.56E-01	4.49E-08
Worker Surface Water Dermal	3.86E+00	2.36E-08
Reclamation Worker Total[1]	4E+00	3E-07
Reclamation Worker Chemical-Specific HI[2]		
Antimony	3E+00	--
Arsenic	2E+00	--
Future Recreational User		
Surface Water Ingestion	3.56E+00	4.49E-08
Surface Water Dermal	7.73E-01	4.96E-09
Future Recreational User Total[1]	4E+00	5E-08
Future Recreational User Chemical-Specific HI[2]		
Antimony	2E+00	--
Arsenic	3E+00	--

RME = Reasonable Maximum Exposure
HI = Hazard Index
CR = Cancer Risk

(1) Total HIs and CRs are expressed with one significant figure, in accordance with USEPA guidelines (USEPA, 1989a).

(2) Non-cancer effects of antimony, arsenic, and mercury are not additive (Section 9.7, Toxicity Assessment)

Table 9-23

Comparison of Surface Water Concentrations to Criteria for Protection of Human Health [1]

Analyte	Numeric Criteria for Toxic Substances: Human Health [2] Consumption (µg/L)		MCLs for Drinking Water (µg/L)		RME Total Concentration in Surface Water (1999) (µg/L)					
	Water and Fish	Fish Only	MCL	Form	Lower Meadow Creek Valley	Upgradient Wetland	Keyway Wetland	EFSFS and Midnight Creek	Glory Hole and EFSFS	Sugar Creek
Antimony	14	4300	6	Total	11	ND	127	39	27	8.3
Arsenic	0.018	0.14	50	Total	32	ND	463	58	59	12
Cadmium	-	-	5	Total	ND	ND	ND	ND	ND	ND
Chromium (III)	-	-	100	Total	ND	ND	ND	ND	ND	ND
Copper	-	-	1300	Total	2	1.7	ND	ND	ND	ND
Lead	-	-	15	Total	1.4	1.0	ND	4.6	0.32	ND
Mercury	0.14	0.15	2	Total	0.054	ND	0.12	0.13	0.39	0.26
Nickel	610	4600	140	Total	ND	ND	ND	ND	14	ND
Cyanide, WAD	700	220,000	200	Total	2.3	2.1	5.6	2.1	ND	ND

(1) Constituents that have criteria and that were analyzed for and detected are included in the table.

(2) IDHW, 1998; USEPA 1997c, 40 CFR 131.36. Criteria are based on an excess cancer risk of 1E-06 and a hazard quotient of 1.

(3) Reasonable maximum exposure concentrations, from Appendix B. Reference stations and miscellaneous small areas of concern are not included.

[11 in box] Exceeds one or more criteria.

ND = Not detected.
MCL = Maximum Contaminant Level
RME = Reasonable Maximum Exposure
µg/L = micrograms per liter

Table 9-24
Arsenic and Antimony in Groundwater Compared to MCLs (1997 and 1999 Data) (1)
μg/L

Areas Considered Not Impacted by Mining Activities	Well Name	Dissolved Arsenic (2) MCL = 50 ug/L	Dissolved Antimony (2) MCL = 6 ug/L
Garnet Creek, Midnight Creek	MW96-3, MW96-9	107 - 146	47 – 50
West End Creek	MW96-11	76 - 96	10
EFSFSR	LA-1, Former Camp Wells	28 - 55	22 - 33, 112 - 138 *
Upgradient Meadow Creek Valley	SOBR-1, -2, -3; HEC-4A	<8	<5 – 40
Meadow Creek Mine Hillside (3)	UG-1, UG-2	833 - 1,200	14 – 50
Areas in Meadow Creek Valley with Bradley Tailing Deposits			
In or just below tailing	CW-2B, GAI-MW-4, HEC-1, UK-1, MW-1B	1,190 - 13,800	30 - 1,990
Below tailing	CW-2A, CW-4, CW-5A; HEC-2, HEC-3D; MW-2A	335 - 4,530	6 - 24, 675 - 985 (HEC-3D)
Undetermined screen depth	GAI- MW-3, HEC-3C, HEC-5, HEC-6, HEC-7, MW-1A,	194 - 2,580	6 - 3,070
Other Locations			
Lower Meadow Creek Valley	SOBR-4, CW-3, MW-3A, MW-4A	< 3 - 51	2 – 21
EFSFSR just below Meadow Cr.	EW-10, MW-9, LA-2, LA-3	4 - 83, 226 - 266 (LA-2)	3 – 71

(1) Groundwater sample results are shown in the SCR Tables 8.2-6 through 8.2-11 (for dissolved metals) and in the SCR Appendix B (dissolved and total metals).
(2) Results from filtered samples are shown in this table because data are readily available for review in summary tables in Section 8.2 of the SCR. Results from unfiltered samples are generally comparable to or somewhat higher than results from filtered samples (see Appendixes B3 and B4 of the SCR).
(3) Wells UG-1 and UG-2 are above the former SMI leach pads. Well UG-1 is near disturbed areas from historic Meadow Creek Mine operations. Well UG-2 was a designated reference well in the site characterization program. Water quality in these wells could reflect natural mineralization of the nearby fault zones or effects of mining activities.

MCL = Federal maximum contaminant level for drinking water (EPA, 1998a).
* Former Primary Camp Well
SCR = Site Characterization Report

Table 9-25

Risk Evaluation for Arsenic in Seep Water

Chronic RfDo	SFo	Ingestion Rate, L	Intake Factor (nc) (1)	Intake Factor (c) (1)
3.00E-04	1.50E+00	0.5	7.14E-03	2.80E-07

Meadow Creek Valley	Arsenic Max. Conc., mg/L (2)	HI (3)	CR (3)	Arsenic Intake, mg/kg-day (4) 0.5 L of seep water	> 0.01? (5)	> 0.02? (5)
SPMC-1, -3, -4, -7, -10: Meadow Creek Valley	0.145	3	6.09E-08	0.001	N	
SPMC-2, -8, -9: Bradley Tailing						
Low Max	1.86	44	7.81E-07	0.013	Y	N
High Max	10.9	259	4.58E-06	0.078	Y	Y
SPMC-5: Meadow Creek Fault/ Mine	2.7	64	1.13E-06	0.019	Y	N
Glory Hole, EFSFSR, and Bradley Waste Rock						
SPGH-1, -2, -4, -5, -8: Glory Hole West	0.073	2	3.07E-08	0.001	N	
SPGH-6: Seep-fed pool above EFSFSR	0.287	7	1.21E-07	0.002	N	
SPGH-3, -7, -9: Glory Hole East	0.152	4	6.38E-08	0.001	N	
SPNW-1, -2: NW Bradley dump	0.666	16	2.80E-07	0.005	N	
Other Seeps						
SPGC-1: Garnet Creek	0.292	7	1.23E-07	0.002	N	
SPEF-3: Below DMEA Dump	0.184	4	7.73E-08	0.001	N	
SPHP-1: Homestake Pit	1.34	32	5.63E-07	0.010	N	

(1) Noncancer intake factor = 0.5 L/ (70 kg x 1 day). Cancer intake factor = 0.5 L / (70 kg x 25,550 days).
(2) Total concentrations from Appendix B.3, SCR.
(3) HI (hazard index) = Conc. x Intake Factor (nc) / RfDo.
(4) Arsenic Intake = noncancer intake factor x Conc.
(5) 0.01 and 0.02 mg/kg-day are no observed (mild) effects and lowest observed effects levels for arsenic in humans for short-duration exposures (see Section 9.12).

SCR = Site Characterization Report
CR (cancer risk) = Conc. x Intake Factor (c) x SFo.

mg/kg = milligrams per kilogram
nc = noncancer
c = cancer
RFD_o = Oral reference dose

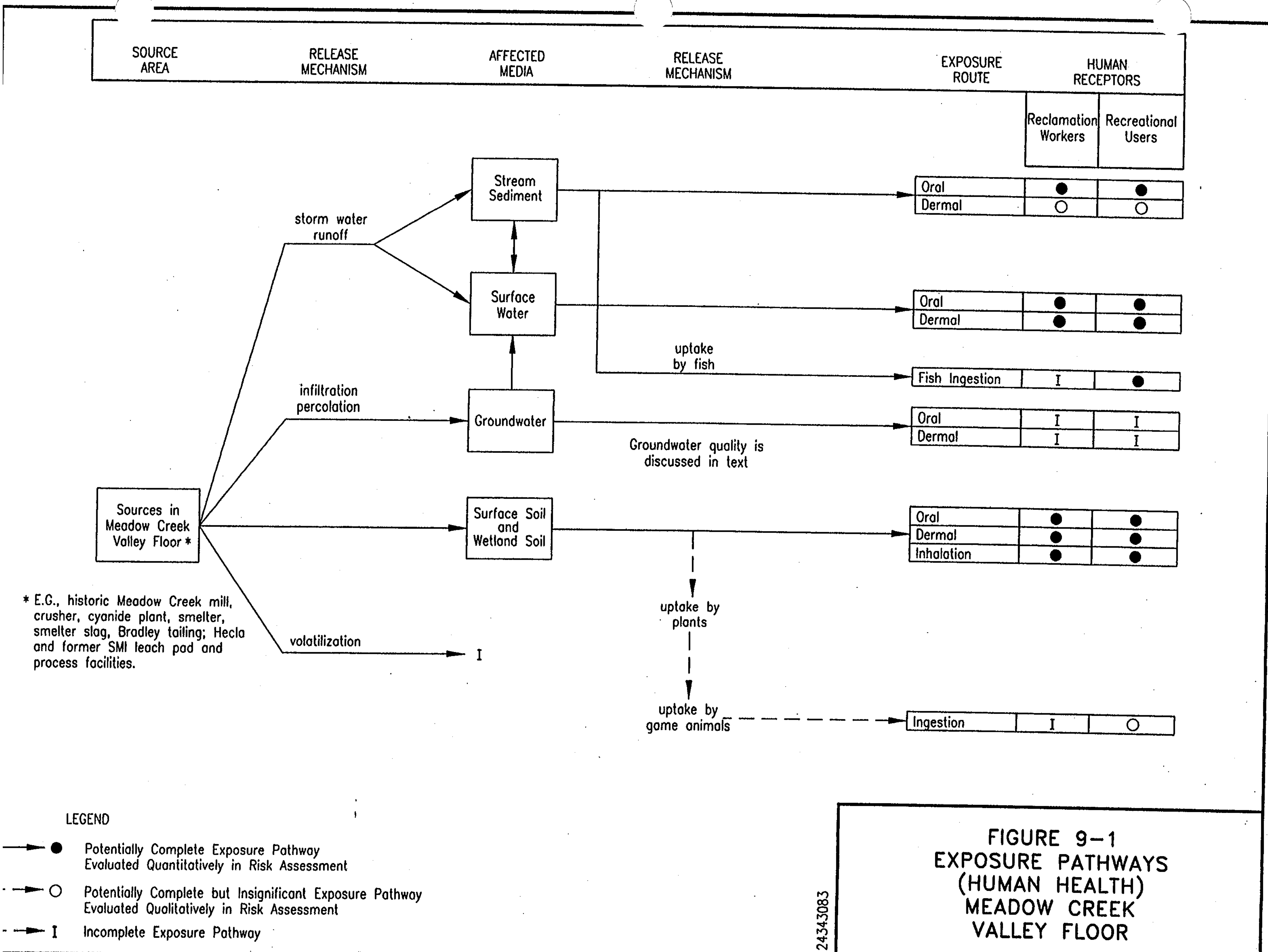
SF_o = oral slope factor
Max. Conc. = Maximum Concentration
Y = Yes
N = No

Table 9-26

Exposure Area Ranking by Risk Level (Human Health)

No unacceptable risk (1)	Reclamation Worker	Recreational User
BT/NO Disposal Area	No unacceptable risk (1)	No unacceptable risk (1)
Meadow Creek Mine Hillside	No unacceptable risk (1)	No unacceptable risk (1)
Upgradient Wetland	No unacceptable risk (1)	No unacceptable risk (1)
Lower Meadow Creek Valley	No unacceptable risk (1)	No unacceptable risk (1)
Low Probability of Actual Health Threat (2) (3)	**Reclamation Worker**	**Recreational User**
Keyway Wetland	No unacceptable risk (1)	Max HI = 1; CR of 3E-04 is probably overestimated by assuming ingestion of 2 L/day, 12 day/yr, for 30 yr.
Meadow Creek Forested Wetland	Max HI = 2; CR < 1E-04.	No unacceptable risk (1)
EFSFSR, SE Dump, and Midnight Cr.	Max HI = 4; CR < 1E-04.	No unacceptable risk (1)
Glory Hole, EFSFSR, NW Dump, Hennessey Cr	Max HI = 3; CR < 1E-04.	No unacceptable risk (1)
NE Dump, Sugar Creek	Max HI = 4; CR < 1E-04.	No unacceptable risk (1)
Location UW-1 (Upgradient Wetland)	Max HI = 4; CR < 1E-04.	Max HI = 3; CR < 1E-04.
BTO	Max HI = 3; CR < 1E-04.	Max HI = 3; CR < 1E-04.
Location BD-6 (NW Waste Rock) (3)	Max HI = 73	Max HI = 22
Potential Unacceptable Risk (4)	**Reclamation Worker**	**Recreational User**
Smelter Stack Ash	Max HI = 736	Max HI = 226
Smelter Stack Soil	Max HI = 14	Max HI = 4. Low probability of risk; see note 2.
Smelter Stack Wood	Max HI = 8	Max HI = 2. Low probability of risk; see note 2.
DMEA Dump	HI = 34	HI = 10

(1) HI </= 1 (total HI, or maximum HI considering non-additive toxic endpoints); CR </= 1E-04.
(2) HIs of 5 or less were considered to represent a low potential of actual health threat because:
(a) HIs above 1 do not indicate that an adverse effect will occur but only indicate potential cause for concern (USEPA 1989a);
(b) the exposure assumptions for both receptors are likely to overestimate actual magnitude of exposure; and
(c) chronic RfDs for lifetime exposure were used to assess risk from short-term and acute exposures; higher doses can be tolerated for short-term exposures.
(3) Exposure potential is minimal at BD6 (one sample in 24 at the NW Bradley waste rock). Therefore, there is a low probability of an actual threat to human health. See text.
(4) HIs are sufficiently above 1 that there may be cause for concern for adverse health effects under the exposure conditions evaluated.
HI = Hazard Index for noncancer effects.
CR = Cancer risk



24343083

FIGURE 9-1
EXPOSURE PATHWAYS
(HUMAN HEALTH)
MEADOW CREEK
VALLEY FLOOR

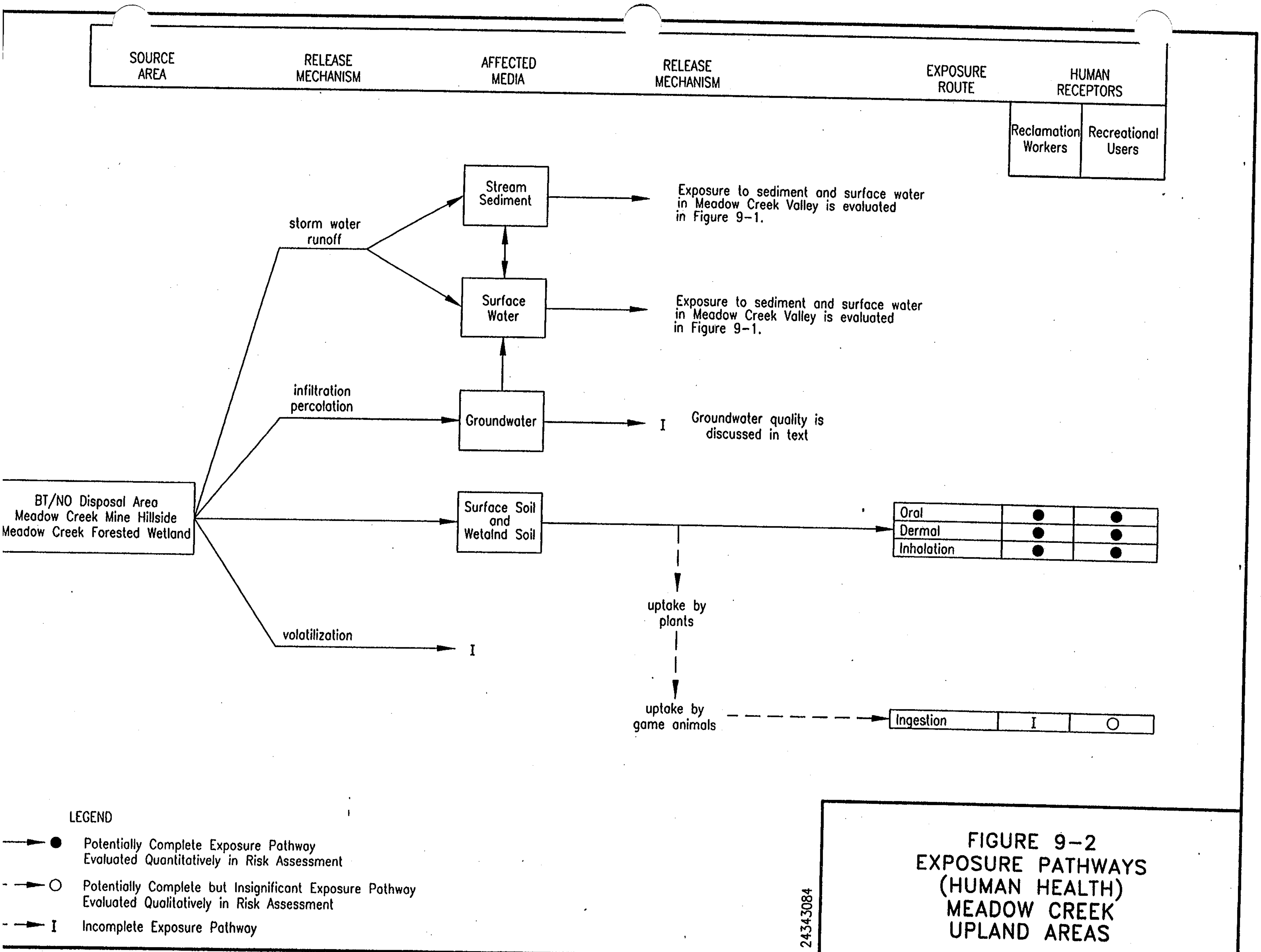


FIGURE 9-2
EXPOSURE PATHWAYS
(HUMAN HEALTH)
MEADOW CREEK
UPLAND AREAS

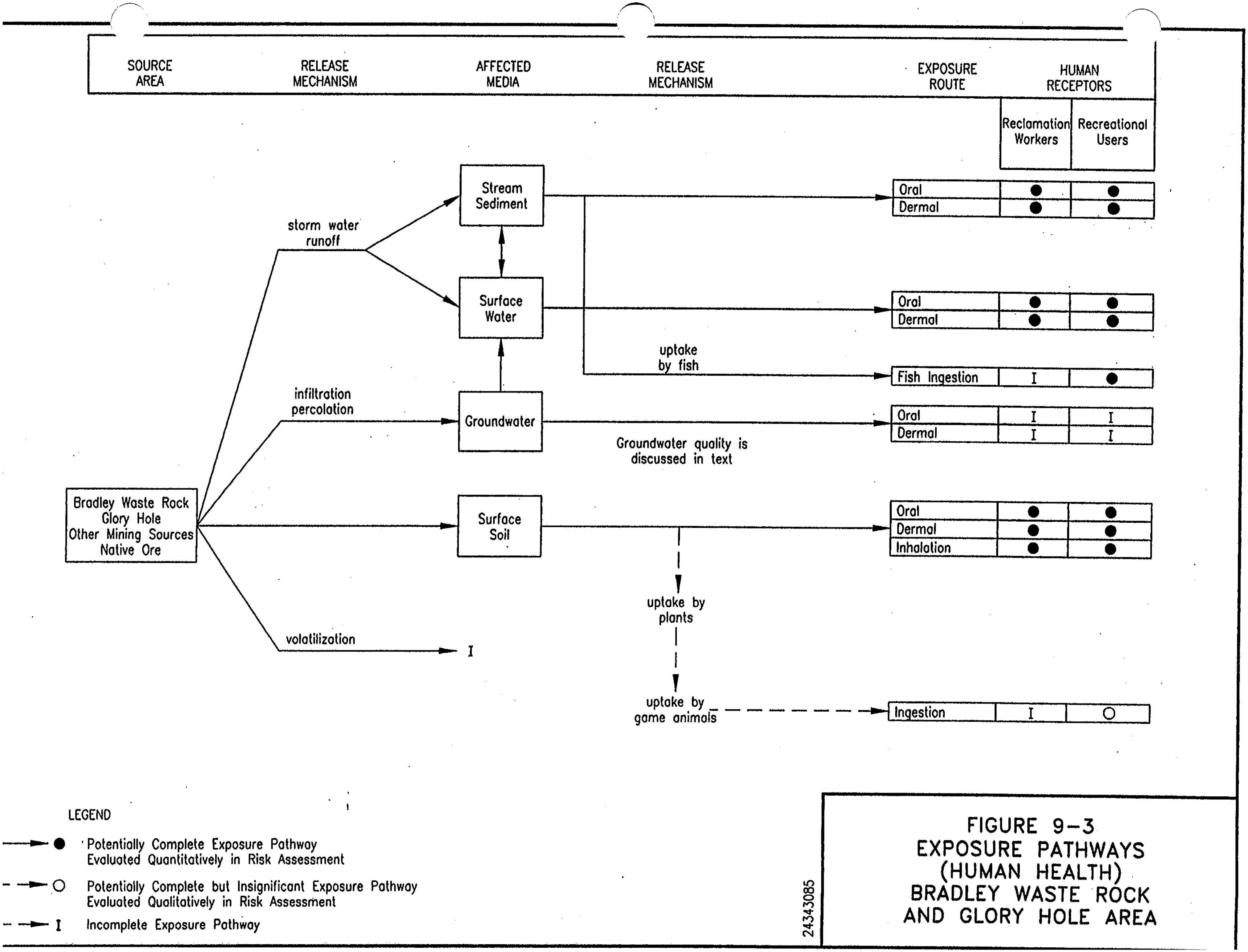
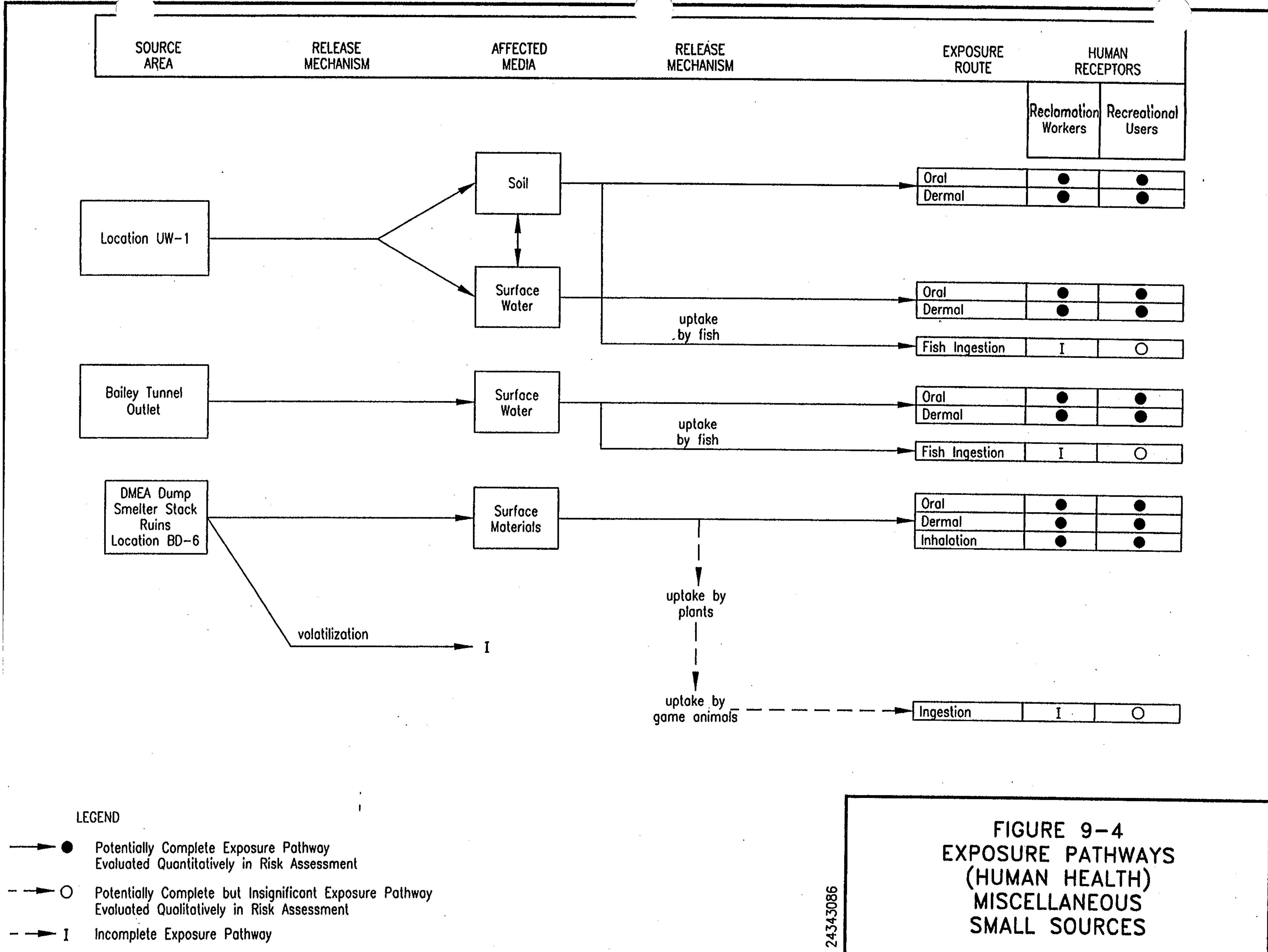


FIGURE 9-3
EXPOSURE PATHWAYS
(HUMAN HEALTH)
BRADLEY WASTE ROCK
AND GLORY HOLE AREA



24343086

FIGURE 9-4
EXPOSURE PATHWAYS
(HUMAN HEALTH)
MISCELLANEOUS
SMALL SOURCES

Table 9-19

Summary of Health Risks
Non-Cancer Hazard and Cancer Risk
Smelter Stack

Receptor/Pathway	RME	
	HI	CR
Future Recreational User Chemical-Specific Ash[2]		
Antimony	8.00E+00	--
Arsenic	2.21E+02	--
Mercury	6.00E+00	--
Future Recreational User (Wood)		
Wood Ingestion	1.09E+00	1.38E-08
Wood Dermal	2.26E+00	2.91E-08
Inhalation of Wood Particulates	3.55E-05	2.80E-11
Future Recreational User Total (Wood)[1]	3E+00	4E+06
Future Recreational User Chemical-Specific Wood[2]		
Antimony	9E-01	--
Arsenic	2E+00	--
Future Recreational User Total[1]	2E+02	4E-06

RME = Reasonable Maximum Exposure
HI = Hazard Index
CR = Cancer Risk

(1) Total HIs and CRs are expressed with one significant figure, in accordance with USEPA guidelines (USEPA, 1989a).

(2) Non-cancer effects of antimony, arsenic, and mercury are not additive (Section 9.7, Toxicity Assessment)

10. REPORT SUMMARY AND CONCLUSIONS

This revised Draft RER is based on current Site conditions, chemical and biological data, and habitat characterization presented in the Draft SCR (Stibnite Group, 2000). The Draft RER assesses whether chemical or physical stressors described in the Draft SCR are likely to pose unacceptable risks to the environment or to human health.

10.1 AQUATIC ECOLOGICAL RISK EVALUATION

Potential risks to aquatic organisms (fish and benthic macroinvertebrates) on the Stibnite were evaluated for four exposure areas and ten Site aquatic stations. A total of six measurement endpoints were considered in evaluating the two assessment endpoints: 1) protection of salmonid fish populations and 2) protection of the benthic macroinvertebrate community. In the four exposure areas (Meadow Creek, Upper EFSFSR, Lower EFSFSR, and Sugar Creek) three measurement endpoints were evaluated: surface water quality, physical habitat, and fish tissue residue levels. At the ten aquatic stations, six aquatic measurement endpoints were measured or described (metals in surface water and sediment, metals in fish and benthic macroinvertebrate tissues, benthic macroinvertebrate community analysis, and physical habitat descriptions). The ten aquatic stations are: MC-1C, 322, and 319 (Meadow Creek); 365, 310, Glory Hole, EF-7, 308, and 314 (EFSFSR); and 316 (Sugar Creek). The measurement endpoints and their relative importance in evaluating risk to fish and benthic macroinvertebrates are listed below:

Relative Importance of Aquatic Measurement Endpoints for Fish and Invertebrates

Measurement Endpoint	Risk to Fish[1]	Risk to Benthic Invertebrates[2]
Surface Water Quality (HQ)	1	3
Sediment Quality (HQ)	Not Evaluated	2
Physical Habitat	2	Not Evaluated
Benthic Community	Not Evaluated	1
Benthic Tissue Metal Residue	Not Evaluated	4
Fish Tissue Metal Residue	3	Not Evaluated

[1] Evaluated for exposure areas and aquatic stations.
[2] Evaluated for aquatic stations only.

Concentrations of metals in water were compared with Idaho and USEPA water quality criteria (Table 7-7) (IDHW, 1998; BNA, 1999; USEPA, 1976, 1992b, 1998b, 1999); metals in sediment were compared with recent compilations of sediment screening benchmarks (Table 7-9 and 7-10) (EVS, 1998; Macdonald et al., 1999). Water quality and sediment quality were evaluated quantitatively by calculating hazard quotients (HQs) based on these comparisons. The remaining measurement endpoints were evaluated qualitatively. The focus of risk assessments in exposure areas was on fish, while the risk at aquatic stations addressed both fish and benthic macroinvertebrates. In the evaluation of the various measurement endpoints, importance of each measurement endpoint was weighted as shown (e.g., surface water quality is most

important in evaluating risk to fish; results of the benthic community analysis is most important in evaluating risk to benthic macroinvertebrates).

As described in Section 7.7, the overall potential for unacceptable risks to fish and benthic macroinvertebrates is described as "unlikely", "possible", or "likely". For the measurement endpoints quantitatively evaluated (water quality and sediment quality), risk is considered "unlikely" if the HQ is less than 1 and "possible" if the HQ is greater than 1. For the four measurement endpoints qualitatively evaluated, judgements are made as to the likelihood of the endpoint representing a stressor (chemical or physical) to the receptor. Stressors described as representing a "possible" risk may occur but are not expected to have any significant effects on the receptors. Measurement endpoints described as "unlikely" are not expected to have any measurable effect on the receptor.

Risks to fish from the three aquatic measurement endpoints considered in each of the four exposure areas is summarized in the following table:

Potential of Risk to Fish in Exposure Areas

Exposure Area	Water Quality	Physical Habitat	Tissue Residue	Overall Risk
Meadow Creek	Unlikely	Possible	Unlikely	Unlikely
Upper EFSFSR	Unlikely	Unlikely	Unlikely	Unlikely
Lower EFSFSR	Unlikely	Possible	Unlikely	Unlikely
Sugar Creek	Unlikely	Possible	NC[1]	Unlikely

[1]Fish tissue samples not collected at station.

Considering all three measurement endpoints, especially water quality, it is unlikely that fish are at potential risk in any area. However, the habitat in portions of Meadow Creek, Lower EFSFSR, and Sugar Creek may represent a physical stressor to fish. In Meadow Creek, unstable banks were found along three sections of the creek. Overall, approximately 700 feet on the south-east bank and 400 feet on the north-west bank were considered unstable, although most of these unstable reaches were vegetated. Half of the areas are adjacent to tailing deposits. In most of Lower EFSFSR, the streambanks have limited riparian cover. Steep, erodible banks occur along about 800 feet of the west bank above the bridge at the main access road. In Sugar Creek, the average percent surface fines at Station 316 was 36 percent, which is in the range of fines that may lead to a loss of viable spawning habitat; however, suitable gravel spawning areas are present in lower Sugar Creek. Downstream of Station 316, riparian vegetation provides only limited cover. Upstream of the station, the stream banks are only moderately stable, due in part to a road cut directly adjacent to the stream.

The potential for risk to fish and benthic macroinvertebrates at aquatic stations was evaluated for a total of six measurement endpoints. Surface water quality and sediment quality were quantitatively evaluated in Section 7.6, and the applicability of the resulting HQs was evaluated in Section 7.7. The remaining aquatic measurement endpoints were evaluated qualitatively. Summaries of the potential of risk to fish and benthic macroinvertebrates at the ten aquatic stations are presented in the following two tables.

Potential of Risk to Fish at Aquatic Stations

Station	Surface Water	Physical Habitat	Tissue Residue	Overall Risk
MC-1C	Unlikely	Possible	NC[1]	Unlikely
322	Unlikely	Possible	Unlikely	Unlikely
319	Unlikely	Unlikely	NC[1]	Unlikely
365	Unlikely[2]	Possible	NC[1]	Unlikely
310	Unlikely[2]	Unlikely	Unlikely	Unlikely
G. H.[3]	Unlikely	Unlikely	NC[1]	Unlikely
EF-7	Unlikely	Possible	NC[1]	Unlikely
308	Unlikely	Possible	Unlikely	Unlikely
314	Unlikely	Unlikely	Unlikely	Unlikely
316	Unlikely	Unlikely	NC[1]	Unlikely

[1]Fish tissue samples not collected at station.
[2]Surface water quality based on results from Station 313.
[3]Glory Hole.

The overall potential for risk to fish at each of the ten aquatic stations is evaluated as "unlikely" based principally on the surface water quality. However, elements of the physical habitat at five aquatic stations (MC-1C, 322, 365, EF-7, and 308) may represent physical stressors to fish. At all five stations, riparian vegetation is sparse (Stations 365, EF-7, and 308) or missing (Stations MC-1C and 322). Instream cover for fish is limited at four stations (MC-1C, 322, 365, and EF-7). Some evidence of streambank erosion is seen at two stations (365 and 308).

Potential of Risk to Benthic Macroinvertebrates at Aquatic Stations

Station	Benthic Community	Sediment Quality	Surface Water	Tissue Residue	Overall Risk
MC-1C	Unlikely	Possible	Unlikely	NC[1]	Unlikely
322	Unlikely	Possible	Unlikely	Unlikely	Unlikely
319	Unlikely	Possible	Unlikely	Unlikely	Unlikely
365	Unlikely	Possible	Unlikely[2]	Unlikely	Unlikely
310	Unlikely	Possible	Unlikely[2]	Unlikely	Unlikely
G. H.[3]	Unlikely	Possible	Unlikely	NC[1]	Unlikely
EF-7	Possible	Possible	Unlikely	NC[1]	Possible
308	Possible	Possible	Unlikely	Possible	Possible
314	Unlikely	Possible	Unlikely	Unlikely	Unlikely
316	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely

[1]Benthic macroinvertebrate tissue samples not collected at station.
[2]Surface water quality based on results from Station 313.
[3]Glory Hole.

The overall potential for risk to benthic macroinvertebrates is evaluated as "possible" at two stations in the EFSFSR (EF-7 and 308) but "unlikely" for the remaining eight stations. Overall "possible" risks at Stations EF 7 and 308 are due to the combination of "possible" ratings for the benthic community and sediment quality.

The current designated beneficial uses of the EFSFSR waters include, among others: cold water biota and salmonid spawning. The dissolved oxygen standard for salmonid spawning is described as a minimum of 6.0 mg/L or 90 percent of dissolved oxygen saturation (8.2 mg/L), whichever is greater. The salmon spawning temperature maximum is 13°C with a maximum daily average of 9°C (IDHW, 1998), and for bull trout (*Salvelinus confluentus*), the temperature criterion is 10°C, expressed as an average of daily maximum temperatures over a 7-day period during June, July, and August (40 CFR 131.33). In addition to dissolved oxygen and temperature standards, salmonid spawning requirements also include all toxic substance standards for the protection of aquatic life.

Dissolved oxygen measurements at all stream stations in 1999 (Appendix A1 of Stibnite Group, 2000) were greater than 8.2 mg/L.

Maximum temperatures in 1999 at most of the EFSFSR stations (except for Station 369) were lower than the 10°C maximum for bull trout. Temperatures in Meadow Creek in July (10.9 to 12.8°C) and September 1999 (10.7 to 12.5°C) were greater than the 10°C maximum. The warmer water temperatures in Meadow Creek are not expected to adversely affect the spawning of bull trout, however, since they cannot migrate upstream past the Glory Hole.

The potential for future risk to aquatic organisms from resuspension of sediments in the Glory Hole and movement downstream also was evaluated. Two related questions were addressed: 1) Will sediments in the Glory Hole be mobilized during various flow events or during seasonal turnover? and 2) If sediments are resuspended, will they pose a risk downstream to the aquatic community downstream?

Physical conditions in the Glory Hole and calculated bottom velocities indicate that the potential for sediment resuspension is low for the 2-year and 100-year events and low-to-moderate for a 500-year event. The Glory Hole probably does experience the physical conditions that permit seasonal (spring and fall) turnover. However, because the depth of each turnover event will vary in response to numerous factors, it cannot be determined if the currents associated with a turnover event are sufficiently high to resuspend sediments.

It is unlikely that bottom sediment from the Glory Hole would pose an unacceptable downstream risk to aquatic biota because: 1) resuspension of sediments has a low frequency and is a transient event, 2) in-place sediments are apparently not toxic based on the analysis of the benthic macroinvertebrate community in the Glory Hole, and 3) Glory Hole sediments would be mixed with stream sediments and redeposition would occur over an extended length of the EFSFSR, after the transient event.

10.2 TERRESTRIAL ECOLOGICAL RISK EVALUATION

A risk evaluation of the terrestrial ecosystem on the Stibnite Site was performed in accordance with current USEPA guidance for ecological risk assessments. Using the results of soil, sediment, surface water, seep, and fish tissue sampling from 1997 and 1999, potential risk to terrestrial populations or communities was evaluated for 17 exposure locations (including five small "hot spot" locations).

Two terrestrial assessment endpoints were evaluated: 1) protection of the upland and riparian plant communities and 2) protection of populations of wildlife functional groups. The measurement endpoints considered in the evaluation of assessment endpoints were: 1) upland and riparian habitat condition (vegetation and soil mapping; soil profiles) and 2) soil, sediment, and water chemical analyses and comparisons with toxicological endpoints.

The overall potential for unacceptable risks to the assessment endpoinds (plant communities and wildlife populations) is described as "unlikely" or "possible" based on terminology parallel to that used in the aquatic risk evaluation.

Risks to habitat, plant communities, and wildlife populations based on the two terrestrial measurement endpoints evaluated for each of the exposure locations are described in detail in Table 8-12 and are summarized in the following table:

Potential of Risk to Terrestrial in Exposure Locations

Risk Classification	Exposure Location	Risk to Habitat or Plant Community	Risk to Wildlife Populations
Unlikely Risk			
	BT/NO Disposal Area		X
	Meadow Creek Hillside	X	X
	Upgradient Wetland	X	X
	Upgradient Wetland Hot Spot	X	X
	Keyway Wetland	X	X
	Smelter Stack	X	X
	DMEA Dump	X	X
	BD-6 (antimony outlier in NW Bradley Dump)		X
Unlikely or Possible Risk			
	Lower Meadow Creek Valley	X	X
	Meadow Creek Forested Wetland	X	X
	Southeast Bradley Waste Rock Dump		X
	Northwest Bradley Waste Rock Dump		X
	Northeast Bradley Waste Rock Dump		X
	BD-6 (antimony outlier in NW Bradley Dump)	X	
	EFSFSR and Midnight Creek		X
	EFSFSR and Glory Hole		X
	Sugar Creek		X
	Seeps in Areas 1 and 3		X
Possible Risk			
	BT/NO Disposal Area	X	
	Southeast Bradley Waste Rock Dump	X	
	Northwest Bradley Waste Rock Dump	X	
	Northeast Bradley Waste Rock Dump	X	

"Possible" risk is shown for terrestrial habitat or plant communities at four exposure locations: BT/NO Disposal Area, Southeast Bradley Waste Rock Dump, Northwest Bradley Waste Rock Dump, and

Northeast Bradley Waste Rock Dump. Risk to the plant community at these three locations is due primarily to exposure to high arsenic and mercury concentrations in soils. In addition, plants in the BT/NO Disposal Area are exposed to high antimony concentrations in soil. Risk to the soil invertebrate community also is due primarily to exposure to elevated arsenic concentrations in soil. Chemical risks to habitats or the plant communities at all other exposure locations are evaluated as being either "unlikely" or "unlikely or possible." No habitat or plant community is evaluated as having "likely" risk.

Overall risk to the wildlife populations at nine exposure locations is judged to be "unlikely or possible." These judgements are based on possible risks from exposure to high antimony, arsenic, and/or mercury concentrations in soil that are reduced by the small areas involved and the sparse vegetation/habitat available at the locations. Risk to wildlife populations at all other locations also is evaluated as "unlikely." No wildlife populations are evaluated as having "possible" or "likely" risk.

10.3 HUMAN HEALTH RISK EVALUATION

The human health risk assessment evaluated potential human health risk for reclamation workers and future recreational users assumed to be exposed to multiple media (soil, sediment, surface water, and fish) in nine exposure areas and five miscellaneous small areas of concern. The exposure areas included several subareas and wetlands within Meadow Creek Valley, the EFSFSR, (including tributaries), the Glory Hole, and the Bradley waste rock dumps. Miscellaneous small areas of concern included the smelter stack, DMEA Dump, BTO, and two sample locations with unique characteristics (i.e., UW-1 in the Meadow Creek Upgradient Wetland and sample location BD-6 in the Northwest Bradley waste rock dump).

Groundwater, surface water, and seep water were evaluated qualitatively for suitability as drinking water sources. Subsurface materials (e.g., tailing deposits) related to historic mining and milling operations in Meadow Creek Valley were also evaluated qualitatively for potential human exposure.

Reclamation workers were assumed to work for 80 days (one season) at any one of the nine exposure areas and for 10 days at the miscellaneous small areas of concern. Recreational users were assumed to visit for 12 days/year for 30 years at any one of the nine exposure areas and to have one-time contact at the small areas of concern. Exposure routes evaluated were soil ingestion, dermal contact, and inhalation; sediment ingestion; surface water ingestion and dermal contact; and fish ingestion.

10.3.1 SUMMARY OF HEALTH RISK RESULTS

Cancer risk and non-cancer HIs were calculated for each COPI, receptor, and exposure area using standard EPA methodologies. Results were compared to EPA's generally acceptable cancer risk range of 1E-06 to 1E-04 and to a hazard index (HI) of 1. HIs above 1 indicate a potential cause for concern for non-cancer effects but do not indicate that an adverse effect will necessarily occur.

The only constituents that contributed significantly to overall health risk estimates were antimony, arsenic, and, at the Smelter Stack area, mercury. Because the toxic effects of these chemicals are different, that is,

they affect different endpoints in the body, the non-cancer effects are not additive (USEPA 1989a). Therefore, HIs were reported for each constituent separately, and maximum HIs are listed in this summary.

Human health risk results are shown in Table 9-8 and are summarized below.

- Cancer risk estimates were within or less than USEPA's acceptable cancer risk range of 1E-06 to 1E-04, for all scenarios evaluated, except for the recreational user at the Keyway Wetland (CR = 3E-04).
- It is unlikely that recreational exposure at the Keyway Wetland poses an unacceptable risk of cancer under realistic exposure conditions. The cancer risk estimate of 3E-04 assumed ingestion of wetland water at a rate of 2 L/day, 12 days/year, for 30 years, which is unrealistically conservative for this exposure area. Considering a lower, but still conservative, rate of exposure (for example, ingestion of 1 L/day for 5 days/year for 30 years), the excess cancer risk would be 6E-05, which is within EPA's generally acceptable range.
- HIs ranged from less than 1 to 4 in all exposure areas, except for three miscellaneous small areas of concern. There is a low probability of unacceptable health hazard at exposure areas with HIs of 5 or less due to the conservative estimates of exposure frequency and duration and chronic toxicity values (applicable to lifetime exposure) that were used in estimating non-cancer hazard.
- Maximum constituent-specific HIs were 10 or above for one or both receptors at three miscellaneous small areas of concern:
  - DMEA Dump (reclamation worker HI = 34; recreational user HI = 10), primarily due to ingestion and dermal absorption of arsenic in the dump material. The DMEA Dump poses a potential non-cancer health hazard under the exposure assumptions evaluated.
  - The smelter stack ash (reclamation worker HI = 736, recreational user HI = 226), soil at the smelter stack (reclamation worker HI = 14; recreational user HI = 4); and flume wood (reclamation worker HI = 8, recreational user HI = 2). Antimony, arsenic, and mercury contributed to HIs above 1 at this area. The smelter stack materials pose a potential non-cancer health hazard under the exposure assumptions evaluated.
  - Location BD-6 at the Northwest Bradley waste rock (reclamation worker HI = 73, recreational visitor HI = 22), due to ingestion and dermal absorption of antimony and arsenic at this sample location. In spite of the magnitude of the HIs, there is a low probability of actual health risk because exposure potential is minimal (the maximum HI for the rest of the Northwest Bradley waste rock dump area was 3).

Table 9-26 summarizes the exposure areas ranked by relative risk levels. Areas with very low to no potential for unacceptable health risk under the exposure conditions evaluated are listed below:

- BT/NO Disposal Area
- Meadow Creek Mine Hillside
- Upgradient Wetland, including Location UW-1
- Lower Meadow Creek Valley
- Keyway Wetland

- Meadow Creek Forested Wetland
- EFSFSR, Southeast Bradley waste rock, and Midnight Creek
- Glory Hole, EFSFSR, Northwest Bradley waste rock, and Hennessey Creek
- Northeast Bradley waste rock and Sugar Creek
- Bailey Tunnel Outlet (incidental ingestion of surface water)
- Location BD-6 (Northwest Bradley waste rock sample location)

Two miscellaneous small areas of concern pose a potential for unacceptable non-cancer health effects under the exposure conditions evaluated are:

- DMEA Dump and
- Smelter Stack ash (both receptors); Smelter Stack soil and flume wood (reclamation worker)

10.3.2 SURFACE WATER AND GROUNDWATER AS DRINKING WATER

In most surface water exposure areas evaluated (Table 9-23), concentrations of antimony (8 to 127 µg/L) and arsenic (12 to 463 µg/L) exceeded MCLs for drinking water and water quality criteria for consumption of water and fish. Levels of arsenic, but not antimony, also exceeded the Idaho numeric criterion for consumption of fish only.

These exceedances of water quality criteria applicable to lifetime consumption by humans do not represent an actual threat to health at the Stibnite Site because:

- no unacceptable health risk was estimated in the risk assessment for incidental ingestion of surface water, for ingestion of surface water as drinking water by recreational users (except for drinking 2 L/day at Keyway Wetland), or for fish ingestion, and
- the likelihood of lifetime or long-term consumption is negligible.

In groundwater (Table 9-24), concentrations of antimony and arsenic in most wells, whether in mining-impacted areas or not, exceeded one or both federal MCLs for drinking water. These results indicate that the quality of untreated groundwater does not meet standards for an approved source of public water supply. However, groundwater at the Stibnite Site is not a source of drinking water, and therefore the exceedances of arsenic and antimony MCLs do not represent an actual threat to health under current conditions.

10.3.3 SEEPS

A screening-level evaluation of arsenic in seep water ingestion was performed as a guide to potential health concerns, if small amounts of seep water were ingested on a one-time basis.

At most seeps, no significant health hazards were identified for ingestion of 500 mL of seep water, because maximum estimated arsenic doses were equal to or below a dose at which no effects have been reported in humans from short term exposures (Table 9-25). At seeps impacted by Bradley tailing, maximum

estimated arsenic does were up to 4 times higher than the dose at which mild gastrointestinal effects have been reported in humans (0.02 mg/kg-day). Cancer risk estimates at all seeps were within or below USEPA's generally acceptable risk range of 1E-06 to 1E-04.

10.3.4 SUBSURFACE SOIL IN MEADOW CREEK VALLEY

Human exposure to subsurface soil in the Lower Meadow Creek Valley could occur through construction activities and in residential scenarios. However, construction activities and residential activities are not expected in the Lower Meadow Creek Valley for the following reasons.

- The presence of buried tailings make the Lower Meadow Creek Valley unsuitable, both structurally and from a risk perspective, for commercial and residential buildings.
- Mining activities are not expected to occur in the foreseeable future.

Therefore, no human exposure to Lower Meadow Creek Valley subsurface soil is expected.

10.4 CONCLUSIONS

The risk evaluations are based primarily on Site conditions in 1999, following the 1998 remediation work in upper Meadow Creek Valley at the Bradley tailing impoundment/neutralized ore disposal area. The principal findings of the aquatic, terrestrial/riparian, and human health risk evaluations for the Stibnite Site are:

Aquatic Risk Evaluation. Conclusions from the aquatic ecological risk evaluation are listed below:

- Considering the three measurement endpoints applicable to fish, especially water quality, it is unlikely that fish are at risk in any of the four areas or at any of the ten aquatic stations. However, the physical habitat in portions of Meadow Creek, Lower EFSFSR, and Sugar Creek may represent physical stressors to fish.
- The potential for risk to benthic macroinvertebrates is possible at two stations in the EFSFSR below the Glory Hole (EF-7 and 308), based primarily on the measurement endpoints of quality of the benthic community and sediment quality (i.e., metals concentrations). Risk to benthic invertebrates is unlikely at the remaining eight stations. Chemical or physical stressors described as representing a possible risk may occur but are not expected to have any significant effects on the receptors.
- In the Glory Hole, the potential for sediment resuspension is low-to-moderate in the 100- and 500-year events, and it is unlikely that bottom sediment from the Glory Hole would pose an unacceptable risk to downstream aquatic organisms.

Terrestrial and Riparian Risk Evaluation. Conclusions from the terrestrial ecological risk evaluation are listed below:

- Possible risk is shown for terrestrial habitat or plant communities at four exposure locations: BT/NO Disposal Area, Southeast Bradley Waste Rock Dump, Northwest Bradley Waste Rock Dump, and Northeast Bradley Waste Rock Dump. Risk to the plant community at these locations is due primarily to exposure to arsenic and mercury in soils. Possible risk at the BT/NO Disposal Area is due to high soil levels of antimony.
- No habitat or plant community is evaluated as having likely risk.
- Risk to the wildlife populations at nine exposure locations is judged to be unlikely or possible. These judgements are based on possible risks from exposure to high antimony, arsenic, and/or mercury concentrations in soil that are reduced by the small areas involved and the sparse vegetation/habitat available.
- No wildlife populations are evaluated as having possible or likely risk.

Human Health Risk. Conclusions from the human health risk evaluation are listed below:

- There is very low to no potential for unacceptable health risk at all main exposure areas and wetlands, most miscellaneous small areas of concern in subsurface soil, and at most seeps. This conclusion is based on HIs and excess cancer risk levels within USEPA acceptable ranges, or consideration of conservative assumptions that affect the interpretation of the numerical risk results if results somewhat exceeded the targets (e.g., HIs <5) and the evaluation of exposure pathways.
- Two miscellaneous small areas of concern (the DMEA Dump and smelter stack) pose a potential for unacceptable non-cancer health effects under the exposure conditions evaluated, based on HIs of 10 or above for the soil ingestion and dermal absorption pathways.
- Surface water and groundwater concentrations of arsenic and antimony exceeded drinking water MCLs or other quality criteria protective of lifetime consumption of water and or fish. However, the risk assessment calculations showed no unacceptable health risk for ingestion of surface water or fish under the exposure conditions evaluated (with the possible exception of Keyway Wetland water ingested at a rate of 2 L/day in the recreational scenario). Furthermore, neither surface water nor groundwater is used as a source of water at the site.
- Short-term ingestion exposure to seeps, except possibly for seeps emerging from Bradley tailing deposits in lower Meadow Creek Valley may pose the potential for mild effects.

11. REFERENCES

References cited in the Draft RER Sections 1 through 10 are provided in the following sections as shown.

11.1 REFERENCES FOR SECTIONS 1 AND 10

Bureau of National Affairs, Inc. (BNA). 1999. Idaho Environmental Revision Dates to Statutes and Regulations – Chapter 02 Water quality criteria and Wastewater Treatment Requirements. BNA Environmental Library on CD. October.

EVS Environment Consultants (EVS). 1998. Compilation of World-Wide Sediment Quality Guidelines for Metals and Metalloids. Final. Prepared for: Intern. Lead Zinc Res. Org., Inc, Intern. Copper Assoc., and Nickel Producers Environ. Res. Org. September.

Idaho Department of Health and Welfare (IDHW). 1998. Rules and Regulations, Title 1, Chapter 2, Water Quality Standards and Wastewater Treatment Requirements. IDAPA 16.01.02. March 1.

MacDonald, D.D., C.G. Ingersoll and T.A. Berger. 1999. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Submitted to Arch. Environ. Contam. Toxicol.

Stibnite Group. 1997a. Stibnite Area Site Characterization Field Sampling and Mapping Work Plan. Prepared by Woodward-Clyde. May 1997.

Stibnite Group. 1997b. Stibnite Area Risk Evaluation Work Plan. Prepared by Woodward-Clyde. August 29.

Stibnite Group. 1999. Stibnite Area Site Characterization Field Sampling and Mapping Work Plan Addendum. Prepared by URS Greiner Woodward Clyde. June.

Stibnite Group. 2000. Stibnite Area Site Characterization Report. Draft. Prepared by URS Greiner Woodward Clyde. March 16.

U.S. Environmental Protection Agency (USEPA). 1976. Quality Criteria for Water. (Red Book). Office of Water and Hazardous Materials. July.

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

U.S. Environmental Protection Agency (USEPA). 1992. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; States' Compliance. Federal Register Vol. 57, No. 246: 60848-60923. December 22.

U.S. Environmental Protection Agency (USEPA). 1998. National Recommended Water Quality Criteria: Notice, Republication. Federal Register Vol. 63, No. 237. December 10.

U.S. Environmental Protection Agency (USEPA). 1999. National Recommended Water Quality Criteria–Correction. Office of Water. EPA 822-Z-88-001.

11.2 REFERENCES FOR SECTIONS 2 THROUGH 6

Aquatic Biology Associates, Inc. (ABA). 1996. Benthic Invertebrate Injury Studies – 1995. East Fork of the South Fork Salmon River Idaho, Payette National Forest, Krassel Ranger District. June.

Burch, S.A. and W.H. Mullins. 1993. Trace Element Concentrations in Sediment, and Algae Collected from Meadow Creek, Stibnite Mine Project, Idaho. Department of the Interior. U.S. Fish and Wildlife Service. Idaho State Office, Boise, ID. May.

Chaney, R. and D. Oliver. 1996. Sources, potential adverse effects and remediation of agricultural soil contaminants. In: Naidu et al. (eds) Contaminants and the Soil Environment in the Australia-Pacific Region, Proceedings of the First Australasia-Pacific Conference on Contaminants and Soil Environment in the Australasia-Pacific Region, February 18-23, 1996. Kluwer Academic Publishers, Boston, MA. pp. 323-359.

Efroymson, R.A., Suter II, G.W., and B.E. Sample. Oak Ridge National Laboratory (ORNL). 1996. Preliminary Remediation Goals for Ecological Endpoints. U.S. Department of Energy. Prepared for Restoration Risk Assessment Program, Oak Ridge, TN.

Galbraith, H., K. Lejeune, and J. Lipton. 1995. Metal and arsenic impacts to soils, vegetation communities and wildlife habitat in southwest Montana uplands contaminated by smelter emissions: 1. Field evaluation. Environmental Toxicology and Chemistry 14(11): 1895-1903.

James M. Montgomery, Consulting Engineers, Inc. (JMM). 1979. Environmental Background Report, Stibnite Mining Project, Summary of Data. February.

Jarvinen, A.W. and G.T. Ankley. 1999. Linkage of Effects to Tissue Residues: Development of a Comprehensive Database for Aquatic Organisms Exposed to Inorganic and Organic Chemicals. SETAC Technical Publications Series. 364 pp.

JMM. 1981. Final Environmental Impact Statement, Stibnite Mining Project Gold Mine and Mill. Prepared for: USDA Forest Service, Region Four, Payette National Forest. May.

Johns, C. 1995. Contamination of riparian wetlands from past copper mining and smelting in the headwater region of the Clark Fork River, Montana. Journal of Geochemical Exploration, 52:193-203.

KK Consulting. 1997. Watershed Analysis of the Upper East Fork South Fork of the Salmon River. Volumes I and II. August.

Mitchell. 1995. History of the Stibnite Mining Area, Valley County, Idaho. Idaho Geological Survey. Moscow, Idaho.

Rich, A.A. and Associates (Rich). 1997. Stibnite Mine Expansion Payette National Forest, Draft Fishery Resources Technical Report. April.

Sheppard, S.C. 1991. Summary of phytotoxic levels of soil arsenic. Water, Air, and Soil Pollution 64:539-550, 1992.

Stibnite Area Characterization Voluntary Consent Order Respondents (Stibnite Group). 1997a. Stibnite Area Site Characterization Field Sampling and Mapping Work Plan. Prepared by Woodward-Clyde. May 1997.

Stibnite Area Characterization Voluntary Consent Order Respondents (Stibnite Group). 1997b. Stibnite Area Risk Evaluation Work Plan. Prepared by Woodward-Clyde. August 29.

Stibnite Area Characterization Voluntary Consent Order Respondents (Stibnite Group). 1998. Stibnite Area Risk Evaluation Report. Draft. Prepared by Woodward-Clyde. September 10.

Stibnite Area Characterization Voluntary Consent Order Respondents (Stibnite Group). 1999. Stibnite Area Site Characterization Field Sampling and Mapping Work Plan Addendum. Prepared by URS Greiner Woodward Clyde. June.

Stibnite Area Characterization Voluntary Consent Order Respondents (Stibnite Group). 2000. Stibnite Area Site Characterization Report. Draft. Prepared by URS Greiner Woodward Clyde. March 16.

United States Department of Agriculture Forest Service (Forest Service). 1993. Preliminary Assessment/Site Investigation - Stibnite Mining Area. Payette National Forest. CERCLIS ID No. I99122307607. Prepared by P. Trainor.

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

U.S. Environmental Protection Agency (USEPA). 1989b. Exposure Factors Handbook. Washington, DC: Exposure Assessment Group, Office of Research and Development. March. EPA/600/8-89/043.

U.S. Environmental Protection Agency (USEPA). 1992a. Framework for Ecological Risk Assessment. Risk Assessment Forum. EPA/630/R-92/001. February.

U.S. Environmental Protection Agency (USEPA). 1992b. Guidance for Data Usability in Risk Assessment (Part A). OERR Publ. 9285.7-09A.

U.S. Environmental Protection Agency (USEPA). 1993. Data Quality Objectives Process for Superfund, Interim Final Guidance, EPA540-R-93-071.

U.S. Environmental Protection Agency (USEPA). 1994. Guidance for the Data Quality Objectives Process. Quality Assurance Management Staff, Washington, D.C. USEPA QA/G-4.

U.S. Environmental Protection Agency (USEPA). 1997a. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. Interim Final. U.S. EPA Environmental Response Team, Edison, New Jersey. June.

U.S. Environmental Protection Agency (USEPA). 1997b. Priorities for Ecological Protection: An Initial List and Discussion Document for USEPA.

U.S. Environmental Protection Agency (USEPA). 1997c. Exposure Factors Handbook. USEPA Office of Research and Development, Washington, D.C. EPA/600/P-95/002Fa. August.

U.S. Environmental Protection Agency (USEPA). 1998a. Guidelines for Ecological Risk Assessment. Final. April.

U.S. Environmental Protection Agency (USEPA). 1998b. Integrated Risk Information System (IRIS). On-line database.

U.S. Environmental Protection Agency Region IV (USEPA Region IV). 2000. Region 4 Human Health Risk Assessment Bulletins – Supplement to RAGS, Human Health Risk Assessment Bulletins. Interim. May 30.

U.S. Environmental Protection Agency Region X (USEPA Region X). 1998. Interim Final Guidance: Developing Risk-Based Cleanup Levels at Resource Conservation and Recovery Act Sites in Region 10. Office of Waste and Chemical Management. USEPA Region 10. January.

11.3 REFERENCES FOR AQUATIC ECOLOGICAL RISK EVALUATION (SECTION 7)

Agency for Toxic Substances and Disease Registry (ATSDR). 1997. Toxicological Profile for Mercury. Draft for Public Comment -- Update. August.

Aquatic Biology Associates, Inc. (ABA). 1999. Glory Hole Benthic Macroinvertebrate Sample Analysis. Letter Report. November 19.

Aquatic Biology Associates, Inc. (ABA). 2000. Benthic Invertebrate Biomonitoring, East Fork of the South Fork Salmon River-Stibnite Mine Project & Marble and Monumental Creek-Thunder Mountain Mine Project, September 1999 Sampling, Idaho, Payette National Forest, Krassel Ranger District. Corvalis, OR.

Barnthouse, L.W. et al. 1982a. Preliminary Environmental Risk Analysis for Indirect Coal Liquefaction. Draft Report. Oak Ridge National Laboratory, Oak Ridge, TN.

Barnthouse, L.W. et al. 1982b. Methodology for Environmental Risk Analysis. ORNL/TM 8167. Oak Ridge National Laboratory, Oak Ridge, TN.

Barnthouse, L.W. et al. 1986. User's Manual for Ecological Risk Assessment. Environmental Sciences Division, Oak Ridge National Laboratory, Publication No. 2679, ORNL-6251, Oak Ridge, TN.

Bjornn, T.C., M.A. Brusven, M.P. Molnau, J.H. Milligan, R.A. Klamt, E. Chacho and C. Schaye. 1977. Transport of Granitic Sediment n Streams and its Effects on Insects and Fish. Bulletin 17. Forest, Range and Wildlife Experiment Station, U. of Idaho, Moscow, ID. 43 pp.

Brook, L.T., D.J. Call, S.H. Poirier, C.A. Lindberg and T.P. Markee. 1986. Acute toxicity of antimony III to several species of freshwater organisms. Report to Battelle Memorial Research Institute. Center for Lake Superior Environmental Studies, University of Wisconsin-Superior. In: USEPA, 1988.

Brookins, D.G. 1988. Eh-pH Diagrams for Geochemistry. Springer-Verlag, New York. 176 pp.

Bureau of National Affairs, Inc. (BNA). 1999. Idaho Environmental Revision Dates to Statutes and Regulations – Chapter 02 Water quality criteria and Wastewater Treatment Requirements. BNA Environmental Library on CD. October.

Chow, V.T. 1959. Open Channel Hydraulics. McGraw Hill, New York.

Clements, W.H. 1991. Community responses of stream organisms to heavy metals: A review of observational and experimental approaches. pp. 363-391. In: Newman and McIntosh (eds).

Clements, W.H. 1994. Benthic invertebrate community responses to heavy metals in the upper Arkansas River basin, Colorado. J. North Amer. Benthol. Soc. 13: 30-44.

Clements, W.H., D.S. Cherry and J. Cairns, Jr. 1988. Impact of heavy metals on insect communities in streams: A comparison of observational and experimental results. Can. J. Fish. Aquatic Sci. 45: 2017-2025.

Colt, J. 1984. Computation of Dissolved Gas Concentrations in Water as Functions of Temperature, Salinity, and Pressure. American Fisheries Society Special Publication 14 (Table 21). Bethesda, MD.

Cubbage, J. and S. Breidenbach. 1994. Discussion draft: Creation of Freshwater Sediment Quality Database and Preliminary Analysis of Freshwater Apparent Effects Thresholds. Washington Department of Ecology, Olympia, Washington.

Doe, K.G., W.R. Parker, S.J. Ponsford and J.D.A. Vaughan. 1987. The acute and chronic toxicity of antimony to *Daphnia magma* and rainbow trout. pp. 40-43. Proceedings of the 13th Annual Aquatic Toxicity Workshop, November 12-14, J.S.S. Lakshminarayana (ed.). Can. Fish. Aquat. Sci. Tech. Rep. No. 1575. In: OMEE, 1996.

Environment Canada (Environ. Canada). 1995. Interim Sediment Quality Guidelines. Draft. Prepared by Guidelines Division, Evaluation and Interpretation Branch, Ecosystem Conservation Directorate, Ottowa, Ontario.

EVS Environment Consultants (EVS). 1998. Compilation of World-Wide Sediment Quality Guidelines for Metals and Metalloids. Final. Prepared for: Intern. Lead Zinc Res. Org., Inc, Intern. Copper Assoc., and Nickel Producers Environ. Res. Org. September.

Federal Water Pollution Control Administration (FWPCA). 1967. Effects of pollution on the aquatic life resources of the South Platte River Basin. South Platte River Basin Project and Technical Advisory and Investigations Branch, Cincinnati, OH.

Hogen, D.M. and D.L. Scarnecchia. 1999. South Fork Salmon River Bull Trout Study – Summary of Sampling and Radio Tagging, 1999. University of Idaho and Payette National Forest. November 29.

Hunter, C.J. 1991. Better Trout Habitat. A Guide to Stream Restoration and Management. Montana land Reliance. Island Press, Washington, D.C. 320 pp.

Idaho Department of Health and Welfare (IDHW). 1998. Rules and Regulations, Title 1, Chapter 2, Water Quality Standards and Wastewater Treatment Requirements. IDAPA 16.01.02. March 1.

Illinois Environmental Protection Agency (IEPA). 1984. Evaluation of Illinois Stream Sediment Data 1974-1980. Division of Water Pollution Control. Springfield, Illinois.

Indiana Department of Environmental Management (IDEM). 1990. Indiana 305(b) Report 1988-1989, Final Draft. Office of Water Management, Indianapolis, Indiana.

Ingersoll, C.G., P.S. Haverland, E.L. Brunson, T.J. Canfield, F.J. Dwyer, C.E. Henke, N.E. Kemble, D.R. Mount and R.G. Fox. 1996. Calculation and evaluation of sediment effect concentrations of the amphipod *Hyalella azteca* and the midge *Chironomus riparius*. National Biological Service Final Report for the USEPA Great Lakes National Program Office (GLNPO) Assessment and Remediation of Contaminated Sediment (ARCS) Project. EPA 905-R96-008. U.S. EPA, Chicago, IL.

Jarvinen, A.W. and G.T. Ankley. 1999. Linkage of Effects to Tissue Residues: Development of a Comprehensive Database for Aquatic Organisms Exposed to Inorganic and Organic Chemicals. SETAC Technical Publications Series. 364 pp.

Khangarot, B.S. 1991. Toxicity of metals to a freshwater tubificid worm, *Tubifex tubifex* (Muller). Bull. Environ. Contam. Toxicol. 46: 906-912. In: OMEE, 1996.

Long, E.R. and L.G. Morgan. 1990. The potential for biological effects of sediment-sorbed contaminants tested in the National Status and Trends Program. NOAA Tech. Memo. NOS OMA 52. National Oceanic and Atmospheric Administration, Seattle, WA.

Long, E.R., D.D. MacDonald, S.L. Smith and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environ. Mngt. 19: 81-97.

MacDonald, D.D., C.G. Ingersoll and T.A. Berger. 1999. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Submitted to Arch. Environ. Contam. Toxicol.

Menzie, C. et al. 1996. Special Report of the Massachusetts Weight-of-Evidence Workgroup: A Weight-of-Evidence Approach for Evaluating Ecological Risks. Human and Ecological Risk Assessment 2(2): 277-304.

New York State Department of Environmental Conservation (NYDEC). 1993. Technical Guidance for Screening Contaminated Sediments. Albany, New York.

Ontario Ministry of Environment and Energy (OMEE). 1996. Scientific Criteria Document for the Development of an Interim Provincial Water Quality Objective for Antimony. ISBN 0-776-4619-5. January.

Persaud, D., R. Jaagumagi and A. Hayton. 1992. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. Ontario Ministry of the Environment, Ontario, Canada.

Richter, T. 2000. Personal communication with T. Campbell, URSGWC, regarding the frequency of freezing of the Glory Hole. February 24.

Shacklette, H.T. and J.G. Boerngen. 1984. Element Concentrations in Soils and Other Surficial Materials of the Coterminous United States. U.S. Geological Survey Professional Paper 1270.

Stibnite Area Characterization Voluntary Consent Order Respondents (Stibnite Group). 1997. Stibnite Area Risk Evaluation Work Plan. Prepared by Woodward-Clyde. August 29.

Stibnite Area Characterization Voluntary Consent Order Respondents (Stibnite Group). 1998a. Stibnite Area Risk Evaluation Report. Draft. Prepared by Woodward-Clyde. September 10.

Stibnite Area Characterization Voluntary Consent Order Respondents (Stibnite Group). 1998b. Stibnite Area Site Characterization Report. Prepared by Woodward-Clyde. August 3.

Stibnite Area Characterization Voluntary Consent Order Respondents (Stibnite Group). 1999. Stibnite Area Site Characterization Field Sampling and Mapping Work Plan Addendum. Prepared by URS Greiner Woodward Clyde. June.

Stibnite Area Characterization Voluntary Consent Order Respondents (Stibnite Group). 2000. Stibnite Area Site Characterization Field Sampling and Mapping Work Plan Addendum. Prepared by URS Greiner Woodward Clyde. June.

Suter, G.W. 1993. Ecological Risk Assessment. Lewis Publishers, Chelsea, MI.

Suter II, G.W. and C. Tsao. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. Risk Assessment Program, Health Sciences Research Division, Oak Ridge National Laboratory, TN. ES/ER/TM-96/R2.

U.S. Environmental Protection Agency (USEPA). 1976. Quality Criteria for Water. (Red Book). Office of Water and Hazardous Materials. July.

U.S. Environmental Protection Agency (USEPA). 1979. Water-Related Environmental Fate of 129 Priority Pollutants. Prepared by Versar, Inc., Springfield, VA. USEPA 440/4-79-029. December.

U.S. Environmental Protection Agency (USEPA). 1980. Ambient Water Quality Criteria for Arsenic. Office of Water Regulations and Standards. USEPA 440/5-80-021. October.

U.S. Environmental Protection Agency (USEPA). 1985a. Ambient Water Quality Criteria for Lead -- 1984. Office of Water, Criteria and Standards Division. USEPA 440/5-84-027.

U.S. Environmental Protection Agency (USEPA). 1985b. Ambient Water Quality Criteria for Mercury -- 1985. Office of Water Regulations and Standards. USEPA 440/5-84-026. January.

U.S. Environmental Protection Agency (USEPA). 1988. Ambient Aquatic Life Water Quality Criteria for Antimony III. Prepared by Wisconsin University-Superior for USEPA Environmental Research Laboratory, Duluth, MN. August 30.

U.S. Environmental Protection Agency (USEPA). 1989. Risk Assessment Guidance for Superfund. Volume 1. Office of Emergency and Remedial Response.

U.S. Environmental Protection Agency (USEPA). 1991. Water Quality Criteria Summary. Office of Science and Technology. May 1.

U.S. Environmental Protection Agency (USEPA). 1992a. Framework for Ecological Risk Assessment. Risk Assessment Forum. EPA/630/R-92/001. February.

U.S. Environmental Protection Agency (USEPA). 1992b. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; States' Compliance. Federal Register Vol. 57, No. 246: 60848-60923. December 22.

U.S. Environmental Protection Agency (USEPA). 1992c. Supplemental Guidance to RAGS: Calculating the Concentration Term. Office of Solid Waste and Emergency Response, Washington, D.C. Publication 9285.7-081. Intermittent Bulletin Volume 1, Number 1.

U.S. Environmental Protection Agency (USEPA). 1995a. Water Quality Standards: Establishment of Numeric Criteria for Priority Toxic Pollutants; States' Compliance--Revision of Metals Criteria. Federal Register Vol. 60, No. 86. May 4.

U.S. Environmental Protection Agency (USEPA). 1995b. Final Water Quality Guidance for the Great Lakes System - Final Rule. Federal Register Vol. 60, No. 56: 15366-15425. March 23.

U.S. Environmental Protection Agency (USEPA). 1996. Proposed Guidelines for Ecological Risk Assessment; Notice. Federal Register Vol. 61, No. 175: 47552-47631. September 9.

U.S. Environmental Protection Agency (USEPA). 1997a. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. USEPA Environmental Response Team. Interim Final. June 5.

U.S. Environmental Protection Agency (USEPA). 1997b. Part 131 -- Water Quality Standards. 40 Code of Federal Regulations (Protection of Environment). Revised as of July 1.

U.S. Environmental Protection Agency (USEPA). 1998a. Guidelines for Ecological Risk Assessment; Notice. Federal Register Vol. 63, No. 93: 26846-26924. May 14.

U.S. Environmental Protection Agency (USEPA). 1998b. National Recommended Water Quality Criteria: Notice, Republication. Federal Register Vol. 63, No. 237. December 10.

U.S. Environmental Protection Agency (USEPA). 1999. National Recommended Water Quality Criteria–Correction. Office of Water. EPA 822-Z-88-001.

vanDerveer, W.D. and S.P. Carton. 1997. Selenium Sediment Toxicity Thresholds and Derivation of Water Quality Criteria for Freshwater Biota of Western Streams. Environ. Toxicol. Chem. 16:1260-1268.

11.4 REFERENCES FOR TERRESTRIAL AND RIPARIAN ECOLOGICAL RISK EVALUATION (SECTION 8)

Agency for Toxic Substances and Disease Registry (ATSDR). 1989. Toxicological Profile for Copper. U.S. Department of Health & Human Services, Atlanta, GA.

Agency for Toxic Substances and Disease Registry (ATSDR). 1990. Toxicological Profile for Silver. U.S. Department of Health & Human Services, Atlanta, GA.

Agency for Toxic Substances and Disease Registry (ATSDR). 1993. Toxicological Profile for Cadmium. U.S. Department of Health & Human Services. April.

Agency for Toxic Substances and Disease Registry (ATSDR). 1994. Toxicological Profile for Mercury. Update. U.S. Department of Health & Human Services, Atlanta, GA. May.

Agency for Toxic Substances and Disease Registry (ATSDR). 1996. Toxicological Profile for Nickel. Update. U.S. Department of Health & Human Services. August.

Agency for Toxic Substances and Disease Registry (ATSDR). 1999. Toxicological Profile for Arsenic. Update. U.S. Department of Health & Human Services, Atlanta, GA. February.

Ainsworth, N., J.A. Cooke, and M.S. Johnson. 1991a. Biological Significance of Antimony in Contaminated Grassland. *Water, Air and Soil Pollution,* 57-58: 193-199.

Ainsworth, N., J.A. Cooke, and M.S. Johnson. 1991b. Behavior and toxicity of antimony in the short-tailed vole. *Ecotoxicology and Environmental Safety*, 21(2): 165-170.

Alloway, B.J. 1990. Heavy Metals in Soils. Blackie and Son, Ltd. 339 pp.

Bagatto, G. and Ali Khan, M.A. 1987. Copper, cadmium, and nickel accumulation in crayfish populations near a copper-nickel smelter at Sudbury, Ontario, Canada. *Bull. Environ. Contam. Toxicol.* 38, 540-545 in Naqvi et al. 1994.

Bech, J., C. Poschenrieder, M. Llungany et al. 1994. Arsenic and heavy Metal Contamination of Soils and Vegetation around a Copper Mine in Northern Peru. *The Science of the Total Environment*, Vol. 203, pp. 83-91.

Beyer, W.N., O.H. Pattee, L. Sileo, D.J. Hoffman and B. Mulhern. 1985. Metal contamination in wildlife living near two zinc smelters. *Environ. Pollut (A)* 38:63-86.

Beyer, W.N., E. Conner, and S . Gerould. 1994. Estimates of Soil Ingestion by Wildlife. J. Wildl. Manage. 58: 375-382.

Braune, B.M., B. Malone, et al. 1999. Chemical residues in waterfowl and gamebirds harvested in Canada, 1987-95. Canadian Wildlife Service Technical Report 326.

Cole, A. 1977. Lead Inhibition of Enzyme Synthesis in Soil. *Appl Environ. Microbiol.* 33(2):L262 in DeMayo et al. 1982.

DeMayo, A., M.C. Taylor, and P.V. Hodson. 1982. Toxic Effects of Lead and Lead Compounds on Human Health, Aquatic Life, Wildlife, Plants, and Livestock. CRC Critical Reviews in Environmental Control, Vol. 12, Issue 4.

Efroymson, R.A., Suter II, G.W., and B.E. Sample. Oak Ridge National Laboratory (ORNL). 1997. Preliminary Remediation Goals For Ecological Endpoints. Environmental Restoration Risk Assessment Program, Lockheed Martin Energy Systems, Inc., Oak Ridge, TN. ES/ER/TM-162/R1.

Eisler, R. 1985. Selenium Hazards to Fish, Wildlife, and Invertebrates: A synoptic review. U.S. Fish and Wildlife Service Biological Report 85 (1.5). 51 pp.

Eisler, R. 1988. Lead Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. U.S. Fish and Wildlife Service Biological Report 85(1.14). 134 pp.

Eisler, R. 1991. Cyanide Hazards to Fish, Wildlife, and Invertebrates, A Synoptic Review. USFWS Biological Report 85(1.23). 55p.

Eisler, R. 1994. A Review of Arsenic Hazards to Plants and Animals with Emphasis on Fishery and Wildlife Resources. Chapter 11 in Arsenic in the Environment, Part II: Human Health and Ecosystem Effects. Edited by Jerome O. Nriagu. John Wiley and Sons, NY, NY.

Eisler, R. 1997. Copper Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. USGS Biological Science Report, USBS/BRD/BSR-1997-0002.

Gebel, T., S. Kevekordes, J. Schaefer, H. von Platen, and H. Dunkelberg. 1996. Assessment of possible genotoxic environmental risk in sheep bred on grounds with strongly elevated contents of mercury, arsenic, and antimony. *Mutat. Res.* Vol. 368, Issue 3-4, pp. 267-274.

Hawkins, D.B., R. Forbes, C. Hok, D. Dinkel. 1982. Arsenic in the Water, Soil, Bedrock and Plants of the Ester Dome Area of Alaska. Institute of Water Resources. Univ. of Alaska, Fairbanks, AK. Report IWR-103.

Hazardous Substances DataBank (HSDB). 2000. National Library of Medicine Toxicological Database.

International Agency for Research on Cancer (IARC) 1987. IARC Monograph on the Evaluation of Carcinogenic Risk of Chemical to Humans. Suppl. 7, Overall Evaluation of Carcinogenicity, Updating of IARC Monographs, Vol. 1-42. World Health Organization, IARC, Lyon, France. pp. 29-33. (In Naqvi 1994).

Irwin, R.J., M. Van Mouwerik, L. Stevens, M. Dubler Seese, and W. Basham. 1997. Environmental Contaminants Encyclopedia. National Park Service, Water Resources Divisions, Water Operations Branch, Fort Collins, CO.

Jiang, Q.Q. and B. Singh. 1994. Effect of Different Forms and Sources of Arsenic on Crop Yield and Arsenic Concentration. *Water, Air and Soil Pollution* 74: 321-343.

Kabata-Pendias, A. and H. Pendias. 1992. Trace Elements in Soils and Plants. 2nd. Ed. Ann Arbor, MI: CRC Press 365 pp.

Kallio, M.P. and P. Manninen. 1997. Speciation of Mobile Arsenic in Soil Samples as a Function of pH. *The Science of the Total Environment.* Vol. 204, p 193-200.

Merry, R.H., K.G. Tiller, and A.M. Alston. 1986. The effects of contamination of soil with copper, lead and arsenic on the growth and composition of plants. I. Effects of season, genotype, soil temperature, and fertilizers. *Plant Soil* 91:115-128.

Munshower, F. 1994. Practical Handbook of Disturbed Land Revegetation. Lewis Publishers. Boca Raton, FL.

National Academy of Sciences (NAS). 1980. Mineral Tolerance of Domestic Animals. National Research Council. Washington, D.C. 597 pp.

National Research Council of Canada (NRCC) 1978. Effects of arsenic in the Canadian Environment. Natl. Res. Counc. Can Publ. NRCC 15391, 1-349. (In Eisler 1994).

Naqvi, S.M., C. Vaishnavi, and H. Singh. 1994. Toxicity and Metabolism of Arsenic in Vertebrates. Chapter 4 in Arsenic in the Environment, Part II: Human Health and Ecosystem Effects. Edited by Jerome O. Nriagu. John Wiley and Sons, NY, NY.

Oehme, F.E. 1978. Toxicity of Heavy Metals in the Environment. Part I.

Sample, B.E., Opresko, D.M., and G.W. Suter II. Oak Ridge National Laboratory (ORNL). 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. ES/ER/TM-86/R3.

Sample, B.E., Alpin, M.S., Efroymson, R.A., Suter II, G.W., and C.J.E. Welsh. Oak Ridge National Laboratory (ORNL). 1997. Methods and Tools for Estimation of the Exposure of Terrestrial Wildlife to Contaminants. Environmental Restoration Risk Assessment Program, Lockheed Martin Energy Systems, Inc., Oak Ridge, TN. ORNL/TM-13391.

Sample, B.E., Beauchamp, J.J., Efroymson, R.A., and G.W. Suter, II. Oak Ridge National Laboratory (ORNL). 1998. Development and Validation of Bioaccumulation Models for Small Mammals. Environmental Restoration Program, Lockheed Martin Energy Systems, Inc., Oak Ridge, TN ES/ER/TM-219.

Scheuhammer. 1991. Effects of acidification on the availability of toxic metals and calcium to wild birds and mammals. *Environ. Pollut.* 71:329-375.

Shacklette, H.T. and J.G. Boerngen. 1984. Element Concentrations in Soils and Other Surficial Materials of the Coterminous United States. U.S. Geological Survey Professional Paper 1270.

Seiler, H. and H. Sigel. 1988. Handbook on Toxicity of Inorganic Compounds. Marcel Dekker, Inc. New York. 1069 pp.

Sheppard, S.C. 1992. Summary of Phytotoxic Levels of Soil Arsenic. *Water, Air and Soil Pollution* 64: 539-550.

Smith and Rongstad. 1982. Small mammal heavy metal concentrations from mined and control sites. *Environ. Pollut.* 28A:121-134.

Stanley, T.R., Jr. J.W. Spann, G.J. Smith, and R. Roscoe. 1994. Main and interactive effects of arsenic and selenium on mallard reproduction and duckling growth and survival. *Archives of Environmental Contamination and Toxicology* 26: 444-451.

Stibnite Area Characterization Voluntary Consent Order Respondents (Stibnite Group). 1998. Stibnite Area Risk Evaluation Report. Draft. Prepared by Woodward-Clyde. September 10.

Stibnite Area Characterization Voluntary Consent Order Respondents (Stibnite Group). 2000. Stibnite Area Site Characterization Report. Draft. Prepared by URS Greiner Woodward Clyde. March 16.

Strickland, R.C., W.R. Chaney, and R.J. Lamoreaux. 1979. Organic matter influences phytotoxicity of cadmium to soybeans. Plant Soil 53(3):393-402.

Suter, G. W. 1993. Ecological Risk Assessment. Lewis Publishers. Boca Raton, FL.

Talmage, S.S. and B.T. Walton. 1991. Small mammals as monitors of environmental contaminants. Rev. *Envir. Contam. and Toxicology.* Vol. 119:47-145.

Terres, J.K. 1991. The Audubon Society Encyclopedia of North American Birds. Random House Publications, NY, NY.

Tornabene, T.G., N.L. Gale, D.E. Koeppe, R.L. Zimdahl, and R.M. Forbes. 1977. Effects on Microorganisms, Plants, and Animals. In Demayo et al. 1982.

U.S. Environmental Protection Agency (USEPA). 1992. Framework for Ecological Risk Assessment. Risk Assessment Forum. EPA/630/R-92/001. February.

U.S. Environmental Protection Agency (USEPA). 1993. Wildlife Exposure Factors Handbook, Volume 1. Office of Research and Development. EPA/600/R-93/187a.

U.S. Environmental Protection Agency (USEPA). 1997a. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. Interim Final. U.S. EPA Environmental Response Team, Edison, New Jersey. June.

U.S. Environmental Protection Agency (USEPA). 1997b. Priorities for Ecological Protection: An Initial List and Discussion Document for USEPA.

U.S. Environmental Protection Agency (USEPA). 1998. Guidelines for Ecological Risk Assessment. Final. April.

U.S. Environmental Protection Agency (USEPA). 1999. Clark Fork Ecological Risk Assessment. Public Review Draft. Prepared for USEPA Region 8 by ISSI Consulting Group. December.

U.S. Environmental Protection Agency (USEPA). 2000. Ecological Soil Screening Level Guidance. Draft. Office of Environmental and Remedial Response. June 27.

Von Hodenberg, A. and A. Finck. 1975. Determination of Toxicity Limiting Values of Zn, Cu, and Pb for Oat and Red Clover. In Demayo et al. 1982.

Will, M.E. and G.W. Suter II. 1995a. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants. Oak Ridge National Laboratory. September.

Will, M.E. and G.W. Suter II. 1995b. Toxicological Benchmarks for Potential Contaminants of Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process. Oak Ridge National Laboratory. September.

11.5 REFERENCES FOR HEALTH RISK EVALUATION (SECTION 9)

Agency for Toxic Substances and Disease Registry (ATSDR). 1989. Relationship of Human Levels of Lead and Cadmium to the Consumption of Fish Caught in and Around Lake Coeur d'Alene, Idaho.

Agency for Toxic Substances and Disease Registry (ATSDR). 1993a. Toxicological Profile for Arsenic. Update. U.S. Department of Health & Human Services, Atlanta, GA. April.

Agency for Toxic Substances and Disease Registry (ATSDR). 1993b. Public Health Statement: Arsenic.

Carrington, C.D., D.M. Sheehan, P.M. Bolger. 1993. Hazard Assessment of Lead. Food Addit. Contam. 10(3):325-335.

Cowherd, C. et al. 1985. Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination Sites. EPA/600/8-85-002. PB85-192219.

Environmental Quality Management (EQM). 1994. Revisions to VF and PEF Equations. Memorandum #5099-3. Prepared for USEPA OERR. (Included as Appendix D to USEPA 1996b).

Hawley, J.K. 1985. Assessment of health risk from exposure to contaminated soil. Risk Analysis 4:289-302.

Idaho Department of Health and Welfare (IDHW). 1998. Rules and Regulations, Title I, Chapter 2, Water Quality Standards and Wastewater Treatment Requirements. IDAPA 16.01.02, March 1).

Kissel, J.C., K.Y. Richter, and R.A. Fenske. 1996. Field measurements of dermal soil loading attributable to various activities: Implications for exposure assessment. Risk Analysis 16:115-125.

Lorenzana, Roseanne. 1998. Personal communication between Roseanne Lorenzana, EPA Region X risk assessor, and Sharon Quiring, URS Seattle risk assessor.

McGrath, S.P. and S. Smith. 1990. Chromium and Nickel in Heavy Metals in Soils, B.J. Alloway, ed., Blackie and Son Ltd.

Rich, A.A. and Associates (Rich). 1997. Stibnite Mine Expansion Payette National Forest, Draft Fishery Resources Technical Report. April.

Singh, Ashok K., Anita Singh, and M. Englehardt. 1997. The Lognormal Distribution in Environmental Applications. USEPA Technology Support Center Issue Paper. EPA/600/R-9/006. December.

Stibnite Group. 1997. Stibnite Area Risk Evaluation Work Plan. August.

U.S. Department of the Interior (USDOI). 1993. 1991 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, Idaho. August.

U.S. Environmental Protection Agency (USEPA). 1986. Guidelines for the Health Risk Assessment of Chemical Mixtures. 51 FR 34014 (September 24, 1986).

U.S. Environmental Protection Agency (USEPA). 1988. Special Report on Ingested Inorganic Arsenic: Skin Cancer; Nutritional Essentiality. Office of Health and Environmental Assessment, Washington, DC. EPA/625/3-87/013. July.

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

U.S. Environmental Protection Agency (USEPA). 1989b. Exposure Factors Handbook. Washington, DC: Exposure Assessment Group, Office of Research and Development. March. EPA/600/8-89/043.

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

U.S. Environmental Protection Agency (USEPA). 1990. National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Final Rule 40 CFR Part 300. 55 FR 8666. Thursday, March 8.

U.S. Environmental Protection Agency (USEPA). 1991a. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors." OSWER 9285.6-03.

U.S. Environmental Protection Agency (USEPA). 1991b. Role of Baseline Risk Assessment in Superfund Remedy Selection Decisions. OSWER 9355.0-30.

U.S. Environmental Protection Agency (USEPA). 1991c. Water Quality Criteria Summary Concentrations. U.S. Environmental Protection Agency. Office of Science and Technology. May.

U.S. Environmental Protection Agency (USEPA). 1992a. Supplemental Guidance to RAGS: Calculating the Concentration Term. OSWER Publ. 9285.7-081.

U.S. Environmental Protection Agency (USEPA). 1992b. Systemic Toxicity and Carcinogenicity Information for Multiple Chemicals (McGraw-Edison/Centerville, IA). Risk Assessment Issue Paper for: Systemic Toxicity and Carcinogenicity for Aluminum (7429-90-5). From: Joan S. Dollarhide. Associate Director. Superfund Health Risk Technical Support Center. Chemical Mixtures Assessment Branch.

U.S. Environmental Protection Agency (USEPA). 1993a. Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure. Preliminary Review Draft. November.

U.S. Environmental Protection Agency (USEPA). 1993b. Region 8 Superfund Technical Section. Clark Fork Position Paper on the Bioavailability of Arsenic. Prepared by Life Systems Inc., under subcontract to Sverdrup Corporation, for USEPA Region VIII.

U.S. Environmental Protection Agency (USEPA). 1994. Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities. OSWER Directive 9355.4-12.

U.S. Environmental Protection Agency (USEPA). 1996a. Exposure Factors Handbook. Review Draft. Office of Research and Development. Washington, DC. EPA/600/P-95/002Ba.

U.S. Environmental Protection Agency (USEPA). 1996b. Soil Screening Guidance: Technical Background Document. OSWER 9355.4-17A. May.

U.S. Environmental Protection Agency (USEPA). 1996c. Bioavailability of Arsenic and Lead in Environmental Substrates. 1. Results of an Oral Dosing Study of Immature Swine. Superfund Office of Environmental Assessment. USEPA Region X. February.

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

U.S. Environmental Protection Agency (USEPA). 1997a. Exposure Factors Handbook. USEPA Office of Research and Development, Washington, D.C. EPA/600/P-95/002Fa. August.

U.S. Environmental Protection Agency (USEPA). 1997b. Health Effects Assessment Summary Table (HEAST) - FY 1997 Update. Office of Research and Development. Office of Emergency and Remedial Response. USEPA, Washington, D.C. July.

U.S. Environmental Protection Agency (USEPA). 1997c. Part 131 – Water Quality Standards. 40 Code of Federal Regulations (Protection of Environment). Revised as of July 1.

U.S. Environmental Protection Agency (USEPA). 1997d. Baseline Human Health Risk Assessment for the Murray Smelter Superfund Site, Site-Wide Evaluation. Prepared for USEPA Region VIII by Roy F. Weston, Inc. May.

U.S. Environmental Protection Agency (USEPA). 1998a. Current Drinking Water Standards. National Primary Drinking Water Regulations. Office of Ground Water and Drinking Water. USEPA Office of Water.

U.S. Environmental Protection Agency (USEPA). 1998b. Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual Supplement Guidance Dermal Risk Assessment Interim Guidance. NCEA-W-0364. May.

U.S. Environmental Protection Agency Region X (USEPA Region X). 1998. Interim Final Guidance: Developing Risk-Based Cleanup Levels at Resource Conservation and Recovery Act Sites in Region 10. Office of Waste and Chemical Management. USEPA Region 10. January.

U.S. Environmental Protection Agency (USEPA). 1999. Frequently Asked Questions (FAQs) on the Adult Lead Model. Guidance Document. Technical Review Workgroup for Lead. April.

U.S. Environmental Protection Agency (USEPA). 2000. Integrated Risk Information System (IRIS). On-line database.

U.S. Environmental Protection Agency Region IX (USEPA Region IX). 2000. Preliminary Remediation Goals (PRGs). Online at http://www.epa.gov/region09/waste/sfund/prg.

U.S. Food and Drug Administration (FDA). 1993. Guidance Document for Arsenic in Shellfish. Center for Food Safety and Applied Nutrition. Washington, DC. January.

Walker, S. and S. Griffin. 1998. Site-specific Data Confirm Arsenic Exposure Predicted by the U.S. Environmental Protection Agency. Environmental Health Perspectives 106(3):133-139. March.

APPENDIX A

SURFACE WATER EXPOSURE CONCENTRATIONS – AQUATIC EVALUATION

SURFACE WATER CONCENTRATION EXPOSURE – AQUATIC EVALUATION

Tables

Table A1-1

Surface Water Exposure Concentrations (µg/L) -- Meadow Creek

		Antimony, total		Arsenic, dissolved		Cadmium, dissolved		Chromium, dissolved		Copper, dissolved		Cyanide, WAD		Lead, dissolved	
Station	Date	Res	Qual	Res	Qual	Res	Qual	Res	Qual	Res	Qual	Res	Qual	Res	Qual
MC-1A	6/10/99 - 6/12/99	2.65	U	3.5	U	0.315	U	0.85	U	0.85	U	1.1	J	0.25	U
MC-1A	6/22/99 - 6/25/99	2.65	U	3.5	UJ	0.315	U	0.85	UJ	0.85	UJ	2.5	U	0.25	U
MC-1A	7/16/99 - 7/18/99	2.65	U	3.5	U	0.315	U	0.85	U	0.95	U	0.75	U	0.25	U
MC-1A	9/14/99 - 9/25/99	2.65	U	3.5	UJ	0.315	U	0.85	U	0.85	U	0.5	UJ	0.25	U
MC-1C	6/10/99 - 6/12/99	2.65	U	14		0.315	U	0.85	U	0.85	U	2.4	J	0.25	U
MC-1C	6/22/99 - 6/25/99	2.65	U	3.5	UJ	0.315	U	0.85	UJ	0.85	UJ	2.5	U	0.25	U
MC-1C	7/16/99 - 7/18/99	7.1		22		0.315	U	0.85	U	1	U	0.75	U	0.25	U
MC-1C	9/14/99 - 9/25/99	6	U	40		0.315	U	0.85	U	0.85	U	0.5	UJ	0.25	U
2040368	6/10/99 - 6/12/99	9.8		24		0.315	U	0.85	U	0.85	U	1.1	J	0.25	U
2040368	6/22/99 - 6/25/99	7.2		13	J	0.315	U	0.85	UJ	0.85	UJ	2.5	U	0.25	U
2040368	7/16/99 - 7/18/99	8		24		0.315	U	0.85	U	1.2	U	0.75	U	0.25	U
2040368	9/14/99 - 9/25/99	5.5	U	45		0.315	U	0.85	U	0.85	U	0.5	UJ	1.4	
2040322	6/10/99 - 6/12/99	5.9		30		0.315	U	0.85	U	0.85	U	2.8	J	0.25	U
2040322	6/22/99 - 6/25/99	5.9		12	J	0.315	U	0.85	UJ	0.85	UJ	2.5	U	0.25	U
2040322	7/16/99 - 7/18/99	9.3		30		0.315	U	0.85	U	0.85	U	0.75	U	0.25	U
2040322	9/14/99 - 9/25/99	6.5	U	46		0.315	U	0.85	U	0.85	U	0.5	UJ	0.25	U
BL-1	6/10/99 - 6/12/99	2.65	U	3.5	U	0.315	U	0.85	U	0.85	U	1.1	J	0.25	U
BL-1	6/22/99 - 6/25/99	2.65	U	3.5	UJ	0.315	U	0.85	UJ	0.85	UJ	2.5	U	0.25	U
BL-1	7/16/99 - 7/18/99	2.65	U	5.5	U	0.315	U	0.85	U	0.9	U	0.75	U	0.25	U
BL-1	9/14/99 - 9/25/99	2.65	U	3.5	UJ	0.315	U	0.85	U	0.85	U	0.5	UJ	0.25	U
MC-2A	6/10/99 - 6/12/99	8.9		25		0.315	U	0.85	U	0.85	U	2.5	J	0.25	U
MC-2A	6/22/99 - 6/25/99	5.3		12	J	0.315	U	0.85	UJ	0.85	UJ	2.5	U	1.2	
MC-2A	7/16/99 - 7/18/99	7.8		24		0.315	U	0.85	U	0.85	U	0.75	U	0.25	U
MC-2A	9/14/99 - 9/25/99	5	U	36		0.315	U	0.85	U	0.85	U	0.5	UJ	0.25	U
MC-2B	6/10/99 - 6/12/99	18		39		0.315	U	0.85	U	0.85	U	2	J	0.25	U
MC-2B	6/22/99 - 6/25/99	13		17	J	0.315	U	0.85	UJ	0.85	UJ	2.5	U	0.25	U
MC-2B	7/16/99 - 7/18/99	13		43		0.315	U	0.85	U	0.85	U	0.75	U	0.25	U
MC-2B	9/14/99 - 9/25/99	23		64		0.315	U	0.85	U	1.05	U	0.5	UJ	0.25	U
2040319	6/10/99 - 6/12/99	26		40		0.315	U	0.85	U	0.85	U	2.8	J	0.25	U
2040319	6/22/99 - 6/25/99	15		17	J	0.315	U	0.85	UJ	0.85	UJ	2.5	U	0.25	U
2040319	7/16/99 - 7/18/99	16		42		0.315	U	0.85	U	0.85	U	0.75	U	0.25	U
2040319	9/14/99 - 9/25/99	22		58		0.315	U	0.85	U	0.85	U	0.5	UJ	0.25	U

Table A1-1

Surface Water Exposure Concentrations (µg/L) -- Meadow Creek

	Antimony, total		Arsenic, dissolved		Cadmium, dissolved		Chromium, dissolved		Copper, dissolved		Cyanide, WAD		Lead, dissolved	
Station Date	Res	Qual	Res	Qual	Res	Qual	Res	Qual	Res	Qual	Res	Qual	Res	Qual
Number of Samples	32		32		32		32		32		32		32	
Number of Nondetects	14		9		32		32		32		24		30	
Maximum Detected	26		64		--		--		--		2.8		1.4	
Normally Distributed?	Neither		Neither		NA		NA		NA		NA		NA	
Average	8.5		23								1.4		0.32	
Standard Deviation	6.56		17.6								0.92		0.259	
t-value or H value	1.696		1.696								1.696		1.696	
95% UCL	10		29								1.7		0.39	
Exposure Concentration	10		29								1.7		0.39	
Basis of Exposure Concentration	95% UCL		95% UCL		ND		ND		ND		95% UCL		95% UCL	

*Stations include from upstream to downstream: MC-1A, MC-1C, 2040368, 2040322, BL-1, MC-2A, MC-2B, and 2040319.
95% UCL = The 95th upper confidence limit of the mean.
NA = Not applicable because detection frequency was less than 50 percent.
ND = Analyte not detected in the area.
Res = Result. In the result column, one-half the detection limit is shown for nondetects.
Qual = Qualifier. (J = estimated; U = nondetected)

Table A1-1

Surface Water Exposure Concentrations (µg/L) -- Meadow Creek

Station	Date	Mercury, total Res	Qual	Mercury, dissolved Res	Qual	Nickel, dissolved Res	Qual	Selenium, total Res	Qual	Silver, dissolved Res	Qual	Zinc, dissolved Res	Qual
MC-1A	6/10/99 - 6/12/99	0.021	UJ	0.085	J	1.5	UJ	0.8	UJ	0.033	U	2.25	U
MC-1A	6/22/99 - 6/25/99	0.021	UJ	0.021	UJ	1.5	UJ	0.8	UJ	0.033	UJ	42	
MC-1A	7/16/99 - 7/18/99	0.021	U	0.084		1.5	U	0.8	U	0.003	UJ	4.8	UJ
MC-1A	9/14/99 - 9/25/99	0.021	U	0.021	UJ	1.5	U	0.8	U	0.033	U	1.8	U
MC-1C	6/10/99 - 6/12/99	0.021	UJ	0.021	UJ	1.5	UJ	0.8	UJ	0.033	U	2.25	U
MC-1C	6/22/99 - 6/25/99	0.021	UJ	0.021	UJ	1.5	UJ	0.8	UJ	0.033	UJ	1.8	U
MC-1C	7/16/99 - 7/18/99	0.021	U	0.021	U	1.5	U	0.8	U	0.003	UJ	1.8	UJ
MC-1C	9/14/99 - 9/25/99	0.021	U	0.021	UJ	1.5	U	0.8	U	0.033	U	2.1	U
2040368	6/10/99 - 6/12/99	0.021	UJ	0.109	J	1.5	UJ	0.8	UJ	0.033	U	2.35	U
2040368	6/22/99 - 6/25/99	0.021	UJ	0.021	UJ	1.5	UJ	0.8	UJ	0.033	UJ	1.8	U
2040368	7/16/99 - 7/18/99	0.021	U	0.021	U	1.5	U	0.8	U	0.003	UJ	1.8	UJ
2040368	9/14/99 - 9/25/99	0.044		0.021	UJ	1.5	U	0.8	U	0.033	U	2.85	U
2040322	6/10/99 - 6/12/99	0.021	UJ	0.021	UJ	1.5	U	0.8	UJ	0.033	U	6	
2040322	6/22/99 - 6/25/99	0.021	UJ	0.021	UJ	1.5	UJ	0.8	UJ	0.033	UJ	1.8	U
2040322	7/16/99 - 7/18/99	0.021	U	0.021	U	1.5	U	0.8	U	0.033	UJ	5.85	UJ
2040322	9/14/99 - 9/25/99	0.054		0.021	UJ	1.5	U	0.8	U	0.033	U	1.95	U
BL-1	6/10/99 - 6/12/99	0.021	UJ	0.021	UJ	1.5	UJ	0.8	UJ	0.033	U	2.1	U
BL-1	6/22/99 - 6/25/99	0.021	UJ	0.029	UJ	1.5	UJ	0.8	UJ	0.033	UJ	1.8	U
BL-1	7/16/99 - 7/18/99	0.021	U	0.053		1.5	U	0.8	U	0.033	UJ	1.8	UJ
BL-1	9/14/99 - 9/25/99	0.021	U	0.021	UJ	1.5	U	0.8	U	0.033	U	1.8	U
MC-2A	6/10/99 - 6/12/99	0.021	UJ	0.021	UJ	1.5	UJ	0.8	UJ	0.033	U	1.95	U
MC-2A	6/22/99 - 6/25/99	0.021	UJ	0.021	UJ	1.5	UJ	0.8	UJ	0.033	UJ	1.8	U
MC-2A	7/16/99 - 7/18/99	0.021	U	0.057		1.5	U	0.8	U	0.033	UJ	2.95	UJ
MC-2A	9/14/99 - 9/25/99	0.021	U	0.021	UJ	1.5	U	0.8	U	0.033	U	3.3	U
MC-2B	6/10/99 - 6/12/99	0.021	UJ	0.021	UJ	1.5	UJ	0.8	UJ	0.033	U	1.8	U
MC-2B	6/22/99 - 6/25/99	0.021	UJ	0.0225	UJ	1.5	UJ	0.8	UJ	0.033	UJ	1.8	U
MC-2B	7/16/99 - 7/18/99	0.026	U	0.082		1.5	U	0.8	U	0.041	UJ	1.8	UJ
MC-2B	9/14/99 - 9/25/99	0.021	U	0.021	UJ	1.5	U	0.8	U	0.033	U	2.1	U
2040319	6/10/99 - 6/12/99	0.021	UJ	0.021	UJ	1.5	UJ	0.8	UJ	0.033	U	1.9	U
2040319	6/22/99 - 6/25/99	0.021	UJ	0.0495	UJ	1.5	UJ	0.8	UJ	0.033	UJ	1.8	U
2040319	7/16/99 - 7/18/99	0.0235	U	0.021	U	1.5	U	0.8	U	0.033	UJ	1.8	UJ
2040319	9/14/99 - 9/25/99	0.027	U	0.021	UJ	1.5	U	0.8	U	0.033	U	2.15	U

Table A1-1

Surface Water Exposure Concentrations (µg/L) -- Meadow Creek

	Mercury, total		Mercury, dissolved		Nickel, dissolved		Selenium, total		Silver, dissolved		Zinc, dissolved	
Station Date	Res	Qual	Res	Qual	Res	Qual	Res	Qual	Res	Qual	Res	Qual
Number of Samples	32		32		32		32		32		32	
Number of Nondetects	30		26		32		32		32		30	
Maximum Detected	0.054		0.109		--		--		--		42	
Normally Distributed?	NA		NA		NA		NA		NA		NA	
Average	0.023		0.033								3.6	
Standard Deviation	0.00704		0.0242								7.09	
t-value or H value	1.696		1.696								1.696	
95% UCL	0.025		0.040								5.7	
Exposure Concentration	0.025		0.040								5.7	
Basis of Exposure Concentration	95% UCL		95% UCL		ND		ND		ND		95% UCL	

*Stations include from upstream to downstream: MC-1A, MC-1C, 2040368, 2040322, BL-1, MC-2A, MC-2B, and 2040319.
95% UCL = The 95th upper confidence limit of the mean.
NA = Not applicable because detection frequency was less than 50 percent.
ND = Analyte not detected in the area.
Res = Result. In the result column, one-half the detection limit is shown for nondetects.
Qual = Qualifier. (J = estimated; U = nondetected)

Table A1-2

Surface Water Exposure Concentrations (µg/L) -- Upper EFSFSR

		Antimony, total			Arsenic, dissolved		Cadmium, dissolved		Chromium, dissolved		Copper, dissolved		Cyanide, WAD		Lead, dissolved	
Station	Date	Res	LnRes	Qual	Res	Qual	Res	Qual	Res	Qual	Res	Qual	Res	Qual	Res	Qual
2040313	6/10/99 - 6/12/99	20	2.9957		27		0.315	U	0.85	U	0.85	U	1.3	J	0.25	U
2040313	6/22/99 - 6/25/99	10	2.3026		12	J	0.315	U	0.85	UJ	0.85	UJ	2.5	U	0.25	U
2040313	7/16/99 - 7/18/99	10	2.3026		19	J	0.315	U	0.85	U	0.85	UJ	0.75	U	0.25	U
2040313	9/14/99 - 9/25/99	13	2.5649		33		0.315	U	0.85	U	0.85	U	0.5	UJ	0.25	U
2040324	6/10/99 - 6/12/99	27	3.2958		28		0.315	U	0.85	U	0.85	U			0.25	U
2040324	6/22/99 - 6/25/99	10	2.3026		9.1	J	0.315	U	0.85	UJ	0.85	UJ			0.25	U
2040324	7/16/99 - 7/18/99	13	2.5649		23	J	0.315	U	0.85	U	4.7	J			0.25	U
2040324	9/14/99 - 9/25/99	22	3.0910		39		0.315	U	0.85	U	0.85	U			0.25	U
2040321	6/10/99 - 6/12/99	38	3.6376		75		0.315	U	0.85	U	0.85	U			0.25	U
2040321	6/22/99 - 6/25/99	38	3.6376		54		0.315	U	0.85	UJ	0.85	UJ			0.25	U
2040321	7/16/99 - 7/18/99	48	3.8712		75		0.315	U	0.85	U	0.85	U			0.25	U
2040321	9/14/99 - 9/25/99	48	3.8712		91		0.315	U	0.85	U	0.95	U			0.25	U
Number of Samples		12			12		12		12		12		4		12	
Number of Nondetects		0			0		12		12		11		3		12	
Maximum Detected		48			91		--		--		4.7		1.3		--	
Normally Distributed?		Lognormal			Normal		NA		NA		NA		NA		NA	
Average			3.0		40						1.2		1.3			
Standard Deviation			0.621		27.1						1.11		0.890			
t-value or H value			2.299		1.796						1.796		2.353			
95% UCL			39		54						1.8		2.3			
Exposure Concentration			39		54						1.8		1.3			
Basis of Exposure Concentration			95% UCL		95% UCL		ND		ND		95% UCL		Max		ND	

Table A1-2

Surface Water Exposure Concentrations (μg/L) -- Upper EFSFSR

Station	Date	Mercury, total Res	Mercury, total Qual	Mercury, dissolved Res	Mercury, dissolved Qual	Nickel, dissolved Res	Nickel, dissolved Qual	Selenium, total Res	Selenium, total Qual	Silver, dissolved Res	Silver, dissolved Qual	Zinc, dissolved Res	Zinc, dissolved Qual
2040313	6/10/99 - 6/12/99	0.021	UJ	0.021	UJ	1.5	UJ	0.8	UJ	0.033	U	1.8	U
2040313	6/22/99 - 6/25/99	0.021	UJ	0.021	UJ	1.5	UJ	0.8	UJ	0.033	UJ	1.8	U
2040313	7/16/99 - 7/18/99	0.021	UJ	0.021	UJ	1.5	U	0.8	U	0.033	UJ	1.8	U
2040313	9/14/99 - 9/25/99	0.03	U	0.021	UJ	1.5	U	0.8	U	0.033	U	1.8	U
2040324	6/10/99 - 6/12/99	0.021	UJ	0.021	UJ	1.5	UJ	0.8	UJ	0.033	U	2.25	U
2040324	6/22/99 - 6/25/99	0.021	UJ	0.021	UJ	1.5	UJ	0.8	UJ	0.033	UJ	16.7	
2040324	7/16/99 - 7/18/99	0.021	UJ	0.021	UJ	1.5	U	0.8	U	0.033	UJ	7.9	U
2040324	9/14/99 - 9/25/99	0.021	U	0.021	UJ	1.5	U	0.8	U	0.033	U	3.35	U
2040321	6/10/99 - 6/12/99	0.021	UJ	0.021	UJ	1.5	U	0.8	UJ	0.033	U	4.4	
2040321	6/22/99 - 6/25/99	0.021	UJ	0.044	UJ	1.5	UJ	0.8	UJ	0.033	UJ	1.8	U
2040321	7/16/99 - 7/18/99	0.021	U	0.021	U	1.5	U	0.8	U	0.033	UJ	1.8	UJ
2040321	9/14/99 - 9/25/99	0.131		0.021	UJ	1.5	U	0.8	U	0.033	U	2.3	U
Number of Samples		12		12		12		12		12		12	
Number of Nondetects		11		12		12		12		12		10	
Maximum Detected		0.131		--		--		--		--		16.7	
Normally Distributed?		NA		NA		NA		NA		NA		NA	
Average		0.031										4.0	
Standard Deviation		0.0316										4.39	
t-value or H value		1.796										1.796	
95% UCL		0.047										6.3	
Exposure Concentration		0.047										6.3	
Basis of Exposure Concentration		95% UCL		ND		ND		ND		ND		95% UCL	

*Stations include from upstream to downstream: 2040313, 2040324, and 2040321.
95% UCL = The 95th upper confidence limit of the mean.
NA = Not applicable because detection frequency was less than 50 percent.
ND = Analyte not detected in the area.
Res = Result. In the result column, one-half the detection limit is shown for non-detects.
Qual = Qualifier. (J = estimated; U = nondected)

Table A1-3

Surface Water Exposure Concentrations (µg/L) -- Lower EFSFSR

Station	Date	Antimony, total Res	Antimony, total Qual	Arsenic, dissolved Res	Arsenic, dissolved Qual	Cadmium, dissolved Res	Cadmium, dissolved Qual	Chromium, dissolved Res	Chromium, dissolved Qual	Copper, dissolved Res	Copper, dissolved Qual	Cyanide, WAD Res	Cyanide, WAD Qual	Lead, dissolved Res	Lead, dissolved Qual
2040369	6/10/99 - 6/12/99	25		32		0.315	U	0.85	U	0.85	U	NA		0.25	U
2040369	6/22/99 - 6/25/99	14		17	J	0.315	U	0.85	UJ	0.85	UJ	NA		0.25	U
2040369	7/16/99 - 7/18/99	19		28	J	0.315	U	0.85	U	0.85	UJ	NA		0.25	U
2040369	9/14/99 - 9/25/99	27		44		0.315	U	0.85	U	0.85	U	NA		0.25	U
GH1-A	07/16/99	26		59		0.315	U	0.85	U	0.85	UJ	NA		0.25	U
GH1-A	09/14/99	33		69		0.315	U	0.85	U	0.85	U	NA		0.25	U
GH1-B	07/16/99	21		56		0.315	U	0.85	U	0.85	UJ	NA		0.25	U
GH1-B	09/14/99	31		78		0.315	U	0.85	U	0.85	U	NA		0.25	U
GH2-A	07/16/99	21		45		0.315	U	0.85	U	0.85	UJ	NA		0.25	U
GH2-A	09/14/99	32		70		0.315	U	0.85	U	0.85	U	NA		0.25	U
GH2-B	07/16/99	21		45		0.315	U	0.85	U	0.85	UJ	NA		0.25	U
GH2-B	09/14/99	30		76		0.315	U	0.85	U	0.85	U	NA		0.25	U
GH2-C	07/16/99	21		44		0.315	U	0.85	U	1.25	UJ	NA		0.25	U
GH2-C	09/14/99	30		85		0.315	U	0.85	U	0.85	U	NA		0.25	U
GH3-A	07/16/99	20		40		0.315	U	0.85	U	0.85	UJ	NA		0.25	U
GH3-A	09/14/99	32		67		0.315	U	0.85	U	0.85	U	NA		0.25	U
GH3-B	07/16/99	21		44		0.315	U	0.85	U	0.85	UJ	NA		0.25	U
GH3-B	09/14/99	31		68		0.315	U	0.85	U	0.85	U	NA		0.25	U
EF-7	6/10/99 - 6/12/99	30		38		0.315	U	0.85	U	0.85	U	NA		0.25	U
EF-7	6/22/99 - 6/25/99	19		22		0.315	U	0.85	UJ	0.85	U	NA		0.25	U
EF-7	7/16/99 - 7/18/99	21		44		0.315	U	0.85	U	0.85	UJ	NA		0.25	U
EF-7	9/14/99 - 9/25/99	32		68		0.315	U	0.85	U	0.85	U	NA		0.25	U
2040308	6/10/99 - 6/12/99	30		39		0.315	U	0.85	U	0.85	U	NA		0.25	U
2040308	6/22/99 - 6/25/99	18		24		0.315	U	0.85	UJ	0.85	U	NA		0.25	U
2040308	7/16/99 - 7/18/99	22		53		0.315	U	0.85	U	0.85	UJ	NA		0.25	U
2040308	9/14/99 - 9/25/99	35		96		0.315	U	0.85	U	0.85	U	NA		0.25	U
HC-2	6/10/99 - 6/12/99	40		45		0.315	U	0.85	U	0.95	U	NA		0.25	U
HC-2	6/22/99 - 6/25/99	25		39		0.315	U	0.85	UJ	0.85	U	NA		0.25	U
HC-2	7/16/99 - 7/18/99	25		20		0.315	U	0.85	U	0.85	U	NA		0.25	U
HC-2	9/14/99 - 9/25/99	24		14	J	0.315	U	0.85	U	0.85	U	NA		0.25	U
2040314	6/10/99 - 6/12/99	17		26		0.315	U	0.85	U	0.85	U	NA		0.25	U
2040314	6/22/99 - 6/25/99	11		16		0.315	U	0.85	UJ	0.85	U	NA		0.25	U
2040314	7/16/99 - 7/18/99	13		32		0.315	U	0.85	U	0.85	UJ	NA		0.25	U
2040314	9/14/99 - 9/25/99	24		57		0.315	U	0.85	U	0.85	U	NA		0.25	U

Table A1-3

Surface Water Exposure Concentrations (µg/L) -- Lower EFSFSR

Station Date	Antimony, total Res	Qual	Arsenic, dissolved Res	Qual	Cadmium, dissolved Res	Qual	Chromium, dissolved Res	Qual	Copper, dissolved Res	Qual	Cyanide, WAD Res	Qual	Lead, dissolved Res	Qual
Number of Samples	34		34		34		34		34				34	
Number of Nondetects	0		0		34		34		34				34	
Maximum Detected	40		96		--		--		--				--	
Normally Distributed?	Normal		Normal		NA		NA		NA		NA		NA	
Average	25		47											
Standard Deviation	6.72		21.1											
t-value or H value	1.693		1.693											
95% UCL	27		53											
Exposure Concentration	27		53											
Basis of Exposure Concentration	95% UCL		95% UCL		ND		ND		ND		NA		ND	

*Stations include from upstream to downstream: 2040369, EF-7, GH1-A, GH1-B, GH2-A, GH2-B, GH2-C, GH3-A, GH3-B, EF-7, 2040308, HC-2, and 2040314.
95% UCL = The 95th upper confidence limit of the mean.
NA = Not applicable because detection frequency was less than 50 percent.
ND = Analyte not detected in the area.
Res = Result. In the result column, one-half the detection limit is shown for nondetects.
Qual = Qualifier. (J = estimated; U = nondetected)

Table A1-3

Surface Water Exposure Concentrations (µg/L) -- Lower EFSFSR

		Mercury, total		Mercury, dissolved		Nickel, dissolved		Selenium, total		Silver, dissolved		Zinc, dissolved	
Station	Date	Res	Qual	Res	Qual	Res	Qual	Res	Qual	Res	Qual	Res	Qual
2040369	6/10/99 - 6/12/99	0.021	UJ	0.021	UJ	1.5	UJ	0.8	UJ	0.033	U	2.1	U
2040369	6/22/99 - 6/25/99	0.021	UJ	0.021	UJ	1.5	UJ	0.8	UJ	0.033	UJ	1.8	U
2040369	7/16/99 - 7/18/99	0.021	UJ	0.021	UJ	1.5	U	0.8	U	0.033	UJ	12	U
2040369	9/14/99 - 9/25/99	0.021	U	0.021	UJ	1.5	U	0.8	U	0.033	U	1.8	U
GH1-A	07/16/99	0.021	UJ	0.021	UJ	1.5	U	0.8	U	0.033	UJ	2.8	U
GH1-A	09/14/99	0.028	U	0.021	UJ	1.5	U	0.8	U	0.088		2.35	U
GH1-B	07/16/99	0.021	UJ	0.021	UJ	1.5	U	0.8	U	0.033	UJ	2.1	U
GH1-B	09/14/99	0.032	U	0.021	UJ	1.5	U	0.8	U	0.033	U	1.8	U
GH2-A	07/16/99	0.021	UJ	0.021	UJ	1.5	U	0.8	U	0.033	UJ	1.9	U
GH2-A	09/14/99	0.021	U	0.021	UJ	1.5	U	0.8	U	0.033	U	1.8	U
GH2-B	07/16/99	0.021	UJ	0.021	UJ	1.5	U	0.8	U	0.033	UJ	2.65	U
GH2-B	09/14/99	0.0315	U	0.021	UJ	1.5	U	0.8	U	0.033	U	1.8	U
GH2-C	07/16/99	0.021	UJ	0.021	UJ	1.5	U	0.8	U	0.033	UJ	4.7	U
GH2-C	09/14/99	0.021	U	0.021	UJ	1.5	U	0.8	U	0.033	U	1.8	U
GH3-A	07/16/99	0.021	UJ	0.021	UJ	1.5	U	0.8	U	0.033	UJ	3.75	U
GH3-A	09/14/99	0.025	U	0.021	UJ	1.5	U	0.8	U	0.033	U	2.85	U
GH3-B	07/16/99	0.021	UJ	0.021	UJ	1.5	U	0.8	U	0.033	UJ	5.65	U
GH3-B	09/14/99	0.0295	U	0.23		1.5	U	0.8	U	0.033	U	2.85	U
EF-7	6/10/99 - 6/12/99	0.021	UJ	0.021	UJ	1.5	UJ	0.8	UJ	0.033	U	7.85	U
EF-7	6/22/99 - 6/25/99	0.021	UJ	0.021	UJ	1.5	UJ	0.8	UJ	0.033	U	2.65	U
EF-7	7/16/99 - 7/18/99	0.021	UJ	0.021	UJ	1.5	U	0.8	U	0.033	UJ	2.7	U
EF-7	9/14/99 - 9/25/99	0.0315	U	0.021	UJ	1.5	U	0.8	U	0.033	U	1.8	U
2040308	6/10/99 - 6/12/99	0.021	UJ	0.021	UJ	1.5	UJ	0.8	UJ	0.033	U	1.8	U
2040308	6/22/99 - 6/25/99	0.021	UJ	0.021	UJ	1.5	UJ	0.8	UJ	0.033	U	2.2	U
2040308	7/16/99 - 7/18/99	0.021	UJ	0.021	UJ	1.5	U	0.8	U	0.033	UJ	1.8	U
2040308	9/14/99 - 9/25/99	0.0225	U	0.021	UJ	1.5	U	0.8	U	0.033	U	1.8	U
HC-2	6/10/99 - 6/12/99	0.021	UJ	0.021	UJ	1.5	U	0.8	UJ	0.033	U	14.5	
HC-2	6/22/99 - 6/25/99	0.021	UJ	0.021	UJ	1.5	UJ	0.8	UJ	0.033	U	2.25	U
HC-2	7/16/99 - 7/18/99	0.021	U	0.061		1.5	U	0.8	U	0.033	UJ	1.8	UJ
HC-2	9/14/99 - 9/25/99	0.0355	U	0.021	UJ	1.5	U	0.8	U	0.033	U	1.8	U
2040314	6/10/99 - 6/12/99	0.098	J	0.021	UJ	1.5	UJ	0.8	UJ	0.033	U	7.05	U
2040314	6/22/99 - 6/25/99	0.39	J	0.021	UJ	1.5	UJ	0.8	U	0.059	U	1.95	U
2040314	7/16/99 - 7/18/99	0.021	UJ	0.021	UJ	1.5	U	0.8	U	0.128	J	1.8	U
2040314	9/14/99 - 9/25/99	0.0335	U	0.021	UJ	1.5	U	0.8	U	0.033	U	1.8	U

Table A1-3

Surface Water Exposure Concentrations (µg/L) -- Lower EFSFSR

	Mercury, total		Mercury, dissolved		Nickel, dissolved		Selenium, total		Silver, dissolved		Zinc, dissolved	
Station Date	Res	Qual	Res	Qual	Res	Qual	Res	Qual	Res	Qual	Res	Qual
Number of Samples	34		34		34		34		34		34	
Number of Nondetects	32		32		34		34		32		33	
Maximum Detected	0.39		0.23		--		--		0.128		14.5	
Normally Distributed?	NA		NA		NA		NA		NA		NA	
Average	0.036		0.028						0.038		3.3	
Standard Deviation	0.0639		0.0363						0.0189		2.95	
t-value or H value	1.693		1.693						1.693		1.693	
95% UCL	0.055		0.039						0.044		4.2	
Exposure Concentration	0.055		0.039						0.044		4.2	
Basis of Exposure Concentration	95% UCL		95% UCL		ND		ND		95% UCL		95% UCL	

*Stations include from upstream to downstream: 2040369, EF-7, GH1-A, GH1-B, GH2-A, GH2-B, GH2-C, GH3-A, GH3-B, EF-7, 2040308, HC-2, and 2040314.
95% UCL = The 95th upper confidence limit of the mean.
NA = Not applicable because detection frequency was less than 50 percent.
ND = Analyte not detected in the area.
Res = Result. In the result column, one-half the detection limit is shown for nondetects.
Qual = Qualifier. (J = estimated; U = nondetected)

Table A1-4

Surface Water Exposure Concentrations (µg/L) -- Sugar Creek

		Antimony, total		Arsenic, dissolved		Cadmium, dissolved		Chromium, dissolved		Copper, dissolved		Cyanide, WAD		Lead, dissolved	
Station	Date	Res	Qual	Res	Qual	Res	Qual	Res	Qual	Res	Qual	Res	Qual	Res	Qual
SC-3	6/10/99 - 6/12/99	2.65	U	3.5	U	0.315	U	0.85	U	0.85	U	NA		0.25	U
SC-3	6/22/99 - 6/25/99	2.65	U	3.5	UJ	0.315	U	0.85	UJ	0.85	U	NA		0.25	U
SC-3	7/16/99 - 7/18/99	2.65	U	7.7	J	0.315	U	0.85	U	0.95	UJ	NA		0.25	U
SC-3	9/14/99 - 9/25/99	2.65	U	11	J	0.315	U	0.85	U	2.1		NA		0.5	
2040316	6/10/99 - 6/12/99	2.65	U	8.2		0.315	U	0.85	U	0.85	U	NA		0.25	U
2040316	6/22/99 - 6/25/99	2.65	U	3.5	UJ	0.315	U	0.85	UJ	0.85	U	NA		0.25	U
2040316	7/16/99 - 7/18/99	2.65	U	8	J	0.315	U	0.85	U	1	UJ	NA		0.25	U
2040316	9/14/99 - 9/25/99	8.3		16	J	0.315	U	0.85	U	2.9		NA		0.25	U
Number of Samples		8		8		8		8		8				8	
Number of Nondetects		7		3		8		8		6				7	
Maximum Detected		8.3		16		--		--		2.9				0.50	
Normally Distributed?		NA		Normal		NA		NA		NA				NA	
Average		3.4		7.7						1.3				0.28	
Standard Deviation		2.00		4.36						0.777				0.0884	
t-value or H value		1.895		1.895						1.895				1.895	
95% UCL		4.7		11						1.8				0.34	
Exposure Concentration		4.7		11						1.8				0.34	
Basis of Exposure Concentration		95% UCL		95% UCL		ND		ND		95% UCL		NA		95% UCL	

Table A1-4

Surface Water Exposure Concentrations (µg/L) -- Sugar Creek

		Mercury, total		Mercury, dissolved		Nickel, dissolved		Selenium, total		Silver, dissolved		Zinc, dissolved	
Station	Date	Res	Qual	Res	Qual	Res	Qual	Res	Qual	Res	Qual	Res	Qual
SC-3	6/10/99 - 6/12/99	0.199	J	0.021	UJ	1.5	UJ	0.8	UJ	0.033	U	8.35	U
SC-3	6/22/99 - 6/25/99	0.33	J	0.047	J	1.5	UJ	0.8	UJ	0.033	U	1.85	U
SC-3	7/16/99 - 7/18/99	0.047	J	0.021	UJ	1.5	U	0.8	U	0.033	UJ	2.2	U
SC-3	9/14/99 - 9/25/99	0.021	UJ	0.021	UJ	1.5	U	0.8	U	0.033	UJ	1.8	U
2040316	6/10/99 - 6/12/99	0.153	J	0.021	UJ	1.5	UJ	0.8	UJ	0.033	U	7.6	U
2040316	6/22/99 - 6/25/99	0.25	J	0.021	UJ	1.5	UJ	0.8	UJ	0.033	U	1.8	U
2040316	7/16/99 - 7/18/99	0.021	UJ	0.021	UJ	1.5	U	0.8	U	0.033	UJ	13	U
2040316	9/14/99 - 9/25/99	0.021	UJ	0.021	UJ	1.5	U	0.8	U	0.033	UJ	1.85	U
Number of Samples		8		8		8		8		8		8	
Number of Nondetects		3		7		8		8		8		8	
Maximum Detected		0.33		0.047		--		--		--		--	
Normally Distributed?		Normal		NA		NA		NA		NA		NA	
Average		0.13		0.024									
Standard Deviation		0.121		0.00919									
t-value or H value		1.895		1.895									
95% UCL		0.21		0.030									
Exposure Concentration		0.21		0.030									
Basis of Exposure Concentration		95% UCL		95% UCL		ND		ND		ND		ND	

*Stations include from upstream to downstream: SC-3 and 2040316.
95% UCL = The 95th upper confidence limit of the mean.
NA = Not applicable because detection frequency was less than 50 percent.
ND = Analyte not detected in the area.
Res = Result. In the result column, one-half the detection limit is shown for nondetects.
Qual = Qualifier. (J = estimated; U = nondected)

APPENDIX B

EXPOSURE POINT CONCENTRATIONS – HUMAN HEALTH

Tables

Calculation of Reasonable Maximum Exposure Concentrations
Bradley Tailings Impoundment and Neutralized Ore Disposal Area
Surface Soil (mg/kg)

	Chemical	Aluminum			Antimony				Arsenic			Cadmium			Calcium		
Location	Date	Result	Q	DL	Result	Ln	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
SOD-1	10/23/97	4220		14	98	4.58497	J	0.09	1580	J	1.9	0.045	0	0.09	19900		38
SOD-2	10/23/97	4880		12	60.7	4.10594	J	0.08	1800	J	16	0.04	0	0.08	11400		33
SOD-3	10/23/97	5560		13	41.4	3.72328	J	0.08	1210	J	1.7	0.04	0	0.08	33300		36
STP-1	6/25/98	4670		33	59	4.07754		22	1120		1.1	2.7		2.2	15200		33
STP-2	6/25/98	4980		34	42	3.73767		22	1370		1.1	1.1	0	2.2	10700		34
STP-3	6/25/98	5250		33	99	4.59512		22	1090		1.1	1.1	0	2.2	10900		33
STP-4	6/25/98	6820		33	57	4.04305		22	1140		1.1	1.1	0	2.2	49400		33
STP-5	6/25/98	4230		32	77	4.34381		22	1150		1.1	1.1	0	2.2	10400		32
STP-6	6/25/98	6210		34	100	4.60517		22	1420		1.1	1.1	0	2.2	30700		34
STP-7	6/25/98	6510		33	83	4.41884		22	1180		1.1	1.1	0	2.2	40000		33
STP-8	6/25/98	4420		33	93	4.5326		22	2180		1.1	1.1	0	2.2	22100		33
STP-9	6/25/98	4880		35	188	5.23644		23	2290		1.2	1.15	0	2.3	32300		35
STP-10	6/25/98	6480		32	45	3.80666		22	1410		1.1	1.1	0	2.2	32200		32
STP-11	6/25/98	5810		34	180	5.19296		23	1730		1.1	1.15	0	2.3	7350		34
STP-12	6/25/98	3670		37	238	5.47227		25	790		1.2	1.25	0	2.5	4670		37
Distribution		Normal			Lognormal				Normal			--			Normal		
Number of Samples		15			15				15			15			15		
Number of Detects		15			15				15			1			15		
Detection frequency		100			100				100			6.6667			100		
Maximum		6820			238				2290			2.7			49400		
Minimum		3670			41.4				790			0.04			4670		
Mean		5239.333			97.40666667	4.43175			1430.67			1.0117			22034.7		
Standard Deviation		958.5962				0.54544			418.355			--			13500.5		
t(1-a, n-1) or H 0.95		1.761				2.12294			1.761			--			1.761		
95% UCL		5675.196			132.9507277				1620.89			--			28173.2		
RME		5675.196			132.9507277				1620.89			2.7			28173.2		
Basis for RME		UCL			UCL				UCL			Max			UCL		

Notes: LN = natural log; NA = Not analyzed; ND = not detected; Max = Maximum; UCL = Upper Confidence Limit of arithmetic mean; t(1-a, n-1) = one tailed student t at the 95% confidence level; 0 = U = not detected; J = estimated value; Q = qualifier; DL = detection limit
RME = reasonable maximum exposure; H = H-statistic at 95% confidence level
For non-detects, 1/2 the DL was used to calculate means.

Calculation of Reasonable Maximum Exposure Concentrations
Bradley Tailings Impoundment and Neutralized Ore Disposal Area
Surface Soil (mg/kg)

	Chemical	Chromium			Copper			Iron			Lead			Magnesium			Manganese		
Location	Date	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
SOD-1	10/23/97	11.6	J	0.09	14		0.09	26100		22	5.25		0.09	4330		15	429		0.93
SOD-2	10/23/97	11.3	J	0.08	13.3		0.08	27600		19	2.85		0.08	5080		13	310		0.8
SOD-3	10/23/97	14	J	0.08	30.7		0.08	29100		21	2.56		0.08	6420		14	356		0.87
STP-1	6/25/98	11.1		4.4	16		4.4	21100		22	5.5	0	11	6950		28	335		2.2
STP-2	6/25/98	16.7		4.5	15.7		4.5	26800		22	5.5	0	11	3980		28	260		2.2
STP-3	6/25/98	14.4		4.5	21.5		4.5	28600		22	5.5	0	11	5550		28	281		2.2
STP-4	6/25/98	22		4.4	11.7		4.4	23900		22	5.5	0	11	5870		28	444		2.2
STP-5	6/25/98	10.1		4.3	16.7		4.3	24500		22	5.5	0	11	4270		27	264		2.2
STP-6	6/25/98	23.2		4.5	18.5		4.5	30700		22	5.5	0	11	7430		28	424		2.2
STP-7	6/25/98	23.5		4.4	17.9		4.4	28300		22	5.5	0	11	9230		28	442		2.2
STP-8	6/25/98	9.4		4.5	17.1		4.5	26000		22	5.5	0	11	9160		28	439		2.2
STP-9	6/25/98	20.8		4.6	13.2		4.6	28300		23	6	0	12	5140		29	461		2.3
STP-10	6/25/98	22.3		4.3	10.6		4.3	35100		220	5.5	0	11	6210		27	402		2.2
STP-11	6/25/98	10		4.5	19.3		4.5	24800		23	11		11	4220		28	350		2.3
STP-12	6/25/98	2.45	0	4.9	20.5		4.9	12200		25	60		12	2710		31	318		2.5
Distribution		Normal			Normal			Normal			--			Normal			Normal		
Number of Samples		15			15			15			15			15			15		
Number of Detects		14			15			15			5			15			15		
Detection frequency		93.33333			100			100			33.333			100			100		
Maximum		23.5			30.7			35100			60			9230			461		
Minimum		2.45			10.6			12200			2.56			2710			260		
Mean		14.85667			17.11333			26206.7			9.144			5770			367.6667		
Standard Deviation		6.311522			4.908574			5049.54			14.186			1860.36			70.92417		
t(1-a, n-1) or H 0.95		1.761			1.761			1.761			1.761			1.761			1.761		
95% UCL		17.72644			19.3452			28502.6			15.594			6615.88			399.9151		
RME		17.72644			19.3452			28502.6			15.594			6615.88			399.9151		
Basis for RME		UCL			UCL			UCL			UCL			UCL			UCL		

Calculation of Reasonable Maximum Exposure Concentrations
Bradley Tailings Impoundment and Neutralized Ore Disposal Area
Surface Soil (mg/kg)

	Chemical	Mercury			Nickel			Potassium			Selenium			Silver			Sulfate		
Location	Date	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
SOD-1	10/23/97	1.38	J	0.1	29.7		0.09	1770		96	0.14	0	0.28	0.81	J	0.09	3.11		0.3
SOD-2	10/23/97	1.48	J	0.09	38		0.08	2660		82	0.12	0	0.24	0.37	J	0.08	30.2		0.3
SOD-3	10/23/97	0.93	J	0.08	36.6		0.08	3110		90	0.13	0	0.26	0.47	J	0.08	45.8		0.3
STP-1	6/25/98	1.38		0.55	29.5		5.5		NA		0.55	0	1.1		NA			NA	
STP-2	6/25/98	1.73		0.55	35.2		5.6		NA		0.55	0	1.1		NA			NA	
STP-3	6/25/98	1.13		0.22	33.3		5.6		NA		0.55	0	1.1		NA			NA	
STP-4	6/25/98	4		2.2	29.7		5.5		NA		0.55	0	1.1		NA			NA	
STP-5	6/25/98	1.33		0.53	28.2		5.4		NA		0.55	0	1.1		NA			NA	
STP-6	6/25/98	3.1		1.1	36.5		5.6		NA		0.55	0	1.1		NA			NA	
STP-7	6/25/98	4.1		1.1	33.8		5.5		NA		0.55	0	1.1		NA			NA	
STP-8	6/25/98	1.94		0.57	25.8		5.6		NA		0.55	0	1.1		NA			NA	
STP-9	6/25/98	3.5		1.2	42.7		5.8		NA		0.6	0	1.2		NA			NA	
STP-10	6/25/98	3.2		1.1	38.5		5.4		NA		0.55	0	1.1		NA			NA	
STP-11	6/25/98	1.12		0.58	24.2		5.6		NA		0.55	0	1.1		NA			NA	
STP-12	6/25/98	1.22		0.61	3.05	0	6.1		NA		0.6	0	1.2		NA			NA	
Distribution		--			Neither			--			--			Normal			Normal		
Number of Samples		15			15			3			15			3			3		
Number of Detects		15			14			3			0			3			3		
Detection frequency		100			93.33333			100			0			100			100		
Maximum		4.1			42.7			3110			0.6			0.81			45.8		
Minimum		0.93			3.05			1770			0.12			0.37			3.11		
Mean		2.1027			30.98333			2513.3			0.473			0.55			26.37		
Standard Deviation		1.1339			9.267718			--			--			0.230651			21.60117		
t(1-a, n-1) or H 0.95		1.761			1.761			--			--			2.92			2.92		
95% UCL		2.6183			35.19726			--			--			0.938846			62.78661		
RME		2.6183			35.19726			3110			--			0.81			45.8		
Basis for RME		UCL			UCL			Max			ND			Max			Max		

Calculation of Reasonable Maximum Exposure Concentrations
Bradley Tailings Impoundment and Neutralized Ore Disposal Area
Surface Soil (mg/kg)

	Chemical	Zinc			Cyanide		
Location	Date	Result	Q	DL	Result	Q	DL
SOD-1	10/23/97	13.9	J	0.09	NA		
SOD-2	10/23/97	11.3	J	0.08	NA		
SOD-3	10/23/97	11.1	J	0.08	NA		
STP-1	6/25/98	12		11	0.7		
STP-2	6/25/98	5.5	0	11	0.54		
STP-3	6/25/98	12		11	0.95		
STP-4	6/25/98	21		11	0.48		
STP-5	6/25/98	13		11	0.67		
STP-6	6/25/98	15		11	0.82		
STP-7	6/25/98	23		11	0.73		
STP-8	6/25/98	20		11	1.05		
STP-9	6/25/98	16		12	1.25		
STP-10	6/25/98	5.5	0	11	1.84		
STP-11	6/25/98	21		11	0.43		
STP-12	6/25/98	28		12	0.075	0	0.15
Distribution		Normal			Neither		
Number of Samples		15			12		
Number of Detects		13			11		
Detection frequency		86.666667			91.66667		
Maximum		28			1.84		
Minimum		5.5			0.075		
Mean		15.22			0.794583		
Standard Deviation		6.3408201			0.450603		
t(1-a, n-1) or H 0.95		1.761			1.796		
95% UCL		18.103096			1.028203		
RME		18.103096			1.028203		
Basis for RME		UCL			UCL		

Calculation of Reasonable Maximum Exposure Concentrations
Meadow Creek Mine Hillside
Surface Soil (mg/kg)

Location	Date	Aluminum Result	Aluminum Q	Antimony Result	Antimony LN	Antimony Q	Arsenic Result	Arsenic LN	Arsenic Q	Chromium Result	Chromium Q	Copper Result	Copper Q	Lead Result	Lead Q
MCM-1	16-Oct-97	11500		23.8	3.1697	J	284	5.649		3.38		5.43		4.32	J
MCM-2	16-Oct-97	5750		7.22	1.9769	J	1250	7.1309		2.09		5.45		3.75	J
MCM-3	16-Oct-97	10300		5.43	1.6919	J	378	5.9349		3.8		5.12		4.98	J
MCM-4	16-Oct-97	15200		4.29	1.4563	J	49.3	3.8979	J	4.78		5.81		4.36	J
MCM-5	16-Oct-97	4460		13.8	2.6247	J	1460	7.2862		2.07		5.43		6.03	J
MCM-6	16-Oct-97	3780		8.48	2.1377	J	715	6.5723		1.45		3.87		3.16	J
MCM-7	17-Oct-97	12700		11.8	2.4681	J	29	3.3673	J	4.12		5.53		4.06	J
MCM-8	17-Oct-97	9960		3.79	1.3324	J	14.7	2.6878	J	3.1		4.56		3.03	J
MCM-9	17-Oct-97	14600		3.62	1.2865	J	10.5	2.3514	J	4.46		5.81		3.75	J
MCM-10	17-Oct-97	12800		4.82	1.5728	J	36.3	3.5918	J	3.88		4.94		4.04	J
MCM-11	17-Oct-97	11800		1.07	0.0677	J	13.8	2.6247	J	3.81		4.13		2.89	J
MCM-12	17-Oct-97	18900		1.97	0.678	J	1.005	0.005	UJ	5.01		6.68		4.17	J
Distribution		Normal			Lognormal			Lognormal		Normal		Normal		Normal	
Number of samples		12			12			12		12		12		12	
Number of detections		12			12			11		12		12		12	
Frequency of detection		1.00			1.00			0.92		1.00		1.00		1.00	
Maximum detected value		18900			23.8			1460		5.01		6.68		6.03	
Arithmetic Mean (Geometric Mean)(1)		10979			7.51 (5.50)			353 (70.7)		3.50		5.23		4.05	
Standard Deviation(2)		4513			0.851			2.25		1.13		0.775		0.870	
t(1-a,n-1) or H 0.95		1.796			2.653			5.478		1.796		1.796		1.796	
95% UCL		13319			15.6			36700		4.079998		5.63		4.50	
RME		**13319**			**15.6**			**1460**		**4.08**		**5.63**		**4.50**	
Basis for RME		UCL			UCL			Max		UCL		UCL		UCL	

Calculation of Reasonable Maximum Exposure Concentrations
Meadow Creek Mine Hillside
Surface Soil (mg/kg)

		Manganese		Mercury		Nickel		Selenium		Silver		Zinc		
Location	**Date**	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	LN	Q
MCM-1	16-Oct-97	4690		0.045	UJ	4.58		0.145	UJ	0.14		68.4	4.2254	J
MCM-2	16-Oct-97	759		0.57	J	2.49		0.13	UJ	0.17		37.6	3.627	J
MCM-3	16-Oct-97	527		0.39	J	3.13		0.125	UJ	0.22		35.8	3.5779	J
MCM-4	16-Oct-97	785		0.05	UJ	5.14		0.135	UJ	0.045	U	41.9	3.7353	J
MCM-5	16-Oct-97	574		1.13	J	3.9		0.135	UJ	0.3		35.9	3.5807	J
MCM-6	16-Oct-97	463		0.32	J	1.46		0.135	UJ	0.12		15.4	2.7344	J
MCM-7	17-Oct-97	545		0.045	UJ	3.36		0.135	UJ	0.045	U	32.4	3.4782	J
MCM-8	17-Oct-97	444		0.045	UJ	2.44		0.125	UJ	0.04	U	27	3.2958	J
MCM-9	17-Oct-97	654		0.15	J	3.46		0.115	UJ	0.035	U	41.3	3.7209	J
MCM-10	17-Oct-97	693		0.045	UJ	3.14		0.14	UJ	0.045	U	35.8	3.5779	J
MCM-11	17-Oct-97	441		0.045	UJ	2.48		0.1	UJ	0.03	U	30.2	3.4078	J
MCM-12	17-Oct-97	630		0.12	J	4.06		0.13	UJ	0.04	U	38.5	3.6507	J
Distribution		Neither		N/A		Normal		ND		N/A			Lognormal	
Number of samples		11		12		12		12		12			12	
Number of detections		11		6		12		0		5			12	
Frequency of detection		1.00		0.50		1.00		0.00		0.42			1.00	
Maximum detected value		4690		1.13		5.14				0.300			68.4	
Arithmetic Mean (Geometric Mean)(1)		934		0.246		3.30				0.103			36.7(34.8)	
Standard Deviation(2)		1189		0.327		1.02				0.089			0.343	
t(1-a,n-1) or H 0.95		1.812		1.796		1.796				1.796			1.965	
95% UCL		1583		0.416		3.83				0.149			45.3	
RME		**1583**		**0.416**		**3.83**				**0.149**			**45.3**	
Basis for RME		UCL		UCL		UCL				UCL			UCL	

(1) Shown for LN data is the mean of the natural log results and the geometric mean.
(2) Shown for LN data is the standard deviation of the natural log results.
Q = qualifier
J = estimated value
U = not detected, value is one-half of the detection limit
UJ = estimated detection limit, not detected, value is one-half of the detection limit
N/A = Not applicable because the number of non-detects is greater than 50%.
ND = not determined, analyte not evaluated in risk assessment because detection frequency was less than 5%

Calculation of Reasonable Maximum Exposure Concentrations
Lower Meadow Creek Valley
Surface Soil (mg/kg)

Location	Date	Aluminum Result	Aluminum Q	Antimony Result	Antimony Q	Arsenic Result	Arsenic Q	Chromium Result	Chromium LN	Chromium Q	Copper Result	Copper Q	Lead Result	Lead LN	Lead Q
MCV-1	23-Oct-97	15600		25.5	J	177	J	9.09	2.2072	J	8.51		7.78	2.0516	
MCV-2	23-Oct-97	3690		202	J	2020	J	6.67	1.8976	J	13.4		5.55	1.7138	
MCV-3	27-Oct-97	8000		126	J	1610	J	3.57	1.2726	J	8.06		5.4	1.6864	
MCV-4	27-Oct-97	9650		4280	J	1720	J	18.3	2.9069	J	42		54.9	4.0055	
MCV-5	27-Oct-97	8460		53.7	J	166	J	4.66	1.539	J	6.18		3.48	1.247	
MCV-6	29-Oct-97	5450		871		1320		4.3	1.4586	J	14.5	J	14.5	2.6741	J
MCV-7	29-Oct-97	6440		1180		1130		9.79	2.2814	J	24	J	16.2	2.785	J
MCV-8	29-Oct-97	3650		3.41		21.7		2.43	0.8879	J	147	J	1.59	0.4637	J
MCV-9	29-Oct-97	8050		16.3		35.4		6.6	1.8871	J	5.07	J	3.06	1.1184	J
MCV-10	29-Oct-97	3040		54.3		64.4		2.11	0.7467	J	5.65	J	4.4	1.4816	J
MCV-11	29-Oct-97	2500		481		398		2.19	0.7839	J	9.23	J	14.9	2.7014	J
MCV-12	29-Oct-97	9440		14.8		106		6.94	1.9373	J	6.76	J	3.4	1.2238	J
MCV-13	29-Oct-97	3740		1080		466		4.18	1.4303	J	8.97	J	16.8	2.8214	J
MCV-14	29-Oct-97	596		2590		384		4.95	1.5994	J	7.59	J	46.9	3.848	J
MCV-15	29-Oct-97	1070		1510		1610		2.98	1.0919	J	34.2	J	11.8	2.4681	J
MCV-16	29-Oct-97	8880		147		248		5.99	1.7901	J	9.13	J	22.3	3.1046	J
MCV-17	29-Oct-97	1090		1250		679		1.47	0.3853		11.2	J	28.1	3.3358	
MCV-18	29-Oct-97	3170		1350		497		3.16	1.1506		10.5	J	20.1	3.0007	
MCV-19	29-Oct-97	5710		1580		527		7.85	2.0605		12.8	J	41.1	3.716	
Distribution		Normal		Bimodal		Bimodal			Lognormal		Neither			Lognormal	
Number of samples		19		19		19			19		19			19	
Number of detections		19		19		19			19		18			19	
Frequency of detection		1.00		1.00		1.00			1.00		0.95			1.00	
Maximum detected value		15600		4280		2020			18.3		147			54.9	
Arithmetic Mean (Geometric Mean)(1)		5696		885		694			5.64 (4.68)		20.3			17.0 (10.9)	
Standard Deviation(2)		3810		1104		656			0.624		32.2			1.02	
t(1-a,n-1) or H 0.95		1.734		1.734		1.734			2.138		1.740			2.645	
95% UCL		7212		1324		955			7.78		33.1			34.7	
RME		**7212**		**1324**		**955**			**7.78**		**33.1**			**34.7**	
Basis for RME		UCL		UCL		UCL			UCL		UCL			UCL	

Calculation of Reasonable Maximum Exposure Concentrations
Lower Meadow Creek Valley
Surface Soil (mg/kg)

Location	Date	Manganese Result	Manganese Q	Mercury Result	Mercury Q	Nickel Result	Nickel Q	Selenium Result	Selenium Q	Silver Result	Silver Q	Zinc Result	Zinc Q
MCV-1	23-Oct-97	259		0.05	UJ	5.03		0.105	UJ	0.18	J	22.5	J
MCV-2	23-Oct-97	442		1.35	J	36.1		0.13	UJ	0.74	J	17.1	J
MCV-3	27-Oct-97	380		0.76	J	4.23		0.13	UJ	0.83	J	26.3	J
MCV-4	27-Oct-97	343		1.09	J	12.9		11.7*	J	3.97	J	289	J
MCV-5	27-Oct-97	244		0.59	J	4.51		0.12	UJ	0.13	J	19.7	J
MCV-6	29-Oct-97	240		1.39	J	4.23	J	0.89	J	2.58		31.6	J
MCV-7	29-Oct-97	344		0.95	J	17.4	J	0.79	J	2.32		26.8	J
MCV-8	29-Oct-97	116		0.04	UJ	2.9	J	0.125	UJ	0.04	U	19.5	J
MCV-9	29-Oct-97	244		0.31	J	4.01	J	0.115	UJ	0.1		23.3	J
MCV-10	29-Oct-97	126		0.2	J	1.98	J	0.135	UJ	0.23		14.9	J
MCV-11	29-Oct-97	162		0.33	J	2.02	J	0.14	UJ	1.96		19.6	J
MCV-12	29-Oct-97	300		0.29	J	6.32	J	0.14	UJ	0.15		22.9	J
MCV-13	29-Oct-97	278		0.57	J	3.08	J	0.27	J	3.98		21.5	J
MCV-14	29-Oct-97	31.5		0.59	J	4.34	J	0.83	J	3.88		7.36	J
MCV-15	29-Oct-97	98.8		0.52	J	2.6	J	0.43	J	3.08		11	J
MCV-16	29-Oct-97	166		0.13	J	4.43	J	0.1	UJ	0.34		16.4	J
MCV-17	29-Oct-97	186		0.43	J	1.38	J	0.63	J	2.6		15.1	J
MCV-18	29-Oct-97	164		0.56	J	2.79	J	0.52	J	4.3		15.3	J
MCV-19	29-Oct-97	242		0.45	J	4.01	J	0.81	J	4.03		16.2	J
Distribution		Normal		Normal		Neither		Neither		Neither		Neither	
Number of samples		19		19		19		18		19		19	
Number of detections		19		17		19		8		18		19	
Frequency of detection		1.00		0.89		1.00		0.44		0.95		1.00	
Maximum detected value		442		1.39		36.1		0.89		4.3		289	
Arithmetic Mean (Geometric Mean)(1)		230		0.558		6.54		0.356		1.87		33.5	
Standard Deviation(2)		105		0.398		8.14		0.303		1.65		62.1	
t(1-a,n-1) or H 0.95		1.734		1.734		1.734		1.740		1.734		1.734	
95% UCL		271		0.716		9.78		0.480		2.52		58.2	
RME		**271**		**0.716**		**9.78**		**0.480**		**2.52**		**58.2**	
Basis for RME		UCL		UCL		UCL		UCL		UCL		UCL	

(1) Shown for LN data is the mean of the natural log results and the geometric mean.
(2) Shown for LN data is the standard deviation of the natural log results.
Q = qualifier
J = estimated value
U = not detected, value is one-half of the detection limit
UJ = estimated detection limit, not detected, value is one-half of the detection limit
* Selenium outlier not used in estimating I iscussed qualitatively in Section 9.7, Qualitative Uncertainty Analysis).

Reasonable Maximum Exposure Concentration
Upgradient Wetland
Surface Soil (mg/kg)

			Analyte	Aluminum			Antimony			Arsenic			Cadmium			Chromium		
Location	Soil Charac.	FieldID	Date	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
UW-2	ss,c,v	SS99-030-UW	17-Sep-99	43300		3.45		U	0.14	24.4		0.29		U	0.07	39.9		0.72
UW-3	ss,c,g,v	SS99-031-UW	17-Sep-99	37900		3.72		U	0.15	9.1		0.31		U	0.08	15.6		0.77
RME				43300			ND			24.4						39.9		

Reasonable Maximum Exposure Concentration
Upgradient Wetland
Surface Soil (mg/kg)

				Copper			Lead			Manganese			Mercury			Nickel		
Location	Soil Charac.	FieldID	Analyte Date	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
UW-2	ss,c,v	SS99-030-UW	17-Sep-99	12.1		0.43	8.3		0.29	206		0.29	0.11		0.07	21		0.29
UW-3	ss,c,g,v	SS99-031-UW	17-Sep-99	9.8		0.46	9.4		0.31	150		0.31		U	0.08	11.7		0.31
RME				12.1			9.4			206			0.11			21		

Reasonable Maximum Exposure Concentration
Upgradient Wetland
Surface Soil (mg/kg)

Location	Soil Charac.	FieldID	Analyte Date	Selenium Result	Selenium Q	Selenium DL	Silver Result	Silver Q	Silver DL	Zinc Result	Zinc Q	Zinc DL	Cyanide Result	Cyanide Q	Cyanide DL
UW-2	ss,c,v	SS99-030-UW	17-Sep-99	0.19		0.14		U	0.07	67.7		0.43		UJ	0.04
UW-3	ss,c,g,v	SS99-031-UW	17-Sep-99		U	0.15	0.1		0.08	56.6		0.46		UJ	0.05
RME				0.19			0.1			67.7					

Average was calculated using one-half the DL for non-detect results.

U = Not detected. J = Estimated. Q = Qualifier. DL = Detection limit.

Soil Characteristics: b = barren, c = clay, g = gravel, ss = sands or silts, su - sulfur odor, t = includes tailing, v = vegetated.

Reasonable Maximum Exposure Concentration
Keyway Wetland
Surface Soil (mg/kg)

Location	Soil Charac.	FieldID	Analyte Date	Aluminum			Antimony			Arsenic			Cadmium			Chromium		
				Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
KW-1	ss,g,v	SS99-032-KW	17-Sep-99	13000		4.42	6.7		0.74	66.3		0.37		U	0.09	7.1		0.92
KW-2	t,ss,su,v	SS99-033-KW	17-Sep-99	4110		4.3	333		17.92	634		0.36		U	0.09	5.5		0.9
KW-3	ss,g,v	SS99-034-KW	17-Sep-99	4860		5.47	62.4		3.42	119		0.46		U	0.11	4.2		1.14
Minimum				4110			6.7			66.3						4.2		
RME				13000			333			634						7.1		
Average				7323			134			273						5.6		

Reasonable Maximum Exposure Concentration
Keyway Wetland
Surface Soil (mg/kg)

Location	Soil Charac.	FieldID	Analyte Date	Copper Result	Copper Q	Copper DL	Cyanide Result	Cyanide Q	Cyanide DL	Lead Result	Lead Q	Lead DL	Manganese Result	Manganese Q	Manganese DL	Mercury Result	Mercury Q	Mercury DL
KW-1	ss,g,v	SS99-032-KW	17-Sep-99	5.1		0.55	0.12	J	0.06	3.2		0.37	233		0.37	0.45		0.09
KW-2	t,ss,su,v	SS99-033-KW	17-Sep-99	19.6		0.54	0.27	J	0.05	47.8		0.36	200		0.36	0.89		0.09
KW-3	ss,g,v	SS99-034-KW	17-Sep-99	4.2		0.68		U	0.07	3.8		0.46	98		0.46	0.31		0.11
Minimum				4.2			<0.07			3.2			98			0.31		
RME				19.6			0.27			47.8			233			0.89		
Average				9.6			0.195			18.3			177			0.55		

Reasonable Maximum Exposure Concentration
Keyway Wetland
Surface Soil (mg/kg)

Location	Soil Charac.	FieldID	Analyte Date	Nickel Result	Nickel Q	Nickel DL	Selenium Result	Selenium Q	Selenium DL	Silver Result	Silver Q	Silver DL	Zinc Result	Zinc Q	Zinc DL	Cyanide Result	Cyanide Q	Cyanide DL
KW-1	ss,g,v	SS99-032-KW	17-Sep-99	3.3		0.37		U	0.18	0.1		0.09	40.9		0.55	0.12	J	0.06
KW-2	t,ss,su,v	SS99-033-KW	17-Sep-99	5.9		0.36	0.52		0.18	2.8		0.09	22.8		0.54	0.27	J	0.05
KW-3	ss,g,v	SS99-034-KW	17-Sep-99	3.3		0.46	0.24		0.23		U	0.11	22.9		0.68		UJ	0.07
Minimum				3.3			<0.18			<0.11			22.8			<0.07		
RME				5.9			0.52			2.8			40.9			0.27		
Average				4.2			0.28			1.0			28.9			0.14		

Average was calculated using one-half the DL for non-detect results.
U = Not detected. J = Estimated. Q = Qualifier. DL = Detection limit.
Soil Characteristics: b = barren, c = clay, g = gravel, ss = sands or silts, su - sulfur odor, t = includes tailing, v = vegetated.

Reasonable Maximum Exposure Concentration
Meadow Creek Forested Wetland
Surface Soil (mg/kg)

Location	Soil Charac.	FieldID	Analyte Date	Aluminum Result	Aluminum Q	Aluminum DL	Antimony Result	Antimony Q	Antimony DL	Arsenic Result	Arsenic Q	Arsenic DL	Cadmium Result	Cadmium Q	Cadmium DL	Chromium Result	Chromium Q	Chromium DL
MCW-1	t,ss,su,v	SS99-035-MCW	17-Sep-99	3320		3.13	1430		45.57	1230		1.3		U	0.33	2.4	U	4.8
MCW-2	t,ss,su,v	SS99-036-MCW	17-Sep-99	1770		3.52	1550		51.32	937		0.29	0.13		0.07	13.1		0.73
MCW-3	ss,c,v	SS99-037-MCW	17-Sep-99	34200		5.15	5.4		0.3	266		0.43		U	0.11	14.3		1.07
Minimum				1770			5.4			266			<0.11			2.4		
RME				34200			1550			1230			0.13			14.3		
Average				13096.7			995			811						9.9		

Reasonable Maximum Exposure Concentration
Meadow Creek Forested Wetland
Surface Soil (mg/kg)

			Analyte	Copper			Lead			Manganese			Mercury			Nickel		
Location	Soil Charac.	FieldID	Date	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
MCW-1	t,ss,su,v	SS99-035-MCW	17-Sep-99	22.3		0.39	160	J	1.3	47.1		0.26	2.2		0.07	0.65	U	1.3
MCW-2	t,ss,su,v	SS99-036-MCW	17-Sep-99	68.8		0.44	94.6	J	0.29	130		0.29	3.1		0.07	2.1		0.29
MCW-3	ss,c,v	SS99-037-MCW	17-Sep-99	21		0.64	8.9	J	0.43	199		0.43	2.8		0.11	8		0.43
Minimum				21			8.9			47.1			2.2			<1.3		
RME				68.8			160			199			3.1			8		
Average				37			88			125			2.7			4		

Reasonable Maximum Exposure Concentration
Meadow Creek Forested Wetland
Surface Soil (mg/kg)

Location	Soil Charac.	FieldID	Analyte Date	Selenium			Silver			Zinc			Cyanide		
				Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
MCW-1	t,ss,su,v	SS99-035-MCW	17-Sep-99	3.5	J	0.08	6		0.33	11		0.39		UJ	0.03
MCW-2	t,ss,su,v	SS99-036-MCW	17-Sep-99	5.3	J	0.44	19.6		0.07	34.7		0.44		UJ	0.04
MCW-3	ss,c,v	SS99-037-MCW	17-Sep-99		UJ	0.13		U	0.11	70.9		0.64		UJ	0.05
Minimum				<0.13			<0.11			11					
RME				5.3			19.6			70.9					
Average				3.0			9			39					

Average was calculated using one-half the DL for non-detect results.

U = Not detected. J = Estimated. Q = Qualifier. DL = Detection limit.

Soil Characteristics: b = barren, c = clay, g = gravel, ss = sands or silts, su - sulfur odor, t = includes tailing, v = vegetated.

Calculation of Reasonable Maximum Exposure Concentrations
SE Bradley Waste Rock Dumps
Surface Soil (mg/kg)

Location	Soil Charac.	Analyte Date	Aluminum Result	Aluminum Q	Aluminum DL	Antimony Result	Antimony Q	Antimony DL	Arsenic Result	Arsenic Q	Arsenic DL	Cadmium Result	Cadmium Q	Cadmium DL	Chromium Result	Chromium Q	Chromium DL
SE-1G	cb,g,s,vp	9/17/99	4030		2.51	0.65	J	0.1	4090		2.09	0.26	0	0.52	5.3		0.52
SE-2G	g,s,b	9/17/99	4030		2.51	0.7	J	0.1	2460		1.05	0.13	0	0.26	5.7		0.52
SE-3S	g,s,b	9/17/99	4740		2.51	0.56	J	0.1	3650		2.09	0.26	0	0.52	4.9		0.52
SE-4S	cb,g,s,vp	9/17/99	3020		2.51	0.45	J	0.1	4970		2.09	0.26	0	0.52	5.4		0.52
Distribution			Normal			Normal			Normal						Normal		
Number of Samples			4			4			4			4			4		
Number of Detects			4			4			4			0			4		
Detection frequency			100			100			100			0			100		
Maximum			4740			0.7			4970			0.26			5.7		
Minimum			3020			0.45			2460			0.13			4.9		
Mean			3955			0.59			3792.5			0.2275			5.325		
Standard Deviation			707.507			0.109848			1044.17			--			0.330404		
t(1-a, n-1) or H 0.95			2.353			2.353			2.353			--			2.353		
95% UCL			4787.38			0.719237			5020.966			--			5.71372		
RME			4740			0.7			4970			--			5.7		
Basis for RME			Max			Max			Max			ND			Max		

Notes: LN = natural log; NA = Not analyzed; ND = not detected; Max = Maximum; UCL = Upper Confidence Limit of arthimetic mean; t(1-a, n-1) = one tailed student t at the 95% confidence level; 0 = U = not detected; J = estimated value; Q = qualifer; DL = detection limit
RME = reasonable maximum exposure; H = H-statistic at 95% confidence level
For non-detects, 1/2 the DL was used to calculate means.

Calculation of Reasonable Maximum Exposure Concentrations
SE Bradley Waste Rock Dumps
Surface Soil (mg/kg)

		Analyte	Copper			Iron			Lead			Magnesium			Manganese		
Location	Soil Charac.	Date	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
SE-1G	cb,g,s,vp	9/17/99	6.3		0.31	22900		2.09	7	J	2.09	382		3.66	395		0.21
SE-2G	g,s,b	9/17/99	5.9		0.31	18000		2.09	4.6	J	1.05	669		3.66	587		0.21
SE-3S	g,s,b	9/17/99	7.4		0.31	18700		2.09	11.5	J	2.09	581		3.66	365		0.21
SE-4S	cb,g,s,vp	9/17/99	6.5		0.31	26800		2.09	9.2	J	2.09	235		3.66	432		0.21
Distribution			Normal			Normal			Normal			Normal			Normal		
Number of Samples			4			4			4			4			4		
Number of Detects			4			4			4			4			4		
Detection frequency			100			100			100			100			100		
Maximum			7.4			26800			11.5			669			587		
Minimum			5.9			18000			4.6			235			365		
Mean			6.525			21600			8.075			466.75			444.75		
Standard Deviation			0.634429			4086.563			2.956772			195.6602			98.71297		
t(1-a, n-1) or H 0.95			2.353			2.353			2.353			2.353			2.353		
95% UCL			7.271406			26407.84			11.55364			696.9442			560.8858		
RME			7.271406			26407.84			11.5			669			560.8858		
Basis for RME			UCL			UCL			Max			Max			UCL		

Calculation of Reasonable Maximum Exposure Concentrations
SE Bradley Waste Rock Dumps
Surface Soil (mg/kg)

		Analyte	Mercury			Nickel			Selenium			Silver			Zinc		
Location	Soil Charac.	Date	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
SE-1G	cb,g,s,vp	9/17/99	2.6	J	0.05	2.7	J	2.09	0.05	0	0.1	0.26	0	0.52	49.8		0.31
SE-2G	g,s,b	9/17/99	1.6	J	0.05	4	J	1.05	0.05	0	0.1	0.13	0	0.26	38.9		0.31
SE-3S	g,s,b	9/17/99	1.6	J	0.05	3.2	J	2.09	0.05	0	0.1	0.26	0	0.52	39.4		0.31
SE-4S	cb,g,s,vp	9/17/99	2	J	0.05	2.5	J	2.09	0.05	0	0.1	0.54		0.52	53.9		0.31
Distribution			Normal			Normal									Normal		
Number of Samples			4			4			4			4			4		
Number of Detects			4			4			0			1			4		
Detection frequency			100			100			0			25			100		
Maximum			2.6			4			0.05			0.54			53.9		
Minimum			1.6			2.5			0.05			0.13			38.9		
Mean			1.95			3.1			0.05			0.2975			45.5		
Standard Deviation			0.472582			0.668331			--			--			7.52374		
t(1-a, n-1) or H 0.95			2.353			2.353			--			--			2.353		
95% UCL			2.505992			3.886292			--			--			54.35168		
RME			2.505992			3.886292			--			0.54			53.9		
Basis for RME			UCL			UCL			ND			Max			Max		

Calculation of Reasonable Maximum Exposure Concentrations
NW Bradley Waste Rock Dumps
Surface Soil (mg/kg)

Location	Analyte SampleDate	Aluminum Result	Aluminum Ln	Aluminum Q	Aluminum DL	Antimony Result	Antimony Ln	Antimony Q	Antimony DL	Arsenic Result	Arsenic Q	Arsenic DL	Cadmium Result	Cadmium Q	Cadmium DL
BD-1	10/30/97	1910	7.554858521		9.4	43.3	3.768152635		0.63	4390		13	0.0315	0	0.063
BD-10	10/30/97	3020	8.01301211		14	344	5.840641657		0.9	663		1.8	0.045	0	0.09
BD-2	10/30/97	5880	8.679312041		13	326	5.786897381		0.84	1360		1.7	0.042	0	0.084
BD-3	10/30/97	5150	8.546751994		13	915	6.818924065		0.85	1200		1.7	0.0425	0	0.085
BD-4	10/30/97	2500	7.824046011		12	896	6.797940413		0.83	1760		17	0.0415	0	0.083
BD-5	10/30/97	2160	7.677863501		8.9	58.4	4.06731589		0.59	3550		12	0.0295	0	0.059
BD-7	10/30/97	4440	8.398409655		13	307	5.726847748		0.84	3680		17	0.042	0	0.084
BD-8	10/30/97	3920	8.273846933		11	27.8	3.325036021		0.75	2490		15	0.0375	0	0.075
BD-9	10/30/97	3070	8.029432841		15	43	3.761200116		0.98	4730		20	0.049	0	0.098
NW-10S	9/7/99	5830	8.670772279		2.56	52.3	3.956996371		5.32	2590		1.07	0.135	0	0.27
NW-11S	9/7/99	12200	9.409191231		2.57	33.5	3.511545439		4.28	678		0.21	0.025	0	0.05
NW-12S	9/8/99	9930	9.203315757		2.53	58.9	4.075841091	J	2.95	458		0.21	0.025	0	0.05
NW-13S	9/6/99	7520	8.925321417		2.56	12.2	2.501435952		0.6	5330		2.13	0.265	0	0.53
NW-14S	9/7/99	5360	8.586719254		2.68	149	5.003946306		4.69	1670		1.12	0.14	0	0.28
NW-1G	9/8/99	6350	8.756210092		2.5	5.6	1.722766598		0.52	67.4		0.21	0.025	0	0.05
NW-2G	9/8/99	4840	8.48467		2.5	37	3.610917913	J	4.17	2370		1.04	0.13	0	0.26
NW-3S	9/8/99	9590	9.168476168		2.53	13.9	2.63188884		2.11	2290		1.05	0.13	0	0.26
NW-4G	9/6/99	9180	9.124782484		2.52	81.3	4.398146017		10.52	1910		1.05	0.13	0	0.26
NW-5G	9/6/99	6380	8.760923376		2.52	69.1	4.235554731		8.39	1290		1.05	0.13	0	0.26
NW-6S	9/6/99	8750	9.076808979		2.53	95.5	4.559126247		10.55	1010		1.05	0.13	0	0.26
NW-7G	9/6/99	3060	8.026170195		2.56	73.8	4.301358732		10.68	3500		2.14	0.265	0	0.53
NW-8G	9/7/99	3580	8.183118079		2.65	42.4	3.747148362		4.41	2830		1.1	0.14	0	0.28
NW-9G	9/7/99	16000	9.680344001		2.7	27.7	3.321432413		2.81	736		0.23	0.03	0	0.06

Calculation of Reasonable Maximum Exposure Concentrations
NW Bradley Waste Rock Dumps
Surface Soil (mg/kg)

Location	Analyte SampleDate	Aluminum Result	Aluminum Ln	Q	DL	Antimony Result	Antimony Ln	Q	DL	Arsenic Result	Q	DL	Cadmium Result	Q	DL
Distribution		Lognormal				Lognormal				Normal			--		
Number of Samples		23				23				23			23		
Number of Detects		23				23				23			0		
Detection frequency		100				100				100			0		
Maximum		16000				915				5330			0.265		
Minimum		1910				5.6				67.4			0.025		
Mean		6113.913	8.567580736			161.4217391	4.237872215			2197.930435			0.089586957		
Standard Deviation			0.565538805				1.287311741			1450.390187			--		
t(1-a, n-1) or H 0.95			2.06864				3.067997			1.717			--		
95% UCL		7918.2105				368.148909				2717.19804			--		
RME		7918.2105				368.148909				2717.19804			--		
Basis for RME		UCL				UCL				UCL			ND		

Notes: LN = natural log; NA = Not analyzed; ND = not detected; Max = Maximum; UCL = Upper Confidence Limit of arithmetic mean;
t(1-a, n-1) = one tailed student t at the 95% confidence level; 0 = U = not detected; J = estimated value; Q = qualifier; DL = detection limit
RME = reasonable maximum exposure; H = H-statistic at 95% confidence level
For non-detects, 1/2 the DL was used to calculate means.

Calculation of Reasonable Maximum Exposure Concentrations
NW Bradley Waste Rock Dumps
Surface Soil (mg/kg)

Location	Analyte SampleDate	Calcium Result	Q	DL	Chloride Result	Q	DL	Chromium Result	Ln	Q	DL	Copper Result	Q	DL	Iron Result	Q	DL
BD-1	10/30/97	2020		26	1.6		0.1	1.71	0.536493371	J	0.063	5.31	J	0.063	13200		15
BD-10	10/30/97	1130	J	37	0.14		0.1	2.37	0.862889955		0.09	2.825	0	5.65	7860		22
BD-2	10/30/97	1610		34	0.26		0.1	2.83	1.040276712	J	0.084	8.74	J	0.084	15100		20
BD-3	10/30/97	1440	J	35	0.28		0.1	2.34	0.850150929		0.085	7.21	J	0.085	15100		20
BD-4	10/30/97	1930	J	34	0.2		0.1	1.02	0.019802627		0.083	6.97	J	0.083	14200		20
BD-5	10/30/97	1470	J	24	0.18		0.1	1.83	0.604315967		0.059	2.84	0	5.68	15300		14
BD-7	10/30/97	1460	J	34	0.21		0.1	3.45	1.238374231		0.084	7.73	J	0.084	17800		20
BD-8	10/30/97	883	J	31	0.21		0.1	5.34	1.675225653		0.075	8.98	J	0.075	12600		18
BD-9	10/30/97	1430	J	40	0.22		0.1	2.34	0.850150929		0.098	9.19	J	0.098	19600		23
NW-10S	9/7/99							9.5	2.251291799		0.53	8.9		0.32	19100		2.13
NW-11S	9/7/99							23.7	3.165475048		0.54	15.8		0.32	21700		2.14
NW-12S	9/8/99							8.7	2.163323026		0.53	5.5		0.32	14400		2.11
NW-13S	9/6/99							7.8	2.054123734		0.53	9.1		0.32	20900		2.13
NW-14S	9/7/99							6	1.791759469		0.56	10.1		0.33	18600		2.23
NW-1G	9/8/99							3.9	1.360976553		0.52	2.4		0.31	10200		2.09
NW-2G	9/8/99							7.2	1.974081026		0.52	11.7		0.31	21600		2.09
NW-3S	9/8/99							13.2	2.58021683		0.53	9.7		0.32	18200		2.11
NW-4G	9/6/99							3.2	1.16315081		0.53	9		0.32	18200		2.1
NW-5G	9/6/99							6.1	1.808288771		0.52	6.1		0.31	13200		2.1
NW-6S	9/6/99							11.7	2.459588842		0.53	5.8		0.32	14700		2.11
NW-7G	9/6/99							5.2	1.648658626		0.53	9.9		0.32	18600		2.14
NW-8G	9/7/99							5	1.609437912		0.55	6.1		0.33	16800		2.21
NW-9G	9/7/99							30.1	3.404525172		0.56	17.9		0.34	27000		2.25

Calculation of Reasonable Maximum Exposure Concentrations
NW Bradley Waste Rock Dumps
Surface Soil (mg/kg)

Location	Analyte SampleDate	Calcium Result	Q	DL	Chloride Result	Q	DL	Chromium Result	Ln	Q	DL	Copper Result	Q	DL	Iron Result	Q	DL
Distribution		Normal			Neither			Lognormal				Normal			Normal		
Number of Samples		9			9			23				23			23		
Number of Detects		9			9			23				21			23		
Detection frequency		100			100			100				91.30434783			100		
Maximum		2020			1.6			30.1				17.9			27000		
Minimum		883			0.14			1.02				2.4			7860		
Mean		1485.888889			0.366666667			7.153478261	1.613590347			8.165			16693.91304		
Standard Deviation		352.5260432			0.464300549				0.840935939			3.697899588			4178.81425		
t(1-a, n-1) or H 0.95		1.86			1.86				2.343729			1.717			1.717		
95% UCL		1704.455036			0.654533007			10.88493582				9.488919233			18190.00898		
RME		1704.455036			0.654533007			10.88493582				9.488919233			18190.00898		
Basis for RME		UCL			UCL			UCL				UCL			UCL		

Calculation of Reasonable Maximum Exposure Concentrations
NW Bradley Waste Rock Dumps
Surface Soil (mg/kg)

	Analyte	Lead			Magnesium				Manganese			Mercury			
Location	SampleDate	Result	Q	DL	Result	Ln	Q	DL	Result	Q	DL	Result	Ln	Q	DL
BD-1	10/30/97	5.9	J	0.063	478	6.169610732	J	10	101		0.63	0.266	-1.32425897	J	0.091
BD-10	10/30/97	3.18		0.09	1340	7.200424893		14	100		0.9	0.22	-1.514127733	J	0.1
BD-2	10/30/97	4.35	J	0.084	1910	7.554858521	J	13	288		0.84	0.39	-0.94160854	J	0.1
BD-3	10/30/97	5.41		0.085	1750	7.467371067		14	265		0.85	0.69	-0.371063681	J	0.1
BD-4	10/30/97	4.41		0.083	1000	6.907755279		13	113		0.83	0.226	-1.48722028	J	0.087
BD-5	10/30/97	10.1		0.059	573	6.350885717		9.5	59.4		0.59	0.532	-0.63111179	J	0.095
BD-7	10/30/97	8.92		0.084	1380	7.229838778		13	123		0.84	0.673	-0.396009949	J	0.083
BD-8	10/30/97	5.13		0.075	1420	7.258412151		12	103		0.75	0.46	-0.776528789	J	0.091
BD-9	10/30/97	6.37		0.098	699	6.549650742		16	163		0.98	0.571	-0.560366069	J	0.091
NW-10S	9/7/99	8		1.07	2500	7.824046011		3.73	325		0.21	0.77	-0.261364764	J	0.05
NW-11S	9/7/99	4.5		0.21	6880	8.836373931		3.75	543		0.21	0.43	-0.84397007	J	0.05
NW-12S	9/8/99	2.4	J	0.21	3540	8.171882006		3.69	254		0.21	0.42	-0.867500568		0.05
NW-13S	9/6/99	6.2	J	2.13	1620	7.390181428		3.73	233		0.21	1.7	0.530628251		0.05
NW-14S	9/7/99	6.8	J	1.12	913	6.816735881		3.91	32.6		0.22	0.53	-0.634878272		0.06
NW-1G	9/8/99	1.8		0.21	2600	7.863266724		3.65	175		0.21	0.14	-1.966112856	J	0.05
NW-2G	9/8/99	5		1.04	1540	7.339537695		3.65	216		0.21	0.55	-0.597837001	J	0.05
NW-3S	9/8/99	6.5		1.05	2920	7.979338895		3.68	236		0.21	1.5	0.405465108	J	0.05
NW-4G	9/6/99	0.55	0	1.1	3570	8.180320875		3.68	305		0.21	1.3	0.262364264	J	0.05
NW-5G	9/6/99	4.6		1.05	2460	7.807916629		3.67	208		0.21	3.8	1.335001067	J	0.05
NW-6S	9/6/99	6.1		1.05	3290	8.098642844		3.69	219		0.21	1.6	0.470003629	J	0.05
NW-7G	9/6/99	9.4		2.14	751	6.621405652		3.74	141		0.21	1.2	0.182321557	J	0.05
NW-8G	9/7/99	7.8		1.1	1090	6.993932975		3.86	229		0.22	0.71	-0.342490309	J	0.06
NW-9G	9/7/99	6.8		0.23	8200	9.011889433		3.94	420		0.23	2.5	0.916290732	J	0.06

Calculation of Reasonable Maximum Exposure Concentrations
NW Bradley Waste Rock Dumps
Surface Soil (mg/kg)

	Analyte	Lead			Magnesium				Manganese			Mercury			
Location	SampleDate	Result	Q	DL	Result	Ln	Q	DL	Result	Q	DL	Result	Ln	Q	DL
Distribution		Normal			Lognormal				Normal			Lognormal			
Number of Samples		23			23				23			23			
Number of Detects		22			23				23			23			
Detection frequency		95.65217391			100				100			100			
Maximum		10.1			8200				543			3.8			
Minimum		0.55			478				32.6			0.14			
Mean		5.66173913			2279.304348	7.461925168			210.9565217			0.920782609	-0.409320654		
Standard Deviation		2.365011344				0.73777066			117.6868102				0.813754378		
t(1-a, n-1) or H 0.95		1.717				2.226651			1.717				2.343729		
95% UCL		6.508458715			3243.19773				253.0906651			1.388741657			
RME		6.508458715			3243.19773				253.0906651			1.388741657			
Basis for RME		UCL			UCL				UCL			UCL			

Calculation of Reasonable Maximum Exposure Concentrations
NW Bradley Waste Rock Dumps
Surface Soil (mg/kg)

	Analyte	Nickel				Potassium				Selenium				Silver		
Location	SampleDate	Result	Ln	Q	DL	Result	Ln	Q	DL	Result	Ln	Q	DL	Result	Q	DL
BD-1	10/30/97	1.71	0.536493371	J	0.063	1080	6.98471632		65	0.095	-2.353878387	0	0.19	1.02		0.063
BD-10	10/30/97	3.04	1.111857515	J	0.09	1220	7.106606138	J	93	0.135	-2.002480501	0	0.27	0.787		0.09
BD-2	10/30/97	2.47	0.904218151	J	0.084	2320	7.749322465		86	0.125	-2.079441542	0	0.25	1.4		0.084
BD-3	10/30/97	2.67	0.982078472	J	0.085	1700	7.43838353	J	87	0.41	-0.891598119	J	0.25	1.88		0.085
BD-4	10/30/97	1.78	0.576613364	J	0.083	964	6.871091295	J	85	0.125	-2.079441542	0	0.25	2.42		0.083
BD-5	10/30/97	2.11	0.746687947	J	0.059	1190	7.081708586	J	61	0.09	-2.407945609	0	0.18	1.78		0.059
BD-7	10/30/97	3.36	1.211940974	J	0.084	1390	7.237059026	J	87	0.125	-2.079441542	0	0.25	2.43		0.084
BD-8	10/30/97	5.41	1.688249093	J	0.075	1240	7.122866659	J	77	0.11	-2.207274913	0	0.22	0.758		0.075
BD-9	10/30/97	2.58	0.947789399	J	0.098	1240	7.122866659	J	100	0.145	-1.931021537	0	0.29	1.71		0.098
NW-10S	9/7/99	5.7	1.740466175		1.07					0.26	-1.347073648	J	0.11	1.3		0.27
NW-11S	9/7/99	17.7	2.87356464		0.21					0.14	-1.966112856	J	0.11	1.1		0.05
NW-12S	9/8/99	3.9	1.360976553		0.21					0.12	-2.120263536	J	0.06	0.93		0.05
NW-13S	9/6/99	4	1.386294361		2.13					0.03	-3.506557897	0	0.06	3.3		0.53
NW-14S	9/7/99	2.7	0.993251773		1.12					1.6	0.470003629	J	0.13	5.4		0.28
NW-1G	9/8/99	1.4	0.336472237		0.21					0.05	-2.995732274	0	0.1	0.09		0.05
NW-2G	9/8/99	4.9	1.589235205		1.04					0.25	-1.386294361	J	0.1	2.1		0.26
NW-3S	9/8/99	6.9	1.931521412		1.05					0.055	-2.900422094	0	0.11	0.89		0.26
NW-4G	9/6/99	6.3	1.840549633		1.05					0.24	-1.427116356	J	0.11	5.6		0.26
NW-5G	9/6/99	3.8	1.335001067		1.05					0.2	-1.609437912	J	0.1	2.8		0.26
NW-6S	9/6/99	4.2	1.435084525		1.05					0.3	-1.203972804	J	0.11	2.3		0.26
NW-7G	9/6/99	1.05	0.048790164	0	2.1					0.32	-1.139434283	J	0.11	3.6		0.53
NW-8G	9/7/99	2.8	1.029619417		1.1					0.18	-1.714798428	J	0.11	1.9		0.28
NW-9G	9/7/99	12.1	2.493205453		0.23					0.15	-1.897119985	J	0.11	0.96		0.06

Calculation of Reasonable Maximum Exposure Concentrations
NW Bradley Waste Rock Dumps
Surface Soil (mg/kg)

Location	Analyte SampleDate	Nickel Result	Nickel Ln	Nickel Q	Nickel DL	Potassium Result	Potassium Ln	Potassium Q	Potassium DL	Selenium Result	Selenium Ln	Selenium Q	Selenium DL	Silver Result	Silver Q	Silver DL
Distribution		Lognormal				Lognormal				Lognormal				Neither		
Number of Samples		23				9				23				23		
Number of Detects		22				9				12				23		
Detection frequency		95.65217391				100				52.17391304				100		
Maximum		17.7				2320				1.6				5.6		
Minimum		1.05				964				0.03				0.09		
Mean		4.46	1.265215691			1371.555556	7.190513409			0.228478261	-1.859863326			2.019782609		
Standard Deviation			0.657837032				0.261793732				0.799815641			1.394147376		
t(1-a, n-1) or H 0.95			2.171568				2.013				2.284032			1.717		
95% UCL		5.966471795				1654.246283				0.316467489				2.518914205		
RME		5.966471795				1654.246283				0.316467489				2.518914205		
Basis for RME		UCL				UCL				UCL				UCL		

Calculation of Reasonable Maximum Exposure Concentrations
NW Bradley Waste Rock Dumps
Surface Soil (mg/kg)

	Analyte	Sodium			Sulfate			Zinc		
Location	SampleDate	Result	Q	DL	Result	Q	DL	Result	Q	DL
BD-1	10/30/97	150	J	11	89.8		0.3	17.3	J	0.063
BD-10	10/30/97	280		16	7.82		0.3	12	J	0.09
BD-2	10/30/97	262	J	15	95.5		0.3	29.6	J	0.084
BD-3	10/30/97	238		15	66.6		0.3	26.7	J	0.085
BD-4	10/30/97	300		15	24		0.3	26.4	J	0.083
BD-5	10/30/97	191		11	187		0.3	14.8	J	0.059
BD-7	10/30/97	279		15	63.6		0.3	15.4	J	0.084
BD-8	10/30/97	227		13	119		0.3	11.8	J	0.075
BD-9	10/30/97	281		18	79.1		0.3	21.8	J	0.098
NW-10S	9/7/99							45.9		0.32
NW-11S	9/7/99							32.3		0.32
NW-12S	9/8/99							44		0.32
NW-13S	9/6/99							33.9		0.32
NW-14S	9/7/99							25.1		0.33
NW-1G	9/8/99							26.1		0.31
NW-2G	9/8/99							33.9		0.31
NW-3S	9/8/99							32.1		0.32
NW-4G	9/6/99							34.5		0.32
NW-5G	9/6/99							30.4		0.31
NW-6S	9/6/99							30.3		0.32
NW-7G	9/6/99							22.8		0.32
NW-8G	9/7/99							32.1		0.33
NW-9G	9/7/99							134		0.34

Calculation of Reasonable Maximum Exposure Concentrations
NW Bradley Waste Rock Dumps
Surface Soil (mg/kg)

	Analyte	Sodium			Sulfate			Zinc		
Location	SampleDate	Result	Q	DL	Result	Q	DL	Result	Q	DL
Distribution		Normal			Normal			Neither		
Number of Samples		9			9			23		
Number of Detects		9			9			23		
Detection frequency		100			100			100		
Maximum		300			187			134		
Minimum		150			7.82			11.8		
Mean		245.3333333			81.38			31.87826087		
Standard Deviation		49.12229636			52.54097544			24.01868508		
t(1-a, n-1) or H 0.95		1.86			1.86			1.717		
95% UCL		275.7891571			113.9554048			40.47741246		
RME		275.7891571			113.9554048			40.47741246		
Basis for RME		UCL			UCL			UCL		

Calculation of Reasonable Maximum Exposure Concentrations
NE Bradley Waste Rock Dumps
Surface Soil (mg/kg)

		Analyte	Aluminum				Antimony				Arsenic			Cadmium		
Location	Soil Charac.	Date	Result	Ln	Q	DL	Result	Ln	Q	DL	Result	Q	DL	Result	Q	DL
BT-1S	g,s,b	9/3/99	2240	7.714231145		2.46	1.6	0.470003629	J	0.21	7570		2.05	0.255	0	0.51
BT-2G	g,s,vp	9/3/99	2330	7.753623547		2.48	0.3	-1.203972804	J	0.1	1940		1.04	0.13	0	0.26
NE-1G	cb,g,s,b	9/3/99	2510	7.828038032		2.53	3.2	1.16315081	J	0.42	5410		2.11	0.265	0	0.53
NE-2S	g,s,b	9/3/99	4960	8.50916102		2.51	3.5	1.252762968	J	0.42	6150		2.09	0.26	0	0.52
NE-3S	cb,g,s,vp	9/3/99	8790	9.081369991		2.49	3.7	1.30833282	J	0.42	2780		1.04	0.13	0	0.26
NE-4G	g,s,b	9/3/99	8900	9.093806556		2.54	7.8	2.054123734	J	0.74	1070		1.06	0.13	0	0.26
NE-5G	g,s,b	9/3/99	1840	7.517520851		2.59	4.6	1.526056303	J	0.32	4830		2.16	0.27	0	0.54
NE-6S	cb,g,s,b	9/2/99	5900	8.68270763		2.5	5.9	1.774952351	J	0.52	5330		2.08	0.26	0	0.52
NE-7S	g,s,vw	9/2/99	15800	9.667765219		2.45	19.1	2.949688335	J	2.05	1080		1.02	0.13	0	0.26
NE-8G	cb,g,s,b	9/3/99	4380	8.384804003		2.57	3.3	1.193922468	J	0.32	6470		2.14	0.27	0	0.54
Distribution			Lognormal				Lognormal				Normal			--		
Number of Samples			10				10				10			10		
Number of Detects			10				10				10			0		
Detection frequency			100				100				100			0		
Maximum			15800				19.1				7570			0.27		
Minimum			1840				0.3				1070			0.13		
Mean			5765	8.423302799			5.3	1.248902061			4263			0.21		
Standard Deviation				0.717518337				1.081757834			2358.57325			--		
t(1-a, n-1) or H 0.95				2.619				3.35			1.833			--		
95% UCL			11016.09418				20.94636204				5630.13636			--		
RME			11016.09418				19.1				5630.13636			--		
Basis for RME			UCL				Max				UCL			ND		

Notes: LN = natural log; NA = Not analyzed; ND = not detected; Max = Maximum; UCL = Upper Confidence Limit of arithmetic mean; t(1-a, n-1) = one tailed student t at the 95% confidence level; 0 = U = not detected; J = estimated value; Q = qualifier; DL = detection limit
RME = reasonable maximum exposure; H = H-statistic at 95% confidence level
For non-detects, 1/2 the DL was used to calculate means.

Calculation of Reasonable Maximum Exposure Concentrations
NE Bradley Waste Rock Dumps
Surface Soil (mg/kg)

		Analyte	Chromium				Copper			Iron			Lead		
Location	Soil Charac.	Date	Result	Ln	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
BT-1S	g,s,b	9/3/99	4.4	1.481604541		0.51	10.8		0.31	23300		2.05	10.4	J	2.05
BT-2G	g,s,vp	9/3/99	3.3	1.193922468		0.52	3.2		0.31	13700		2.07	3.2	J	1.04
NE-1G	cb,g,s,b	9/3/99	4.1	1.410986974		0.53	7.8		0.32	17700		2.11	7.3	J	2.11
NE-2S	g,s,b	9/3/99	5.6	1.722766598		0.52	9.6		0.31	21700		2.09	10.8	J	2.09
NE-3S	cb,g,s,vp	9/3/99	11.9	2.4765384		0.52	10.9		0.31	19300		2.08	6.1	J	1.04
NE-4G	g,s,b	9/3/99	8.7	2.163323026		0.53	10.6		0.32	15400		2.11	4.1	J	1.06
NE-5G	g,s,b	9/3/99	3.1	1.131402111		0.54	4.6		0.32	13300		2.16	6.7	J	2.16
NE-6S	cb,g,s,b	9/2/99	9.9	2.292534757		0.52	11.7		0.31	22200		2.08	6.8	J	2.08
NE-7S	g,s,vw	9/2/99	32.5	3.481240089		0.51	14.7		0.31	21500		2.05	4.3	J	1.02
NE-8G	cb,g,s,b	9/3/99	4.6	1.526056303		0.54	6.9		0.32	21300		2.14	10.1	J	2.14
Distribution			Lognormal				Normal			Normal			Normal		
Number of Samples			10				10			10			10		
Number of Detects			10				10			10			10		
Detection frequency			100				100			100			100		
Maximum			32.5				14.7			23300			10.8		
Minimum			3.1				3.2			13300			3.2		
Mean			8.81	1.888037527			9.08			18940			6.98		
Standard Deviation				0.724908466			3.469486033			3694.500417			2.723886113		
t(1-a, n-1) or H 0.95				2.619			1.833			1.833			1.833		
95% UCL			16.17761925				11.09107195			21081.50052			8.558888314		
RME			16.17761925				11.09107195			21081.50052			8.558888314		
Basis for RME			UCL				UCL			UCL			UCL		

Calculation of Reasonable Maximum Exposure Concentrations
NE Bradley Waste Rock Dumps
Surface Soil (mg/kg)

		Analyte	Magnesium				Manganese				Mercury			Nickel			
Location	Soil Charac.	Date	Result	Ln	Q	DL	Result	Ln	Q	DL	Result	Q	DL	Result	Ln	Q	DL
BT-1S	g,s,b	9/3/99	521	6.255750042		3.59	111	4.709530201		0.21	1.5	J	0.05	1	0	0	2.1
BT-2G	g,s,vp	9/3/99	2370	7.770645234		3.62	256	5.545177444		0.21	0.65	J	0.05	2.5	0.916290732	J	1.04
NE-1G	cb,g,s,b	9/3/99	250	5.521460918		3.7	74.5	4.310799125	J	0.21	1.1	J	0.05	1.05	0.048790164	0	2.1
NE-2S	g,s,b	9/3/99	457	6.124683391		3.66	104	4.644390899		0.21	1.4	J	0.05	2.2	0.78845736	J	2.09
NE-3S	cb,g,s,vp	9/3/99	1990	7.595889918		3.64	223	5.407171771		0.21	1.1	J	0.05	7.3	1.987874348	J	1.04
NE-4G	g,s,b	9/3/99	2900	7.972466016		3.7	319	5.765191103		0.21	0.39	J	0.05	5.4	1.686398954	J	1.06
NE-5G	g,s,b	9/3/99	287	5.659482216		3.78	163	5.093750201		0.22	2.3	J	0.05	1.1	0.09531018	0	2.2
NE-6S	cb,g,s,b	9/2/99	1720	7.45007957		3.65	241	5.484796933		0.21	1.2	J	0.05	6.9	1.931521412	J	2.08
NE-7S	g,s,vw	9/2/99	10400	9.249561085		3.58	545	6.300785795		0.2	0.92	J	0.05	22.3	3.104586678	J	1.02
NE-8G	cb,g,s,b	9/3/99	353	5.866468057		3.75	111	4.709530201		0.21	1.6	J	0.05	1.05	0.048790164	0	2.1
Distribution			Lognormal				Lognormal				Normal			Lognormal			
Number of Samples			10				10				10			10			
Number of Detects			10				10				10			6			
Detection frequency			100				100				100			60			
Maximum			10400				545				2.3			22.3			
Minimum			250				74.5				0.39			1			
Mean			2124.8	6.946648645			214.75	5.197112367			1.216			5.08	1.060801999		
Standard Deviation				1.234564684				0.611560282			0.53275385				1.074290937		
t(1-a, n-1) or H 0.95				3.639				2.448125			1.833				3.348		
95% UCL			9959.185651				358.9467426				1.52480837			17.0604206			
RME			9959.185651				358.9467426				1.52480837			17.0604206			
Basis for RME			UCL				UCL				UCL			UCL			

Calculation of Reasonable Maximum Exposure Concentrations
NE Bradley Waste Rock Dumps
Surface Soil (mg/kg)

		Analyte	Selenium			Silver			Zinc		
Location	Soil Charac.	Date	Result	Q	DL	Result	Q	DL	Result	Q	DL
BT-1S	g,s,b	9/3/99	0.13	J	0.1	2		0.51	27.1		0.31
BT-2G	g,s,vp	9/3/99	0.05	0	0.1	0.13	0	0.26	31.5		0.31
NE-1G	cb,g,s,b	9/3/99	0.21	J	0.11	1.7	J	0.53	17.5		0.32
NE-2S	g,s,b	9/3/99	0.28	J	0.1	2.4		0.52	26.5		0.31
NE-3S	cb,g,s,vp	9/3/99	0.05	0	0.1	0.82		0.26	29.1		0.31
NE-4G	g,s,b	9/3/99	0.055	0	0.11	0.88		0.26	39.5		0.32
NE-5G	g,s,b	9/3/99	0.3	J	0.11	2.6		0.54	15.6		0.32
NE-6S	cb,g,s,b	9/2/99	0.18	J	0.1	1.9		0.52	24.2		0.31
NE-7S	g,s,vw	9/2/99	0.05	0	0.1	0.7		0.26	28.3		0.31
NE-8G	cb,g,s,b	9/3/99	0.42	J	0.11	1.7		0.54	18.7		0.32
Distribution			Normal			Normal			Normal		
Number of Samples			10			10			10		
Number of Detects			6			9			10		
Detection frequency			60			90			100		
Maximum			0.42			2.6			39.5		
Minimum			0.05			0.13			15.6		
Mean			0.1725			1.483			25.8		
Standard Deviation			0.12959874			0.807658481			7.191043812		
t(1-a, n-1) or H 0.95			1.833			1.833			1.833		
95% UCL			0.247621326			1.9511556			29.96825615		
RME			0.247621326			1.9511556			29.96825615		
Basis for RME			UCL			UCL			UCL		

Calculation of Reaosnable Maximum Exposure Concentrations
Lower Meadow Creek Valley
Surface Water (ug/L)

			Aluminum, total			Antimony, total			Arsenic, total			Cadmium, total			Chromium, total		
Area/Stream	Location	Date	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
Meadow Creek	2040319	10-Jun-99	89			26			41			0.315	0	0.63	0.85	0	1.7
Meadow Creek	2040319	Jul-16-99	62	0	124	16			39			0.315	0	0.63	0.85	0	1.7
Meadow Creek	2040319	Jun-25-99	117			15			25			0.315	0	0.63	0.85	0	1.7
Meadow Creek	2040319	Sept-25-99	26.5	0	53	22			69			0.315	0	0.63	0.85	0	1.7
Meadow Creek	2040322	10-Jun-99	26	0	52	5.9			32			0.315	0	0.63	0.85	0	1.7
Meadow Creek	2040322	Jul-16-99	64.5	0	129	9.3			26			0.315	0	0.63	0.85	0	1.7
Meadow Creek	2040322	Jun-25-99	77			5.9			14			0.315	0	0.63	0.85	0	1.7
Meadow Creek	2040322	Sept-25-99	26	0	52	6.5	0	13	54			0.315	0	0.63	0.85	0	1.7
Meadow Creek	2040368	10-Jun-99	142			9.8			22	J		0.315	0	0.63	0.85	0	1.7
Meadow Creek	2040368	Jul-16-99	58.5	0	117	8			26			0.315	0	0.63	0.85	0	1.7
Meadow Creek	2040368	Jun-25-99	101			7.2			17			0.315	0	0.63	0.85	0	1.7
Meadow Creek	2040368	Sept-25-99	26	0	52	6.5	0	11	55			0.315	0	0.63	0.85	0	1.7
Blowout Creek	BL-1	10-Jun-99	113			2.65	0	5.3	3.5	0	7	0.315	0	0.63	0.85	0	1.7
Blowout Creek	BL-1	Jul-16-99	51.5	0	103	2.65	0	5.3	10	J		0.315	0	0.63	0.85	0	1.7
Blowout Creek	BL-1	Jun-25-99	115			2.65	0	5.3	3.5	0	7	0.315	0	0.63	0.85	0	1.7
Blowout Creek	BL-1	Sept-25-99	26	0	52	2.65	0	5.3	3.5	0	7	0.315	0	0.63	0.85	0	1.7
Meadow Creek	MC-1A	10-Jun-99	153			2.65	0	5.3	3.5	0	7	0.315	0	0.63	0.85	0	1.7
Meadow Creek	MC-1A	Jul-16-99	47	0	94	2.65	0	5.3	3.5	0	7	0.315	0	0.63	0.85	0	1.7
Meadow Creek	MC-1A	Jun-25-99	114			2.65	0	5.3	3.5	0	7	0.315	0	0.63	0.85	0	1.7
Meadow Creek	MC-1A	Sept-25-99	26	0	52	2.65	0	5.3	3.5	0	7	0.315	0	0.63	0.85	0	1.7
Meadow Creek	MC-2A	10-Jun-99	83			8.9			25	J		0.315	0	0.63	0.85	0	1.7
Meadow Creek	MC-2A	Jul-16-99	57.5	0	115	7.8			21			0.315	0	0.63	0.85	0	1.7
Meadow Creek	MC-2A	Jun-25-99	81			5.3			17			0.315	0	0.63	0.85	0	1.7
Meadow Creek	MC-2A	Sept-25-99	28	0	56	5	0	10	44			0.315	0	0.63	0.85	0	1.7
Meadow Creek	MC-2B	10-Jun-99	73			18			38			0.315	0	0.63	0.85	0	1.7
Meadow Creek	MC-2B	Jul-16-99	64.5	0	129	13			39			0.315	0	0.63	0.85	0	1.7
Meadow Creek	MC-2B	Jun-25-99	108			13			23			0.315	0	0.63	0.85	0	1.7
Meadow Creek	MC-2B	Sept-25-99	26	0	52	23			67			0.315	0	0.63	0.85	0	1.7

Calculation of Reaosnable Maximum Exposure Concentrations
Lower Meadow Creek Valley
Surface Water (ug/L)

			Aluminum, total			Antimony, total			Arsenic, total			Cadmium, total			Chromium, total		
Area/Stream	Location	Date	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
Distribution			Neither			Neither			Neither			--			--		
Number of Samples			28			28			28			28			28		
Number of Detects			13			17			21			0			0		
Detection frequency			46.43			60.71			75.00			0.00			0.00		
Maximum			153			26			69			0.315			0.85		
Minimum			26			2.65			3.5			0.315			0.85		
Mean			70.785714			9.046429			26.017857			0.315			0.85		
Standard Deviation			38.367238			6.783285			19.60701			--			--		
t(1-a, n-1) or H 0.95			1.703			1.703			1.703			--			--		
95% UCL			83.133702			11.22954			32.328114			--			--		
RME			83.133702			11.22954			32.328114			--			--		
Basis for RME			UCL			UCL			UCL			ND			ND		

Notes: LN = natural log; NA = Not analyzed; ND = not detected; Max = Maximum; UCL = Upper Confidence Limit of arthimetic mean;
t(1-a, n-1) = one tailed student t at the 95% confidence level; 0 = U = not detected; J = estimated value; Q = qualifer; DL = detection li mit
RME = reasonable maximum exposure; H = H-statistic at 95% confidence level
For non-detects, 1/2 the DL was used to calculate means.

Calculation of Reaosnable Maximum Exposure Concentrations
Lower Meadow Creek Valley
Surface Water (ug/L)

			Copper, total			Cyanide, total			Cyanide, WAD			Iron, total			Lead, total		
Area/Stream	Location	Date	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
Meadow Creek	2040319	10-Jun-99	0.85	0	1.7	5.3			2.8	J		200			0.5		
Meadow Creek	2040319	Jul-16-99	0.85	0	1.7	1.8			0.75	0	1.5	130			0.25	0	0.5
Meadow Creek	2040319	Jun-25-99	0.85	0	1.7	2.05	0	4.1	2.5	0	5	180	J		1		
Meadow Creek	2040319	Sept-25-99	0.85	0	1.7	0.5	0	1	0.5	0	1	200			0.25	0	0.5
Meadow Creek	2040322	10-Jun-99	1	0	2	1.5	J		2.8	J		60	J		0.25	0	0.5
Meadow Creek	2040322	Jul-16-99	0.85	0	1.7	2.1			0.75	0	1.5	60	0	120	0.25	0	0.5
Meadow Creek	2040322	Jun-25-99	0.85	0	1.7	2.5	0	5	2.5	0	5	94	J		9.7		
Meadow Creek	2040322	Sept-25-99	2			0.5	0	1	0.5	0	1	190			0.25	0	0.5
Meadow Creek	2040368	10-Jun-99	0.85	0	1.7	3	J		1.1	J		190			1.1		
Meadow Creek	2040368	Jul-16-99	0.85	0	1.7	2.9			0.75	0	1.5	60	0	120	0.25	0	0.5
Meadow Creek	2040368	Jun-25-99	0.85	0	1.7	1.5	0	3	2.5	0	5	120	J		1.1		
Meadow Creek	2040368	Sept-25-99	0.85	0	1.7	0.5	0	1	0.5	0	1	200			0.25	0	0.5
Blowout Creek	BL-1	10-Jun-99	0.85	0	1.7	1.5	J		1.1	J		160			0.5		
Blowout Creek	BL-1	Jul-16-99	0.85	0	1.7	0.75	0	1.5	0.75	0	1.5	24	0	48	0.25	0	0.5
Blowout Creek	BL-1	Jun-25-99	0.85	0	1.7	2.8	0	5.6	2.5	0	5	160	J		0.25	0	0.5
Blowout Creek	BL-1	Sept-25-99	0.85	0	1.7	0.5	0	1	0.5	0	1	50	0	100	0.25	0	0.5
Meadow Creek	MC-1A	10-Jun-99	0.85	0	1.7	1.1	J		1.1	J		180			0.9		
Meadow Creek	MC-1A	Jul-16-99	0.85	0	1.7	0.75	0	1.5	0.75	0	1.5	41	0	82	0.25	0	0.5
Meadow Creek	MC-1A	Jun-25-99	1.7			2.05	0	4.1	2.5	0	5	88	J		1		
Meadow Creek	MC-1A	Sept-25-99	0.85	0	1.7	0.5	0	1	0.5	0	1	27.5	0	55	0.25	0	0.5
Meadow Creek	MC-2A	10-Jun-99	0.85	0	1.7	3.2	J		2.5	J		65	0	130	1.8		
Meadow Creek	MC-2A	Jul-16-99	0.85	0	1.7	0.75	0	1.5	0.75	0	1.5	50	0	100	0.25	0	0.5
Meadow Creek	MC-2A	Jun-25-99	0.85	0	1.7	1.5	0	3	2.5	0	5	87	J		0.9		
Meadow Creek	MC-2A	Sept-25-99	0.85	0	1.7	0.5	0	1	0.5	0	1	180			0.25	0	0.5
Meadow Creek	MC-2B	10-Jun-99	0.85	0	1.7	4.5	J		2	J		150			0.6		
Meadow Creek	MC-2B	Jul-16-99	0.85	0	1.7	3.1			0.75	0	1.5	60	0	120	0.25	0	0.5
Meadow Creek	MC-2B	Jun-25-99	0.85	0	1.7	4.1	0	8.2	2.5	0	5	160	J		1		
Meadow Creek	MC-2B	Sept-25-99	0.85	0	1.7	0.5	0	1	0.5	0	1	220			0.25	0	0.5

Calculation of Reaosnable Maximum Exposure Concentrations
Lower Meadow Creek Valley
Surface Water (ug/L)

			Copper, total			Cyanide, total			Cyanide, WAD			Iron, total			Lead, total		
Area/Stream	Location	Date	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
Distribution			--			--			--			Neither			--		
Number of Samples			28			28			28			28			28		
Number of Detects			2			11			7			19			12		
Detection frequency			7.14			39.29			25.00			67.86			42.86		
Maximum			2			5.3			2.8			220			9.7		
Minimum			0.85			0.5			0.5			24			0.25		
Mean			0.9268			1.8661			1.41607			120.9464			0.86071		
Standard Deviation			--			1.343			0.91995			63.71295			1.77938		
t(1-a, n-1) or H 0.95			--			1.703			1.703			1.703			1.703		
95% UCL			--			2.2983			1.71214			141.4516			1.43338		
RME			2			2.2983			1.71214			141.4516			1.43338		
Basis for RME			Max			UCL			UCL			UCL			UCL		

Calculation of Reaosnable Maximum Exposure Concentrations
Lower Meadow Creek Valley
Surface Water (ug/L)

			Magnesium, total				Manganese, total				Mercury, total			Nickel, total		
Area/Stream	Location	Date	Result	Ln	Q	DL	Result	Ln	Q	DL	Result	Q	DL	Result	Q	DL
Meadow Creek	2040319	10-Jun-99	1290	7.162397			19.3	2.9601			0.021	0	0.042	1.5	0	3
Meadow Creek	2040319	Jul-16-99	1640	7.402452			27.1	3.2995			0.0235	0	0.047	1.5	0	3
Meadow Creek	2040319	Jun-25-99	910	6.813445			15.7	2.7537			0.021	0	0.042	1.5	0	3
Meadow Creek	2040319	Sept-25-99	2890	7.969012			53.8	3.9853			0.027	0	0.054	1.5	0	3
Meadow Creek	2040322	10-Jun-99	1040	6.946976			13	2.5649			0.021	0	0.042	1.5	0	3
Meadow Creek	2040322	Jul-16-99	1410	7.251345			26.6	3.2809			0.021	0	0.042	1.5	0	3
Meadow Creek	2040322	Jun-25-99	780	6.659294			10	2.3026			0.021	0	0.042	1.5	0	3
Meadow Creek	2040322	Sept-25-99	2750	7.919356			63.5	4.151			0.054			1.5	0	3
Meadow Creek	2040368	10-Jun-99	1060	6.966024			13.2	2.5802			0.021	0	0.042	1.5	0	3
Meadow Creek	2040368	Jul-16-99	1400	7.244228			26.4	3.2734			0.021	0	0.042	1.5	0	3
Meadow Creek	2040368	Jun-25-99	780	6.659294			10.6	2.3609			0.021	0	0.042	1.5	0	3
Meadow Creek	2040368	Sept-25-99	2610	7.867106			67.9	4.218			0.044			1.5	0	3
Blowout Creek	BL-1	10-Jun-99	1390	7.237059			5	1.6094			0.021	0	0.042	1.5	0	3
Blowout Creek	BL-1	Jul-16-99	1920	7.56008			5	1.6094			0.021	0	0.042	1.5	0	3
Blowout Creek	BL-1	Jun-25-99	1100	7.003065			7.3	1.9879			0.021	0	0.042	1.5	0	3
Blowout Creek	BL-1	Sept-25-99	2340	7.757906			5.4	1.6864			0.021	0	0.042	1.5	0	3
Meadow Creek	MC-1A	10-Jun-99	880	6.779922			6.8	1.9169			0.021	0	0.042	1.5	0	3
Meadow Creek	MC-1A	Jul-16-99	1160	7.056175			6	1.7918			0.021	0	0.042	1.5	0	3
Meadow Creek	MC-1A	Jun-25-99	660	6.49224			7.2	1.9741			0.021	0	0.042	1.5	0	3
Meadow Creek	MC-1A	Sept-25-99	1920	7.56008			6.7	1.9021			0.021	0	0.042	1.5	0	3
Meadow Creek	MC-2A	10-Jun-99	1180	7.07327			11.3	2.4248			0.021	0	0.042	1.5	0	3
Meadow Creek	MC-2A	Jul-16-99	1580	7.36518			22.2	3.1001			0.021	0	0.042	1.5	0	3
Meadow Creek	MC-2A	Jun-25-99	820	6.709304			10.1	2.3125			0.021	0	0.042	1.5	0	3
Meadow Creek	MC-2A	Sept-25-99	2690	7.897296			53.5	3.9797			0.021	0	0.042	1.5	0	3
Meadow Creek	MC-2B	10-Jun-99	1280	7.154615			17.9	2.8848			0.021	0	0.042	1.5	0	3
Meadow Creek	MC-2B	Jul-16-99	1700	7.438384			28.8	3.3604			0.026	0	0.052	1.5	0	3
Meadow Creek	MC-2B	Jun-25-99	890	6.791221			14.3	2.6603			0.021	0	0.042	1.5	0	3
Meadow Creek	MC-2B	Sept-25-99	2700	7.901007			55.9	4.0236			0.021	0	0.042	1.5	0	3

Calculation of Reaosnable Maximum Exposure Concentrations
Lower Meadow Creek Valley
Surface Water (ug/L)

			Magnesium, total				Manganese, total				Mercury, total			Nickel, total		
Area/Stream	Location	Date	Result	Ln	Q	DL	Result	Ln	Q	DL	Result	Q	DL	Result	Q	DL
Distribution			Lognormal				Lognormal				--			--		
Number of Samples			28				28				28			28		
Number of Detects			28				28				2			0		
Detection frequency			100.00				100.00				7.14			0.00		
Maximum			2890				67.9				0.054			1.5		
Minimum			660				5				0.021			1.5		
Mean			1527.5	7.237062			21.80357	2.7484			0.0235			1.5		
Standard Deviation				0.439355				0.8201			--			--		
t(1-a, n-1) or H 0.95				1.906054				2.2867			--			--		
95% UCL			1798.5619				31.36193				--			--		
RME			1798.5619				31.36193				0.054			--		
Basis for RME			UCL				UCL				Max			ND		

Calculation of Reaosnable Maximum Exposure Concentrations
Lower Meadow Creek Valley
Surface Water (ug/L)

			Selenium, total			Silver, total			Zinc, total		
Area/Stream	Location	Date	Result	Q	DL	Result	Q	DL	Result	Q	DL
Meadow Creek	2040319	10-Jun-99	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Meadow Creek	2040319	Jul-16-99	0.8	0	1.6	0.033	0	0.066	3.8		
Meadow Creek	2040319	Jun-25-99	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Meadow Creek	2040319	Sept-25-99	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Meadow Creek	2040322	10-Jun-99	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Meadow Creek	2040322	Jul-16-99	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Meadow Creek	2040322	Jun-25-99	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Meadow Creek	2040322	Sept-25-99	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Meadow Creek	2040368	10-Jun-99	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Meadow Creek	2040368	Jul-16-99	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Meadow Creek	2040368	Jun-25-99	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Meadow Creek	2040368	Sept-25-99	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Blowout Creek	BL-1	10-Jun-99	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Blowout Creek	BL-1	Jul-16-99	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Blowout Creek	BL-1	Jun-25-99	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Blowout Creek	BL-1	Sept-25-99	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Meadow Creek	MC-1A	10-Jun-99	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Meadow Creek	MC-1A	Jul-16-99	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Meadow Creek	MC-1A	Jun-25-99	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Meadow Creek	MC-1A	Sept-25-99	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Meadow Creek	MC-2A	10-Jun-99	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Meadow Creek	MC-2A	Jul-16-99	0.8	0	1.6	0.033	0	0.066	4.2		
Meadow Creek	MC-2A	Jun-25-99	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Meadow Creek	MC-2A	Sept-25-99	0.8	0	1.6	0.033	0	0.066	7.2		
Meadow Creek	MC-2B	10-Jun-99	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Meadow Creek	MC-2B	Jul-16-99	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Meadow Creek	MC-2B	Jun-25-99	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Meadow Creek	MC-2B	Sept-25-99	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6

Calculation of Reaosnable Maximum Exposure Concentrations
Lower Meadow Creek Valley
Surface Water (ug/L)

			Selenium, total			Silver, total			Zinc, total		
Area/Stream	Location	Date	Result	Q	DL	Result	Q	DL	Result	Q	DL
Distribution			--			--			Neither		
Number of Samples			28			28			28		
Number of Detects			0			0			3		
Detection frequency			0.00			0.00			10.71		
Maximum			0.8			0.033			7.2		
Minimum			0.8			0.033			1.8		
Mean			0.8			0.033			2.15		
Standard Deviation			--			--			1.14649		
t(1-a, n-1) or H 0.95			--			--			1.703		
95% UCL			--			--			2.51898		
RME			--			--			2.51898		
Basis for RME			ND			ND			UCL		

Calculation of Reasonable Maximum Exposure Concentrations
Upgradient Wetland
Surface Water (ug/L)

			Aluminum, total			Antimony, total			Arsenic, total			Cadmium, total			Chromium, total			Copper, total		
Area/Stream	Station	Date	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
Meadow Creek	MC-1A	10-Jun-99	153			2.65	0	5.3	3.5	0	7	0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Meadow Creek	MC-1A	22-Jun-99	114			2.65	0	5.3	3.5	0	7	0.315	0	0.63	0.85	0	1.7	1.7		
Meadow Creek	MC-1A	16-Jul-99	46	0	94	2.65	0	5.3	3.5	0	7	0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Meadow Creek	MC-1A	15-Sep-99	26	0	52	2.65	0	5.3	3.5	0	7	0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Number of Samples			4			4			4			4			4			4		
Number of Non-detects			2			4			4			4			4			3		
Number of Detects			2			0			0			0			0			1		
Detection frequency			50.00			0.00			0.00			0.00			0.00			25.00		
Maximum			153			2.65			3.5			0.315			0.85			1.7		
Minimum			26			2.65			3.5			0.315			0.85			0.85		
Mean			84.75			2.65			3.5			0.315			0.85			1.0625		
RME			153			--			--			--			--			1.7		
Basis for RME			Max			ND			ND			ND			ND			Max		

Notes: LN = natural log; NA = Not analyzed; ND = not detected; Max = Maximum; UCL = Upper Confidence Limit of arithmetic mean; t(1-a, n-1) = one tailed student t at the 95% confidence level; 0 = U = not detected; J = estimated value; Q = qualifier; DL = detection limit
RME = reasonable maximum exposure; H = H-statistic at 95% confidence level
For non-detects, 1/2 the DL was used to calculate means.

Calculation of Reasonable Maximum Exposure Concentrations
Upgradient Wetland
Surface Water (ug/L)

			Cyanide, total			Cyanide, WAD			Iron, total			Lead, total			Magnesium, total			Manganese, total		
Area/Stream	**Station**	**Date**	**Result**	**Q**	**DL**	**Result**	**Q**	**DL**	**Result**	**Q**	**DL**	**Result**	**Q**	**DL**	**Result**	**Q**	**DL**	**Result**	**Q**	**DL**
Meadow Creek	MC-1A	10-Jun-99	1.1	J		1.1	J		180			0.9			880			6.8		
Meadow Creek	MC-1A	22-Jun-99	2.05	0	4.1	2.5	0	5	88	J		1			660			7.2		
Meadow Creek	MC-1A	16-Jul-99	0.75	0	1.5	0.75	0	1.5	41	0	82	0.25	0	0.5	1160			6		
Meadow Creek	MC-1A	15-Sep-99	0.5	0	1	0.5	0	1	27.5	0	55	0.25	0	0.5	1920			6.7		
Number of Samples			4			4			4			4			4			4		
Number of Non-detects			3			3			2			2			0			0		
Number of Detects			1			1			2			2			4			4		
Detection frequency			25.00			25.00			50.00			50.00			100.00			100.00		
Maximum			2.05			2.5			180			1			1920			7.2		
Minimum			0.5			0.5			27.5			0.25			660			6		
Mean			1.1			1.2125			84.125			0.6			1155			6.675		
RME			2.05			2.5			180			1			1920			7.2		
Basis for RME			Max			Max			Max			Max			Max			Max		

Calculation of Reasonable Maximum Exposure Concentrations
Upgradient Wetland
Surface Water (ug/L)

			Mercury, total			Nickel, total			Selenium, total			Silver, total			Zinc, total		
Area/Stream	Station	Date	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
Meadow Creek	MC-1A	10-Jun-99	0.021	0	0.04	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Meadow Creek	MC-1A	22-Jun-99	0.021	0	0.04	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Meadow Creek	MC-1A	16-Jul-99	0.021	0	0.04	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Meadow Creek	MC-1A	15-Sep-99	0.021	0	0.04	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Number of Samples			4			4			4			4			4		
Number of Non-detects			4			4			4			4			4		
Number of Detects			0			0			0			0			0		
Detection frequency			0.00			0.00			0.00			0.00			0.00		
Maximum			0.021			1.5			0.8			0.033			1.8		
Minimum			0.021			1.5			0.8			0.033			1.8		
Mean			0.021			1.5			0.8			0.033			1.8		
RME			--			--			--			--			--		
Basis for RME			ND			ND			ND			ND			ND		

Calculation of Reasonable Maximum Exposure Concentrations
Keyway Wetland
Surface Water (ug/L)

			Aluminum, total			Antimony, total			Arsenic, total			Cadmium, total			Chromium, total			Copper, total		
Area/Stream	Date Station	Date	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
Keyway	KW-1	10-Jun-99	NS			NS			NS			NS			NS			NS		
Keyway	KW-1	22-Jun-99	67			127			304			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Keyway	KW-1	16-Jul-99	120	0	240	97			463			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Keyway	KW-1	15-Sep-99	28.5	0	57	51			276			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Number of Samples			3			3			3			3			3			3		
Number of Detects			1			3			3			0			0			0		
Detection frequency			33.33			100.00			100.00			0.00			0.00			0.00		
Maximum			120			127			463			0.315			0.85			0.85		
Minimum			28.5			51			276			0.315			0.85			0.85		
Mean			71.833			91.667			347.667			0.315			0.85			0.85		
RME			120			127			463			--			--			--		
Basis for RME			Max			Max			Max			ND			ND			ND		

Notes: LN = natural log; NA = Not analyzed; ND = not detected; Max = Maximum; UCL = Upper Confidence Limit of arithmetic mean;
t(1-a, n-1) = one tailed student t at the 95% confidence level; 0 = U = not detected; J = estimated value; Q = qualifier; DL = detection li mit
RME = reasonable maximum exposure; H = H-statistic at 95% confidence level
For non-detects, 1/2 the DL was used to calculate means.

Calculation of Reasonable Maximum Exposure Concentrations
Keyway Wetland
Surface Water (ug/L)

			Cyanide, total			Cyanide, WAD			Iron, total			Lead, total			Magnesium, total			Manganese, total		
Area/Stream	Date Station	Date	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
Keyway	KW-1	10-Jun-99	NS			NS			NS			NS			NS			NS		
Keyway	KW-1	22-Jun-99	3.7	0	7.4	2.5	0	5	650			0.25	0	0.5	4360			194		
Keyway	KW-1	16-Jul-99	5.6			0.75	0	1.5	2520			0.25	0	0.5	8770			785		
Keyway	KW-1	15-Sep-99	0.5	0	1	0.5	0	1	1460			0.25	0	0.5	11800			726		
Number of Samples			3			3			3			3			3			3		
Number of Detects			1			0			3			0			3			3		
Detection frequency			33.33			0.00			100.00			0.00			100.00			100.00		
Maximum			5.6			2.5			2520			0.25			11800			785		
Minimum			0.5			0.5			650			0.25			4360			194		
Mean			3.2667			1.25			1543.3			0.25			8310			568.33		
RME			5.6			--			2520			--			11800			785		
Basis for RME			Max			ND			Max			ND			Max			Max		

Calculation of Reasonable Maximum Exposure Concentrations
Keyway Wetland
Surface Water (ug/L)

			Mercury, total			Nickel, total			Selenium, total			Silver, total			Zinc, total		
Area/Stream	Date Station	Date	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
Keyway	KW-1	10-Jun-99	NS			NS			NS			NS			NS		
Keyway	KW-1	22-Jun-99	0.021	0	0.042	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Keyway	KW-1	16-Jul-99	0.034	0	0.067	1.5	0J	3	0.8	0	1.6	0.033	0	0.066	4.4		
Keyway	KW-1	15-Sep-99	0.118			1.5	0J	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Number of Samples			3			3			3			3			3		
Number of Detects			1			2			0			0			1		
Detection frequency			33.33			66.67			0.00			0.00			33.33		
Maximum			0.118			1.5			0.8			0.033			4.4		
Minimum			0.021			1.5			0.8			0.033			1.8		
Mean			0.058			1.5			0.8			0.033			2.6667		
RME			0.118			--			--			--			4.4		
Basis for RME			Max			ND			ND			ND			Max		

Calculation of Reasonable Maximum Exposure Concentrations
EFSFSR and Midnight Creek
Surface Water (ug/L)

			Aluminum, total			Antimony, total				Arsenic, total			Cadmium, total		
Area/Stream	Station	Date	Result	Q	DL	Result	Ln	Q	DL	Result	Q	DL	Result	Q	DL
EFSFSR	2040313	10-Jun-99	80			20	2.995732274			24	J		0.315	0	0.63
EFSFSR	2040313	22-Jun-99	78			10	2.302585093			17			0.315	0	0.63
EFSFSR	2040313	16-Jul-99	26	0	52	10	2.302585093			26			0.315	0	0.63
EFSFSR	2040313	15-Sep-99	26	0	52	13	2.564949357			34			0.315	0	0.63
Midnight Creek	2040321	10-Jun-99	26	0	52	38	3.63758616			71			0.315	0	0.63
Midnight Creek	2040321	22-Jun-99	143			38	3.63758616			65			0.315	0	0.63
Midnight Creek	2040321	16-Jul-99	55	0	110	48	3.871201011			83			0.315	0	0.63
Midnight Creek	2040321	15-Sep-99	26	0	52	48	3.871201011			89			0.315	0	0.63
EFSFSR	2040324	10-Jun-99	89			27	3.295836866			31	J		0.315	0	0.63
EFSFSR	2040324	22-Jun-99	103			10	2.302585093			18			0.315	0	0.63
EFSFSR	2040324	16-Jul-99	26	0	52	13	2.564949357			27			0.315	0	0.63
EFSFSR	2040324	15-Sep-99	26	0	52	22	3.091042453			46			0.315	0	0.63
Distribution			--			Lognormal				Normal			--		
Number of Detects			5			12				12			0		
Detection frequency			41.67			100.00				100.00			0.00		
Maximum			143			48				89			0.315		
Minimum			26			10				17			0.315		
Mean			58.6666667			24.75	3.036486661			44.25			0.315		
Standard Deviation			39.5918571				0.621476722			25.94793739			--		
t(1-a, n-1) or H 0.95			1.796				2.340875			1.796			--		
95% UCL			79.1934824			39.18295453				57.70298167			--		
RME			79.1934824			39.18295453				57.70298167			--		
Basis for RME			UCL			UCL				UCL			ND		

Notes: LN = natural log; NA = Not analyzed; ND = not detected; Max = Maximum; UCL = Upper Confidence Limit of arithmetic mean;
t(1-a, n-1) = one tailed student t at the 95% confidence level; 0 = U = not detected; J = estimated value; Q = qualifier; DL = detection limit
RME = reasonable maximum exposure; H = H-statistic at 95% confidence level
For non-detects, 1/2 the DL was used to calculate means.

Calculation of Reasonable Maximum Exposure Concentrations
EFSFSR and Midnight Creek
Surface Water (ug/L)

			Chromium, total			Copper, total			Cyanide, total			Cyanide, WAD			Iron, total		
Area/Stream	Station	Date	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
EFSFSR	2040313	10-Jun-99	0.85	0	1.7	0.85	0	1.7	2.1	J		1.3	J		140		
EFSFSR	2040313	22-Jun-99	0.85	0	1.7	0.85	0	1.7	1.8	0	3.6	2.5	0	5	100	J	
EFSFSR	2040313	16-Jul-99	0.85	0	1.7	0.85	0	1.7	0.75	0	1.5	0.75	0	1.5	90		
EFSFSR	2040313	15-Sep-99	0.85	0	1.7	0.85	0	1.7	0.5	0	1	0.5	0	1	48.5	0	97
Midnight Creek	2040321	10-Jun-99	0.85	0	1.7	1.05	0	2.1	NA			NA			48	J	
Midnight Creek	2040321	22-Jun-99	0.85	0	1.7	0.85	0	1.7	NA			NA			220		
Midnight Creek	2040321	16-Jul-99	0.85	0	1.7	0.85	0	1.7	NA			NA			55	0	110
Midnight Creek	2040321	15-Sep-99	0.85	0	1.7	0.85	0	1.7	NA			NA			34.5	0	69
EFSFSR	2040324	10-Jun-99	0.85	0	1.7	0.85	0	1.7	NA			NA			140		
EFSFSR	2040324	22-Jun-99	0.85	0	1.7	0.85	0	1.7	NA			NA			130	J	
EFSFSR	2040324	16-Jul-99	0.85	0	1.7	0.85	0	1.7	NA			NA			76		
EFSFSR	2040324	15-Sep-99	0.85	0	1.7	0.85	0	1.7	NA			NA			41	0	82
Distribution			--			--			--			--			Normal		
Number of Detects			0			0			1			1			8		
Detection frequency			0.00			0.00			25.00			25.00			66.67		
Maximum			0.85			1.05			2.1			2.5			220		
Minimum			0.85			0.85			0.5			0.5			34.5		
Mean			0.85			0.866666667			1.2875			1.2625			93.58333333		
Standard Deviation			--			--			--			--			55.46040083		
t(1-a, n-1) or H 0.95			--			--			--			--			1.796		
95% UCL			--			--			--			--			122.3373628		
RME			--			--			2.1			2.5			122.3373628		
Basis for RME			ND			ND			Max			Max			UCL		

Calculation of Reasonable Maximum Exposure Concentrations
EFSFSR and Midnight Creek
Surface Water (ug/L)

			Lead, total			Magnesium, total				Manganese, total			Mercury, total		
Area/Stream	Station	Date	Result	Q	DL	Result	Ln	Q	DL	Result	Q	DL	Result	Q	DL
EFSFSR	2040313	10-Jun-99	0.25	0	0.5	1510	7.31986493			12.9			0.021	0	0.042
EFSFSR	2040313	22-Jun-99	4.6			1020	6.927557906			10.7			0.021	0	0.042
EFSFSR	2040313	16-Jul-99	0.25	0	0.5	1820	7.50659178			17			0.021	0	0.042
EFSFSR	2040313	15-Sep-99	0.25	0	0.5	2910	7.97590836			26.7			0.03	0	0.06
Midnight Creek	2040321	10-Jun-99	0.25	0	0.5	5610	8.632305999			3.4			0.021	0	0.042
Midnight Creek	2040321	22-Jun-99	0.25	0	0.5	4800	8.476371197			7.9			0.021	0	0.042
Midnight Creek	2040321	16-Jul-99	0.25	0	0.5	7980	8.98469369			3.9			0.021	0	0.042
Midnight Creek	2040321	15-Sep-99	0.075	0	0.15	8190	9.010669177			3			0.131		
EFSFSR	2040324	10-Jun-99	0.25	0	0.5	1480	7.299797367			11.8			0.021	0	0.042
EFSFSR	2040324	22-Jun-99	0.6			960	6.866933284			11.3			0.021	0	0.042
EFSFSR	2040324	16-Jul-99	0.25	0	0.5	1860	7.528331767			13.3			0.021	0	0.042
EFSFSR	2040324	15-Sep-99	0.25	0	0.5	3190	8.067776196			19.2			0.021	0	0.042
Distribution			--			Lognormal				Normal			--		
Number of Detects			2			12				12			1		
Detection frequency			16.67			100.00				100.00			8.33		
Maximum			4.6			8190				26.7			0.131		
Minimum			0.075			960				3			0.021		
Mean			0.627083333			3444.166667	7.883066804			11.75833333			0.030916667		
Standard Deviation			--				0.757488077			6.969603919			--		
t(1-a, n-1) or H 0.95			--				2.57			1.796			--		
95% UCL			--			6354.550229				15.37179796			--		
RME			4.6			6354.550229				15.37179796			0.131		
Basis for RME			Max			UCL				UCL			Max		

Calculation of Reasonable Maximum Exposure Concentrations
EFSFSR and Midnight Creek
Surface Water (ug/L)

			Nickel, total			Selenium, total			Silver, total			Zinc, total		
Area/Stream	Station	Date	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
EFSFSR	2040313	10-Jun-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
EFSFSR	2040313	22-Jun-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
EFSFSR	2040313	16-Jul-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
EFSFSR	2040313	15-Sep-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	29		
Midnight Creek	2040321	10-Jun-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Midnight Creek	2040321	22-Jun-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Midnight Creek	2040321	16-Jul-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	3.6		
Midnight Creek	2040321	15-Sep-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	3.8		
EFSFSR	2040324	10-Jun-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
EFSFSR	2040324	22-Jun-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
EFSFSR	2040324	16-Jul-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
EFSFSR	2040324	15-Sep-99	1.75	0	3.5	0.8	0	1.6	0.033	0	0.066	48		
Distribution			--			--			--			--		
Number of Detects			0			0			0			4		
Detection frequency			0.00			0.00			0.00			33.33		
Maximum			1.75			0.8			0.033			48		
Minimum			1.5			0.8			0.033			1.8		
Mean			1.520833333			0.8			0.033			8.233333333		
Standard Deviation			--			--			--			14.72433566		
t(1-a, n-1) or H 0.95			--			--			--			1.796		
95% UCL			--			--			--			15.86732038		
RME			--			--			--			15.86732038		
Basis for RME			ND			ND			ND			UCL		

Calculation of Reasonable Maximum Exposure Concentrations
Glory Hole and EFSFSR
Surface Water (ug/L)

			Aluminum, total			Antimony, total			Arsenic, total			Cadmium, total			Chromium, total			Copper, total		
Area/Stream	**Station**	**Date**	**Result**	**Q**	**DL**	**Result**	**Q**	**DL**	**Result**	**Q**	**DL**	**Result**	**Q**	**DL**	**Result**	**Q**	**DL**	**Result**	**Q**	**DL**
EFSFSR	2040308	10-Jun-99	61			30			42			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
EFSFSR	2040308	22-Jun-99	49	0	98	18			28			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
EFSFSR	2040308	16-Jul-99	26	0	52	22			59			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
EFSFSR	2040308	15-Sep-99	26.5	0	53	35			109			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
EFSFSR	2040314	10-Jun-99	72			17			24	J		0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
EFSFSR	2040314	22-Jun-99	58	0	116	11			21			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
EFSFSR	2040314	16-Jul-99	26	0	52	13			38			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
EFSFSR	2040314	15-Sep-99	26	0	52	24			67			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
EFSFSR	2040369	10-Jun-99	88			25			32	J		0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
EFSFSR	2040369	22-Jun-99	122			14			23			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
EFSFSR	2040369	16-Jul-99	26	0	52	19			32			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
EFSFSR	2040369	15-Sep-99	27	0	54	27			53			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
EFSFSR	EF-7	10-Jun-99	83			30			34	J		0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
EFSFSR	EF-7	22-Jun-99	49.5	0	99	19			25			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
EFSFSR	EF-7	16-Jul-99	26	0	52	21			47			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
EFSFSR	EF-7	15-Sep-99	32.5	0	65	32			82			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Glory Hole	GH1-A[1]	16-Jul-99	26	0	52	26			64			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Glory Hole	GH1-A[1]	14-Sep-99	26	0	52	33			81			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Glory Hole	GH1-B	16-Jul-99	26	0	52	21			61			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Glory Hole	GH1-B	14-Sep-99	26	0	52	31			98			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Glory Hole	GH2-A[4]	16-Jul-99	26	0	52	21			48			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Glory Hole	GH2-A[4]	14-Sep-99	26	0	52	32			68			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Glory Hole	GH2-B	16-Jul-99	26	0	52	21			48			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Glory Hole	GH2-B	14-Sep-99	26	0	52	30			70			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Glory Hole	GH2-C	16-Jul-99	26	0	52	21			50			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Glory Hole	GH2-C	14-Sep-99	26	0	52	30			77			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Glory Hole	GH3-A[5]	16-Jul-99	26	0	52	20			47			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Glory Hole	GH3-A[5]	14-Sep-99	29.5	0	59	32			90			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Glory Hole	GH3-B	16-Jul-99	26	0	52	21			49			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Glory Hole	GH3-B	14-Sep-99	26	0	52	31			80			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Hennessey Creek	HC-2	10-Jun-99	91	J		40			48			0.315	0	0.63	0.85	0	1.7	1.1	0	2.2
Hennessey Creek	HC-2	22-Jun-99	26	0	52	25			41			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Hennessey Creek	HC-2	16-Jul-99	54.5	0	109	25			18			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Hennessey Creek	HC-2	15-Sep-99	26	0	52	24			14			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Distribution			--			Normal			Normal			--			--			--		
Number of Samples			34			34			34			34			34			34		

Calculation of Reasonable Maximum Exposure Concentrations
Glory Hole and EFSFSR
Surface Water (ug/L)

			Aluminum, total			Antimony, total			Arsenic, total			Cadmium, total			Chromium, total			Copper, total		
Area/Stream	Station	Date	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
Number of Detects			6			34			34			0			0			0		
Detection frequency			17.65			100.00			100.00			0.00			0.00			0.00		
Maximum			122			40			109			0.315			0.85			1.1		
Minimum			26			11			14			0.315			0.85			0.85		
Mean			40.103			24.735			52			0.315			0.85			0.85735		
Standard Deviation			24.671			6.7164			24.11			--			--			--		
t(1-a, n-1) or H 0.95			1.697			1.697			1.697			--			--			--		
95% UCL			47.283			26.69			59.017			--			--			--		
RME			47.283			26.69			59.017			--			--			--		
Basis for RME			UCL			UCL			UCL			ND			ND			ND		

Notes: LN = natural log; NA = Not analyzed; ND = not detected; Max = Maximum; UCL = Upper Confidence Limit of arthimetic mean;
t(1-a, n-1) = one tailed student t at the 95% confidence level; 0 = U = not detected; J = estimated value; Q = qualifer; DL = detection limit
RME = reasonable maximum exposure; H = H-statistic at 95% confidence level
For non-detects, 1/2 the DL was used to calculate means.

Calculation of Reasonable Maximum Exposure Concentrations
Glory Hole and EFSFSR
Surface Water (ug/L)

			Iron, total				Lead, total			Magnesium, total				Manganese, total			Mercury, total		
Area/Stream	Station	Date	Result	Ln	Q	DL	Result	Q	DL	Result	Ln	Q	DL	Result	Q	DL	Result	Q	DL
EFSFSR	2040308	10-Jun-99	150	5.0106			0.5			1820	7.5066			18.2			0.021	0	0.042
EFSFSR	2040308	22-Jun-99	200	5.2983			0.6			1160	7.0562			16.1			0.021	0	0.042
EFSFSR	2040308	16-Jul-99	100	4.6052			0.25	0	0.5	2230	7.7098			26.4			0.021	0	0.042
EFSFSR	2040308	15-Sep-99	190	5.247			0.25	0	0.5	5790	8.6639			38.5			0.0225	0	0.045
EFSFSR	2040314	10-Jun-99	60	4.0943	0	120	0.25	0	0.5	2070	7.6353			10.3			0.098	J	
EFSFSR	2040314	22-Jun-99	180	5.193			0.25	0	0.5	1400	7.2442			11.6			0.39	J	
EFSFSR	2040314	16-Jul-99	65	4.1744			0.25	0	0.5	2480	7.816			13.8			0.021	0	0.042
EFSFSR	2040314	15-Sep-99	50	3.912	0	100	0.25	0	0.5	3750	8.2295			18.8			0.0335	0	0.067
EFSFSR	2040369	10-Jun-99	170	5.1358			0.25	0	0.5	1630	7.3963			12.4			0.021	0	0.042
EFSFSR	2040369	22-Jun-99	150	5.0106	J		0.7			1150	7.0475			13.1			0.021	0	0.042
EFSFSR	2040369	16-Jul-99	74	4.3041			0.25	0	0.5	2040	7.6207			10.8			0.021	0	0.042
EFSFSR	2040369	15-Sep-99	43.5	3.7728	0	87	0.25	0	0.5	3370	8.1227			13.5			0.021	0	0.042
EFSFSR	EF-7	10-Jun-99	140	4.9416			0.25	0	0.5	1720	7.4501			14.3			0.021	0	0.042
EFSFSR	EF-7	22-Jun-99	180	5.193			0.5			1110	7.0121			12.9			0.021	0	0.042
EFSFSR	EF-7	16-Jul-99	73	4.2905			0.25	0	0.5	2150	7.6732			23.3			0.021	0	0.042
EFSFSR	EF-7	15-Sep-99	75	4.3175	0	150	0.25	0	0.5	3540	8.1719			46			0.0315	0	0.063
Glory Hole	GH1-A[1]	16-Jul-99	65	4.1744			0.25	0	0.5	2360	7.7664			24.4			0.021	0	0.042
Glory Hole	GH1-A[1]	14-Sep-99	55	4.0073	0	110	0.25	0	0.5	3550	8.1747			39.4			0.028	0	0.056
Glory Hole	GH1-B	16-Jul-99	81	4.3944			0.25	0	0.5	2200	7.6962			32.3			0.021	0	0.042
Glory Hole	GH1-B	14-Sep-99	200	5.2983			0.25	0	0.5	3560	8.1775			65.1			0.032	0	0.064
Glory Hole	GH2-A[4]	16-Jul-99	69	4.2341			0.25	0	0.5	2210	7.7007			22.2			0.021	0	0.042
Glory Hole	GH2-A[4]	14-Sep-99	29.5	3.3844	0	59	0.25	0	0.5	3400	8.1315			28.3			0.021	0	0.042
Glory Hole	GH2-B	16-Jul-99	71	4.2627			0.25	0	0.5	2200	7.6962			23.9			0.021	0	0.042
Glory Hole	GH2-B	14-Sep-99	31.5	3.45	0	63	0.25	0	0.5	3420	8.1374			37.2			0.0315	0	0.063
Glory Hole	GH2-C	16-Jul-99	84	4.4308			0.25	0	0.5	2130	7.6639			27			0.021	0	0.042
Glory Hole	GH2-C	14-Sep-99	42.5	3.7495	0	85	0.25	0	0.5	3410	8.1345			50.1			0.021	0	0.042
Glory Hole	GH3-A[5]	16-Jul-99	110	4.7005			0.25	0	0.5	2140	7.6686			22.3			0.021	0	0.042
Glory Hole	GH3-A[5]	14-Sep-99	90	4.4998	0	180	0.25	0	0.5	3490	8.1577			46.6			0.025	0	0.05
Glory Hole	GH3-B	16-Jul-99	150	5.0106			0.25	0	0.5	2150	7.6732			24.2			0.021	0	0.042
Glory Hole	GH3-B	14-Sep-99	210	5.3471			0.25	0	0.5	3450	8.1461			50.3			0.0295	0	0.059
Hennessey Creek	HC-2	10-Jun-99	110	4.7005	J		0.25	0	0.5	1140	7.0388			6.6			0.021	0	0.042
Hennessey Creek	HC-2	22-Jun-99	37	3.6109	0	74	0.25	0	0.5	630	6.4457			3.9			0.021	0	0.042
Hennessey Creek	HC-2	16-Jul-99	140	4.9416			0.25	0	0.5	790	6.672			3.6			0.021	0	0.042
Hennessey Creek	HC-2	15-Sep-99	22.5	3.1135	0	45	0.25	0	0.5	1090	6.9939			1.1	0	2.2	0.0355	0	0.071
Distribution			Lognormal				--			Lognormal				Neither			--		
Number of Samples			34				34			34				34			34		

Calculation of Reasonable Maximum Exposure Concentrations
Glory Hole and EFSFSR
Surface Water (ug/L)

			Iron, total				Lead, total			Magnesium, total				Manganese, total			Mercury, total		
Area/Stream	Station	Date	Result	Ln	Q	DL	Result	Q	DL	Result	Ln	Q	DL	Result	Q	DL	Result	Q	DL
Number of Detects			23				4			34				33			2		
Detection frequency			67.65				11.76			100.00				97.06			5.88		
Maximum			210				0.7			5790				65.1			0.39		
Minimum			22.5				0.25			630				1.1			0.021		
Mean			102.89706	4.465			0.28824			2374.4118	7.6597			23.779			0.0365		
Standard Deviation				0.6158			0.11014				0.5014			15.332			--		
t(1-a, n-1) or H 0.95				2.0436			1.697				1.9585			1.697			--		
95% UCL			130.80143				0.32029			2853.636				28.241			--		
RME			130.80143				0.32029			2853.636				28.241			0.39		
Basis for RME			UCL				UCL			UCL				UCL			Max		

Calculation of Reasonable Maximum Exposure Concentrations
Glory Hole and EFSFSR
Surface Water (ug/L)

			Nickel, total			Selenium, total			Silver, total			Zinc, total			Sulfate, total		
Area/Stream	Station	Date	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
EFSFSR	2040308	10-Jun-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6	NA		
EFSFSR	2040308	22-Jun-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6	NA		
EFSFSR	2040308	16-Jul-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6	NA		
EFSFSR	2040308	15-Sep-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6	NA		
EFSFSR	2040314	10-Jun-99	1.5	0	3	0.8	0	1.6	0.035	0	0.07	1.8	0	3.6	NA		
EFSFSR	2040314	22-Jun-99	1.5	0	3	0.8	0	1.6	0.129			11.9			NA		
EFSFSR	2040314	16-Jul-99	1.5	0	3	0.8	0	1.6	0.111	J		1.8	0	3.6	NA		
EFSFSR	2040314	15-Sep-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6	NA		
EFSFSR	2040369	10-Jun-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6	NA		
EFSFSR	2040369	22-Jun-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.95	0	3.9	NA		
EFSFSR	2040369	16-Jul-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6	NA		
EFSFSR	2040369	15-Sep-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	3.05	0	6.1	NA		
EFSFSR	EF-7	10-Jun-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6	NA		
EFSFSR	EF-7	22-Jun-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6	NA		
EFSFSR	EF-7	16-Jul-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6	NA		
EFSFSR	EF-7	15-Sep-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6	NA		
Glory Hole	GH1-A[1]	16-Jul-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6	4400	J	
Glory Hole	GH1-A[1]	14-Sep-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6	7900		
Glory Hole	GH1-B	16-Jul-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6	3900	J	
Glory Hole	GH1-B	14-Sep-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6	7700		
Glory Hole	GH2-A[4]	16-Jul-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	4.95	0	9.9	4200	J	
Glory Hole	GH2-A[4]	14-Sep-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6	7800		
Glory Hole	GH2-B	16-Jul-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6	4300	J	
Glory Hole	GH2-B	14-Sep-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6	8400		
Glory Hole	GH2-C	16-Jul-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6	3800	J	
Glory Hole	GH2-C	14-Sep-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	18			7700		
Glory Hole	GH3-A[5]	16-Jul-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	2.25	0	4.5	3900	J	
Glory Hole	GH3-A[5]	14-Sep-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	3.6	0	7.2	7600		
Glory Hole	GH3-B	16-Jul-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6	4100	J	
Glory Hole	GH3-B	14-Sep-99	14.4			0.8	0	1.6	0.033	0	0.066	1.8	0	3.6	7300		
Hennessey Creek	HC-2	10-Jun-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	5.8			NA		
Hennessey Creek	HC-2	22-Jun-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6	NA		
Hennessey Creek	HC-2	16-Jul-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6	NA		
Hennessey Creek	HC-2	15-Sep-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6	NA		
Distribution			--			--			--			Neither			Neither		
Number of Samples			34			34			34			34			14		

Calculation of Reasonable Maximum Exposure Concentrations
Glory Hole and EFSFSR
Surface Water (ug/L)

			Nickel, total			Selenium, total			Silver, total			Zinc, total			Sulfate, total		
Area/Stream	Station	Date	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
Number of Detects			1			0			2			3			14		
Detection frequency			2.94			0.00			5.88			8.82			100.00		
Maximum			14.4			0.8			0.129			18			8400		
Minimum			1.5			0.8			0.033			1.8			3800		
Mean			1.87941			0.8			0.03818			2.89118			5928.57		
Standard Deviation			--			--			--			3.27949			1932.09		
t(1-a, n-1) or H 0.95			--			--			--			1.697			1.771		
95% UCL			--			--			--			3.84562			6843.07		
RME			14.4			--			0.129			3.84562			6843.07		
Basis for RME			Max			ND			Max			UCL			UCL		

Calculation of Reasonable Maximum Exposure Concentrations
Sugar Creek
Surface Water (ug/L)

			Aluminum, total			Antimony, total			Arsenic, total			Cadmium, total			Chromium, total			Copper, total		
Area/Stream	Station	Date	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
Sugar Creek	2040316	10-Jun-99	136			2.65	0	5.3	3.5	0	7	0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Sugar Creek	2040316	22-Jun-99	79.5	0	159	2.65	0	5.3	8.2			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Sugar Creek	2040316	16-Jul-99	26	0	52	2.65	0	5.3	12			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Sugar Creek	2040316	15-Sep-99	26	0	52	8.3			15	J		0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Sugar Creek	SC-3	10-Jun-99	137			2.65	0	5.3	3.5	0	7	0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Sugar Creek	SC-3	22-Jun-99	55	0	110	2.65	0	5.3	8.5			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Sugar Creek	SC-3	16-Jul-99	26	0	52	2.65	0	5.3	10			0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Sugar Creek	SC-3	15-Sep-99	26	0	52	2.65	0	5.3	14	J		0.315	0	0.63	0.85	0	1.7	0.85	0	1.7
Distribution			--			--			Normal			--			--			--		
Number of Samples			8			8			8			8			8			8		
Number of Detects			2			1			6			0			0			0		
Detection frequency			25.00			12.50			75.00			0.00			0.00			0.00		
Maximum			137			8.3			15			0.315			0.85			0.85		
Minimum			26			2.65			3.5			0.315			0.85			0.85		
Mean			63.938			3.3563			9.338			0.315			0.85			0.85		
Standard Deviation			--			--			4.334			--			--			--		
t(1-a, n-1) or H 0.95			--			--			1.895			--			--			--		
95% UCL			--			--			12.24			--			--			--		
RME			137			8.3			12.24			--			--			--		
Basis for RME			Max			Max			UCL			ND			ND			ND		

Notes: LN = natural log; NA = Not analyzed; ND = not detected; Max = Maximum; UCL = Upper Confidence Limit of arithmetic mean; t(1-a, n-1) = one tailed student t at the 95% confidence level; 0 = U = not detected; J = estimated value; Q = qualifier; DL = detection limit
RME = reasonable maximum exposure; H = H-statistic at 95% confidence level
For non-detects, 1/2 the DL was used to calculate means.

Calculation of Reasonable Maximum Exposure Concentrations
Sugar Creek
Surface Water (ug/L)

			Iron, total				Lead, total			Magnesium, total			Manganese, total			Mercury, total		
Area/Stream	Station	Date	Result	Ln	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
Sugar Creek	2040316	10-Jun-99	140	4.94164			0.25	0	0.5	2240			4.3			0.153	J	
Sugar Creek	2040316	22-Jun-99	170	5.1358			0.25	0	0.5	1660			6.8			0.25	J	
Sugar Creek	2040316	16-Jul-99	30	3.4012			0.25	0	0.5	2840			1.62			0.21	0	0.42
Sugar Creek	2040316	15-Sep-99	9.5	2.25129	0	19	0.25	0	0.5	4080			1.15	0	2.3	0.21	0	0.42
Sugar Creek	SC-3	10-Jun-99	150	5.01064			0.25	0	0.5	2150			4.3			0.199	J	
Sugar Creek	SC-3	22-Jun-99	140	4.94164			0.25	0	0.5	1600			6.5			0.33	J	
Sugar Creek	SC-3	16-Jul-99	31	3.43399			0.25	0	0.5	2740			1.56			0.047	J	
Sugar Creek	SC-3	15-Sep-99	16	2.77259	0	32	0.25	0	0.5	4000			0.68	0	1.36	0.21	0	0.42
Distribution			Lognormal				--			Normal			Normal			Normal		
Number of Samples			8				8			8			8			8		
Number of Detects			6				0			8			6			5		
Detection frequency			75.00				0.00			100.00			75.00			62.50		
Maximum			170				0.25			4080			6.8			0.33		
Minimum			9.5				0.25			1600			0.68			0.047		
Mean			85.8125	3.9861			0.25			2663.8			3.3638			0.20113		
Standard Deviation				1.15429			--			956.99			2.4435			0.08045		
t(1-a, n-1) or H 0.95				4.091			--			1.895			1.895			1.895		
95% UCL			624.6033				--			3304.9			5.0008			0.25503		
RME			170				--			3304.9			5.0008			0.25503		
Basis for RME			Max				ND			UCL			UCL			UCL		

Calculation of Reasonable Maximum Exposure Concentrations
Sugar Creek
Surface Water (ug/L)

			Nickel, total			Selenium, total			Silver, total			Zinc, total		
Area/Stream	Station	Date	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
Sugar Creek	2040316	10-Jun-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Sugar Creek	2040316	22-Jun-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Sugar Creek	2040316	16-Jul-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Sugar Creek	2040316	15-Sep-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Sugar Creek	SC-3	10-Jun-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Sugar Creek	SC-3	22-Jun-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Sugar Creek	SC-3	16-Jul-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	1.8	0	3.6
Sugar Creek	SC-3	15-Sep-99	1.5	0	3	0.8	0	1.6	0.033	0	0.066	8		
Distribution			--			--			--			--		
Number of Samples			8			8			8			8		
Number of Detects			0			0			0			1		
Detection frequency			0.00			0.00			0.00			12.50		
Maximum			1.5			0.8			0.033			8		
Minimum			1.5			0.8			0.033			1.8		
Mean			1.5			0.8			0.033			2.575		
Standard Deviation			--			--			--			--		
t(1-a, n-1) or H 0.95			--			--			--			--		
95% UCL			--			--			--			--		
RME			--			--			--			8		
Basis for RME			ND			ND			ND			Max		

Calculation of Reasonable Maximum Exposure Concentrations
Lower Meadow Creek Valley
Sediment (mg/kg)

		Antimony		Arsenic		Cadmium		Chromium		Copper		Lead		Mercury		Selenium		Zinc	
Station	**Chemical Year**	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
2040322	1996	2.45		37.9		0.025	U	--		4.8		--		0.134		1.57		9.19	
2040322	1997	1		15		0.05	U	2.3		2.2		1.79		0.1	U	0.025	U	11.6	
2040319	1996	2.25		41		1.27		--		2.53		--		0.086		1.69		7.5	
2040319	1997	22.5		99		0.05	U	1.7		3		3.31		0.1	U	0.025	U	11.6	
Number of samples		4		4		4		2		4		2		4		4		4	
Number of detections		4		4		1		2		4		2		2		2		4	
Frequency of detection		1.00		1.00		0.25		1.00		1.00		1.00		0.50		0.50		1.00	
Maximum detected value		22.5		99.0		1.27		2.30		4.80		3.31		0.134		1.69		11.6	
Mean		7.05		48.2		0.349		2.00		3.13		2.55		0.105		0.828		9.97	
Standard Deviation		10.3		35.8		0.614		0.424		1.16		1.07		0.0204		0.928		2.00	
t(1-a,n-1)		2.353		2.353		2.353		6.314		2.353		6.314		2.353		2.353		2.353	
95% UCL(1)		19.2		90.3		1.07		3.89		4.50		7.35		0.129		1.92		12.3	
RME(2)		**19.2**		**90.3**		**1.07**		**2.30**		**4.50**		**3.31**		**0.129**		**1.69**		**11.6**	
Basis for RME		UCL		UCL		UCL		Max		UCL		Max		UCL		Max		Max	

(1) 95 percent upper confidence limit (UCL) on the mean
(2) Reasonable maximum exposure (RME)
Q = qualifier
U = not detected, value is one-half the detection limit
-- = no sample was obtained

Calculation of Reasonable Maximum Exposure Concentrations
EFSFSR and Midnight Creek
Sediment (mg/kg)

		Antimony		Arsenic		Cadmium		Chromium		Copper		Lead		Mercury		Selenium		Zinc	
Station	**Chemical Year**	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
2040365	1996	1.8		40.6		0.025	U	--		2.18		--		0.13		2.37		7.67	
2040365	1997	15.4		50		0.05	U	3		1.8		2.76		0.1	U	0.025	U	13	
2040310	1996	2.67		40.8		1.22		--		2.07		--		0.143		2.33		9.31	
2040310	1997	18.9		57		0.05	U	2.2		1.5		3.45		0.1	U	0.025	U	12.9	
Number of samples		4		4		4		2		4		2		4		4		4	
Number of detections		4		4		1		2		4		2		2		2		4	
Frequency of detection		1.00		1.00		0.25		1.00		1.00		1.00		0.5		0.5		1.00	
Maximum detected value		18.9		57.0		1.22		3.00		2.18		3.45		0.143		2.37		13.0	
Mean		9.69		47.1		0.336		2.60		1.89		3.11		0.118		1.19		10.7	
Standard Deviation		8.74		7.92		0.589		0.566		0.304		0.488		0.022		1.34		2.66	
t(1-a,n-1)		2.353		2.353		2.353		6.314		2.353		6.314		2.353		3.353		4.353	
95% UCL[(1)]		20.0		56.4		1.03		5.13		2.25		5.28		0.144		3.44		16.5	
RME[(2)]		**18.9**		**56.4**		**1.03**		**3.00**		**2.18**		**3.45**		**0.143**		**2.37**		**13.0**	
Basis for RME		Max		UCL		UCL		Max		Max		Max		Max		Max		Max	

(1) 95 percent upper confidence limit (UCL) on the mean
(2) Reasonable maximum exposure (RME)
Q = qualifier
U = not detected, value is one-half the detection limit
-- = no sample was obtained

Calculation of Reasonable Maximum Exposure Concentrations
Glory Hole and EFSFSR
Sediment (mg/kg)

		Aluminum			Antimony				Arsenic				Cadmium			Chromium		
Analyte	**Date**	**Result**	**Q**	**DL**	**Result**	**Ln**	**Q**	**DL**	**Result**	**Ln**	**Q**	**DL**	**Result**	**Q**	**DL**	**Result**	**Q**	**DL**
2040308	1996	NA			4.66	1.53902			1430	7.26543			40.4			NA		
2040308	1997	NA			35.4	3.56671			1522	7.32778			0.05	0	0.1	1.8		
2040314	1996	NA			1.07	0.06766			82.7	4.41522			2.54			NA		
2040314	1997	NA			34.6	3.54385			92	4.52179			0.05	0	0.1	4.1		
369A	1999	4450			9.4	2.24071			278	5.62762			0.035	0	0.07	7.2		
369B	1999	8850			17.1	2.83908			372	5.91889			0.035	0	0.07	8.5		
GH4	1999	8730			128	4.85203			437	6.07993			0.045	0	0.09	10.5		
EF-7	1999	6080			10	2.30259			1490	7.30653			0.18	0	0.36	7.6		
Distribution		Normal			Lognormal				Lognormal				--			Normal		
Number of Samples		4			8				8				8			6		
Number of Detects		4			8				8				2			6		
Detection frequency		100			100				100				25			100		
Maximum		8850			128				1522				40.4			10.5		
Minimum		4450			1.07				82.7				0.035			1.8		
Mean		7027.5			30.02875	2.61896			712.9625	6.0579			5.41688			6.61666667		
Standard Deviation		2141.75				1.4495				1.1888			--			3.14541995		
t(1-a, n-1) or H 0.95		2.353				4.77				4.09			--			2.015		
95% UCL		9547.268			535.265223				5444.00438				--			9.20415299		
RME		8850			128				1522				40.4			9.20415299		
Basis for RME		Max			Max				Max				Max			UCL		

Notes: LN = natural log; NA = Not analyzed; ND = not detected; Max = Maximum; UCL = Upper Confidence Limit of arthimetic mean;
t(1-a, n-1) = one tailed student t at the 95% confidence level; 0 = U = not detected; J = estimated value; Q = qualifer; DL = detection limit
RME = reasonable maximum exposure; H = H-statistic at 95% confidence level
For non-detects, 1/2 the DL was used to calculate means.

Calculation of Reasonable Maximum Exposure Concentrations
Glory Hole and EFSFSR
Sediment (mg/kg)

		Copper			Iron			Lead			Magnesium			Manganese		
Analyte	Date	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
2040308	1996	3.98			11300			NA			NA			NA		
2040308	1997	4.5			11698			5.58			NA			NA		
2040314	1996	2.31			7200			NA			NA			NA		
2040314	1997	6.2			7766			5.19			NA			NA		
369A	1999	6.2			9730			5.2			2010			461	J	
369B	1999	6.3			13900			6.8			3250			562	J	
GH4	1999	9.6			14300			15.1			4120			247	J	
EF-7	1999	7.4			14300			6.9			1680			294	J	
Distribution		Normal			Normal			Neither			Normal			Normal		
Number of Samples		8			8			6			4			4		
Number of Detects		8			8			6			4			4		
Detection frequency		100			100			100			100			100		
Maximum		9.6			14300			15.1			4120			562		
Minimum		2.31			7200			5.19			1680			247		
Mean		5.81125			11274.25			7.46166667			2765			391		
Standard Deviation		2.2281154			2845.4765			3.81873496			1128.19915			146.385336		
t(1-a, n-1) or H 0.95		1.895			1.895			2.015			2.353			2.353		
95% UCL		7.30405094			13180.6728			10.6030356			4092.32631			563.222348		
RME		7.30405094			13180.6728			10.6030356			4092.32631			562		
Basis for RME		UCL			UCL			UCL			UCL			Max		

Calculation of Reasonable Maximum Exposure Concentrations
Glory Hole and EFSFSR
Sediment (mg/kg)

		Mercury			Nickel			Selenium			Silver			Zinc		
Analyte	Date	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
2040308	1996	0.286			NA			7.20			NA			19.8		
2040308	1997	0.45			NA			0.025	0	0.05	NA			26.2		
2040314	1996	2.10			NA			2.84			NA			15.6		
2040314	1997	3.14			NA			0.025	0	0.05	NA			19.3		
369A	1999	0.37			3.4			0.075	0	0.15	0.37			21.3	J	
369B	1999	0.19			5.6			0.07	0	0.14	0.48			33.3	J	
GH4	1999	1.1			7.2			0.21			1.6			38.1	J	
EF-7	1999	1.4			3.9			0.07	0	0.14	1.1			34.5	J	
Distribution		Normal			Normal			--			Normal			Normal		
Number of Samples		8			4			8			4			8		
Number of Detects		8			4			3			4			8		
Detection frequency		100			100			37.5			100			100		
Maximum		3.14			7.2			7.2			1.6			38.1		
Minimum		0.19			3.4			0.025			0.37			15.6		
Mean		1.1295			5.025			1.31438			0.8875			26.0125		
Standard Deviation		1.0481776			1.72892067			2.56754			0.57349077			8.32868323		
t(1-a, n-1) or H 0.95		1.895			2.353			2.353			2.353			1.895		
95% UCL		1.83176188			7.05907516			3.45034			1.56221189			31.5925818		
RME		1.83176188			7.05907516			3.45034			1.56221189			31.5925818		
Basis for RME		UCL			UCL			UCL			UCL			UCL		

Calculation of Reasonable Maximum Exposure Concentrations
Sugar Creek
Sediment (mg/kg)

Analyte	Date	Antimony			Arsenic			Cadmium			Chromium			Copper			Iron			Lead		
		Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL	Result	Q	DL
2040307	1996	0.5	0	1	37.9			1.13			NA			2.22			7850			NA		
2040316	1997	0.59			37			0.05	0	0.1	4			2			7360			4.52		
Number of Samples		2			2			2			1			2			2			1		
Number of Non-detects		1			0			1			0			0			0			0		
Number of Detects		1			2			1			1			2			2			1		
Detection frequency		50			100			50			100			100			100			100		
Maximum		0.59			37.9			1.13			4			2.22			7850			4.52		
Minimum		0.5			37			0.05			4			2			7360			4.52		
Mean		--			--			--			--			--			--			--		
RME		0.59			37.9			1.13			4			2.22			7850			4.52		
Basis for RME		Max			Max			Max			Max			Max			Max			Max		

Calculation of Reasonable Maximum Exposure Concentrations
Sugar Creek
Sediment (mg/kg)

Analyte	Date	Mercury Result	Mercury Q	Mercury DL	Selenium Result	Selenium Q	Selenium DL	Zinc Result	Zinc Q	Zinc DL
2040307	1996	**9.14**			1.80			16.2		
2040316	1997	2.03			0.025	0	0.05	19.6		
Number of Samples		2			2			2		
Number of Non-detects		0			1			0		
Number of Detects		2			1			2		
Detection frequency		100			50			100		
Maximum		9.14			1.8			19.6		
Minimum		2.03			0.025			16.2		
Mean		--			--			--		
RME		9.14			1.8			19.6		
Basis for RME		Max			Max			Max		

Calculation of Reasonable Maximum Exposure Concentrations
EFSFSR and Midnight Creek and Lower Meadow Creek Valley
Fish (mg/kg)

Station	Chemical Fish No. [(1)]	Aluminum Result	Aluminum Q	Antimony Result	Antimony Q	Arsenic Result	Arsenic Q	Cadmium Result	Cadmium Q	Chromium Result	Chromium Q	Copper Result	Copper Q	Lead Result	Lead Q
2040322	1	0.75	U	0.025	U	0.75		0.075	U	0.25	U	0.37	U	0.025	U
2040322	2	0.75	U	0.025	U	0.66		0.075	U	0.25	U	0.25	U	0.025	U
2040322	3	0.75	U	0.025	U	0.76		0.075	U	0.25	U	0.25	U	0.025	U
2040310	1	0.75	U	0.025	U	0.56		0.075	U	0.25	U	0.425	U	0.025	U
2040310	2	0.75	U	0.025	U	0.44		0.075	U	0.25	U	0.365	U	0.025	U
2040310	3	0.75	U	0.025	U	0.30		0.075	U	0.25	U	0.345	U	0.025	U
Number of samples		6		6		6		6		6		6		6	
Number of detections		0		0		6		0		0		0		0	
Frequency of detection		0		0		1.00		0		0		0		0	
Maximum detected value						0.760									
Mean						0.578									
Standard Deviation						0.182									
t(1-a,n-1)						2.015									
95% UCL[(2)]						0.728									
RME[(3)]						**0.728**									
Basis for RME						UCL									

Calculation of Reasonable Maximum Exposure Concentrations
EFSFSR and Midnight Creek and Lower Meadow Creek Valley
Fish (mg/kg)

	Chemical	Manganese		Mercury		Nickel		Selenium		Silver		Zinc	
Station	**Fish No.** [1]	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
2040322	1	0.98		0.25		0.25	U	0.70		0.125	U	7.1	
2040322	2	0.125	U	0.19		0.25	U	0.66		0.125	U	6.9	
2040322	3	0.3		0.21		0.25	U	0.74		0.125	U	6.1	
2040310	1	0.125	U	0.16		0.25	U	0.59		0.125	U	6.6	
2040310	2	0.125	U	0.11		0.25	U	0.66		0.125	U	5.8	
2040310	3	0.3		0.10		0.25	U	0.58		0.125	U	7.1	
Number of samples		6		6		6		6		6		6	
Number of detections		3		6		0		6		0		6	
Frequency of detection		0.5		1.00		0		1.00		0		1.00	
Maximum detected value		0.980		0.250				0.740				7.100	
Mean		0.326		0.170				0.655				6.60	
Standard Deviation		0.332		0.058				0.062				0.544	
t(1-a,n-1)		2.015		2.015				2.015				2.015	
95% UCL[2]		0.599		0.218				0.706				7.05	
RME[3]		**0.599**		**0.218**				**0.706**				**7.05**	
Basis for RME		UCL		UCL				UCL				UCL	

(1) Three fish were caught at each station (August 1997).
(2) 95 percent upper confidence limit (UCL) on the mean
(3) Reasonable maximum exposure (RME)
Q = qualifier
U = not detected, value is one-half the detection limit

Calculation of Reasonable Maximum Exposure Concentrations
Glory Hole and EFSFSR
Fish (mg/kg)

Station	Chemical Fish No. (1)	Aluminum Result	Aluminum Q	Antimony Result	Antimony Q	Arsenic Result	Arsenic Q	Cadmium Result	Cadmium Q	Chromium Result	Chromium Q	Copper Result	Copper Q	Lead Result	Lead Q	Manganese Result	Manganese Q
2040308	1	0.75	U	0.025	U	0.67		0.075	U	0.25	U	0.55	U	0.025	U	0.125	U
2040308	2	0.75	U	0.025	U	0.96		0.075	U	0.25	U	0.80	U	0.06		0.125	U
2040308	3	0.75	U	0.025	U	0.53		0.075	U	0.25	U	0.445	U	0.025	U	0.125	U
2040314	1	0.75	U	0.025	U	0.36		0.075	U	0.25	U	0.465	U	0.025	U	0.41	
2040314	2	0.75	U	0.025	U	0.34		0.075	U	0.25	U	0.50	U	0.025	U	0.44	
2040314	3	0.75	U	0.025	U	0.39		0.075	U	0.25	U	0.485	U	0.025	U	0.125	U
Number of samples		6		6		6		6		6		6		6		6	
Number of detections		0		0		6		0		0		0		1		2	
Frequency of detection		0.00		0.00		1.00		0.00		0.00		0.00		0.167		0.333	
Maximum detected value						0.960								0.060		0.440	
Mean						0.542								0.031		0.225	
Standard Deviation						0.240								0.014		0.155	
t(1-a,n-1)						2.015								2.015		2.015	
95% UCL[2]						0.739								0.042		0.353	
RME[3]						**0.739**								**0.042**		**0.353**	
Basis for RME						UCL								UCL		UCL	

Calculation of Reasonable Maximum Exposure Concentrations
Glory Hole and EFSFSR
Fish (mg/kg)

Station	Chemical Fish No. [1]	Mercury Result	Mercury Q	Nickel Result	Nickel Q	Selenium Result	Selenium Q	Silver Result	Silver Q	Zinc Result	Zinc Q
2040308	1	0.16		0.25	U	0.40		0.125	U	6.6	
2040308	2	0.08		0.25	U	0.69		0.125	U	6.7	
2040308	3	0.07		0.25	U	0.54		0.125	U	7.0	
2040314	1	0.06		0.25	U	0.51		0.125	U	6.9	
2040314	2	0.07		0.25	U	0.55		0.125	U	7.7	
2040314	3	0.08		0.25	U	0.54		0.125	U	8.5	
Number of samples		6		6		6		6		6	
Number of detections		6		0		6		0		6	
Frequency of detection		1.00		0.00		1.00		0.00		1.00	
Maximum detected value		0.160				0.690				8.50	
Mean		0.087				0.538				7.233	
Standard Deviation		0.037				0.093				0.731	
t(1-a,n-1)		2.015				2.015				2.015	
95% UCL[2]		0.117				0.615				7.83	
RME[3]		**0.117**				**0.615**				**7.83**	
Basis for RME		UCL				UCL				UCL	

(1) Three fish were caught at each station (August 1997).
(2) 95 percent upper confidence limit (UCL) on the mean
(3) Reasonable maximum exposure (RME)
Q = qualifier
U = not detected, value is one-half the detection limit

APPENDIX C

TERRESTRIAL AND RIPARIAN RISK CALCULATIONS

Tables

C.A. HQ MODEL PARAMETERS

C.B NOAEL-HQ CALCULATIONS

C.B.A. Surface Soil NOAEL-HQs

C.B.B Surface Water NOAEL-HQs

C.B.C Sediment NOAEL-HQs

C.B.D Drinking Water NOAEL-RBCs

C.B.E Fish Tissue NOAEL-HQs

C.C LOAEL-HQ CALCULATIONS

C.C.A Surface Soil LOAEL-HQs

C.C.B Surface Water LOAEL-HQs

C.C.C Sediment LOAEL-HQs

C.C.D Drinking Water LOAEL-RBCs

C.C.E Fish Tissue LOAEL-HQs

C.D NOAEL- AND LOAEL-HQ SUMMARY TABLES BY SITE

APPENDIX C.A

HQ MODEL PARAMETERS

Table C.A-1

Wildlife Exposure Factors

Representative Species			Body Weight		Food Ingestion Rate			Composition of Diet (%)					Soil Ingestion Rate			Water Intake		
Food-web classification	**Common Name**	**Scientific Name**	**kg wet wt.**	**Reference**	**kg wet wt./day(a)**	**Comment**	**Reference**	**Plants**	**Inverte-brates**	**Small Mammals**	**Fish**	**Reference**	**kg dry wt./day**	**Comment**	**Reference**	**L/d**	**Comment**	**Reference**
Birds																		
avian, small invertivore	Snipe	*Capella gallinago*	0.134	Terres 1991	0.102	based on woodcock = 76% of BW	Sample et al. 1996	0%	100%	0%	0%		0.011	based on woodcock = 10.4% of FI rate wet weight	EPA 1993	0.015	WI (L/day)= $0.059*BW^{0.67}$ (BW in wet wt. kg)	EPA 1993
avian, small piscivore	Belted kingfisher	*Ceryle alcyon*	0.148	Sample et al. 1996	0.075		Sample et al. 1996	0%	0%	0%	100%		0		Sample et al. 1997	0.016		Sample et al. 1996
Mammals																		
mammal, small herbivore	Meadow vole	*Microtus pennsylvanicus*	0.044	Sample et al. 1996	0.005		Sample et al. 1996	100%	0%	0%	0%	Sample et al. 1996	2.4E-05	2.4% of dry weight FI, assuming 80% diet moisture content(c)	Beyer et al. 1994	0.006		Sample et al. 1996
mammal, medium piscivore	Mink	*Mustela vison*	1.0	Sample et al. 1996	0.137		Sample et al. 1996	0%	0%	0%	100%		0	negligible	Sample et al. 1997	0.099		Sample et al. 1996
mammal, medium carnivore	Red fox	*Vulpes vulpes*	3.94	EPA 1993	0.66	Dry weight - FI (b) (kg/day) = $0.0687BW^{0.822}$ (kg) = 0.21	EPA 1993	0%	0%	100%	0%	EPA 1993	0.00588	2.8% of dry weight food ingestion rate (0.21 kg/day)	EPA 1993	0.34	WI (L/day) = 0.099 $BW^{0.90}$ (BW in kg wet wt.)	EPA 1993
mammal, small invertivore	Short-tailed shrew	*Blarina brevicauda*	0.015	Sample et al. 1996	0.009		Sample et al. 1996	0%	100%	0%	0%	Efroymson et al. 1997	0.00117		Efroymson et al. 1997	0.0033		Sample et al. 1996
mammal, large herbivore	White-tailed deer	*Odocoileus virginianus*	56.5	Sample et al. 1996	1.74		Sample et al. 1996	100%	0%	0%	0%	Efroymson et al. 1997	0.0348		Efroymson et al. 1997	3.7		Sample et al. 1996

(a) kg wet wt/day = (kg dry wt/day) /(fraction solids)
(b)Assumed small mammals are 68% moisture (EPA 1993, p.4-13)
(c) Assumed plants are 80% moisture (EPA 1993, p.4-14)
FI = food ingestion rate
BW=body weight
WI=water intake
wt.=weight

Beyer, W.N., E. Conner, and S. Gerould. 1994. Estimates of Soil Ingestion by Wildlife. J. Wildl. Manage. 58: 375-382.
Efroymson, R.A., G.W. Suter II, B.E. Sample, D.S. Jones. 1997. Preliminary Remediation Goals for Ecological Endpoints. Prepared for the U.S. Department of Energy. ES/ER/TM-162/R2.
Sample, B.E., M.S. Aplin, R.A. Efroymson et al. 1997. Methods and Tools for Estimation of the Exposure of Terrestrial Wildlife to Contaminants. Prepared by Oak Ridge National Laboratory. ORNL/TM-13391.
Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. Table B.1. Prepared by Oak Ridge National Laboratory. ES/ER/TM-86/R3.
Terres, J.K. 1991. The Audubon Society Encyclopedia of North American Birds. Random House Publications, NY, NY
United States Environmental Protection Agency (EPA). 1993. Wildlife Exposure Factors Handbook, Volume 1. Office of Research and Development. EPA/600/R-93/187a.

Table C.A-2

Bioconcentration/Bioaccumulation Factors for Plants, Soil Invertebrates, and Small Birds/Mammals

	Terrestrial Food Items					
Analyte	Plants*	Reference	Soil Invertebrates**	Reference	Small Birds/ Mammals***	Reference
Inorganics						
Aluminum	8.0E-04	Baes et al. (1984)	9.9E-02	Beyer and Stafford (1993)	7.5E-02	Baes et al. (1984)
Antimony	4.0E-02	Baes et al. (1984)	5.2E-01	Zinc used as surrogate	5.0E-02	Baes et al. (1984)
Arsenic	8.0E-03	Baes et al. (1984)	2.64E-01	Beyer and Stafford (1993)	1.0E-01	Baes et al. (1984)
Cadmium	1.1E-01	Baes et al. (1984)	1.3E+00	Beyer and Stafford (1993)	2.8E-02	Baes et al. (1984)
Chromium	1.5E-03	Baes et al. (1984)	1.4E-01	Beyer and Stafford (1993)	2.8E-01	Baes et al. (1984)
Cobalt	4.0E-03	Baes et al. (1984)	5.2E-01	Zinc used as surrogate	1.0E+00	Baes et al. (1984)
Copper	8.0E-02	Baes et al. (1984)	1.51E-01	Beyer and Stafford (1993)	5.0E-01	Baes et al. (1984)
Cyanide	6.0E+00	Nitrogen value from Baes et al. (1984) used as a surrogate.	5.2E-01	Zinc used as surrogate	3.8E+00	Beyer and Stafford (1993)
Lead	9.0E-03	Baes et al. (1984)	1.3E-01	Beyer and Stafford (1993)	1.5E-02	Baes et al. (1984)
Manganese	5.0E-02	Baes et al. (1984)	1.2E-01	Beyer and Stafford (1993)	2.0E-02	Baes et al. (1984)
Mercury	1.8E-01	Baes et al. (1984)	2.8E-01	Beyer and Stafford (1993)	1.3E+01	Baes et al. (1984)
Nickel	1.2E-02	Baes et al. (1984)	1.2E-01	Beyer and Stafford (1993)	3.0E-01	Baes et al. (1984)
Selenium	5.0E-03	Baes et al. (1984)	5.2E-01	Zinc used as surrogate	7.5E-01	Baes et al. (1984)
Silver	8.0E-02	Baes et al. (1984)	5.2E-01	Zinc used as surrogate	1.5E-01	Baes et al. (1984)
Zinc	3.0E-01	Baes et al. (1984)	5.2E-01	Beyer and Stafford (1993)	5.0E+00	Baes et al. (1984)

Notes:
* (mg of chemical / kg of plant material wet weight) / (mg of chemical / kg of soil dry weight)
**(mg of chemical / kg of soil invertebrate wet weight) / (mg of chemical / kg of soil dry weight)
***(mg of chemical / kg of bird wet weight) / (mg of chemical / kg of soil dry weight)

Dry weight BCF values for plants were converted to wet weight by multiplying the dry weight value by the fraction of solids in plants (0.2; average of young grasses, dicots and fruits in EPA 1993).
Dry weight BCF values for invertebrates were converted to wet weight by multiplying the dry weight value by the fraction of solids in invertebrates (0.29; average of values provided in EPA 1993)

BCF for zinc (the highest BCF value for inorganics) was used as surrogate for metals in invertebrates.

BAF and BCF References:

Baes, C.F., R. Sharp, A. Sjoreen, and R. Shor. 1984. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture. Prepared by Oak Ridge National Laboratory for U.S. Dept. of Energy. 150 pp. In: USACE, 1998.

Vegetation (mg/kg dry weight plant)/(mg/kg dry weight soil) -- Log BCF = 1.588 - 0.578 x Log Kow. BCF * 0.2 (the 0.2 fraction of solids for plants is the average of young grasses, dicots and fruits in EPA 1993 and adjusts BCF to (mg/kg wet weight plant)/(mg/kg dry weight soil)).
Small mammals-- Log biotransfer factor (BTF) = -7.6 + log Kow and BAF (mg/kg wet weight tissue)/(mg/kg dry weight of food or soil) = BTF * 12 kg/d

Beyer, W. and C. Stafford. 1993. Survey and evaluation of contaminants in earthworms and in soils derived from dredged material at confined disposal facilities in the Great Lakes Region. Environmental Monitoring and Assessment. 24:151-165.

Table C.A-3

ORNL Soil Benchmarks for Functional Ecological Groups (mg/kg soil)

Analyte	Plants[a]	Microorganisms[b]	Earthworms[b]	Mammals[c]				Birds[c]	
				Medium Omnivore	Large Herbivore	Small Omnivore	Small Carnivore (Insectivore/ Invertivore)	Small Carnivore	Large Carnivore
Aluminum	**50**	600	nc[d]	nc	nc	nc	nc	nc	nc
Antimony	**5**	nc	nc	nc	nc	nc	nc	nc	nc
Arsenic	10	100	60	92	144	149	**9.9**	102	143000
Chromium	1	10	**0.4**	1090	1970	880	110	16.1	UND[e]
Copper	100	100	**50**	3000	7000	10100	370	515	UND[e]
Lead	50	900	500	7150	18600	6250	740	**40.5**	55000
Manganese	500	**100**	nc	nc	nc	nc	nc	nc	nc
Mercury	0.3	30	0.1	0.83	5.4	7.1	0.146	**0.00051[f]**	12.3
Nickel	**30**	90	200	nc	nc	nc	nc	nc	nc
Selenium	1	100	70	0.93	1.66	**0.21[g]**	UND[h]	UND[h]	420
Silver	**2**	50	nc	nc	nc	nc	nc	nc	nc
Zinc	**50**	100	200	32500	19100	35000	1600	**8.5[g]**	UND[e]

Notes:
[a] Will, M.E. and G.W. Suter II. 1995. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants: 1995 Revision. Prepared by Oak Ridge National Laboratory. ES/ER/TM-85/R2.
[b] Will, M.E. and G.W. Suter II. 1995. Toxicological Benchmarks for Potential Contaminants of Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process. Prepared by Oak Ridge National Laboratory. ES/ER/TM-126/R1.
[c] Efroymson, R.A., G.W. Suter II, B.E. Sample, D.S. Jones. 1997. Preliminary Remediation Goals for Ecological Endpoints. Prepared by Oak Ridge National Laboratory. ES/ER/TM-162/R2.
[d] No soil benchmark screening criterion.
[e] UND = Undefined. Due to characteristics of soil-small mammal uptake model, soil concentration cannot be raised sufficiently high to produce exposure equivalent to LOAEL.
[f] This value is so low that it is within background soil concentrations.
[g] Soil-plant uptake models, soil-earthworm uptake models or LOAELs were not available for this chemical for wildlife. Therefore, the soil benchmark cannot be assumed to protect wildlife.
[h] UND = Undefined. Due to characteristics of soil-earthworm uptake model, soil concentration cannot be reduced sufficiently low to produce exposure equivalent to LOAEL.
■ = Shaded and bolded values are the lowests, most conservative toxicity benchmark for soil.

Mammals:
Omnivore (medium) = red fox
Herbivore (large) = white-tailed deer
Omnivore (small) = deer mouse
Carnivore (small) = short-tailed shrew

Birds:
Carnivore/Vermivore (medium) = woodcock
Carnivore (large) = red-tailed hawk

Table C.A-4

Benchmark Summary for Birds

Analytes	Chronic LOAEL	Chronic NOAEL	Test Species
	(mg/kg-bw/d)		
Inorganics			
Aluminum	15	4.5	day-old white leghorn chicks
Antimony	--	--	--
Arsenic	4.3	1.7	mallard duck
Cadmium	20	1.5	mallard duck
Chromium	5	1	black duck
Copper	21	16	1 day old chicks
Cyanide	--	--	--
Lead	11	1.1	Japanese quail
Manganese	2991	997	1-d old Japanese quail
Mercury	0.90	0.45	Japanese Quail
Nickel	107	77	mallard duckling
Selenium	0.8	0.4	mallard duck
Silver	166	55	turkey
Zinc	131	15	white leghorn hen

Source: Table C.A-6

Table C.A-5
Benchmark Summary For Mammals

Analytes	Final Toxicity Reference: Chronic LOAEL (mg/kg-bw/d)	Final Toxicity Reference: Chronic NOAEL (mg/kg-bw/d)	Test Species	Small Mammal Herbivore(b) (Meadow vole): Chronic LOAEL	Small Mammal Herbivore(b) (Meadow vole): Chronic NOAEL	Small Mammal Invertivore(b) (Short-tailed shrew): Chronic LOAEL	Small Mammal Invertivore(b) (Short-tailed shrew): Chronic NOAEL	Medium Mammal Omnivore(b) (Red fox): Chronic LOAEL	Medium Mammal Omnivore(b) (Red fox): Chronic NOAEL	Large Mammal Herbivore(b) (Whitetailed deer): Chronic LOAEL	Large Mammal Herbivore(b) (Whitetailed deer): Chronic NOAEL	Medium Mammal Piscivore(b) (Mink): Chronic LOAEL	Medium Mammal Piscivore(b) (Mink): Chronic NOAEL
				(mg/kg-bw/d)									
Aluminum	19	6.4	mouse	6.33	2.13	3.80	1.28	3.80	1.28	3.80	1.28	3.80	1.28
Antimony	1.3	0.42	mouse	0.433	0.140	0.260	0.084	0.260	0.084	0.260	0.084	0.260	0.084
Arsenic	1.3	0.4	mouse	0.433	0.133	0.260	0.080	0.260	0.080	0.260	0.080	0.260	0.080
Cadmium	10	1	rat	3.33	0.333	2.00	0.200	2.00	0.200	2.00	0.200	2.00	0.200
Chromium	8211	2737	rat	2740	912	1640	547	1640	547	1640	547	1640	547
Copper	15	12	mink	3.00	2.40	3.00	2.40	3.75	3.00	3.00	2.40	15.0	12.0
Cyanide	206	69	rat	68.7	23.0	41.2	13.8	41.2	13.8	41.2	13.8	41.2	13.8
Lead	80	8	rat	26.7	2.67	16.0	1.60	16.0	1.60	16.0	1.60	16.0	1.60
Manganese	284	88	rat	94.7	29.3	56.8	17.6	56.8	17.6	56.8	17.6	56.8	17.6
Mercury	0.08	0.05	mink	0.0160	0.0100	0.0160	0.0100	0.0200	0.0125	0.0160	0.0100	0.0800	0.0500
Nickel	80	40	rat	26.7	13.3	16.0	8.00	16.0	8.00	16.0	8.00	16.0	8.00
Selenium	0.33	0.20	rat	0.110	0.0667	0.0660	0.0400	0.0660	0.0400	0.0660	0.0400	0.0660	0.0400
Silver	222	74	rat	74.0	24.7	44.4	14.8	44.4	14.8	44.4	14.8	44.4	14.8
Zinc	320	160	rat	107	53.3	64.0	32.0	64.0	32.0	64.0	32.0	64.0	32.0

(a)See Table C.A-7 for estimation of final toxicity reference values.

(b)Final toxicity reference values were divided by taxon uncertainty factors. The taxon uncertainty factors used for a given test species-receptor combination are:

	mouse		rat	mink	
Receptor	UF	Basis	Basis	UF	Basis
Meadow vole	3	Genus	Genus	5	Order
Mink	5	Order	Order	1	Species
Red fox	5	Order	Order	4	Family
Short-tailed shrew	5	Order	Order	5	Order
White-tailed deer	5	Order	Order	5	Order

Table C.A-6

Source of Benchmarks for Birds

Analyte	Form	Test Species	Exposure Duration	Exposure Route	Endpoint	Lethal/Non-lethal Endpoint	Acute LD_{50} (mg/kg-bw/d)	Acute LD_{50} to Acute nonlethal NOAEL UF	Acute LOAEL	Acute NOAEL	Acute to Chronic UF	Subchronic LOAEL (mg/kg-bw/d)	Subchronic NOAEL (mg/kg-bw/d)	Subchronic to Chronic UF	Chronic LOAEL (mg/kg-bw/d)	Chronic NOAEL (mg/kg-bw/d)	Lethal LOAEL to nonlethal LOAEL UF	Lethal LOAEL to nonlethal NOAEL UF	Nonlethal LOAEL to nonlethal NOAEL UF	Lethal NOAEL to nonlethal NOAEL UF	Final Chronic LOAEL (mg/kg-bw/d)	Final Chronic NOAEL (mg/kg-bw/d)	Source
Aluminum	$AlCl_3$	day-old white leghorn chicks	--	--	--	lethal	--	--	--	--	--	--	--	--	44.5	--	3	10	--	--	15	4.5	Sample et al., 1996
Antimony	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Arsenic	sodium arsenite	mallard duck	128 d	food	mortality	lethal	--	--	--	--	--	--	--	--	12.84	5.14	3	--	--	3	4.28	1.71	Sample et al., 1996
Cadmium	cadmium chloride	mallard duck	90 d, critical lifestage	food	reproduction	non-lethal	--	--	--	--	--	--	--	--	20	1.45	--	--	--	--	20	1.45	Sample et al., 1996
Chromium	Cr+3 as CrK(SO4)2	black duck	10 mo, critical lifestage	food	reproduction	non-lethal	--	--	--	--	--	--	--	--	5	1	--	--	--	--	5	1	Sample et al., 1996
Copper	copper oxide	1 day old chicks	10 wks	food	mortality, growth	lethal	--	--	--	--	--	--	--	--	61.7	47	3	--	--	3	21	16	Sample et al., 1996
Cyanide	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lead	lead acetate	Japanese quail	12 wks, critical lifestage	food	reproduction	non-lethal	--	--	--	--	--	--	--	--	11.3	1.13	--	--	--	--	11.3	1.13	Sample et al., 1996
Manganese	Mn3O4	1-d old Japanese quail	75 d	food	growth	non-lethal	--	--	--	--	--	--	--	--	--	997	--	--	--	--	2991	997	Sample et al., 1996
Mercury	mercuric chloride	Japanese Quail	1 yr	food	reproduction	non-lethal	--	--	--	--	--	--	--	--	0.90	0.45	--	--	--	--	0.90	0.45	Sample et al., 1996
Nickel	nickel sulfate	mallard duckling	90 d	food	mortality, growth, behavior	non-lethal	--	--	--	--	--	--	--	--	107	77.4	--	--	--	--	107	77	Sample et al., 1996
Selenium	selanomethio-nine	mallard duck	100 d, critical lifestage	food	reproduction	non-lethal	--	--	--	--	--	--	--	--	0.8	0.4	--	--	--	--	0.8	0.4	Sample et al., 1996
Silver		turkey	5 wks	food	cardiovascular, hematological	non-lethal	--	--	--	--	--	496.8	166	3	--	--	--	--	--	--	165.6	55.2	Jensen et al., 1974
Zinc	zinc sulfate	white leghorn hen	44 wks	food	reproduction	non-lethal	--	--	--	--	--	--	--	--	131	14.5	--	--	--	--	131	14.5	Sample et al., 1996

UF = uncertainty factor
LD_{50} = median lethal dose (dose at which 50 percent of the exposed organisms do not survive).
LOAEL = lowest obervable adverse effect level.
NOAEL = no obervable adverse effect level

References:

Jensen, L. S., R. P. Peterson, and L. Falen. 1974. Inducement of enlarged hearts and muscular dystrophy in turkey poults with dietary silver. Poultry Science 53:57-64.
Sample, B. E., D. M. Opresko, and G. W. Suter II. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. Prepared by Oak Ridge National Laboratory. ES/ER/TM-86/RB.

Table C.A-7

Source of Benchmarks for Mammals

Analyte	Form	Test Species	Exposure Duration	Exposure Route	Endpoint(s)	Lethal/ Non-lethal Endpoint Designation	Acute LD_{50} (mg/kg-bw/d)	Acute LD_{50} to Acute Nonlethal NOAEL UF	Acute LOAEL	Acute NOAEL	Acute to Chronic UF	Subchronic LOAEL (mg/kg-bw/d)	Subchronic NOAEL (mg/kg-bw/d)	Subchronic to Chronic UF	Chronic LOAEL (mg/kg-bw/d)	Chronic NOAEL (mg/kg-bw/d)	Lethal LOAEL to nonlethal LOAEL UF	Lethal LOAEL to nonlethal NOAEL UF	Nonlethal LOAEL to nonlethal NOAEL UF	Lethal NOAEL to nonlethal NOAEL UF	Final Chronic LOAEL (mg/kg-bw/d)	Final Chronic NOAEL (mg/kg-bw/d)	Source of Toxicity Data
Inorganics																							
Aluminum	$AlCl_3$	mouse	3 gen	food	reproduction	non-lethal	--	--	--	--	--	--	--	--	19.3	--	--	--	3	--	19	6.4	Sample et al., 1996
Antimony	antimony potassium tartrate	mouse	Lifetime (>1 yr)	water	lifespan	non-lethal	--	--	--	--	--	--	--	--	1.25	--	--	--	3	--	1.25	0.417	Sample et al., 1996
Arsenic	Arsenite	mouse	3 gen	water	reproduction	non-lethal	--	--	--	--	--	--	--	--	1.26	--	--	--	3	--	1.26	0.42	Sample et al., 1996
Cadmium	cadmium chloride	rat	6 wks, critical lifestage	oral, gavage	reproduction	non-lethal	--	--	--	--	--	--	--	--	10	1	--	--	--	--	10	1	Sample et al., 1996
Chromium	Cr+3 as Cr2O3	rat	90 d and 2 yr	food	reproduction	non-lethal	--	--	--	--	--	--	--	--	--	2737	--	--	--	--	8211	2737	Sample et al., 1996
Chromium	Cr+6	rat	1 yr	water	body weight, food consumption	non-lethal	--	--	--	--	--	--	--	--	--	3.28	--	--	--	--	10	3	Sample et al., 1996
Copper	copper sulfate	mink	357 d, critical lifestage	food	reproduction	non-lethal	--	--	--	--	--	--	--	--	15.4	11.7	--	--	--	--	15.4	11.7	Sample et al., 1996
Cyanide	potassium cyanide	rat	gestation/ lactation	food	reproduction	non-lethal	--	--	--	--	--	--	--	--	--	68.7	--	--	--	--	206	68.7	Sample et al., 1996
Lead	lead acetate	rat	3 gen	food	reproduction	non-lethal	--	--	--	--	--	--	--	--	80	8	--	--	--	--	80	8	Sample et al., 1996
Manganese	Mn_3O_4	rat	Through gestation for 224 d	food	reproduction	non-lethal	--	--	--	--	--	--	--	--	284.00	88	--	--	--	--	284	88	Sample et al., 1996
Mercury	Methyl Mercury Chloride	mink	93 d, not during critical	food	mortality, weight loss, ataxia	non-lethal	--	--	--	--	--	0.245	0.15	3	--	--	--	--	--	--	0.082	0.05	Sample et al., 1996
Nickel	nickel sulfate hexahydrate	rat	3 gen	food	reproduction	non-lethal	--	--	--	--	--	--	--	--	80	40	--	--	--	--	80	40	Sample et al., 1996
Selenium	Selenate (SeO4)	rat	1 yr, 2 gen	water	reproduction	non-lethal	--	--	--	--	--	--	--	--	0.33	0.2	--	--	--	--	0.33	0.2	Sample et al., 1996
Silver		rat	37 wks	water	body weight	non-lethal	--	--	--	--	--	--	--	--	222	--	--	--	3	--	222	74	ATSDR, 1990
Zinc	zinc oxide	rat	days 1 to 16 of gestation	food	reproduction	non-lethal	--	--	--	--	--	--	--	--	320	160	--	--	--	--	320	160	Sample et al., 1996

UF = uncertainty factor

LD_{50} = median lethal dose (dose at which 50 percent of exposed organisms do not survive).

LOAEL = lowest obervable adverse effect level.

NOAEL = no obervable adverse effect level.

References:

Agency for Toxic Substances and Disease Registry (ATSDR). 1990. Toxicological profile for silver. U.S. Department of Human Health Services.

Sample, B. E., D. M. Opresko, and G. W. Suter II. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. Prepared by Oak Ridge National Laboratory. ES/ER/TM-86/RB.

Table C.A-8

Critical Tissue Residue Levels for Plants

Analytes	Critical Tissue Limit mg/kg (wet wt.)	Source
Inorganics		
Aluminum	nc	--
Antimony	30	Kabata-Pendias and Pendias, 1992
Arsenic	4	Kabata-Pendias and Pendias, 1992
Cadmium	6	Kabata-Pendias and Pendias, 1992
Chromium	6	Kabata-Pendias and Pendias, 1992
Copper	20	Kabata-Pendias and Pendias, 1992
Cyanide	nc	--
Lead	60	Kabata-Pendias and Pendias, 1992
Manganese	200	Kabata-Pendias and Pendias, 1992
Mercury	0.6	Kabata-Pendias and Pendias, 1992
Nickel	20	Kabata-Pendias and Pendias, 1992
Selenium	6	Kabata-Pendias and Pendias, 1992
Silver	2	Kabata-Pendias and Pendias, 1992
Zinc	80	Kabata-Pendias and Pendias, 1992

Kabata-Pendias, A. and Pendias. 1992. Trace Elements in Soils and Plants. 2nd Edition. Table 33 (maximum of excessive to toxic range); assumed plants are 80% moisture to convert reported dry weights to wet weights.

Table C.A-9

Critical Tissue Residue Levels for Mammals/Birds

Analytes	Critical Whole Body Residue Level mg/kg (wet wt.)	Source
Aluminum	nc	--
Antimony	2.5	NAS 1980
Arsenic	2.5	NAS 1980
Cadmium	5	Braune et al. 1999
Chromium	0.2	NAS 1980
Copper	7.1	Eisler 1997
Cyanide	nc	--
Lead	8	Braune et al. 1999
Manganese	nc	--
Mercury	1	Braune et al. 1999
Nickel	2.5	NAS 1980
Selenium	20	Braune et al. 1999
Silver	nc	--
Zinc	125	NAS 1980

Notes:
Some wet weight levels converted from reported dry weight levels by assuming a generic animal moisture content of 75%. Critical whole body residue levels (wet-wt) conservatively estimated from data reported by NAS (1980) for antimony (10 mg/kg-dw); arsenic (10mg/kg-dw); nickel (10 mg/kg-dw); and zinc (500 mg/kg-dw). Critical body residue for copper conservatively estimated from 28.5 mg/kg-dw level reported by Eisler (1997).

References:

Braune, B.M., B. Malone, et al. 1999. Chemical residues in waterfowl and gamebirds harvested in Canada, 1987-95. Canadian Wildlife Service Technical Report 326.

Eisler, R. 1997. Copper Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review, USGS Biological Science Report. USBS/BRD/BSR-1997-0002.

National Academy of Sciences (NAS). 1980. Mineral Tolerance of Domestic Animals. National Research Council. 577 pg.

APPENDICES C.B AND C.C

NOAEL-HQ CALCULATIONS AND LOAEL-HQ CALCULATIONS

Table C.D-1

Summary of Surface Soil HQs for the BT/NO Disposal Area: NOAEL

Analyte	RME Concentration (mg/kg)	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Large Mammal Herbivore (White-tailed Deer)
Antimony	133	**27**	nc	nc	**904**	**4.8**	**619**	**16**	**2.9**
Arsenic	1620	**162**	**16**	**27**	**266**	**18**	**4786**	**369**	**17**
Cadmium	2.7	0.90	0.14	0.14	**2.0**	0.11	**12**	0.08	0.05
Cyanide	1.03	nc	nc	nc	0.04	0.03	0.03	0.05	0.01
Mercury	2.62	**8.7**	0.09	**26**	**1.7**	**5.5**	**64**	**439**	**1.6**
Nickel	35.2	**1.2**	0.39	0.18	0.08	0.01	0.66	0.23	<0.01
Silver	0.81	0.41	0.02	nc	0.01	<0.01	0.02	<0.01	<0.01
HI =		**200**	**17**	**54**	**1174**	**29**	**5482**	**825**	**22**

RME concentration = reasonable maximum exposure concentration which is the lower of the 95 percent upper confidence limit of the mean or the maximum (Appendix B Tables).
HI (hazard index) = sum of the hazard quotients (HQs)
mg/kg = milligrams per kilogram
nc = no benchmark criterion available.
17 = bolded and shaded are HQ values greater than 1.

Table C.D-2

Summary of Surface Soil HQs for the BT/NO Disposal Area: LOAEL

Analyte	RME Concentration (mg/kg)	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Large Mammal Herbivore (White-tailed Deer)
Antimony	133	**27**	nc	nc	**292**	**1.6**	**200**	**5.1**	0.95
Arsenic	1620	**162**	**16**	**27**	**105**	**5.5**	**1473**	**114**	**5.4**
Cadmium	2.7	0.90	0.14	0.14	0.15	0.01	**1.2**	0.01	0.01
Cyanide	1.03	nc	nc	nc	0.01	0.01	0.01	0.02	<0.01
Mercury	2.62	**8.7**	0.09	**26**	0.85	**3.4**	**40**	**285**	1.0
Nickel	35.2	**1.2**	0.39	0.18	0.06	<0.01	0.33	0.11	<0.01
Silver	0.81	0.41	0.02	nc	<0.01	<0.01	0.01	<0.01	<0.01
HI =		**200**	**17**	**54**	**398**	**11**	**1714**	**404**	**7.3**

RME concentration = reasonable maximum exposure concentration which is the lower of the 95 percent upper confidence limit of the mean or the maximum (Appendix B Tables).

HI (hazard index) = sum of the hazard quotients (HQs)

mg/kg = milligrams per kilogram

nc = no benchmark criterion available.

17 = bolded and shaded are HQ values greater than to 1.

Table C.D-3

Summary of Surface Soil HQs for the Meadow Creek Mine Hillside: NOAEL

Analyte	RME Concentration (mg/kg)	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Large Mammal Herbivore (White-tailed Deer)
Antimony	15.6	**3.1**	nc	nc	**106**	0.57	**73**	**1.8**	0.34
Arsenic	1460	**146**	**15**	**24**	**240**	**16**	**4313**	**333**	**16**
Manganese	1583	**3.2**	**16**	nc	0.27	0.34	**13**	0.43	0.19
Mercury	0.416	**1.4**	0.01	**4.2**	0.27	0.87	**10**	**70**	0.26
HI =		**154**	**30**	**28**	**347**	**18**	**4409**	**405**	**17**

RME concentration = reasonable maximum exposure concentration which is the lower of the 95 percent upper confidence limit of the mean or the maximum (Appendix B Tables).

HI (hazard index) = sum of the hazard quotients (HQs)

mg/kg = milligrams per kilogram

nc = no benchmark criterion available.

17 = bolded and shaded HQ values are greater than 1.

Table C.D-4

Summary of Surface Soil HQs for the Meadow Creek Mine Hillside: LOAEL

Analyte	RME Concentration (mg/kg)	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Large Mammal Herbivore (White-tailed Deer)
Antimony	15.6	**3.1**	nc	nc	**34**	0.18	**23**	0.59	0.11
Arsenic	1460	**146**	**15**	**24**	**95**	**4.9**	**1327**	**102**	**4.8**
Manganese	1583	**3.2**	**16**	nc	0.09	0.10	**4.1**	0.13	0.06
Mercury	0.416	**1.4**	0.01	**4.2**	0.13	0.55	**6.4**	**45**	0.16
HI =		**154**	**30**	**28**	**129**	**5.8**	**1361**	**149**	**5.2**

RME concentration = reasonable maximum exposure concentration which is the lower of the 95 percent upper confidence limit of the mean or the maximum (Appendix B Tables).
HI (hazard index) = sum of the hazard quotients (HQs)
mg/kg = milligrams per kilogram
nc = no benchmark criterion available.
17 = bolded and shaded HQ values are greater than 1.

Table C.D-5

Summary of Surface Soil, Surface Water, and Sediment HQs for the Lower Meadow Creek Valley: NOAEL

Analyte	RME Concentration of Specified Media	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Avian Piscivore (Belted Kingfisher)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Medium Mammal Piscivore (Mink)	Large Mammal Herbivore (White-tailed Deer)
SURFACE SOILS	(mg/kg)										
Antimony	1324	**265**	nc	nc	**8998**	NA	**48**	**6166**	**156**	NA	**29**
Arsenic	955	**96**	**9.6**	**16**	**157**	NA	**11**	**2821**	**218**	NA	**10**
Lead	34.7	0.69	0.04	0.07	**5.6**	NA	0.02	**3.4**	0.09	NA	0.02
Mercury	0.716	**2.4**	0.02	**7.2**	0.46	NA	**1.5**	**18**	**120**	NA	0.44
Selenium	0.48	0.48	<0.01	<0.01	0.57	NA	0.01	**4.7**	**1.5**	NA	0.01
Silver	2.52	**1.3**	0.05	nc	0.02	NA	<0.01	0.07	<0.01	NA	<0.01
HI =		**365**	**10**	**23**	**9162**	NA	**60**	**9013**	**495**	NA	**40**
SURFACE WATER	(mg/L)										
Aluminum	0.0831	NA	NA	NA	<0.01	<0.01	0.01	0.01	0.01	0.01	<0.01
Antimony	0.0112	NA	NA	NA	0.02	0.02	0.01	0.03	0.01	0.01	0.01
Arsenic	0.0323	NA	NA	NA	<0.01	<0.01	0.03	0.09	0.03	0.04	0.03
Copper	0.002	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cyanide	0.0023	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead	0.00143	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Manganese	0.0314	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury	0.000054	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.00252	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
HI =		NA	NA	NA	0.02	0.02	0.05	0.13	0.05	0.06	0.04
SEDIMENT	(mg/kg)										
Antimony	19.2	**3.8**	nc	nc	**130**	NA	0.70	**89**	**2.3**	NA	0.42
Arsenic	90.3	**9.0**	0.90	**1.5**	**15**	NA	1.0	**267**	**21**	NA	0.97
Cadmium	1.07	0.36	0.05	0.05	0.78	NA	0.04	**4.7**	0.03	NA	0.02
Mercury	0.129	0.43	<0.01	**1.3**	0.08	NA	0.27	**3.2**	**22**	NA	0.08
Selenium	1.69	**1.7**	0.02	0.02	**2.0**	NA	0.03	**17**	**5.4**	NA	0.03
HI =		**15**	1.0	**2.9**	**148**	NA	**2.1**	**381**	**50**	NA	**1.5**

RME concentration = reasonable maximum exposure concentration which is the lower of the 95 percent upper confidence limit of the mean or the maximum (Appendix B Tables).
HI (hazard index) = sum of the hazard quotients (HQs)
mg/kg = milligrams per kilogram
mg/L = milligrams per liter
nc = no benchmark criterion available.
NA = not applicable
17 = bolded and shaded HQ values are greater than 1.

Table C.D-6

Summary of Surface Soil, Surface Water, and Sediment HQs for the Lower Meadow Creek Valley: LOAEL

Analyte	RME Concentration of Specified Media	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Avian Piscivore (Belted Kingfisher)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Medium Mammal Piscivore (Mink)	Large Mammal Herbivore (White-tailed Deer)
SURFACE SOILS	(mg/kg)										
Antimony	1324	**265**	nc	nc	**2907**	NA	**16**	**1992**	**50**	NA	**9.4**
Arsenic	955	**96**	**9.6**	**16**	**62**	NA	**3.2**	**868**	**67**	NA	**3.2**
Lead	34.7	0.69	0.04	0.07	0.56	NA	<0.01	0.34	0.01	NA	<0.01
Mercury	0.716	**2.4**	0.02	**7.2**	0.23	NA	0.94	**11**	**78**	NA	0.28
Selenium	0.48	0.48	<0.01	<0.01	0.29	NA	<0.01	**2.9**	0.92	NA	0.01
Silver	2.52	**1.3**	0.05	nc	0.01	NA	<0.01	0.02	<0.01	NA	<0.01
HI =		**365**	**10**	**23**	**2970**	NA	**20**	**2874**	**196**	NA	**13**
SURFACE WATER	(mg/L)										
Aluminum	0.0831	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Antimony	0.0112	NA	NA	NA	0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01
Arsenic	0.0323	NA	NA	NA	<0.01	<0.01	0.01	0.03	0.01	0.01	0.01
Copper	0.002	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cyanide	0.0023	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead	0.00143	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Manganese	0.0314	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury	0.000054	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.00252	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
HI =		NA	NA	NA	0.01	0.01	0.01	0.04	0.01	0.01	0.01
SEDIMENT	(mg/kg)										
Antimony	19.2	**3.8**	nc	nc	**42**	NA	0.23	**29**	0.73	NA	0.14
Arsenic	90.3	**9.0**	0.90	**1.5**	**5.9**	NA	0.31	**82**	**6.3**	NA	0.30
Cadmium	1.07	0.36	0.05	0.05	0.06	NA	<0.01	0.47	<0.01	NA	<0.01
Mercury	0.129	0.43	<0.01	**1.3**	0.04	NA	0.17	**2.0**	**14**	NA	0.05
Selenium	1.69	**1.7**	0.02	0.02	1.00	NA	0.02	**10**	**3.3**	NA	0.02
HI =		**15**	1.0	**2.9**	**49**	NA	0.74	**123**	**24**	NA	0.51

RME concentration = reasonable maximum exposure concentration which is the lower of the 95 percent upper confidence limit of the mean or the maximum (Appendix B Tables).
HI (hazard index) = sum of the hazard quotients (HQs)
mg/kg = milligrams per kilogram
mg/L = milligrams per liter
mg/l = milligrams per liter
mg/l = milligrams per liter
17 = bolded and shaded HQ values are greater than 1.

Tab D-7

Summary of Surface Soil and Surface Water HQs for the Upgradient Wetland (Excluding Hot Spot UW-1): NOAEL

Analyte	Maximum Concentration in Specified Media	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Avian Piscivore (Belted Kingfisher)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Medium Mammal Piscivore (Mink)	Large Mammal Herbivore (White-tailed Deer)
SURFACE SOILS	(mg/kg)										
Arsenic	24.4	**2.4**	0.24	0.41	**4.0**	NA	0.27	**72**	**5.6**	NA	0.26
Mercury	0.11	0.37	<0.01	**1.1**	0.07	NA	0.23	**2.7**	**18**	NA	0.07
Nickel	21	0.70	0.23	0.11	0.05	NA	<0.01	0.39	0.14	NA	<0.01
Silver	0.1	0.05	<0.01	nc	<0.01	NA	<0.01	<0.01	<0.01	NA	<0.01
HI =		**3.6**	0.48	**1.6**	**4.1**	NA	0.50	**75**	**24**	NA	0.33
SURFACE WATER	(mg/L)										
Aluminum	0.153	NA	NA	NA	<0.01	<0.01	0.01	0.03	0.01	0.01	0.01
Copper	0.0017	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cyanide	0.0021	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead	0.001	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Manganese	0.0072	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
HI =		NA	NA	NA	<0.01	<0.01	0.01	0.03	0.01	0.01	0.01

HI (hazard index) = sum of the hazard quotients (HQs)
mg/kg = milligrams per kilogram
mg/L = milligrams per liter
nc = no benchmark criterion available.
NA = not applicable
17 = bolded and shaded HQ values are greater than 1.

Tab D-8

Summary of Surface Soil and Surface Water HQs for the Upgradient Wetland (Excluding Hot Spot UW-1): LOAEL

Analyte	Maximum Concentration in Specified Media	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Avian Piscivore (Belted Kingfisher)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Medium Mammal Piscivore (Mink)	Large Mammal Herbivore (White-tailed Deer)
SURFACE SOILS	(mg/kg)										
Arsenic	24.4	**2.4**	0.24	0.41	**1.6**	NA	0.08	**22**	**1.7**	NA	0.08
Mercury	0.11	0.37	<0.01	**1.1**	0.04	NA	0.14	**1.7**	**12**	NA	0.04
Nickel	21	0.70	0.23	0.11	0.03	NA	<0.01	0.20	0.07	NA	<0.01
Silver	0.1	0.05	<0.01	nc	<0.01	NA	<0.01	<0.01	<0.01	NA	<0.01
HI =		**3.6**	0.48	**1.6**	**1.7**	NA	0.22	**24**	**14**	NA	0.12
SURFACE WATER	(mg/L)										
Aluminum	0.153	NA	NA	NA	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
Copper	0.0017	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cyanide	0.0021	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead	0.001	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Manganese	0.0072	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
HI =		NA	NA	NA	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01

HI (hazard index) = sum of the hazard quotients (HQs)
mg/kg = milligrams per kilogram
mg/L = milligrams per liter
nc = no benchmark criterion available.
NA = not applicable
17 = bolded and shaded HQ values are greater than 1.

Tal :.D-9

Summary of Surface Soil and Surface Water HQs for the Keyway Wetland: NOAEL

Analyte	Maximum Concentration in Specified Media	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Avian Piscivore (Belted Kingfisher)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Medium Mammal Piscivore (Mink)	Large Mammal Herbivore (White-tailed Deer)
SURFACE SOILS	(mg/kg)										
Antimony	333	**67**	nc	nc	**2263**	NA	**12**	**1551**	**39**	NA	**7.3**
Arsenic	634	**63**	**6.3**	**11**	**104**	NA	**7.1**	**1873**	**145**	NA	**6.8**
Cyanide	0.27	nc	nc	nc	0.01	NA	0.01	0.01	0.01	NA	<0.01
Lead	47.8	0.96	0.05	0.10	**7.7**	NA	0.03	**4.7**	0.12	NA	0.03
Mercury	0.89	**3.0**	0.03	**8.9**	0.57	NA	**1.9**	**22**	**149**	NA	0.55
Selenium	0.52	0.52	<0.01	<0.01	0.62	NA	0.01	**5.1**	**1.7**	NA	0.01
Silver	2.8	**1.4**	0.06	nc	0.02	NA	<0.01	0.07	<0.01	NA	<0.01
HI =		**136**	**6.5**	**20**	**2376**	NA	**21**	**3455**	**335**	NA	**15**
SURFACE WATER	(mg/L)										
Aluminum	0.12	NA	NA	NA	<0.01	<0.01	0.01	0.02	0.01	0.01	<0.01
Antimony	0.127	NA	NA	NA	0.20	0.20	0.12	0.33	0.13	0.15	0.12
Arsenic	0.463	NA	NA	NA	0.03	0.03	0.49	**1.3**	0.50	0.57	0.02
Cyanide	0.0056	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Manganese	0.785	NA	NA	NA	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
Mercury	0.000118	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.0044	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
HI =		NA	NA	NA	0.23	0.23	0.62	**1.6**	0.64	0.73	0.14

HI (hazard index) = sum of the hazard quotients (HQs)
mg/kg = milligrams per kilogram
mg/L = milligrams per liter
nc = no benchmark criterion available.
NA = not applicable
17 = bolded and shaded HQ values are greater than 1.

Tab .D-10

Summary of Surface Soil and Surface Water HQs for the Keyway Wetland: LOAEL

Analyte	Maximum Concentration in Specified Media	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Avian Piscivore (Belted Kingfisher)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Medium Mammal Piscivore (Mink)	Large Mammal Herbivore (White-tailed Deer)
SURFACE SOILS	(mg/kg)										
Antimony	333	**67**	nc	nc	**731**	NA	**3.9**	**501**	**13**	NA	**2.4**
Arsenic	634	**63**	**6.3**	**11**	**41**	NA	**2.1**	**576**	**44**	NA	**2.1**
Cyanide	0.27	nc	nc	nc	<0.01	NA	<0.01	<0.01	<0.01	NA	<0.01
Lead	47.8	0.96	0.05	0.10	0.77	NA	<0.01	0.47	0.01	NA	<0.01
Mercury	0.89	**3.0**	0.03	**8.9**	0.29	NA	**1.2**	**14**	**97**	NA	0.34
Selenium	0.52	0.52	<0.01	<0.01	0.31	NA	0.01	**3.1**	1.00	NA	0.01
Silver	2.8	**1.4**	0.06	nc	0.01	NA	<0.01	0.02	<0.01	NA	<0.01
HI =		**136**	**6.5**	**20**	**774**	NA	**7.3**	**1095**	**155**	NA	**4.8**
SURFACE WATER	(mg/L)										
Aluminum	0.12	NA	NA	NA	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
Antimony	0.127	NA	NA	NA	0.07	0.06	0.04	0.11	0.04	0.05	0.04
Arsenic	0.463	NA	NA	NA	0.01	0.01	0.15	0.39	0.15	0.18	0.01
Cyanide	0.0056	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Manganese	0.785	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury	0.000118	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.0044	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
HI =		NA	NA	NA	0.08	0.07	0.19	0.5	0.19	0.23	0.05

HI (hazard index) = sum of the hazard quotients (HQs)
mg/kg = milligrams per kilogram
mg/L = milligrams per liter
nc = no benchmark criterion available.
NA = not applicable
17 = bolded and shaded HQ values are greater than 1.

Table C.D-11

Summary of Surface Soil HQs for the Meadow Creek Forested Wetland: NOAEL

Analyte	Maximum Concentration (mg/kg)	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Large Mammal Herbivore (White-tailed Deer)
Aluminum	34200	**684**	**57**	nc	**1170**	**10**	**3608**	**370**	**17**
Antimony	1550	**310**	nc	nc	**10534**	**56**	**7219**	**182**	**34**
Arsenic	1230	**123**	**12**	**21**	**202**	**14**	**3634**	**281**	**13**
Cadmium	0.13	0.04	<0.01	<0.01	0.09	0.01	0.57	<0.01	<0.01
Chromium	14.3	**14**	**1.4**	**36**	**2.7**	<0.01	<0.01	<0.01	<0.01
Copper	68.8	0.69	0.69	**1.4**	0.83	0.28	**4.8**	**2.0**	0.09
Lead	160	**3.2**	0.18	0.32	**26**	0.09	**16**	0.40	0.09
Mercury	3.1	**10**	0.10	**31**	**2.0**	**6.5**	**76**	**520**	**1.9**
Nickel	8	0.27	0.09	0.04	0.02	<0.01	0.15	0.05	<0.01
Selenium	5.3	**5.3**	0.05	0.08	**6.3**	0.09	**52**	**17**	0.10
Silver	19.6	**9.8**	0.39	nc	0.17	0.01	0.51	0.03	<0.01
Zinc	70.9	**1.4**	0.71	0.35	**2.3**	0.05	0.87	**1.9**	0.02
HI =		**1162**	**73**	**89**	**11947**	**88**	**14611**	**1373**	**66**

HI (hazard index) = sum of the hazard quotients (HQs)
mg/kg = milligrams per kilogram
nc = no benchmark criterion available.
17 = bolded and shaded HQ values are greater than 1.

Table C.D-12

Summary of Surface Soil HQs for the Meadow Creek Forested Wetland: LOAEL

Analyte	Maximum Concentration (mg/kg)	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Large Mammal Herbivore (White-tailed Deer)
Aluminum	34200	**684**	**57**	nc	**351**	**3.5**	**1234**	**127**	**5.8**
Antimony	1550	**310**	nc	nc	**3403**	**18**	**2332**	**59**	**11**
Arsenic	1230	**123**	**12**	**21**	**80**	**4.2**	**1118**	**86**	**4.1**
Cadmium	0.13	0.04	<0.01	<0.01	0.01	<0.01	0.06	<0.01	<0.01
Chromium	14.3	**14**	**1.4**	**36**	0.53	<0.01	<0.01	<0.01	<0.01
Copper	68.8	0.69	0.69	**1.4**	0.63	0.22	**3.9**	**1.5**	0.07
Lead	160	**3.2**	0.18	0.32	**2.6**	0.01	**1.6**	0.04	0.01
Mercury	3.1	**10**	0.10	**31**	1.0	**4.1**	**47**	**338**	**1.2**
Nickel	8	0.27	0.09	0.04	0.01	<0.01	0.07	0.03	<0.01
Selenium	5.3	**5.3**	0.05	0.08	**3.2**	0.05	**31**	**10**	0.06
Silver	19.6	**9.8**	0.39	nc	0.06	<0.01	0.17	0.01	<0.01
Zinc	70.9	**1.4**	0.71	0.35	0.26	0.02	0.43	0.93	0.01
HI =		**1162**	**73**	**89**	**3842**	**30**	**4770**	**622**	**22**

HI (hazard index) = sum of the hazard quotients (HQs)
mg/kg = milligrams per kilogram
nc = no benchmark criterion available.
17 = bolded and shaded HQ values are greater than 1.

Table C.D-13

Summary of Surface Soil HQs for the SE Bradley Waste Rock Dumps: NOAEL

Analyte	RME Concentration (mg/kg)	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Large Mammal Herbivore (White-tailed Deer)
Arsenic	4970	**497**	**50**	**83**	**817**	**56**	**14683**	**1133**	**54**
Mercury	2.51	**8.4**	0.08	**25**	**1.6**	**5.3**	**62**	**421**	**1.6**
Silver	0.54	0.27	0.01	nc	<0.01	<0.01	0.01	<0.01	<0.01
HI =		**506**	**50**	**108**	**819**	**61**	**14744**	**1554**	**55**

RME concentration = reasonable maximum exposure concentration which is the lower of the 95 percent upper confidence limit of the mean or the maximum (Appendix B Tables).
HI (hazard index) = sum of the hazard quotients (HQs)
mg/kg = milligrams per kilogram
nc = no benchmark criterion available.
17 = bolded and shaded HQ values are greater than 1.

Table ..D-14

Summary of Surface Soil HQs for the SE Bradley Waste Rock Dumps: LOAEL

Analyte	RME Concentration (mg/kg)	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Large Mammal Herbivore (White-tailed Deer)
Arsenic	4970	**497**	**50**	**83**	**323**	**17**	**4518**	**349**	**16**
Mercury	2.51	**8.4**	0.08	**25**	0.81	**3.3**	**38**	**273**	0.97
Silver	0.54	0.27	0.01	nc	<0.01	<0.01	<0.01	<0.01	<0.01
HI =		**506**	**50**	**108**	**324**	**20**	**4556**	**622**	**17**

RME concentration = reasonable maximum exposure concentration which is the lower of the 95 percent upper confidence limit of the mean or the maximum (Appendix B Tables).
HI (hazard index) = sum of the hazard quotients (HQs)
mg/kg = milligrams per kilogram
nc = no benchmark criterion available.
17 = bolded and shaded HQ values are greater than 1.

Table C.D-15

Summary of Surface Soil HQs for the NW Bradley Waste Rock Dumps: NOAEL

Analyte	RME Concentration (mg/kg)	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Large Mammal Herbivore (White-tailed Deer)
Antimony	368	**74**	nc	nc	**2501**	**13**	**1714**	**43**	**8.1**
Arsenic	2717	**272**	**27**	**45**	**447**	**30**	**8027**	**620**	**29**
Mercury	1.39	**4.6**	0.05	**14**	0.90	**2.9**	**34**	**233**	0.86
Selenium	0.316	0.32	<0.01	<0.01	0.38	0.01	**3.1**	1.00	0.01
Silver	2.52	**1.3**	0.05	nc	0.02	<0.01	0.07	<0.01	<0.01
HI =		**352**	**27**	**59**	**2949**	**47**	**9778**	**897**	**38**

RME concentration = reasonable maximum exposure concentration which is the lower of the 95 percent upper confidence limit of the mean or the maximum (Appendix B Tables).
HI (hazard index) = sum of the hazard quotients (HQs)
mg/kg = milligrams per kilogram
nc = no benchmark criterion available.
17 = bolded and shaded HQ values are greater than 1.

Table C.D-16

Summary of the Surface Soil HQs for the NW Bradley Waste Rock Dumps: LOAEL

Analyte	RME Concentration (mg/kg)	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Large Mammal Herbivore (White-tailed Deer)
Antimony	368	**74**	nc	nc	**808**	**4.4**	**554**	**14**	**2.6**
Arsenic	2717	**272**	**27**	**45**	**177**	**9.2**	**2470**	**191**	**9.0**
Mercury	1.39	**4.6**	0.05	**14**	0.45	**1.8**	**21**	**151**	0.54
Selenium	0.316	0.32	<0.01	<0.01	0.19	<0.01	**1.9**	0.61	<0.01
Silver	2.52	**1.3**	0.05	nc	0.01	<0.01	0.02	<0.01	<0.01
HI =		**352**	**27**	**59**	**985**	**15**	**3047**	**357**	**12**

RME concentration = reasonable maximum exposure concentration which is the lower of the 95 percent upper confidence limit of the mean or the maximum (Appendix B Tables).
HI (hazard index) = sum of the hazard quotients (HQs)
mg/kg = milligrams per kilogram
nc = no benchmark criterion available.
17 = bolded and shaded values are HQ values are greater than 1.

Table C.D-17

Summary of Surface Soil HQs for the NE Bradley Waste Rock Dumps: NOAEL

Analyte	RME Concentration (mg/kg)	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Large Mammal Herbivore (White-tailed Deer)
Arsenic	5630	**563**	**56**	**94**	**926**	**63**	**16632**	**1284**	**61**
Mercury	1.52	**5.1**	0.05	**15**	0.98	**3.2**	**37**	**255**	0.94
Selenium	0.248	0.25	<0.01	<0.01	0.29	<0.01	**2.4**	0.79	<0.01
Silver	1.95	0.98	0.04	nc	0.02	<0.01	0.05	<0.01	<0.01
HI =		**569**	**56**	**109**	**927**	**66**	**16672**	**1539**	**62**

RME concentration = reasonable maximum exposure concentration which is the lower of the 95 percent upper confidence limit of the mean or the maximum (Appendix B Tables).

HI (hazard index) = sum of the hazard quotients (HQs)

mg/kg = milligrams per kilogram

nc = no benchmark criterion available.

17 = bolded and shaded HQ values are greater than 1.

Table C.D-18

Summary of Surface Soil HQs for the NE Bradley Waste Rock Dumps: LOAEL

Analyte	RME Concentration (mg/kg)	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Large Mammal Herbivore (White-tailed Deer)
Arsenic	5630	**563**	**56**	**94**	**366**	**19**	**5118**	**395**	**19**
Mercury	1.52	**5.1**	0.05	**15**	0.49	**2.0**	**23**	**166**	0.59
Selenium	0.248	0.25	<0.01	<0.01	0.15	<0.01	**1.5**	0.48	<0.01
Silver	1.95	0.98	0.04	nc	0.01	<0.01	0.02	<0.01	<0.01
HI =		**569**	**56**	**109**	**367**	**21**	**5142**	**561**	**19**

RME concentration = reasonable maximum exposure concentration which is the lower of the 95 percent upper confidence limit of the mean or the maximum (Appendix B Tables).
HI (hazard index) = sum of the hazard quotients (HQs)
mg/kg = milligrams per kilogram
nc = no benchmark criterion available.
17 = bolded and shaded HQ values are greater than 1.

Table C.D-19

Summary of Surface Soil and Surface Water HQs for the UW-1 Hot Spot: NOAEL

Analyte	Maximum Maximum Concentration in Specified Media	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Avian Piscivore (Belted Kingfisher)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Medium Mammal Piscivore (Mink)	Large Mammal Herbivore (White-tailed Deer)
SURFACE SOILS	(mg/kg)										
Antimony	689	**138**	nc	nc	**4683**	NA	**25**	**3209**	**81**	NA	**15**
Arsenic	983	**98**	**9.8**	**16**	**162**	NA	**11**	**2904**	**224**	NA	**11**
Copper	286	**2.9**	**2.9**	**5.7**	**3.5**	NA	**1.2**	**20**	**8.1**	NA	0.37
Lead	754	**15**	0.84	**1.5**	**122**	NA	0.44	**74**	**1.9**	NA	0.42
Mercury	2.3	**7.7**	0.08	**23**	**1.5**	NA	**4.8**	**56**	**386**	NA	**1.4**
Selenium	1.1	**1.1**	0.01	0.02	**1.3**	NA	0.02	**11**	**4**	NA	0.02
Silver	2.2	**1.1**	0.04	nc	0.02	NA	<0.01	0.06	<0.01	NA	<0.01
HI =		**264**	**14**	**47**	**4973**	NA	**42**	**6274**	**704**	NA	**28**
SURFACE WATER	(mg/L)										
Antimony	0.069	NA	NA	NA	0.11	0.11	0.07	0.18	0.07	0.08	0.05
Arsenic	0.316	NA	NA	NA	0.02	0.02	0.33	0.87	0.34	0.39	0.26
Copper	0.004	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead	0.0053	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Manganese	0.0491	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
HI =		NA	NA	NA	0.13	0.13	0.40	**1.1**	0.41	0.47	0.31

HI (hazard index) = sum of the hazard quotients (HQs)
mg/kg = milligrams per kilogram
mg/L = milligrams per liter
nc = no benchmark criterion available.
NA = not applicable
17 = bolded and shaded HQ values are greater than 1.

Table C.D-20

Summary of Surface Soil and Surface Water HQs for the UW-1 Hot Spot: LOAEL

Analyte	Maximum Concentration in Specified Media	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Avian Piscivore (Belted Kingfisher)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Medium Mammal Piscivore (Mink)	Large Mammal Herbivore (White-tailed Deer)
SURFACE SOILS	(mg/kg)										
Antimony	689	**138**	nc	nc	**1513**	NA	**8.2**	**1037**	**26**	NA	**4.9**
Arsenic	983	**98**	**9.8**	**16**	**64**	NA	**3.3**	**894**	**69**	NA	**3.3**
Copper	286	**2.9**	**2.9**	**5.7**	**2.6**	NA	0.92	**16**	**6.4**	NA	0.29
Lead	754	**15**	0.84	**1.5**	**12**	NA	0.04	**7.4**	0.19	NA	0.04
Mercury	2.3	**7.7**	0.08	**23**	0.74	NA	**3.0**	**35**	**250.6**	NA	0.89
Selenium	1.1	**1.1**	0.01	0.02	0.65	NA	0.0	**7**	**2.1**	NA	0.01
Silver	2.2	**1.1**	0.04	nc	0.01	NA	<0.01	0.02	<0.01	NA	<0.01
HI =		**264**	**14**	**47**	**1593**	NA	**15**	**1995**	**354**	NA	**9.4**
SURFACE WATER	(mg/L)										
Antimony	0.069	NA	NA	NA	0.04	0.03	0.02	0.06	0.02	0.03	0.02
Arsenic	0.316	NA	NA	NA	0.01	0.01	0.10	0.27	0.10	0.12	0.08
Copper	0.004	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead	0.0053	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Manganese	0.0491	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
HI =		NA	NA	NA	0.05	0.04	0.12	0.33	0.12	0.15	0.10

HI (hazard index) = sum of the hazard quotients (HQs)
mg/kg = milligrams per kilogram
mg/L = milligrams per liter
nc = no benchmark criterion available.
17 = bolded and shaded HQ values are greater than 1.

Table ..D-21

Summary of Surface Soil HQs for the Smelter Stack Hot Spot: NOAEL

Analyte	Maximum Concentration (mg/kg)	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Large Mammal Herbivore (White-tailed Deer)
Antimony	292	**58**	nc	nc	**1984**	**11**	**1360**	**34**	**6.4**
Arsenic	3750	**375**	**38**	**63**	**617**	**42**	**11078**	**855**	**40**
Lead	16.6	0.33	0.02	0.03	**2.7**	0.01	**1.6**	0.04	0.01
Mercury	471	**1570**	**16**	**4710**	**304**	**989**	**11541**	**78953**	**290**
Selenium	66.7	**67**	0.67	0.95	**79**	**1.1**	**652**	**212**	**1.3**
Silver	4.1	**2.1**	0.08	nc	0.04	<0.01	0.11	0.01	<0.01
HI =		**2072**	**54**	**4773**	**2987**	**1043**	**24634**	**80054**	**338**

HI (hazard index) = sum of the hazard quotients (HQs)
mg/kg = milligrams per kilogram
nc = no benchmark criterion available.
17 = bolded and shaded HQ values are greater than 1.

Table C.D-22

Summary of Surface Soil HQs for the Smelter Stack Hot Spot: LOAEL

Analyte	Maximum Concentration (mg/kg)	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Large Mammal Herbivore (White-tailed Deer)
Antimony	292	**58**	nc	nc	**641**	**3.5**	**439**	**11**	**2.1**
Arsenic	3750	**375**	**38**	**63**	**244**	**13**	**3409**	**263**	**12**
Lead	16.6	0.33	0.02	0.03	0.27	<0.01	0.16	<0.01	<0.01
Mercury	471	**1570**	**16**	**4710**	**152**	**618**	**7213**	**51319**	**181**
Selenium	66.7	**67**	0.67	0.95	**40**	0.68	**395**	**128**	0.78
Silver	4.1	**2.1**	0.08	nc	0.01	<0.01	0.04	<0.01	<0.01
HI =		**2072**	**54**	**4773**	**1077**	**635**	**11457**	**51722**	**197**

HI (hazard index) = sum of the hazard quotients (HQs)
mg/kg = milligrams per kilogram
nc = no benchmark criterion available.
17 = bolded and shaded HQ values are greater than 1.

Table C.D-23

Summary of Surface Soil HQs for the DMEA Dump Hot Spot: NOAEL

Analyte	Maximum Concentration (mg/kg)	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Large Mammal Herbivore (White-tailed Deer)
Arsenic	9460	**946**	**95**	**158**	**1556**	**106**	**27947**	**2157**	**102**
Mercury	9.9	**33**	0.33	**99**	**6.4**	**21**	**243**	**1660**	**6.1**
Selenium	0.35	0.35	<0.01	<0.01	0.42	0.01	**3.4**	**1.1**	0.01
Silver	3.4	**1.7**	0.07	nc	0.03	<0.01	0.09	0.01	<0.01
HI =		**981**	**95**	**257**	**1563**	**127**	**28193**	**3818**	**108**

HI (hazard index) = sum of the hazard quotients (HQs)

mg/kg = milligrams per kilogram

nc = no benchmark criterion available.

17 = bolded and shaded HQ values are greater than 1.

Tabl. .D-24

Summary of Surface Soil HQs for the DMEA Dump Hot Spot: LOAEL

Analyte	Maximum Concentration (mg/kg)	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Large Mammal Herbivore (White-tailed Deer)
Arsenic	9460	**946**	**95**	**158**	**615**	**32**	**8599**	**664**	**31**
Mercury	9.9	**33**	0.33	**99**	**3.2**	**13**	**152**	**1079**	**3.8**
Selenium	0.35	0.35	<0.01	<0.01	0.21	<0.01	**2.1**	0.67	<0.01
Silver	3.4	**1.7**	0.07	nc	0.01	<0.01	0.03	<0.01	<0.01
HI =		**981**	**95**	**257**	**618**	**45**	**8753**	**1743**	**35**

HI (hazard index) = sum of the hazard quotients (HQs)
mg/kg = milligrams per kilogram
nc = no benchmark criterion available.
17 = bolded and shaded HQ values are greater than 1.

Table C.D-25

Summary of Surface Soil HQs for the 1997 Antimony Outlier NW Bradley Waste Rock Dump Hot Spot: NOAEL

Analyte	Maximum Concentration (mg/kg)	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Large Mammal Herbivore (White-tailed Deer)
Antimony	16400	**3280**	nc	nc	**111457**	**596**	**76377**	**1927**	**361**
Arsenic	4790	**479**	**48**	**80**	**788**	**54**	**14151**	**1092**	**52**
Copper	26.5	0.27	0.27	0.53	0.32	0.11	**1.9**	0.75	0.03
Lead	34.7	0.69	0.04	0.07	**5.6**	0.02	**3.4**	0.09	0.02
Mercury	13.6	**45**	0.45	**136**	**8.8**	**29**	**333**	**2280**	**8.4**
Selenium	7.7	**7.7**	0.08	0.11	**9.2**	0.13	**75**	**24**	0.15
Silver	6.79	**3.4**	0.14	nc	0.06	<0.01	0.18	0.01	<0.01
Zinc	150	**3.0**	**1.5**	0.75	**4.8**	0.10	**1.8**	**3.9**	0.05
HI =		**3819**	**50**	**217**	**112273**	**679**	**90944**	**5328**	**421**

HI (hazard index) = sum of the hazard quotients (HQs)
mg/kg = milligrams per kilogram
nc = no benchmark criterion available.
17 = bolded and shaded HQ values are greater than 1.

Table C.D-26

Summary of Surface Soil HQs for the 1997 Antimony Outlier NW Bradley Waste Rock Dump Hot Spot: LOAEL

Analyte	Maximum Concentration (mg/kg)	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Large Mammal Herbivore (White-tailed Deer)
Antimony	16400	**3280**	nc	nc	**36009**	**194**	**24676**	**622**	**117**
Arsenic	4790	**479**	**48**	**80**	**311**	**16**	**4354**	**336**	**16**
Copper	26.5	0.27	0.27	0.53	0.24	0.09	**1.5**	0.59	0.03
Lead	34.7	0.69	0.04	0.07	0.56	<0.01	0.34	0.01	<0.01
Mercury	13.6	**45**	0.45	**136**	**4.4**	**18**	**208**	**1482**	**5.2**
Selenium	7.7	**7.7**	0.08	0.11	**4.6**	0.08	**46**	**15**	0.09
Silver	6.79	**3.4**	0.14	nc	0.02	<0.01	0.06	<0.01	<0.01
Zinc	150	**3.0**	**1.5**	0.75	0.54	0.05	0.92	**2.0**	0.02
HI =		**3819**	**50**	**217**	**36331**	**228**	**29287**	**2458**	**138**

HI (hazard index) = sum of the hazard quotients (HQs)
mg/kg = milligrams per kilogram
nc = no benchmark criterion available.
17 = bolded and shaded HQ values are greater than 1.

Tab .D-27

Summary of Surface Water and Sediment HQs for EFSFSR and Midnight Creek: NOAEL

Analyte	RME Concentration of Specified Media	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Avian Piscivore (Belted Kingfisher)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Medium Mammal Piscivore (Mink)	Large Mammal Herbivore (White-tailed Deer)
SURFACE WATER	(mg/L)										
SURFACE WATER (mg/l)					3	4	5	7	6	9	8
Aluminum	0.079	NA	NA	NA	<0.01	<0.01	0.01	0.01	0.01	0.01	<0.01
Antimony	0.0392	NA	NA	NA	0.06	0.06	0.04	0.10	0.04	0.05	0.03
Arsenic	0.0577	NA	NA	NA	<0.01	<0.01	0.06	0.16	0.06	0.07	0.05
Cyanide	0.0021	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead	0.0046	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Manganese	0.0154	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury	0.000131	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.0159	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
HI =		NA	NA	NA	0.06	0.06	0.11	0.27	0.11	0.13	0.08
SEDIMENT	(mg/kg)										
Antimony	18.9	**3.8**	nc	nc	**128**	NA	0.69	**88**	**2.2**	NA	0.42
Arsenic	56.4	**5.6**	0.56	0.94	**9.3**	NA	0.63	**167**	**13**	NA	0.61
Cadmium	1.03	0.34	0.05	0.05	0.75	NA	0.04	**4.5**	0.03	NA	0.02
Chromium	3	**3.0**	0.30	**7.5**	0.56	NA	<0.01	<0.01	<0.01	NA	<0.01
Copper	2.18	0.02	0.02	0.04	0.03	NA	0.01	0.15	0.06	NA	<0.01
Lead	3.45	0.07	<0.01	<0.01	0.56	NA	<0.01	0.34	0.01	NA	<0.01
Mercury	0.143	0.48	<0.01	**1.4**	0.09	NA	0.30	**3.5**	**24**	NA	0.09
Selenium	2.37	**2.4**	0.02	0.03	**2.8**	NA	0.04	**23**	**7.5**	NA	0.05
Zinc	13	0.26	0.13	0.07	0.41	NA	0.01	0.16	0.34	NA	<0.01
HI =		**16**	**1.1**	**10**	**143**	<0.01	**1.7**	**286**	**47**	<0.01	**1.2**

RME = Reasonable maximum exposure concentration which is the lower of the 95 percent upper confidence limit of the mean or the maximum (Appendix B Tables).
HI (hazard index) = sum of the hazard quotients (HQs)
mg/kg = milligrams per kilogram
mg/l = milligrams per liter
nc = no benchmark criterion available.
-- = not applicable
17 = bolded and shaded HQ values are greater than 1.

Tab .D-28

Summary of Surface Water and Sediment HQs for EFSFSR and Midnight Creek: LOAEL

Analyte	RME Concentration of Specified Media	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Avian Piscivore (Belted Kingfisher)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Medium Mammal Piscivore (Mink)	Large Mammal Herbivore (White-tailed Deer)
SURFACE WATE	(mg/L)										
Aluminum	0.079	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Antimony	0.0392	NA	NA	NA	0.02	0.02	0.01	0.03	0.01	0.01	0.01
Arsenic	0.0577	NA	NA	NA	<0.01	<0.01	0.02	0.05	0.02	0.02	0.01
Cyanide	0.0021	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead	0.0046	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Manganese	0.0154	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury	0.000131	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.0159	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
HI =		NA	NA	NA	0.02	0.02	0.03	0.08	0.03	0.03	0.02
SEDIMENT	(mg/kg)										
Antimony	18.9	**3.8**	nc	nc	**42**	NA	0.22	**28**	0.72	NA	0.13
Arsenic	56.4	**5.6**	0.56	0.94	**3.7**	NA	0.19	**51**	**4.0**	NA	0.19
Cadmium	1.03	0.34	0.05	0.05	0.06	NA	<0.01	0.45	<0.01	NA	<0.01
Chromium	3	**3.0**	0.30	**7.5**	0.11	NA	<0.01	<0.01	<0.01	NA	<0.01
Copper	2.18	0.02	0.02	0.04	0.02	NA	0.01	0.12	0.05	NA	<0.01
Lead	3.45	0.07	<0.01	<0.01	0.06	NA	<0.01	0.03	<0.01	NA	<0.01
Mercury	0.143	0.48	<0.01	**1.4**	0.05	NA	0.19	**2.2**	**16**	NA	0.06
Selenium	2.37	**2.4**	0.02	0.03	**1.4**	NA	0.02	**14**	**4.6**	NA	0.03
Zinc	13	0.26	0.13	0.07	0.05	NA	<0.01	0.08	0.17	NA	<0.01
HI =		**16**	**1.1**	**10**	**47**	<0.01	0.63	**97**	**25**	<0.01	0.41

RME = Reasonable maximum exposure concentration which is the lower of the 95 percent upper confidence limit of the mean or the maximum (Appendix B Table).
HI (hazard index) = sum of the hazard quotients (HQs)
mg/kg = milligrams per kilogram
mg/l = milligrams per liter
nc = no benchmark criterion available.
17 = bolded and shaded HQ values are greater than 1.

Table C.D-29

Summary of Surface Water and Sediment HQs for the Glory Hole and EFSFSR: NOAEL

Analyte	RME Concentration of Specified Media	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Avian Piscivore (Belted Kingfisher)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Medium Mammal Piscivore (Mink)	Large Mammal Herbivore (White-tailed Deer)
SURFACE WATER	(mg/L)										
Aluminum	0.047	NA	NA	NA	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
Antimony	0.0267	NA	NA	NA	0.04	0.04	0.03	0.07	0.03	0.03	0.02
Arsenic	0.059	NA	NA	NA	<0.01	<0.01	0.06	0.16	0.06	0.07	0.05
Lead	0.00032	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Manganese	0.0282	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury	0.00039	NA	NA	NA	<0.01	<0.01	0.01	0.01	<0.01	<0.01	<0.01
Nickel	0.0144	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	0.000129	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.00385	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
HI =		NA	NA	NA	0.04	0.04	0.10	0.25	0.09	0.10	0.07
SEDIMENT	(mg/kg)										
Aluminum	8850	**177**	**15**	nc	**303**	NA	**2.7**	**934**	**96**	NA	**4.4**
Antimony	128	**26**	nc	nc	**870**	NA	**4.7**	**596**	**15**	NA	**2.8**
Arsenic	1522	**152**	**15**	**25**	**250**	NA	**17**	**4496**	**347**	NA	**16**
Cadmium	40.4	**13**	**2.0**	**2.0**	**29**	NA	**1.6**	**177**	**1.3**	NA	0.81
Chromium	9.2	**9.2**	0.92	**23**	**1.7**	NA	<0.01	<0.01	<0.01	NA	<0.01
Copper	7.3	0.07	0.07	0.15	0.09	NA	0.03	0.51	0.21	NA	0.01
Lead	10.6	0.21	0.01	0.02	**1.7**	NA	0.01	1.0	0.03	NA	0.01
Manganese	562	**1.1**	**5.6**	nc	0.09	NA	0.12	**4.6**	0.15	NA	0.07
Mercury	1.83	**6.1**	0.06	**18**	**1.2**	NA	**3.8**	**45**	**307**	NA	**1.1**
Nickel	7.06	0.24	0.08	0.04	0.02	NA	<0.01	0.13	0.05	NA	<0.01
Selenium	3.45	**3.5**	0.03	0.05	**4.1**	NA	0.06	**34**	**11**	NA	0.07
Silver	1.56	0.78	0.03	nc	0.01	NA	<0.01	0.04	<0.01	NA	<0.01
Zinc	31.6	0.63	0.32	0.16	1.00	NA	0.02	0.39	0.83	NA	0.01
HI =		**390**	**39**	**69**	**1462**	NA	**30**	**6289**	**778**	NA	**26**

RME concentration = reasonable maximum exposure concentration which is the lower of the 95 percent upper confidence limit of the mean or the maximum (Appendix B Tables).

HI (hazard index) = sum of the hazard quotients (HQs)

mg/kg = milligrams per kilogram

mg/L= milligrams per liter

nc = no benchmark criterion available.

17 = bolded and shaded HQ values are greater than 1.

Table C.D-30

Summary of Surface Water and Sediment HQs for the Glory Hole and EFSFSR: LOAEL

Analyte	RME Concentration of Specified Media	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Avian Piscivore (Belted Kingfisher)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Medium Mammal Piscivore (Mink)	Large Mammal Herbivore (White-tailed Deer)
SURFACE WATER	(mg/L)										
Aluminum	0.047	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Antimony	0.0267	NA	NA	NA	0.01	0.01	0.01	0.02	0.01	0.01	0.01
Arsenic	0.059	NA	NA	NA	<0.01	<0.01	0.02	0.05	0.02	0.02	0.01
Lead	0.00032	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Manganese	0.0282	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury	0.00039	NA	NA	NA	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
Nickel	0.0144	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	0.000129	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.00385	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
HI =		NA	NA	NA	0.01	0.01	0.03	0.08	0.03	0.03	0.02
SEDIMENT	(mg/kg)										
Aluminum	8850	**177**	**15**	nc	**91**	NA	0.89	**319**	**33**	NA	**1.5**
Antimony	128	**26**	nc	nc	**281**	NA	**1.5**	**193**	**4.9**	NA	0.91
Arsenic	1522	**152**	**15**	**25**	**99**	NA	**5.2**	**1384**	**107**	NA	**5.1**
Cadmium	40.4	**13**	**2.0**	**2.0**	**2.2**	NA	0.16	**18**	0.12	NA	0.08
Chromium	9.2	**9.2**	0.92	**23**	0.34	NA	<0.01	<0.01	<0.01	NA	<0.01
Copper	7.3	0.07	0.07	0.15	0.07	NA	0.02	0.41	0.16	NA	0.01
Lead	10.6	0.21	0.01	0.02	0.17	NA	<0.01	0.10	<0.01	NA	<0.01
Manganese	562	**1.1**	**5.6**	nc	0.03	NA	0.04	**1.5**	0.05	NA	0.02
Mercury	1.83	**6.1**	0.06	**18**	0.59	NA	**2.4**	**28**	**199**	NA	0.70
Nickel	7.06	0.24	0.08	0.04	0.01	NA	<0.01	0.07	0.02	NA	<0.01
Selenium	3.45	**3.5**	0.03	0.05	**2.1**	NA	0.03	**20**	**6.7**	NA	0.04
Silver	1.56	0.78	0.03	nc	<0.01	NA	<0.01	0.01	<0.01	NA	<0.01
Zinc	31.6	0.63	0.32	0.16	0.11	NA	0.01	0.19	0.41	NA	<0.01
HI =		**390**	**39**	**69**	**476**	NA	**10**	**1964**	**351**	NA	**8**

RME concentration = reasonable maximum exposure concentration which is the lower of the 95 percent upper confidence limit of the mean or the maximum (Appendix B Tables).
HI (hazard index) = sum of the hazard quotients (HQs)
mg/kg = milligrams per kilogram
mg/L = milligrams per liter
nc = no benchmark criterion available.
17 = bolded and shaded HQ values are greater than 1.

Tabl[illegible]D-31

Summary of Surface Water and Sediment HQs for Sugar Creek: NOAEL

Analyte	Maximum Concentration of Specified Media	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Avian Piscivore (Belted Kingfisher)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Medium Mammal Piscivore (Mink)	Large Mammal Herbivore (White-tailed Deer)
SURFACE WATER	(mg/L)										
Aluminum	0.137	NA	NA	NA	<0.01	<0.01	0.01	0.02	0.01	0.01	<0.01
Antimony	0.0083	NA	NA	NA	0.01	0.01	0.01	0.02	0.01	0.01	0.01
Arsenic	0.012	NA	NA	NA	<0.01	<0.01	0.01	0.03	0.01	0.01	<0.01
Manganese	0.005	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury	0.000255	NA	NA	NA	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
Zinc	0.008	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
HI =		NA	NA	NA	0.01	0.01	0.03	0.08	0.03	0.03	0.01
SEDIMENT	(mg/kg)										
Antimony	0.59	0.12	nc	nc	**4.0**	NA	0.02	**2.8**	0.07	NA	0.01
Arsenic	37.9	**3.8**	0.38	0.63	**6.2**	NA	0.42	**112**	**8.6**	NA	0.41
Cadmium	1.13	0.38	0.06	0.06	0.82	NA	0.04	**5.0**	0.03	NA	0.02
Chromium	4	**4.0**	0.40	**10**	0.75	NA	<0.01	<0.01	<0.01	NA	<0.01
Copper	2.22	0.02	0.02	0.04	0.03	NA	0.01	0.16	0.06	NA	<0.01
Lead	4.52	0.09	<0.01	<0.01	0.73	NA	<0.01	0.44	0.01	NA	<0.01
Mercury	9.14	**30**	0.30	**91**	**5.9**	NA	**19**	**224**	**1532**	NA	**5.6**
Selenium	1.8	**1.8**	0.02	0.03	**2.1**	NA	0.03	**18**	**5.7**	NA	0.03
Zinc	19.6	0.39	0.20	0.10	0.62	NA	0.01	0.24	0.51	NA	0.01
HI =		**41**	**1.4**	**102**	**21**	NA	**20**	**362**	**1547**	NA	**6.1**

HI (hazard index) = sum of the hazard quotients (HQs)
mg/kg = milligrams per kilogram
mg/l = milligrams per liter
nc = no benchmark criterion available.
17 = bolded and shaded HQ values are greater than 1.

Table C.D-32

Summary of Surface Water and Sediment HQs for Sugar Creek: LOAEL

Analyte	Maximum Concentration of Specified Media	Plant	Soil Micro-organisms	Earthworm	Small Avian Invertivore (Snipe)	Small Avian Piscivore (Belted Kingfisher)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Medium Mammal Piscivore (Mink)	Large Mammal Herbivore (White-tailed Deer)
SURFACE WATER	(mg/L)										
Aluminum	0.137	NA	NA	NA	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
Antimony	0.0083	NA	NA	NA	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
Arsenic	0.012	NA	NA	NA	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
Manganese	0.005	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury	0.000255	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.008	NA	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
HI =		NA	NA	NA	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01
SEDIMENT	(mg/kg)										
Antimony	0.59	0.12	nc	nc	1.3	NA	0.01	0.89	0.02	NA	<0.01
Arsenic	37.9	3.8	0.38	0.63	2.5	NA	0.13	34	2.7	NA	0.13
Cadmium	1.13	0.38	0.06	0.06	0.06	NA	<0.01	0.50	<0.01	NA	<0.01
Chromium	4	4.0	0.40	10	0.15	NA	<0.01	<0.01	<0.01	NA	<0.01
Copper	2.22	0.02	0.02	0.04	0.02	NA	0.01	0.12	0.05	NA	<0.01
Lead	4.52	0.09	<0.01	<0.01	0.07	NA	<0.01	0.04	<0.01	NA	<0.01
Mercury	9.14	30	0.30	91	3.0	NA	12	140	996	NA	3.5
Selenium	1.8	1.8	0.02	0.03	1.1	NA	0.02	11	3.5	NA	0.02
Zinc	19.6	0.39	0.20	0.10	0.07	NA	0.01	0.12	0.26	NA	<0.01
HI =		41	1.4	102	8.2	NA	12	187	1002	NA	3.7

Table C.D-33

Summary of Surface Water HQs for the BTO Hot Spot: NOAEL

Analyte	Maximum Concentration (mg/L)	Small Avian Invertivore (Snipe)	Small Avian Piscivore (Belted Kingfisher)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Medium Mammal Piscivore (Mink)	Large Mammal Herbivore (White-tailed Deer)
Antimony	0.281	0.45	0.43	0.27	0.74	0.29	0.33	0.26
Arsenic	0.535	0.04	0.03	0.56	**1.5**	0.58	0.66	0.02
Lead	0.0064	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Manganese	0.181	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	0.000106	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.0075	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
HI =		0.49	0.46	0.83	**2.2**	0.87	0.99	0.28

HI (hazard index) = sum of the hazard quotients (HQs)
mg/L = milligrams per liter
17 = bolded and shaded HQ values are greater than 1.

Table C.D-34

Summary of Surface Water HQs for the BTO Hot Spot: LOAEL

Analyte	Maximum Concentration (mg/L)	Small Avian Invertivore (Snipe)	Small Avian Piscivore (Belted Kingfisher)	Small Mammal Herbivore (Meadow Vole)	Small Mammal Invertivore (Short-tailed Shrew)	Medium Mammal Carnivore (Red Fox)	Medium Mammal Piscivore (Mink)	Large Mammal Herbivore (White-tailed Deer)
Antimony	0.281	0.15	0.14	0.09	0.24	0.09	0.11	0.08
Arsenic	0.535	0.01	0.01	0.17	0.45	0.18	0.20	0.01
Lead	0.0064	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Manganese	0.181	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	0.000106	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	0.0075	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
HI =		0.16	0.15	0.26	0.69	0.27	0.31	0.09

HI (hazard index) = sum of the hazard quotients (HQs)
mg/L = milligrams per liter
17 = bolded and shaded HQ values are greater than 1.

REFERENCES FOR TOXICITY REFERENCE VALUES

Ambrose, A.M.; P.S. Larson; J.F. Borzelleca; and G.R. Hennigar, Jr. 1996. Long-term toxicologic assessment of nickel in rats and dogs. *J Food Sci. Tech.* 13: 181-187.

Aulerich, R.J.; R.K. Ringer, M.R. Bleavins, and A. Napolitano. 1982. Effects of supplemental dietary copper on growth, reproductive performance, and kit survival of standard dark mink and the acute toxicity of copper to mink. *J Animal Sci.* V. 55, No. 2. 337-343.

Bodek, I., W.J. Lyman, W.F. Reehl, and D.H. Rosenblatt. 1988. Environmental Inorganic Chemistry. Pergamon Press, Elmsford, NY (Chapters 4 and 7).

Cain, B.W. and E.A. Pafford. 1981. Effects of dietary nickel on survival and growth of mallard ducklings. *Arch. Environ. Contam. Toxicol. 10:* 737-745.

Carriere, D.; K. Fischer; D. Peakall; and P. Angehm. 1986. Effects of dietary aluminum in combination with reduced calcium and phosphorus on the ring dove *(Streptopellia risoria). Water, Air, and Soil Poll. 3* 0: 75 7-764.

CEPA. 1994. Chromium. Priority Substances List Assessment Report Health Canada, Canada Communications Group Publishing, Ottawa, Canada.

Domingo, J.L. 1994. Metal-induced developmental toxicity in mammals: A Review. J *Toxicol. and Environ. Health.* 43: 123-141.

Edens, F.; W.E. Benton; S.J. Bursian; and G.W. Morgan. 1976. Effects of dietary lead on reproductive performance in Japanese quail, *Coturnix coturnix japonica. Toxicol. Appl. Pharmacol.* 38: 307-314.

Friberg, L., *et al.* 1979. Handbook on the Toxicology of Metal. Elsevier/North Holland Biomedical Press.

Gasaway, W.C. and 1.0. Buss. 1972. Zinc toxicity in the mallard. *J. Wildl. Mgt.* 36: 1107-1117.

Hebert, C.D., M.R. Elwell, G.S. Travlos, C.J. Fitz, and J.R. Bucher. 1993. Subchronic toxicity of cupric sulfate administered in drinking water and feed to rats and mice. *Fundamental and Applied Technology.* 21: 461-475.

Heinz, G.H.; D.J. Hoffman; and L.G. Gold. 1989. Impaired reproduction of mallards fed an organic form of selenium. *J Wildl. Mgt.* 53: 418-428.

Hill, E.F. and C.S. Schaffner. 1976. Sexual maturation and productivity of Japanese quail fed graded concentrations of mercuric chloride. *Poult. Sci.* 55: 1449-1459.

Horwitt, M.K. and G.R. Cowgill. 1939. The effects of ingested lead on the organism: 11. Studies on the Dog. *J Pharmacology and Experimental Therapy.* 66: 289-301.

Hudson, R.H.; R.K. Tucker; and M.A. Haegele. 1984. Handbook of toxicity of pesticides to wildlife. U.S. Fish and Wildl. Serv. Resource. Publ. 153. 90 pp.

Jackson, N. and M.H. Stevenson. 1981. Identification of the component responsible for the effects of added dietary copper sulphate in the female domestic fowl. *J Sci. Food Agric.* V. 32. 1047-1056.

James, L.F.; V.A. Lazar, V.A.; W. Binns. 1966. Effects of sublethal doses of certain minerals on pregnant ewes and fetal development. Am. *J Vet. Res.* V. 17 No. 11. 132-135.

Johnson, D., Jr., A.L. Mehring, Jr., and H.W. Titus. 1960. Tolerance of chickens for barium. *Proc. Soc. Exp. Biol. Med.* 104: 436-438.

Kubena, I.F.; R.B. Harvey; T.D. Phillips; and O.J. Fletcher. 1986. Influence of ochratoxin A and vanadium on various parameters in growing chicks. *Poult. Sci.* 65:1671-1678.

Laskey, J.W. and F.W. Edens. 1985. Effects of chronic high-level manganese exposure on male behavior in the Japanese Quail *(Coturnix coturnix japonica)*. *Poult. Sci.* 64:579-584.

Lepore, P.D. and R.F. Miller. 1965. Embryonic viability as influenced by excess molybdenum in chicken breeder diets. *Proc. Soc. Exp. Biol. Med.* 118: 155-157.

Mills, C.F. and A.C. Dalgamo. 1972. Copper and zinc status of ewes and lamb receiving increased dietary concentrations of cadmium. *Nature.* V. 239. 171-173.

NAS (National Academy of Sciences). 1977 (as cited in Eisler 1988a). Arsenic. Washington, D.C. 332. pp.

NTP (National Toxicology Program). 1993. The Chronic Study of Manganese Sulfate Monohydrate in F344 Rats. *National Toxicology Program.* Research Triangle Park, NC.

Ondreicka, R.; E. Ginter; and J. Kortus. 1966. Chronic toxicity of aluminum in rats and mice and its effects on phosphorus metabolism. *Brit. J. Indust. Med.* 23: 305-313.

Ott, E.A.; W.H. Smith, R.B. Harrington, W.M. Beeson. 1966. Zinc toxicity in ruminants. II. Effects of high levels of dietary zinc on gains, feed consumption and feed efficiency of beef cattle. *J Animal Sci.* V. 25. 419-423.

Patemian, J.L.; J.L. Domingo; A. Ortega; and J.M. Llobet. 1989. The effects of uranium on reproduction, gestation, and postnatal survival in mice. *Ecotoxicol. Environ. Saf.* 17: 291-296.

Perry, H.M., E.F. Perry, M.M. Erlanger, and S.J. Kopp. 1983. Cardiovascular effects of chromic barium ingestion. In: Proc 17'h Annual Conference Trace Substances in Environ. *Health,* Vol. 17. Univ. of Missouri Press. Columbia, MO.

Pershagen, G. and M. Vahter. 1979. Arsenic-a toxicological and epidemiological appraisal. Naturvardsverket Rapp. SNV PM 1128, Liber Tryck, Stockholm. 265 pp.

Revis, N.; G. Holdsworth; G. Bingham; A. King; and J. Elmore. 1989. An assessment of health risk associated with mercury in soil and sediment from East Fork Poplar Creek, Oak Ridge, Tennessee. Oak Ridge Research Institute, Final Report, 58 pp.

Roll, R. and G. Matthiaschk. 1981 (as cited in Borges & Daugherty 1996). Investigations on embryotoxic effects of thallium chloride and thallium acetate in mice and rat. *Teratology.* 24:46A-47A.

Rosenfeld, I. and O.A. Beath. 1954. Effect of selenium on reproduction in rats. *Proc. Soc. Exp. Biol. Med.* 87: 295-297.

Schlicker, S. and D. Cox. 1968. Maternal dietary zinc, and development and zinc, iron, and copper content of the rat fetus. *J Nutr.* V. 95. 287-294.

Schroeder, H.A. and M. Mitchner. 1971. Toxic effects of trace elements on the reproduction of mice and rats. *Arch. Environ. Health.* 23: 102-106.

Stowe, H.D. and R.A. Goyer. 1971. The reproductive ability and progeny of Fl lead-toxic rats. *Fertility and Sterility.* 22: 110-115.

Valdivia, R.; C.B. Ammerman; C.J. Wilcox; and P.R. Henry. 1978. Effect of dietary aluminum on animal performance and tissue mineral levels in growing Steers. *J Animal Sci.* 47:13 5 1.

Van Vleet, J.F. 1976. Induction of lesions of selenium-vitamin E deficiency in pigs fed silver. *Amer. J Vet. Res.* 37: 1415-1420.

Walker, F. 1971. Experimental argyria: A model for basement membrane studies. *British J. Experimental Pathology.* 52: 589-593.

WHO. 1990. Beryllium. Environmental Health Criteria 106, Geneva, Switzerland.

Zmudzki, J.; G.R. Bratton; C. Womac; and L.D. Rowe. 1984. The influence of milk diet, grain diet and method of dosing on lead toxicity in young calves. *Toxicol. Appl. Pharmacol.* 76:490-497.

APPENDIX D

HUMAN HEALTH RISK CALCULATIONS

APPENDIX D

HUMAN HEALTH RISK CALCULATIONS

Lower Meadow Creek Valley Soil Dermal – RME (Recreational User)
Lower Meadow Creek Valley Inhalation (Particulate Matter) – RME (Recreational User)
Lower Meadow Creek Valley Sediment Ingestion – RME (Recreational User)
Lower Meadow Creek Valley Surface Water Ingestion – RME (Recreational User)
Lower Meadow Creek Valley Surface Water Dermal – RME (Recreational User)
Lower Meadow Creek Valley Fish Ingestion – RME (Recreational User)
Area 1 (Upgradient Wetland) Soil Ingestion – RME (Reclamation Worker)
Area 1 (Upgradient Wetland) Soil Dermal – RME (Reclamation Worker)
Area 1 (Upgradient Wetland) Inhalation (Particulate Matter) – RME (Reclamation Worker)
Area 1 (Upgradient Wetland) Surface Water Ingestion – RME (Reclamation Worker)
Area 1 (Upgradient Wetland) Surface Water Dermal – RME (Reclamation Worker)
Area 1 (Upgradient Wetland) Soil Ingestion – RME (Recreational User)
Area 1 (Upgradient Wetland) Soil Dermal – RME (Recreational User)
Area 1 (Upgradient Wetland) Inhalation (Particulate Matter) – RME (Recreational User)
Area 1 (Upgradient Wetland) Surface Water Ingestion – RME (Recreational User)
Area 1 (Upgradient Wetland) Surface Water Dermal – RME (Recreational User)
Area 1 (Keyway Wetland) Soil Ingestion – RME (Reclamation Worker)
Area 1 (Keyway Wetland) Soil Dermal – RME (Reclamation Worker)
Area 1 (Keyway Wetland) Inhalation (Particulate Matter) – RME (Reclamation Worker)
Area 1 (Keyway Wetland) Surface Water Ingestion – RME (Reclamation Worker)
Area 1 (Keyway Wetland) Surface Water Dermal – RME (Reclamation Worker)
Area 1 (Keyway Wetland) Soil Ingestion – RME (Recreational User)
Area 1 (Keyway Wetland) Soil Dermal – RME (Recreational User)
Area 1 (Keyway Wetland) Inhalation (Particulate Matter) – RME (Recreational User)
Area 1 (Keyway Wetland) Surface Water Ingestion – RME (Recreational User)
Area 1 (Keyway Wetland) Surface Water Dermal – RME (Recreational User)
Area 1 (Meadow Creek Forested Wetland) Soil Ingestion – RME (Reclamation Worker)
Area 1 (Meadow Creek Forested Wetland) Soil Dermal – RME (Reclamation Worker)
Area 1 (Meadow Creek Forested Wetland) Inhalation (Particulate Matter) – RME (Reclamation Worker)
Area 1 (Meadow Creek Forested Wetland) Soil Ingestion – RME (Recreational User)
Area 1 (Meadow Creek Forested Wetland) Soil Dermal – RME (Recreational User)
Area 1 (Meadow Creek Forested Wetland) Inhalation (Particulate Matter) – RME (Recreational User)
Southeast Dump and Midnight Creek Soil Ingestion – RME (Reclamation Worker)
Southeast Dump and Midnight Creek Soil Dermal – RME (Reclamation Worker)
Southeast Dump and Midnight Creek Inhalation (Particulate Matter) – RME (Reclamation Worker)
Southeast Dump and Midnight Creek Sediment Ingestion – RME (Reclamation Worker)
Southeast Dump and Midnight Creek Surface Water Ingestion – RME (Reclamation Worker)
Southeast Dump and Midnight Creek Surface Water Dermal – RME (Reclamation Worker)
Southeast Dump and Midnight Creek Soil Ingestion – RME (Recreational User)

Southeast Dump and Midnight Creek Soil Dermal – RME (Recreational User)

Southeast Dump and Midnight Creek Inhalation (Particulate Matter) – RME (Recreational User)

Southeast Dump and Midnight Creek Sediment Ingestion – RME (Recreational User)

Southeast Dump and Midnight Creek Surface Water Ingestion – RME (Recreational User)

Southeast Dump and Midnight Creek Surface Water Dermal – RME (Recreational User)

Southeast Dump and Midnight Creek Fish Ingestion – RME (Recreational User)

Glory Hole, Northwest Dump and EFSFSR Soil Ingestion – RME (Reclamation Worker)

Glory Hole, Northwest Dump and EFSFSR Soil Dermal – RME (Reclamation Worker)

Glory Hole, Northwest Dump and EFSFSR Inhalation (Particulate Matter) – RME (Reclamation Worker)

Glory Hole, Northwest Dump and EFSFSR Sediment Ingestion – RME (Reclamation Worker)

Glory Hole, Northwest Dump and EFSFSR Surface Water Ingestion – RME (Reclamation Worker)

Glory Hole, Northwest Dump and EFSFSR Surface Water Dermal – RME (Reclamation Worker)

Glory Hole, Northwest Dump and EFSFSR Soil Ingestion – RME (Recreational User)

Glory Hole, Northwest Dump and EFSFSR Soil Dermal – RME (Recreational User)

Glory Hole, Northwest Dump and EFSFSR Inhalation (Particulate Matter) – RME (Recreational User)

Glory Hole, Northwest Dump and EFSFSR Sediment Ingestion – RME (Recreational User)

Glory Hole, Northwest Dump and EFSFSR Surface Water Ingestion – RME (Recreational User)

Glory Hole, Northwest Dump and EFSFSR Surface Water Dermal – RME (Recreational User)

Glory Hole, Northwest Dump and EFSFSR Fish Ingestion – RME (Recreational User)

Northeast Dump and Sugar Creek Soil Ingestion – RME (Reclamation Worker)

Northeast Dump and Sugar Creek Soil Dermal – RME (Reclamation Worker)

Northeast Dump and Sugar Creek Inhalation (Particulate Matter) – RME (Reclamation Worker)

Northeast Dump and Sugar Creek Sediment Ingestion – RME (Reclamation Worker)

Northeast Dump and Sugar Creek Surface Water Ingestion – RME (Reclamation Worker)

Northeast Dump and Sugar Creek Surface Water Dermal – RME (Reclamation Worker)

Northeast Dump and Sugar Creek Soil Ingestion – RME (Recreational User)

Northeast Dump and Sugar Creek Soil Dermal – RME (Recreational User)

Northeast Dump and Sugar Creek Inhalation (Particulate Matter) – RME (Recreational User)

Northeast Dump and Sugar Creek Sediment Ingestion – RME (Recreational User)

Northeast Dump and Sugar Creek Surface Water Ingestion – RME (Recreational User)

Northeast Dump and Sugar Creek Surface Water Dermal – RME (Recreational User)

Location UW-1 (Upgradient Wetland) Soil Ingestion – RME (Reclamation Worker)

Location UW-1 (Upgradient Wetland) Soil Dermal – RME (Reclamation Worker)

Location UW-1 (Upgradient Wetland) Inhalation (Particulate Matter) – RME (Reclamation Worker)

Location UW-1 (Upgradient Wetland) Surface Water Ingestion – RME (Reclamation Worker)

Location UW-1 (Upgradient Wetland) Surface Water Dermal – RME (Reclamation Worker)

Location UW-1 (Upgradient Wetland) Soil Ingestion – RME (Recreational User)

Location UW-1 (Upgradient Wetland) Soil Dermal – RME (Recreational User)

Location UW-1 (Upgradient Wetland) Inhalation (Particulate Matter) – RME (Recreational User)

Location UW-1 (Upgradient Wetland) Surface Water Ingestion – RME (Recreational User)
Location UW-1 (Upgradient Wetland) Surface Water Dermal – RME (Recreational User)
Smelter Soil Ingestion – RME (Reclamation Worker)
Smelter Soil Dermal – RME (Reclamation Worker)
Smelter Inhalation (Particulate Matter) – RME (Reclamation Worker)
Smelter Ash Ingestion – RME (Reclamation Worker)
Smelter Inhalation (Particulate Matter, Ash) – RME (Reclamation Worker)
Smelter Ash Dermal – RME (Reclamation Worker)
Smelter Wood Ingestion – RME (Reclamation Worker)
Smelter Inhalation (Particulate Matter, Wood) – RME (Reclamation Worker)
Smelter Wood Dermal – RME (Reclamation Worker)
Smelter Soil Ingestion – RME (Recreational User)
Smelter Soil Dermal – RME (Recreational User)
Smelter Inhalation (Particulate Matter, Soil) – RME (Recreational User)
Smelter Ash Ingestion – RME (Recreational User)
Smelter Ash Dermal – RME (Recreational User)
Smelter Inhalation (Particulate Matter, Ash) – RME (Recreational User)
Smelter Wood Ingestion – RME (Recreational User)
Smelter Wood Dermal – RME (Recreational User)
Smelter Inhalation (Particulate Matter, Wood) – RME (Recreational User)
DMEA Dump Soil Ingestion – RME (Reclamation Worker)
DMEA Dump Soil Dermal – RME (Reclamation Worker)
DMEA Dump Inhalation (Particulate Matter) – RME (Reclamation Worker)
DMEA Dump Soil Ingestion – RME (Recreational User)
DMEA Dump Soil Dermal – RME (Recreational User)
DMEA Dump Inhalation (Particulate Matter) – RME (Recreational User)
Location BD6 (Northwest Dump) Soil Ingestion – RME (Reclamation Worker)
Location BD6 (Northwest Dump) Soil Dermal – RME (Reclamation Worker)
Location BD6 (Northwest Dump) Inhalation (Particulate Matter) – RME (Reclamation Worker)
Location BD6 (Northwest Dump) Soil Ingestion – RME (Recreational User)
Location BD6 (Northwest Dump) Soil Dermal – RME (Recreational User)
Location BD6 (Northwest Dump) Inhalation (Particulate Matter) – RME (Recreational User)
Bailey Tunnel Outlet Surface Water Ingestion – RME (Reclamation Worker)
Bailey Tunnel Outlet Surface Water Dermal – RME (Reclamation Worker)
Bailey Tunnel Outlet Surface Water Ingestion – RME (Recreational User)
Bailey Tunnel Outlet Surface Water Dermal – RME (Recreational User)

AREA 1 (BRADLEY TAILINGS AND NEUTRALIZED ORE DISPOSAL AREA)
SUMMARY OF HEALTH RISKS

Receptor/Pathway	RME	
	HI	CR
Reclamation Worker		
Worker Soil Ingestion	1.13E+00	6.52E-06
Worker Soil Dermal	2.96E-01	1.72E-06
Worker Inhalation of Particulates	2.71E-03	2.89E-08
Reclamation Worker Total	1.42E+00	8.27E-06
Future Recreational User		
Soil Ingestion	2.11E-02	3.67E-06
Soil Dermal	4.44E-02	7.72E-06
Inhalation of Particulates	2.32E-05	7.43E-09
Future Recreational User Total	6.55E-02	1.14E-05

AREA 1 (MEADOW CREEK MINE HILLSIDE)
SUMMARY OF HEALTH RISKS

Receptor/Pathway	RME	
	HI	CR
Reclamation Worker		
Worker Soil Ingestion	9.35E-01	5.88E-06
Worker Soil Dermal	2.46E-01	1.55E-06
Worker Inhalation of Particulates	1.02E-02	2.60E-08
Reclamation Worker Total	1.19E+00	7.45E-06
Future Recreational User		
Soil Ingestion	1.75E-02	3.31E-06
Soil Dermal	3.69E-02	6.96E-06
Inhalation of Particulates	8.72E-05	6.68E-09
Future Recreational User Total	5.45E-02	1.03E-05

LOWER MEADOW CREEK VALLEY
SUMMARY OF HEALTH RISKS

Receptor/Pathway	RME	
	HI	CR
Reclamation Worker		
Worker Soil Ingestion	1.64E+00	3.84E-06
Worker Soil Dermal	4.18E-01	1.01E-06
Worker Inhalation of Particulates	2.04E-03	1.70E-08
Worker Sediment Ingestion	2.89E-02	1.45E-07
Worker Surface Water Ingestion	1.71E-03	8.67E-09
Worker Surface Water Dermal	1.62E-02	4.56E-08
Reclamation Worker Total	2.09E+00	5.03E-06
Future Recreational User		
Soil Ingestion	3.07E-02	2.16E-06
Soil Dermal	6.26E-02	4.55E-06
Inhalation of Particulates	1.74E-05	4.37E-09
Sediment Ingestion	2.71E-03	4.09E-07
Surface Water Ingestion	1.28E-01	1.95E-05
Surface Water Dermal	2.43E-03	2.05E-07
Fish Ingestion	2.43E-01	4.40E-06
Future Recreational User Total	4.70E-01	3.12E-05

AREA 1 (UPGRADIENT WETLAND)
SUMMARY OF HEALTH RISKS

Receptor/Pathway	RME	
	HI	**CR**
Reclamation Worker		
Worker Soil Ingestion	2.99E-02	9.82E-08
Worker Soil Dermal	7.69E-03	2.58E-08
Worker Inhalation of Particulates	3.79E-03	4.55E-10
Worker Surface Water Ingestion	5.73E-06	0.00E+00
Worker Surface Water Dermal	1.43E-04	0.00E+00
Reclamation Worker Total	4.14E-02	1.25E-07
Future Recreational User		
Soil Ingestion	5.61E-04	5.53E-08
Soil Dermal	1.15E-03	1.16E-07
Inhalation of Particulates	3.25E-05	1.17E-10
Surface Water Ingestion	4.29E-04	0.00E+00
Surface Water Dermal	2.15E-05	0.00E+00
Future Recreational User Total	2.20E-03	1.72E-07

AREA 1 (KEYWAY WETLAND)
SUMMARY OF HEALTH RISKS

	HI	CR
Reclamation Worker		
Worker Soil Ingestion	6.64E-01	2.55E-06
Worker Soil Dermal	1.71E-01	6.72E-07
Worker Inhalation of Particulates	2.15E-03	1.13E-08
Worker Surface Water Ingestion	2.35E-02	1.24E-07
Worker Surface Water Dermal	2.07E-01	6.54E-07
Reclamation Worker Total	1.07E+00	4.01E-06
Future Recreational User		
Soil Ingestion	1.24E-02	1.44E-06
Soil Dermal	2.57E-02	3.02E-06
Inhalation of Particulates	1.85E-05	2.90E-09
Surface Water Ingestion	1.76E+00	2.80E-04
Surface Water Dermal	3.10E-02	2.94E-06
Future Future Recreational User Total	1.83E+00	2.87E-04

STIBNITE - AREA 1 (MEADOW CREEK FORESTED WETLAND)
SUMMARY OF HEALTH RISKS

Receptor/Pathway	RME	
	HI	**CR**
Reclamation Worker		
Worker Soil Ingestion	2.00E+00	4.95E-06
Worker Soil Dermal	5.10E-01	1.30E-06
Worker Inhalation of Particulates	3.21E-03	2.19E-08
Reclamation Worker Total	2.51E+00	6.28E-06
Future Recreational User		
Soil Ingestion	3.75E-02	2.79E-06
Soil Dermal	7.65E-02	5.86E-06
Inhalation of Particulates	2.75E-05	5.63E-09
Future Recreational User Total	1.14E-01	8.65E-06

SOUTHEAST DUMP AND MIDNIGHT CREEK
SUMMARY OF HEALTH RISKS

Receptor/Pathway	RME	
	HI	CR
Reclamation Worker		
Worker Soil Ingestion	3.12E+00	2.00E-05
Worker Soil Dermal	8.21E-01	5.27E-06
Worker Inhalation of Particulates	3.61E-03	8.84E-08
Worker Sediment Ingestion	2.03E-02	9.08E-08
Worker Surface Water Ingestion	3.65E-03	1.55E-08
Worker Surface Water Dermal	4.37E-02	8.15E-08
Current Worker Total	4.01E+00	2.55E-05
Future Recreational User		
Soil Ingestion	5.85E-02	1.13E-05
Soil Dermal	1.23E-01	2.37E-05
Inhalation of Particulates	3.09E-05	2.27E-08
Sediment Ingestion	1.90E-03	2.55E-07
Surface Water Ingestion	2.74E-01	3.48E-05
Surface Water Dermal	6.55E-03	3.67E-07
Fish Ingestion	2.43E-01	4.40E-06
Future Recreational User Total	7.07E-01	7.48E-05

GLORY HOLE, NORTHWEST DUMP AND EFSFSR
SUMMARY OF HEALTH RISKS

Receptor/Pathway	RME	
	HI	CR
Reclamation Worker		
Worker Soil Ingestion	1.99E+00	1.09E-05
Worker Soil Dermal	5.21E-01	2.88E-06
Worker Inhalation of Particulates	1.97E-03	4.83E-08
Worker Sediment Ingestion	4.29E-01	2.45E-06
Worker Surface Water Ingestion	3.33E-03	1.58E-08
Worker Surface Water Dermal	3.45E-02	8.33E-08
Current Worker Total	2.98E+00	1.64E-05
Future Recreational User		
Soil Ingestion	3.74E-02	6.15E-06
Soil Dermal	7.81E-02	1.30E-05
Inhalation of Particulates	1.69E-05	1.24E-08
Sediment Ingestion	4.02E-02	6.89E-06
Surface Water Ingestion	2.50E-01	3.56E-05
Surface Water Dermal	5.18E-03	3.75E-07
Fish Ingestion	1.47E-01	4.46E-06
Future Recreational User Total	5.58E-01	6.65E-05

TABLE
NORTHEAST DUMP AND SUGAR CREEK
SUMMARY OF HEALTH RISKS

Receptor/Pathway	**RME**	
	HI	**CR**
Reclamation Worker		
Worker Soil Ingestion	3.55E+00	2.27E-05
Worker Soil Dermal	9.33E-01	5.96E-06
Worker Inhalation of Particulates	2.78E-03	1.00E-07
Worker Sediment Ingestion	1.37E-02	6.10E-08
Worker Surface Water Ingestion	7.75E-04	3.22E-09
Worker Surface Water Dermal	9.48E-03	1.70E-08
Reclamation Worker Total	4.51E+00	2.88E-05
Future Recreational User		
Soil Ingestion	6.65E-02	1.27E-05
Soil Dermal	1.40E-01	2.68E-05
Inhalation of Particulates	2.39E-05	2.58E-08
Sediment Ingestion	1.28E-03	1.72E-07
Surface Water Ingestion	5.81E-02	7.25E-06
Surface Water Dermal	1.42E-03	7.63E-08
Future Recreational User Total	2.67E-01	4.71E-05

TABLE
LOCATION UW-1 (UPGRADIENT WETLAND)
SUMMARY OF HEALTH RISKS

Receptor/Pathway	RME	
	HI	CR
Reclamation Worker		
Worker Soil Ingestion	5.32E+00	4.95E-07
Worker Soil Dermal	1.37E+00	1.30E-07
Worker Inhalation of Particulates	9.45E-03	2.19E-09
Worker Surface Water Ingestion	1.75E-01	2.65E-08
Worker Surface Water Dermal	1.41E+00	1.39E-07
Reclamation Worker Total	8.29E+00	7.93E-07
Future Recreational User		
Soil Ingestion	6.65E-01	6.18E-09
Soil Dermal	1.37E+00	1.30E-08
Inhalation of Particulates	5.40E-04	1.25E-11
Surface Water Ingestion	1.75E+00	2.65E-08
Surface Water Dermal	2.82E-01	2.79E-09
Future Recreational User Total	4.07E+00	4.85E-08

SMELTER
SUMMARY OF HEALTH RISKS

Receptor/Pathway	RME	
	HI	**CR**
Reclamation Worker		
Worker Soil Ingestion	1.40E+01	1.89E-06
Worker Soil Dermal	3.65E+00	4.97E-07
Worker Inhalation of Soil Particulates	1.57E-02	8.34E-09
Worker Ash Ingestion	6.20E+02	1.03E-04
Worker Ash Dermal	1.63E+02	2.70E-05
Work Inhalation of Ash Particulates	1.41E-02	4.54E-07
Worker Wood Ingestion	8.71E+00	1.11E-06
Worker Wood Dermal	2.26E+00	2.91E-07
Worker Inhalation of Wood particulates	6.21E-04	4.89E-09
Reclamation Worker Total	8.12E+02	1.34E-04
Future Recreational User		
Soil Ingestion	1.76E+00	2.36E-08
Soil Dermal	3.65E+00	4.97E-08
Inhalation of Soil Particulates	8.99E-04	4.77E-11
Ash Ingestion	7.75E+01	1.28E-06
Ash Dermal	1.63E+02	2.70E-06
Inhalation of Ash Particulates	8.07E-04	2.59E-09
Wood Ingestion	1.09E+00	1.38E-08
Wood Dermal	2.26E+00	2.91E-08
Inhalation of Wood Particulates	3.55E-05	2.80E-11
Future Recreational User Total	2.49E+02	4.10E-06

TABLE
DMEA DUMP
SUMMARY OF HEALTH RISKS

Receptor/Pathway	RME	
	HI	CR
Reclamation Worker		
Worker Soil Ingestion	2.71E+01	4.76E-06
Worker Soil Dermal	7.14E+00	1.25E-06
Worker Inhalation of Particulates	2.52E-02	2.10E-08
Reclamation Worker Total	3.43E+01	6.03E-06
Future Recreational User		
Soil Ingestion	3.39E+00	5.95E-08
Soil Dermal	7.14E+00	1.25E-07
Inhalation of Particulates	1.44E-03	1.20E-10
Future Recreational User Total	1.05E+01	1.85E-07

LOCATION BD6 (NORTHWEST DUMP)
SUMMARY OF HEALTH RISKS

Receptor/Pathway	RME	
	HI	CR
Reclamation Worker		
Worker Soil Ingestion	7.23E+01	2.41E-06
Worker Soil Dermal	1.83E+01	6.34E-07
Worker Inhalation of Particulates	5.43E-03	1.07E-08
Reclamation Worker Total	9.06E+01	3.06E-06
Future Recreational User		
Soil Ingestion	9.04E+00	3.01E-08
Soil Dermal	1.83E+01	6.34E-08
Inhalation of Particulates	3.10E-04	6.09E-11
Future Recreational User Total	2.73E+01	9.36E-08

TABLE
BAILEY TUNNEL OUTLET
SUMMARY OF HEALTH RISKS

Receptor/Pathway	RME	
	HI	**CR**
Reclamation Worker		
Worker Surface Water Ingestion	3.56E-01	4.49E-08
Worker Surface Water Dermal	3.86E+00	2.36E-07
Current Worker Total	4.22E+00	2.81E-07
Future Recreational User		
Surface Water Ingestion	3.56E+00	4.49E-08
Surface Water Dermal	7.73E-01	4.72E-09
Future Recreational User Total	4.33E+00	4.96E-08

AREA 1 (BRADLEY TAILINGS AND NEUTRALIZED ORE DISPOSAL AREA)
SOIL INGESTION - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ($(mg/kg\text{-}day)^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF $(mg/kg\text{-}day)^{-1}$	Cancer Risk
Aluminum	5.68E+03	3.13E-07	1.78E-03	1.00E+00	1.78E-03	4.47E-09	2.54E-05	-	-
Antimony	1.33E+02	3.13E-07	4.16E-05	4.00E-04	1.04E-01	4.47E-09	5.95E-07	-	-
Arsenic	1.62E+03	3.13E-07	3.04E-04	3.00E-04	1.01E+00	4.47E-09	4.35E-06	1.50E+00	6.52E-06
Cadmium	2.70E+00	3.13E-07	8.45E-07	1.00E-03	8.45E-04	4.47E-09	1.21E-08	-	-
Chromium III	1.77E+01	3.13E-07	5.54E-06	1.50E+00	3.69E-06	4.47E-09	7.92E-08	-	-
Copper	1.93E+01	3.13E-07	6.04E-06	3.70E-02	1.63E-04	4.47E-09	8.63E-08	-	-
Cyanide	1.03E+00	3.13E-07	3.23E-07	2.00E-02	1.61E-05	4.47E-09	4.61E-09	-	-
Lead	1.56E+01	3.13E-07	4.88E-06	-	-	4.47E-09	6.98E-08	-	-
Manganese	4.00E+02	3.13E-07	1.25E-04	1.40E-01	8.95E-04	4.47E-09	1.79E-06	-	-
Mercury	2.62E+00	3.13E-07	8.20E-07	3.00E-04	2.73E-03	4.47E-09	1.17E-08	-	-
Nickel	3.52E+01	3.13E-07	1.10E-05	2.00E-02	5.51E-04	4.47E-09	1.57E-07	-	-
Selenium	-	3.13E-07	-	5.00E-03	0.00E+00	4.47E-09	-	-	-
Silver	8.10E-01	3.13E-07	2.54E-07	5.00E-03	5.07E-05	4.47E-09	3.62E-09	-	-
Zinc	1.81E+01	3.13E-07	5.67E-06	3.00E-01	1.89E-05	4.47E-09	8.10E-08	-	-
				Hazard Index =	1.13E+00			Total Cancer Risk =	6.52E-06

1. Chemical Intake for Arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

AREA 1 (BRADLEY TAILINGS AND NEUTRALIZED ORE DISPOSAL AREA)
SOIL DERMAL - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Absorption Factor	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	5.68E+03	1.00E-02	1.57E-06	8.89E-05	2.00E-01	4.45E-04	2.24E-08	1.27E-06	-	-
Antimony	1.33E+02	1.00E-02	1.57E-06	2.08E-06	8.00E-05	2.60E-02	2.24E-08	2.97E-08	-	-
Arsenic	1.62E+03	3.00E-02	1.57E-06	7.61E-05	2.85E-04	2.67E-01	2.24E-08	1.09E-06	1.58E+00	1.72E-06
Cadmium	2.70E+00	1.00E-02	1.57E-06	4.23E-08	2.50E-05	1.69E-03	2.24E-08	6.04E-10	-	-
Chromium III	1.77E+01	1.00E-02	1.57E-06	2.77E-07	3.00E-01	9.24E-07	2.24E-08	3.96E-09	-	-
Copper	1.93E+01	1.00E-02	1.57E-06	3.02E-07	7.40E-03	4.08E-05	2.24E-08	4.32E-09	-	-
Cyanide	1.03E+00	1.00E-02	1.57E-06	1.61E-08	4.00E-03	4.03E-06	2.24E-08	2.30E-10	-	-
Lead	1.56E+01	1.00E-02	1.57E-06	2.44E-07	-	-	2.24E-08	3.49E-09	-	-
Manganese	4.00E+02	1.00E-02	1.57E-06	6.26E-06	2.80E-02	2.24E-04	2.24E-08	8.95E-08	-	-
Mercury	2.62E+00	1.00E-02	1.57E-06	4.10E-08	6.00E-05	6.84E-04	2.24E-08	5.86E-10	-	-
Nickel	3.52E+01	1.00E-02	1.57E-06	5.51E-07	1.80E-02	3.06E-05	2.24E-08	7.87E-09	-	-
Selenium	-	1.00E-02	1.57E-06	-	1.00E-03	-	2.24E-08	-	-	-
Silver	8.10E-01	1.00E-02	1.57E-06	1.27E-08	1.00E-03	1.27E-05	2.24E-08	1.81E-10	-	-
Zinc	1.81E+01	1.00E-02	1.57E-06	2.83E-07	6.00E-02	4.72E-06	2.24E-08	4.05E-09	-	-
					Hazard Index =	2.96E-01			Total Cancer Risk =	1.72E-06

AREA 1 (BRADLEY TAILINGS AND NEUTRALIZED ORE DISPOSAL AREA)
INHALATION (PARTICULATE MATTER) - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ($(mg/kg\text{-}day)^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)$^{-1}$	Cancer Risk
Aluminum	5.68E+03	8.30E-11	4.72E-07	1.40E-03	3.37E-04	1.19E-12	6.74E-09	-	-
Antimony	1.33E+02	8.30E-11	1.10E-08	-	-	1.19E-12	1.58E-10	-	-
Arsenic	1.62E+03	8.30E-11	1.34E-07	-	-	1.19E-12	1.92E-09	1.50E+01	2.88E-08
Cadmium	2.70E+00	8.30E-11	2.24E-10	-	-	1.19E-12	3.20E-12	6.30E+00	2.02E-11
Chromium III	1.77E+01	8.30E-11	1.47E-09	-	-	1.19E-12	2.10E-11	-	-
Copper	1.93E+01	8.30E-11	1.60E-09	-	-	1.19E-12	2.29E-11	-	-
Cyanide	1.03E+00	8.30E-11	8.55E-11	-	-	1.19E-12	1.22E-12	-	-
Lead	1.56E+01	8.30E-11	1.30E-09	-	-	1.19E-12	1.85E-11	-	-
Manganese	4.00E+02	8.30E-11	3.32E-08	1.40E-05	2.37E-03	1.19E-12	4.74E-10	-	-
Mercury	2.62E+00	8.30E-11	2.18E-10	8.60E-05	2.53E-06	1.19E-12	3.11E-12	-	-
Nickel	3.52E+01	8.30E-11	2.92E-09	-	-	1.19E-12	4.17E-11	8.40E-01	3.51E-11
Selenium	-	8.30E-11	-	-	-	1.19E-12	-	-	-
Silver	8.10E-01	8.30E-11	6.72E-11	-	-	1.19E-12	9.61E-13	-	-
Zinc	1.81E+01	8.30E-11	1.50E-09	-	-	1.19E-12	2.15E-11	-	-
				Hazard Index =	2.71E-03			Cancer Risk =	2.89E-08

AREA 1 (BRADLEY TAILINGS AND NEUTRALIZED ORE DISPOSAL AREA)
SOIL INGESTION - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)$^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)$^{-1}$	Cancer Risk
Aluminum	5.68E+03	5.87E-09	3.33E-05	1.00E+00	3.33E-05	2.52E-09	1.43E-05	-	-
Antimony	1.33E+02	5.87E-09	7.81E-07	4.00E-04	1.95E-03	2.52E-09	3.35E-07	-	-
Arsenic	1.62E+03	5.87E-09	5.71E-06	3.00E-04	1.90E-02	2.52E-09	2.45E-06	1.50E+00	3.67E-06
Cadmium	2.70E+00	5.87E-09	1.59E-08	1.00E-03	1.59E-05	2.52E-09	6.79E-09	-	-
Chromium III	1.77E+01	5.87E-09	1.04E-07	1.50E+00	6.93E-08	2.52E-09	4.45E-08	-	-
Copper	1.93E+01	5.87E-09	1.13E-07	3.70E-02	3.06E-06	2.52E-09	4.86E-08	-	-
Cyanide	1.03E+00	5.87E-09	6.05E-09	2.00E-02	3.02E-07	2.52E-09	2.59E-09	-	-
Lead	1.56E+01	5.87E-09	9.16E-08	-	-	2.52E-09	3.93E-08	-	-
Manganese	4.00E+02	5.87E-09	2.35E-06	1.40E-01	1.68E-05	2.52E-09	1.01E-06	-	-
Mercury	2.62E+00	5.87E-09	1.54E-08	3.00E-04	5.13E-05	2.52E-09	6.59E-09	-	-
Nickel	3.52E+01	5.87E-09	2.07E-07	2.00E-02	1.03E-05	2.52E-09	8.86E-08	-	-
Selenium	-	5.87E-09	-	5.00E-03	0.00E+00	2.52E-09	-	-	-
Silver	8.10E-01	5.87E-09	4.76E-09	5.00E-03	9.51E-07	2.52E-09	2.04E-09	-	-
Zinc	1.81E+01	5.87E-09	1.06E-07	3.00E-01	3.54E-07	2.52E-09	4.55E-08	-	-
				Hazard Index =	2.11E-02			Total Cancer Risk =	3.67E-06

1. Chemical Intake for Arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

AREA 1 (BRADLEY TAILINGS AND NEUTRALIZED ORE DISPOSAL AREA)
SOIL DERMAL - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Absorption Factor	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	5.68E+03	1.00E-02	2.35E-07	1.33E-05	2.00E-01	6.67E-05	1.01E-07	5.72E-06	-	-
Antimony	1.33E+02	1.00E-02	2.35E-07	3.12E-07	8.00E-05	3.90E-03	1.01E-07	1.34E-07	-	-
Arsenic	1.62E+03	3.00E-02	2.35E-07	1.14E-05	2.85E-04	4.00E-02	1.01E-07	4.89E-06	1.58E+00	7.72E-06
Cadmium	2.70E+00	1.00E-02	2.35E-07	6.34E-09	2.50E-05	2.54E-04	1.01E-07	2.72E-09	-	-
Chromium III	1.77E+01	1.00E-02	2.35E-07	4.16E-08	3.00E-01	1.39E-07	1.01E-07	1.78E-08	-	-
Copper	1.93E+01	1.00E-02	2.35E-07	4.53E-08	7.40E-03	6.12E-06	1.01E-07	1.94E-08	-	-
Cyanide	1.03E+00	1.00E-02	2.35E-07	2.42E-09	4.00E-03	6.05E-07	1.01E-07	1.04E-09	-	-
Lead	1.56E+01	1.00E-02	2.35E-07	3.66E-08	-	-	1.01E-07	1.57E-08	-	-
Manganese	4.00E+02	1.00E-02	2.35E-07	9.39E-07	2.80E-02	3.35E-05	1.01E-07	4.03E-07	-	-
Mercury	2.62E+00	1.00E-02	2.35E-07	6.15E-09	6.00E-05	1.03E-04	1.01E-07	2.64E-09	-	-
Nickel	3.52E+01	1.00E-02	2.35E-07	8.27E-08	1.80E-02	4.59E-06	1.01E-07	3.54E-08	-	-
Selenium	-	1.00E-02	2.35E-07	-	1.00E-03	-	1.01E-07	-	-	-
Silver	8.10E-01	1.00E-02	2.35E-07	1.90E-09	1.00E-03	1.90E-06	1.01E-07	8.15E-10	-	-
Zinc	1.81E+01	1.00E-02	2.35E-07	4.25E-08	6.00E-02	7.08E-07	1.01E-07	1.82E-08	-	-
					Hazard Index =	4.44E-02			Total Cancer Risk =	7.72E-06

AREA 1 (BRADLEY TAILINGS AND NEUTRALIZED ORE DISPOSAL AREA)
INHALATION (PARTICULATE MATTER) - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)$^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)$^{-1}$	Cancer Risk
Aluminum	5.68E+03	7.12E-13	4.04E-09	1.40E-03	2.89E-06	3.05E-13	1.73E-09	-	-
Antimony	1.33E+02	7.12E-13	9.46E-11	-	-	3.05E-13	4.06E-11	-	-
Arsenic	1.62E+03	7.12E-13	1.15E-09	-	-	3.05E-13	4.94E-10	1.50E+01	7.41E-09
Cadmium	2.70E+00	7.12E-13	1.92E-12	-	-	3.05E-13	8.23E-13	6.30E+00	5.19E-12
Chromium III	1.77E+01	7.12E-13	1.26E-11	-	-	3.05E-13	5.40E-12	-	-
Copper	1.93E+01	7.12E-13	1.37E-11	-	-	3.05E-13	5.89E-12	-	-
Cyanide	1.03E+00	7.12E-13	7.33E-13	-	-	3.05E-13	3.14E-13	-	-
Lead	1.56E+01	7.12E-13	1.11E-11	-	-	3.05E-13	4.76E-12	-	-
Manganese	4.00E+02	7.12E-13	2.85E-10	1.40E-05	2.03E-05	3.05E-13	1.22E-10	-	-
Mercury	2.62E+00	7.12E-13	1.86E-12	8.60E-05	2.17E-08	3.05E-13	7.99E-13	-	-
Nickel	3.52E+01	7.12E-13	2.50E-11	-	-	3.05E-13	1.07E-11	8.40E-01	9.02E-12
Selenium	-	7.12E-13	-	-	-	3.05E-13	-	-	-
Silver	8.10E-01	7.12E-13	5.76E-13	-	-	3.05E-13	2.47E-13	-	-
Zinc	1.81E+01	7.12E-13	1.29E-11	-	-	3.05E-13	5.52E-12	-	-
				Hazard Index =	2.32E-05			Cancer Risk =	7.43E-09

AREA 1 (MEADOW CREEK MINE HILLSIDE)
SOIL INGESTION - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.33E+04	3.13E-07	4.17E-03	1.00E+00	4.17E-03	4.47E-09	5.96E-05	-	-
Antimony	1.56E+01	3.13E-07	4.88E-06	4.00E-04	1.22E-02	4.47E-09	6.98E-08	-	-
Arsenic	1.46E+03	3.13E-07	2.74E-04	3.00E-04	9.14E-01	4.47E-09	3.92E-06	1.50E+00	5.88E-06
Cadmium	-	3.13E-07	-	1.00E-03	-	4.47E-09	-	-	-
Chromium III	4.08E+00	3.13E-07	1.28E-06	1.50E+00	8.52E-07	4.47E-09	1.82E-08	-	-
Copper	5.63E+00	3.13E-07	1.76E-06	3.70E-02	4.76E-05	4.47E-09	2.52E-08	-	-
Cyanide	-	3.13E-07	-	2.00E-02	-	4.47E-09	-	-	-
Lead	4.50E+00	3.13E-07	1.41E-06	-	-	4.47E-09	2.01E-08	-	-
Manganese	1.58E+03	3.13E-07	4.96E-04	1.40E-01	3.54E-03	4.47E-09	7.08E-06	-	-
Mercury	4.16E-01	3.13E-07	1.30E-07	3.00E-04	4.34E-04	4.47E-09	1.86E-09	-	-
Nickel	3.83E+00	3.13E-07	1.20E-06	2.00E-02	6.00E-05	4.47E-09	1.71E-08	-	-
Selenium	-	3.13E-07	-	5.00E-03	0.00E+00	4.47E-09	-	-	-
Silver	1.49E-01	3.13E-07	4.67E-08	5.00E-03	9.33E-06	4.47E-09	6.66E-10	-	-
Zinc	4.53E+01	3.13E-07	1.42E-05	3.00E-01	4.73E-05	4.47E-09	2.03E-07	-	-
				Hazard Index =	9.35E-01			Total Cancer Risk =	5.88E-06

[1] Chemical intake for arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

AREA 1 (MEADOW CREEK MINE HILLSIDE)
SOIL DERMAL - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Absorption Factor	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.33E+04	1.00E-02	1.57E-06	2.09E-04	2.00E-01	1.04E-03	2.24E-08	2.98E-06	-	-
Antimony	1.56E+01	1.00E-02	1.57E-06	2.44E-07	8.00E-05	3.05E-03	2.24E-08	3.49E-09	-	-
Arsenic	1.46E+03	3.00E-02	1.57E-06	6.86E-05	2.85E-04	2.41E-01	2.24E-08	9.80E-07	1.58E+00	1.55E-06
Cadmium	-	1.00E-02	1.57E-06	-	2.50E-05	-	2.24E-08	-	-	-
Chromium III	4.08E+00	1.00E-02	1.57E-06	6.39E-08	3.00E-01	2.13E-07	2.24E-08	9.12E-10	-	-
Copper	5.63E+00	1.00E-02	1.57E-06	8.81E-08	7.40E-03	1.19E-05	2.24E-08	1.26E-09	-	-
Cyanide	-	1.00E-02	1.57E-06	-	4.00E-03	-	2.24E-08	-	-	-
Lead	4.50E+00	1.00E-02	1.57E-06	7.05E-08	-	-	2.24E-08	1.01E-09	-	-
Manganese	1.58E+03	1.00E-02	1.57E-06	2.48E-05	2.80E-02	8.85E-04	2.24E-08	3.54E-07	-	-
Mercury	4.16E-01	1.00E-02	1.57E-06	6.51E-09	6.00E-05	1.09E-04	2.24E-08	9.30E-11	-	-
Nickel	3.83E+00	1.00E-02	1.57E-06	6.00E-08	4.00E-03	1.50E-05	2.24E-08	8.57E-10	-	-
Selenium	-	1.00E-02	1.57E-06	-	1.00E-03	-	2.24E-08	-	-	-
Silver	1.49E-01	1.00E-02	1.57E-06	2.33E-09	1.00E-03	2.33E-06	2.24E-08	3.33E-11	-	-
Zinc	4.53E+01	1.00E-02	1.57E-06	7.09E-07	6.00E-02	1.18E-05	2.24E-08	1.01E-08	-	-
					Hazard Index =	2.46E-01			Total Cancer Risk =	1.55E-06

AREA 1 (MEADOW CREEK MINE HILLSIDE)
INHALATION (PARTICULATE MATTER) - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ($(mg/kg\text{-}day)^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg day)$^{-1}$	Cancer Risk
Aluminum	1.33E+04	8.30E-11	1.11E-06	1.40E-03	7.90E-04	1.19E-12	1.58E-08	-	-
Antimony	1.56E+01	8.30E-11	1.30E-09	-	-	1.19E-12	1.85E-11	-	-
Arsenic	1.46E+03	8.30E-11	1.21E-07	-	-	1.19E-12	1.73E-09	1.50E+01	2.60E-08
Cadmium	-	8.30E-11	-	-	-	1.19E-12	-	6.30E+00	-
Chromium III	4.08E+00	8.30E-11	3.39E-10	-	-	1.19E-12	4.84E-12	-	-
Copper	5.63E+00	8.30E-11	4.67E-10	-	-	1.19E-12	6.68E-12	-	-
Cyanide	-	8.30E-11	-	-	-	1.19E-12	-	-	-
Lead	4.50E+00	8.30E-11	3.74E-10	-	-	1.19E-12	5.34E-12	-	-
Manganese	1.58E+03	8.30E-11	1.31E-07	1.40E-05	9.39E-03	1.19E-12	1.88E-09	-	-
Mercury	4.16E-01	8.30E-11	3.45E-11	8.60E-05	4.02E-07	1.19E-12	4.93E-13	-	-
Nickel	3.83E+00	8.30E-11	3.18E-10	-	-	1.19E-12	4.54E-12	8.40E-01	3.82E-12
Selenium	-	8.30E-11	-	-	-	1.19E-12	-	-	-
Silver	1.49E-01	8.30E-11	1.24E-11	-	-	1.19E-12	1.77E-13	-	-
Zinc	4.53E+01	8.30E-11	3.76E-09	-	-	1.19E-12	5.37E-11	-	-
				Hazard Index =	1.02E-02			Cancer Risk =	2.60E-08

AREA 1 (MEADOW CREEK MINE HILLSIDE)
SOIL INGESTION - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.33E+04	5.87E-09	7.82E-05	1.00E+00	7.82E-05	2.52E-09	3.35E-05	-	-
Antimony	1.56E+01	5.87E-09	9.16E-08	4.00E-04	2.29E-04	2.52E-09	3.93E-08	-	-
Arsenic	1.46E+03	5.87E-09	5.14E-06	3.00E-04	1.71E-02	2.52E-09	2.20E-06	1.50E+00	3.31E-06
Cadmium	-	5.87E-09	-	1.00E-03	-	2.52E-09	-	-	-
Chromium III	4.08E+00	5.87E-09	2.40E-08	1.50E+00	1.60E-08	2.52E-09	1.03E-08	-	-
Copper	5.63E+00	5.87E-09	3.31E-08	3.70E-02	8.93E-07	2.52E-09	1.42E-08	-	-
Cyanide	-	5.87E-09	-	2.00E-02	-	2.52E-09	-	-	-
Lead	4.50E+00	5.87E-09	2.64E-08	-	-	2.52E-09	1.13E-08	-	-
Manganese	1.58E+03	5.87E-09	9.29E-06	1.40E-01	6.64E-05	2.52E-09	3.98E-06	-	-
Mercury	4.16E-01	5.87E-09	2.44E-09	3.00E-04	8.14E-06	2.52E-09	1.05E-09	-	-
Nickel	3.83E+00	5.87E-09	2.25E-08	2.00E-02	1.12E-06	2.52E-09	9.64E-09	-	-
Selenium	-	5.87E-09	-	5.00E-03	0.00E+00	2.52E-09	-	-	-
Silver	1.49E-01	5.87E-09	8.75E-10	5.00E-03	1.75E-07	2.52E-09	3.75E-10	-	-
Zinc	4.53E+01	5.87E-09	2.66E-07	3.00E-01	8.86E-07	2.52E-09	1.14E-07	-	-
				Hazard Index =	1.75E-02			Total Cancer Risk =	3.31E-06

[1] Chemical intake for arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

AREA 1 (MEADOW CREEK MINE HILLSIDE)
SOIL DERMAL - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Absorption Factor	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.33E+04	1.00E-02	2.35E-07	3.13E-05	2.00E-01	1.56E-04	1.01E-07	1.34E-05	-	-
Antimony	1.56E+01	1.00E-02	2.35E-07	3.66E-08	8.00E-05	4.58E-04	1.01E-07	1.57E-08	-	-
Arsenic	1.46E+03	3.00E-02	2.35E-07	1.03E-05	2.85E-04	3.61E-02	1.01E-07	4.41E-06	1.58E+00	6.96E-06
Cadmium	-	1.00E-02	2.35E-07	-	2.50E-05	-	1.01E-07	-	-	-
Chromium III	4.08E+00	1.00E-02	2.35E-07	9.58E-09	3.00E-01	3.19E-08	1.01E-07	4.11E-09	-	-
Copper	5.63E+00	1.00E-02	2.35E-07	1.32E-08	7.40E-03	1.79E-06	1.01E-07	5.67E-09	-	-
Cyanide	-	1.00E-02	2.35E-07	-	4.00E-03	-	1.01E-07	-	-	-
Lead	4.50E+00	1.00E-02	2.35E-07	1.06E-08	-	-	1.01E-07	4.53E-09	-	-
Manganese	1.58E+03	1.00E-02	2.35E-07	3.72E-06	2.80E-02	1.33E-04	1.01E-07	1.59E-06	-	-
Mercury	4.16E-01	1.00E-02	2.35E-07	9.77E-10	6.00E-05	1.63E-05	1.01E-07	4.19E-10	-	-
Nickel	3.83E+00	1.00E-02	2.35E-07	8.99E-09	4.00E-03	2.25E-06	1.01E-07	3.85E-09	-	-
Selenium	-	1.00E-02	2.35E-07	-	1.00E-03	-	1.01E-07	-	-	-
Silver	1.49E-01	1.00E-02	2.35E-07	3.50E-10	1.00E-03	3.50E-07	1.01E-07	1.50E-10	-	-
Zinc	4.53E+01	1.00E-02	2.35E-07	1.06E-07	6.00E-02	1.77E-06	1.01E-07	4.56E-08	-	-
					Hazard Index =	3.69E-02			Total Cancer Risk =	6.96E-06

AREA 1 (MEADOW CREEK MINE HILLSIDE)
INHALATION (PARTICULATE MATTER) - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg day)-1	Cancer Risk
Aluminum	1.33E+04	7.12E-13	9.48E-09	1.40E-03	6.77E-06	3.05E-13	4.06E-09	-	-
Antimony	1.56E+01	7.12E-13	1.11E-11	-	-	3.05E-13	4.76E-12	-	-
Arsenic	1.46E+03	7.12E-13	1.04E-09	-	-	3.05E-13	4.45E-10	1.50E+01	6.68E-09
Cadmium	-	7.12E-13	-	-	-	3.05E-13	-	6.30E+00	-
Chromium III	4.08E+00	7.12E-13	2.90E-12	-	-	3.05E-13	1.24E-12	-	-
Copper	5.63E+00	7.12E-13	4.01E-12	-	-	3.05E-13	1.72E-12	-	-
Cyanide	-	7.12E-13	-	-	-	3.05E-13	-	-	-
Lead	4.50E+00	7.12E-13	3.20E-12	-	-	3.05E-13	1.37E-12	-	-
Manganese	1.58E+03	7.12E-13	1.13E-09	1.40E-05	8.05E-05	3.05E-13	4.83E-10	-	-
Mercury	4.16E-01	7.12E-13	2.96E-13	8.60E-05	3.44E-09	3.05E-13	1.27E-13	-	-
Nickel	3.83E+00	7.12E-13	2.73E-12	-	-	3.05E-13	1.17E-12	8.40E-01	9.81E-13
Selenium	-	7.12E-13	-	-	-	3.05E-13	-	-	-
Silver	1.49E-01	7.12E-13	1.06E-13	-	-	3.05E-13	4.54E-14	-	-
Zinc	4.53E+01	7.12E-13	3.22E-11	-	-	3.05E-13	1.38E-11	-	-
				Hazard Index =	8.72E-05			Cancer Risk =	6.68E-09

LOWER MEADOW CREEK VALLEY
SOIL INGESTION - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ($(mg/kg\text{-}day)^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF $(mg/kg\text{-}day)^{-1}$	Cancer Risk
Aluminum	7.21E+03	3.13E-07	2.26E-03	1.00E+00	2.26E-03	4.47E-09	3.23E-05	-	-
Antimony	1.32E+03	3.13E-07	4.15E-04	4.00E-04	1.04E+00	4.47E-09	5.92E-06	-	-
Arsenic	9.55E+02	3.13E-07	1.79E-04	3.00E-04	5.98E-01	4.47E-09	2.56E-06	1.50E+00	3.84E-06
Cadmium	-	3.13E-07	-	1.00E-03	-	4.47E-09	-	-	-
Chromium III	7.78E+00	3.13E-07	2.44E-06	1.50E+00	1.62E-06	4.47E-09	3.48E-08	-	-
Copper	1.74E+01	3.13E-07	5.45E-06	3.70E-02	1.47E-04	4.47E-09	7.78E-08	-	-
Cyanide	-	3.13E-07	-	2.00E-02	-	4.47E-09	-	-	-
Lead	3.47E+01	3.13E-07	1.09E-05	-	-	4.47E-09	1.55E-07	-	-
Manganese	2.71E+02	3.13E-07	8.49E-05	1.40E-01	6.06E-04	4.47E-09	1.21E-06	-	-
Mercury	7.16E-01	3.13E-07	2.24E-07	3.00E-04	7.47E-04	4.47E-09	3.20E-09	-	-
Nickel	9.78E+00	3.13E-07	3.06E-06	2.00E-02	1.53E-04	4.47E-09	4.37E-08	-	-
Selenium	4.80E-01	3.13E-07	1.50E-07	5.00E-03	3.01E-05	4.47E-09	2.15E-09	-	-
Silver	2.52E+00	3.13E-07	7.89E-07	5.00E-03	1.58E-04	4.47E-09	1.13E-08	-	-
Zinc	5.82E+01	3.13E-07	1.82E-05	3.00E-01	6.07E-05	4.47E-09	2.60E-07	-	-
				Hazard Index =	1.64E+00			Total Cancer Risk =	3.84E-06

[1] Chemical intake for arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

LOWER MEADOW CREEK VALLEY
SOIL DERMAL - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	ABS	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	7.21E+03	1.00E-02	1.57E-08	1.13E-04	2.00E-01	5.65E-04	2.24E-10	1.61E-06	-	-
Antimony	1.32E+03	1.00E-02	1.57E-08	2.07E-05	8.00E-05	2.59E-01	2.24E-10	2.96E-07	-	-
Arsenic	9.55E+02	3.00E-02	4.70E-08	4.49E-05	2.85E-04	1.57E-01	6.71E-10	6.41E-07	1.58E+00	1.01E-06
Cadmium	-	1.00E-02	1.57E-08	-	2.50E-05	-	2.24E-10	-	-	-
Chromium III	7.78E+00	1.00E-02	1.57E-08	1.22E-07	3.00E-01	4.06E-07	2.24E-10	1.74E-09	-	-
Copper	1.74E+01	1.00E-02	1.57E-08	2.72E-07	7.40E-03	3.68E-05	2.24E-10	3.89E-09	-	-
Cyanide	-	1.00E-02	1.57E-08	-	4.00E-03	-	2.24E-10	-	-	-
Lead	3.47E+01	1.00E-02	1.57E-08	5.43E-07	-	-	2.24E-10	7.76E-09	-	-
Manganese	2.71E+02	1.00E-02	1.57E-08	4.24E-06	2.80E-02	1.52E-04	2.24E-10	6.06E-08	-	-
Mercury	7.16E-01	1.00E-02	1.57E-08	1.12E-08	6.00E-05	1.87E-04	2.24E-10	1.60E-10	-	-
Nickel	9.78E+00	1.00E-02	1.57E-08	1.53E-07	4.00E-03	3.83E-05	2.24E-10	2.19E-09	-	-
Selenium	4.80E-01	1.00E-02	1.57E-08	7.51E-09	1.00E-03	7.51E-06	2.24E-10	1.07E-10	-	-
Silver	2.52E+00	1.00E-02	1.57E-08	3.95E-08	1.00E-03	3.95E-05	2.24E-10	5.64E-10	-	-
Zinc	5.82E+01	1.00E-02	1.57E-08	9.11E-07	6.00E-02	1.52E-05	2.24E-10	1.30E-08	-	-
					Hazard Index =	4.18E-01			Total Cancer Risk =	1.01E-06

LOWER MEADOW CREEK VALLEY
INHALATION (PARTICULATE MATTER) - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ($(\text{mg/kg-day})^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg day)$^{-1}$	Cancer Risk
Aluminum	7.21E+03	8.30E-11	5.99E-07	1.40E-03	4.28E-04	1.19E-12	8.55E-09	-	-
Antimony	1.32E+03	8.30E-11	1.10E-07	-	-	1.19E-12	1.57E-09	-	-
Arsenic	9.55E+02	8.30E-11	7.93E-08	-	-	1.19E-12	1.13E-09	1.50E+01	1.70E-08
Cadmium	-	8.30E-11	-	-	-	1.19E-12	-	6.30E+00	-
Chromium III	7.78E+00	8.30E-11	6.46E-10	-	-	1.19E-12	9.23E-12	-	-
Copper	1.74E+01	8.30E-11	1.44E-09	-	-	1.19E-12	2.06E-11	-	-
Cyanide	-	8.30E-11	-	-	-	1.19E-12	-	-	-
Lead	3.47E+01	8.30E-11	2.88E-09	-	-	1.19E-12	4.12E-11	-	-
Manganese	2.71E+02	8.30E-11	2.25E-08	1.40E-05	1.61E-03	1.19E-12	3.21E-10	-	-
Mercury	7.16E-01	8.30E-11	5.94E-11	8.60E-05	6.91E-07	1.19E-12	8.49E-13	-	-
Nickel	9.78E+00	8.30E-11	8.12E-10	-	-	1.19E-12	1.16E-11	8.40E-01	9.74E-12
Selenium	4.80E-01	8.30E-11	3.99E-11	-	-	1.19E-12	5.69E-13	-	-
Silver	2.52E+00	8.30E-11	2.09E-10	-	-	1.19E-12	2.99E-12	-	-
Zinc	5.82E+01	8.30E-11	4.83E-09	-	-	1.19E-12	6.90E-11	-	-
				Hazard Index =	2.04E-03			Cancer Risk =	1.70E-08

LOWER MEADOW CREEK VALLEY
SEDIMENT INGESTION - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ($(mg/kg\text{-}day)^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Sediment Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF $(mg/kg\text{-}day)^{-1}$	Cancer Risk
Aluminum	-	1.25E-07	-	1.00E+00	-	1.79E-09	-	-	-
Antimony	1.92E+01	1.25E-07	2.40E-06	4.00E-04	6.01E-03	1.79E-09	3.44E-08	-	-
Arsenic	9.03E+01	1.25E-07	6.79E-06	3.00E-04	2.26E-02	1.79E-09	9.69E-08	1.50E+00	1.45E-07
Cadmium	1.07E+00	1.25E-07	1.34E-07	1.00E-03	1.34E-04	1.79E-09	1.91E-09	-	-
Chromium III	2.30E+00	1.25E-07	2.88E-07	1.50E+00	1.92E-07	1.79E-09	4.12E-09	-	-
Copper	4.50E+00	1.25E-07	5.64E-07	3.70E-02	1.52E-05	1.79E-09	8.05E-09	-	-
Cyanide	-	1.25E-07	-	2.00E-02	-	1.79E-09	-	-	-
Lead	3.31E+00	1.25E-07	4.15E-07	-	-	1.79E-09	5.92E-09	-	-
Manganese	-	1.25E-07	-	1.40E-01	-	1.79E-09	-	-	-
Mercury	1.29E-01	1.25E-07	1.62E-08	3.00E-04	5.39E-05	1.79E-09	2.31E-10	-	-
Nickel	-	1.25E-07	-	2.00E-02	-	1.79E-09	-	-	-
Selenium	1.69E+00	1.25E-07	2.12E-07	5.00E-03	4.23E-05	1.79E-09	3.02E-09	-	-
Silver	-	1.25E-07	-	5.00E-03	-	1.79E-09	-	-	-
Zinc	1.16E+01	1.25E-07	1.45E-06	3.00E-01	4.84E-06	1.79E-09	2.08E-08	-	-
				Hazard Index =	2.89E-02			Cancer Risk =	1.45E-07

[1] Chemical intake for arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

LOWER MEADOW CREEK VALLEY
SURFACE WATER INGESTION - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ($(mg/kg\text{-}day)^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF $(mg/kg\text{-}day)^{-1}$	Cancer Risk
Aluminum	8.31E-02	1.25E-05	1.04E-06	1.00E+00	1.04E-06	1.79E-07	1.49E-08	-	-
Antimony	1.12E-02	1.25E-05	1.40E-07	4.00E-04	3.51E-04	1.79E-07	2.00E-09	-	-
Arsenic	3.23E-02	1.25E-05	4.05E-07	3.00E-04	1.35E-03	1.79E-07	5.78E-09	1.50E+00	8.67E-09
Cadmium	-	1.25E-05	-	1.00E-03	-	1.79E-07	-	-	-
Chromium III	-	1.25E-05	-	1.50E+00	-	1.79E-07	-	-	-
Copper	2.00E-03	1.25E-05	2.50E-08	3.70E-02	6.77E-07	1.79E-07	3.58E-10	-	-
Cyanide	2.30E-03	1.25E-05	2.88E-08	2.00E-02	1.44E-06	1.79E-07	4.12E-10	-	-
Lead	1.43E-03	1.25E-05	1.79E-08	-	-	1.79E-07	2.56E-10	-	-
Manganese-w	3.14E-02	1.25E-05	3.93E-07	4.70E-02	8.37E-06	1.79E-07	5.62E-09	-	-
Mercury	5.40E-05	1.25E-05	6.76E-10	3.00E-04	2.25E-06	1.79E-07	9.66E-12	-	-
Nickel	-	1.25E-05	-	2.00E-02	-	1.79E-07	-	-	-
Selenium	-	1.25E-05	-	5.00E-03	-	1.79E-07	-	-	-
Silver	-	1.25E-05	-	5.00E-03	-	1.79E-07	-	-	-
Zinc	2.52E-03	1.25E-05	3.16E-08	3.00E-01	1.05E-07	1.79E-07	4.51E-10	-	-
				Hazard Index =	1.71E-03			Cancer Risk =	8.67E-09

LOWER MEADOW CREEK VALLEY
SURFACE WATER DERMAL- RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	PC	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	8.31E-02	1.00E-03	6.26E-05	5.20E-06	2.00E-01	2.60E-05	8.95E-07	7.43E-08	-	-
Antimony	1.12E-02	1.00E-03	6.26E-05	7.01E-07	8.00E-05	8.77E-03	8.95E-07	1.00E-08	-	-
Arsenic	3.23E-02	1.00E-03	6.26E-05	2.02E-06	2.85E-04	7.10E-03	8.95E-07	2.89E-08	1.58E+00	4.56E-08
Cadmium	-	1.00E-03	6.26E-05	-	2.50E-05	-	8.95E-07	-	-	-
Chromium III	-	1.00E-03	6.26E-05	-	3.00E-01	-	8.95E-07	-	-	-
Copper	2.00E-03	1.00E-03	6.26E-05	1.25E-07	7.40E-03	1.69E-05	8.95E-07	1.79E-09	-	-
Cyanide	2.30E-03	1.00E-03	6.26E-05	1.44E-07	4.00E-03	3.60E-05	8.95E-07	2.06E-09	-	-
Lead	1.43E-03	1.00E-04	6.26E-06	8.95E-09	-	-	8.95E-08	1.28E-10	-	-
Manganese-w	3.14E-02	1.00E-03	6.26E-05	1.97E-06	9.40E-03	2.09E-04	8.95E-07	2.81E-08	-	-
Mercury	5.40E-05	1.00E-03	6.26E-05	3.38E-09	6.00E-05	5.64E-05	8.95E-07	4.83E-11	-	-
Nickel	-	2.00E-04	1.25E-05	-	4.00E-03	-	1.79E-07	-	-	-
Selenium	-	1.00E-03	6.26E-05	-	1.00E-03	-	8.95E-07	-	-	-
Silver	-	6.00E-04	3.76E-05	-	1.00E-03	-	5.37E-07	-	-	-
Zinc	2.52E-03	1.00E-03	6.26E-05	1.58E-07	6.00E-02	2.63E-06	8.95E-07	2.25E-09	-	-
					Hazard Index =	1.62E-02			Cancer Risk =	4.56E-08

LOWER MEADOW CREEK VALLEY
SURFACE WATER DERMAL - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	PC	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	8.31E-02	1.00E-03	9.39E-06	7.81E-07	2.00E-01	3.90E-06	4.03E-06	3.35E-07	-	-
Antimony	1.12E-02	1.00E-03	9.39E-06	1.05E-07	8.00E-05	1.32E-03	4.03E-06	4.51E-08	-	-
Arsenic	3.23E-02	1.00E-03	9.39E-06	3.03E-07	2.85E-04	1.06E-03	4.03E-06	1.30E-07	1.58E+00	2.05E-07
Cadmium	-	1.00E-03	9.39E-06	-	2.50E-05	-	4.03E-06	-	-	-
Chromium III	-	1.00E-03	9.39E-06	-	3.00E-01	-	4.03E-06	-	-	-
Copper	2.00E-03	1.00E-03	9.39E-06	1.88E-08	7.40E-03	2.54E-06	4.03E-06	8.05E-09	-	-
Cyanide	2.30E-03	1.00E-03	9.39E-06	2.16E-08	4.00E-03	5.40E-06	4.03E-06	9.26E-09	-	-
Lead	1.43E-03	1.00E-04	9.39E-07	1.34E-09	-		4.03E-07	5.76E-10	-	-
Manganese-w	3.14E-02	1.00E-03	9.39E-06	2.95E-07	9.40E-03	3.14E-05	4.03E-06	1.26E-07	-	-
Mercury	5.40E-05	1.00E-03	9.39E-06	5.07E-10	6.00E-05	8.45E-06	4.03E-06	2.17E-10	-	-
Nickel	-	2.00E-04	1.88E-06	-	4.00E-03	-	8.05E-07	-	-	-
Selenium	-	1.00E-03	9.39E-06	-	1.00E-03	-	4.03E-06	-	-	-
Silver	-	6.00E-04	5.64E-06	-	1.00E-03	-	2.42E-06	-	-	-
Zinc	2.52E-03	1.00E-03	9.39E-06	2.37E-08	6.00E-02	3.95E-07	4.03E-06	1.01E-08	-	-
					Hazard Index =	2.43E-03			Cancer Risk =	2.05E-07

LOWER MEADOW CREEK VALLEY
FISH INGESTION - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Fish Tissue Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	-	9.39E-05	-	1.00E+00	-	4.03E-05	-	-	-
Antimony	-	9.39E-05	-	4.00E-04	-	4.03E-05	-	-	-
Arsenic	7.28E-02	9.39E-05	6.84E-06	3.00E-04	2.28E-02	4.03E-05	2.93E-06	1.50E+00	4.40E-06
Cadmium	-	9.39E-05	-	1.00E-03	-	4.03E-05	-	-	-
Chromium III	-	9.39E-05	-	1.50E+00	-	4.03E-05	-	-	-
Copper	-	9.39E-05	-	3.70E-02	-	4.03E-05	-	-	-
Cyanide	-	9.39E-05	-	2.00E-02	-	4.03E-05	-	-	-
Lead	-	9.39E-05	-	-	-	4.03E-05	-	-	-
Manganese	5.99E-01	9.39E-05	5.63E-05	1.40E-01	4.02E-04	4.03E-05	2.41E-05	-	-
Mercury	-	9.39E-05	-	3.00E-04	-	4.03E-05	-	-	-
Methyl mercury	2.18E-01	9.39E-05	2.05E-05	1.00E-04	2.05E-01	4.03E-05	8.78E-06	-	-
Nickel	-	9.39E-05	-	2.00E-02	-	4.03E-05	-	-	-
Selenium	7.06E-01	9.39E-05	6.63E-05	5.00E-03	1.33E-02	4.03E-05	2.84E-05	-	-
Silver	-	9.39E-05	-	5.00E-03	-	4.03E-05	-	-	-
Zinc	7.05E+00	9.39E-05	6.62E-04	3.00E-01	2.21E-03	4.03E-05	2.84E-04	-	-
				Hazard Index =	2.43E-01			Cancer Risk =	4.40E-06

AREA 1 (UPGRADIENT WETLAND)
SOIL INGESTION - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ($(mg/kg\text{-}day)^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF $(mg/kg\text{-}day)^{-1}$	Cancer Risk
Aluminum	4.33E+04	3.13E-07	1.36E-02	1.00E+00	1.36E-02	4.47E-09	1.94E-04	-	-
Antimony	-	3.13E-07	-	4.00E-04	-	4.47E-09	-	-	-
Arsenic	2.44E+01	3.13E-07	4.58E-06	3.00E-04	1.53E-02	4.47E-09	6.55E-08	1.50E+00	9.82E-08
Cadmium	-	3.13E-07	-	1.00E-03	-	4.47E-09	-	-	-
Chromium III	3.99E+01	3.13E-07	1.25E-05	1.50E+00	8.33E-06	4.47E-09	1.78E-07	-	-
Copper	1.21E+01	3.13E-07	3.79E-06	3.70E-02	1.02E-04	4.47E-09	5.41E-08	-	-
Cyanide	-	3.13E-07	-	2.00E-02	-	4.47E-09	-	-	-
Lead	9.40E+00	3.13E-07	2.94E-06	-	-	4.47E-09	4.20E-08	-	-
Manganese	2.06E+02	3.13E-07	6.45E-05	1.40E-01	4.61E-04	4.47E-09	9.21E-07	-	-
Mercury	1.10E-01	3.13E-07	3.44E-08	3.00E-04	1.15E-04	4.47E-09	4.92E-10	-	-
Nickel	2.10E+01	3.13E-07	6.58E-06	2.00E-02	3.29E-04	4.47E-09	9.39E-08	-	-
Selenium	1.90E-01	3.13E-07	5.95E-08	5.00E-03	1.19E-05	4.47E-09	8.50E-10	-	-
Silver	1.00E-01	3.13E-07	3.13E-08	5.00E-03	6.26E-06	4.47E-09	4.47E-10	-	-
Zinc	6.77E+01	3.13E-07	2.12E-05	3.00E-01	7.07E-05	4.47E-09	3.03E-07	-	-
				Hazard Index =	2.99E-02			Total Cancer Risk =	9.82E-08

[1] Chemical intake for arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

AREA 1 (UPGRADIENT WETLAND)
SOIL DERMAL - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	ABS	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	4.33E+04	1.00E-02	1.57E-08	6.78E-04	2.00E-01	3.39E-03	2.24E-10	9.68E-06	-	-
Antimony	-	1.00E-02	1.57E-08	-	8.00E-05	-	2.24E-10	-	-	-
Arsenic	2.44E+01	3.00E-02	4.70E-08	1.15E-06	2.85E-04	4.02E-03	6.71E-10	1.64E-08	1.58E+00	2.58E-08
Cadmium	-	1.00E-02	1.57E-08	-	2.50E-05	-	2.24E-10	-	-	-
Chromium III	3.99E+01	1.00E-02	1.57E-08	6.25E-07	3.00E-01	2.08E-06	2.24E-10	8.92E-09	-	-
Copper	1.21E+01	1.00E-02	1.57E-08	1.89E-07	7.40E-03	2.56E-05	2.24E-10	2.71E-09	-	-
Cyanide	-	1.00E-02	1.57E-08	-	4.00E-03	-	2.24E-10	-	-	-
Lead	9.40E+00	1.00E-02	1.57E-08	1.47E-07	-	-	2.24E-10	2.10E-09	-	-
Manganese	2.06E+02	1.00E-02	1.57E-08	3.23E-06	2.80E-02	1.15E-04	2.24E-10	4.61E-08	-	-
Mercury	1.10E-01	1.00E-02	1.57E-08	1.72E-09	6.00E-05	2.87E-05	2.24E-10	2.46E-11	-	-
Nickel	2.10E+01	1.00E-02	1.57E-08	3.29E-07	4.00E-03	8.22E-05	2.24E-10	4.70E-09	-	-
Selenium	1.90E-01	1.00E-02	1.57E-08	2.97E-09	1.00E-03	2.97E-06	2.24E-10	4.25E-11	-	-
Silver	1.00E-01	1.00E-02	1.57E-08	1.57E-09	1.00E-03	1.57E-06	2.24E-10	2.24E-11	-	-
Zinc	6.77E+01	1.00E-02	1.57E-08	1.06E-06	6.00E-02	1.77E-05	2.24E-10	1.51E-08	-	-
					Hazard Index =	7.69E-03			Total Cancer Risk =	2.58E-08

AREA 1 (UPGRADIENT WETLAND)
INHALATION (PARTICULATE MATTER) - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ($(mg/kg\text{-}day)^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg day)	SF (mg/kg day)$^{-1}$	Cancer Risk
Aluminum	4.33E+04	8.30E-11	3.59E-06	1.40E-03	2.57E-03	1.19E-12	5.14E-08	-	-
Antimony	-	8.30E-11	-	-	-	1.19E-12	-	-	-
Arsenic	2.44E+01	8.30E-11	2.03E-09	-	-	1.19E-12	2.89E-11	1.50E+01	4.34E-10
Cadmium	-	8.30E-11	-	-	-	1.19E-12	-	6.30E+00	-
Chromium III	3.99E+01	8.30E-11	3.31E-09	-	-	1.19E-12	4.73E-11	-	-
Copper	1.21E+01	8.30E-11	1.00E-09	-	-	1.19E-12	1.44E-11	-	-
Cyanide	-	8.30E-11	-	-	-	1.19E-12	-	-	-
Lead	9.40E+00	8.30E-11	7.80E-10	-	-	1.19E-12	1.11E-11	-	-
Manganese	2.06E+02	8.30E-11	1.71E-08	1.40E-05	1.22E-03	1.19E-12	2.44E-10	-	-
Mercury	1.10E-01	8.30E-11	9.13E-12	8.60E-05	1.06E-07	1.19E-12	1.30E-13	-	-
Nickel	2.10E+01	8.30E-11	1.74E-09	-	-	1.19E-12	2.49E-11	8.40E-01	2.09E-11
Selenium	1.90E-01	8.30E-11	1.58E-11	-	-	1.19E-12	2.25E-13	-	-
Silver	1.00E-01	8.30E-11	8.30E-12	-	-	1.19E-12	1.19E-13	-	-
Zinc	67.7	8.3022E-11	5.62059E-09	-	-	1.19E-12	8.02941E-11	-	-
				Hazard Index =	3.79E-03			Cancer Risk =	4.55E-10

AREA 1 (UPGRADIENT WETLAND)
SURFACE WATER INGESTION - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RFD
CR. = Chemical Intake x SF

Where:
RFd = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)$^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR. = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	Intake Factor (L/kg-day)	Chemical Intake (mg/kg day)	RFd (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg day)	SF (mg/kg-day)$^{-1}$	Cancer Risk
Aluminum	1.53E-01	1.25E-05	1.92E-06	1.00E+00	1.92E-06	1.79E-07	2.74E-08	-	-
Antimony	-	1.25E-05	-	4.00E-04	-	1.79E-07	-	-	-
Arsenic	-	1.25E-05	-	3.00E-04	-	1.79E-07	-	1.50E+00	-
Cadmium	-	1.25E-05	-	1.00E-03	-	1.79E-07	-	-	-
Chromium III	-	1.25E-05	-	1.50E+00	-	1.79E-07	-	-	-
Copper	1.70E-03	1.25E-05	2.13E-08	3.70E-02	5.75E-07	1.79E-07	3.04E-10	-	-
Cyanide	2.10E-03	1.25E-05	2.63E-08	2.00E-02	1.32E-06	1.79E-07	3.76E-10	-	-
Lead	1.00E-03	1.25E-05	1.25E-08	-	-	1.79E-07	1.79E-10	-	-
Manganese-w	7.20E-03	1.25E-05	9.02E-08	4.70E-02	1.92E-06	1.79E-07	1.29E-09	-	-
Mercury	-	1.25E-05	-	3.00E-04	-	1.79E-07	-	-	-
Nickel	-	1.25E-05	-	2.00E-02	-	1.79E-07	-	-	-
Selenium	-	1.25E-05	-	5.00E-03	-	1.79E-07	-	-	-
Silver	-	1.25E-05	-	5.00E-03	-	1.79E-07	-	-	-
Zinc	-	1.25245E-05	-	0.3	-	1.79E-07	-	-	-
				Hazard Index =	5.725E-06			Cancer Risk =	0.00E+00

AREA 1 (UPGRADIENT WETLAND)
SURFACE WATER DERMAL- RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	PC	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.53E-01	1.00E-03	6.26E-05	9.58E-06	2.00E-01	4.79E-05	8.95E-07	1.37E-07	-	-
Antimony	-	1.00E-03	6.26E-05	-	8.00E-05	-	8.95E-07	-	-	-
Arsenic	-	1.00E-03	6.26E-05	-	2.85E-04	-	8.95E-07	-	1.58E+00	-
Cadmium	-	1.00E-03	6.26E-05	-	2.50E-05	-	8.95E-07	-	-	-
Chromium III	-	1.00E-03	6.26E-05	-	3.00E-01	-	8.95E-07	-	-	-
Copper	1.70E-03	1.00E-03	6.26E-05	1.06E-07	7.40E-03	1.44E-05	8.95E-07	1.52E-09	-	-
Cyanide	2.10E-03	1.00E-03	6.26E-05	1.32E-07	4.00E-03	3.29E-05	8.95E-07	1.88E-09	-	-
Lead	1.00E-03	1.00E-04	6.26E-06	6.26E-09	-		8.95E-08	8.95E-11	-	-
Manganese-w	7.20E-03	1.00E-03	6.26E-05	4.51E-07	9.40E-03	4.80E-05	8.95E-07	6.44E-09	-	-
Mercury	-	1.00E-03	6.26E-05	-	6.00E-05	-	8.95E-07	-	-	-
Nickel	-	2.00E-04	1.25E-05	-	4.00E-03	-	1.79E-07	-	-	-
Selenium	-	1.00E-03	6.26E-05	-	1.00E-03	-	8.95E-07	-	-	-
Silver	-	6.00E-04	3.76E-05	-	1.00E-03	-	5.37E-07	-	-	-
Zinc	-	1.00E-03	6.26E-05	-	6.00E-02	-	8.95E-07	-	-	-
					Hazard Index =	1.43E-04			Cancer Risk	0.00E+00

AREA 1 (UPGRADIENT WETLAND)
SOIL INGESTION - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)-1	Cancer Risk
Aluminum	4.33E+04	5.87E-09	2.54E-04	1.00E+00	2.54E-04	2.52E-09	1.09E-04	-	-
Antimony	-	5.87E-09	-	4.00E-04	-	2.52E-09	-	-	-
Arsenic	2.44E+01	5.87E-09	8.59E-08	3.00E-04	2.86E-04	2.52E-09	3.68E-08	1.50E+00	5.53E-08
Cadmium	-	5.87E-09	-	1.00E-03	-	2.52E-09	-	-	-
Chromium III	3.99E+01	5.87E-09	2.34E-07	1.50E+00	1.56E-07	2.52E-09	1.00E-07	-	-
Copper	1.21E+01	5.87E-09	7.10E-08	3.70E-02	1.92E-06	2.52E-09	3.04E-08	-	-
Cyanide	-	5.87E-09	-	2.00E-02	-	2.52E-09	-	-	-
Lead	9.40E+00	5.87E-09	5.52E-08	-	-	2.52E-09	2.37E-08	-	-
Manganese	2.06E+02	5.87E-09	1.21E-06	1.40E-01	8.64E-06	2.52E-09	5.18E-07	-	-
Mercury	1.10E-01	5.87E-09	6.46E-10	3.00E-04	2.15E-06	2.52E-09	2.77E-10	-	-
Nickel	2.10E+01	5.87E-09	1.23E-07	2.00E-02	6.16E-06	2.52E-09	5.28E-08	-	-
Selenium	1.90E-01	5.87E-09	1.12E-09	5.00E-03	2.23E-07	2.52E-09	4.78E-10	-	-
Silver	1.00E-01	5.87E-09	5.87E-10	5.00E-03	1.17E-07	2.52E-09	2.52E-10	-	-
Zinc	6.77E+01	5.87E-09	3.97E-07	3.00E-01	1.32E-06	2.52E-09	1.70E-07	-	-
				Hazard Index =	5.61E-04			Total Cancer Risk =	5.53E-08

[1] Chemical intake for arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

AREA 1 (UPGRADIENT WETLAND)
SOIL DERMAL - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	ABS	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	4.33E+04	1.00E-02	2.35E-09	1.02E-04	2.00E-01	5.08E-04	1.01E-09	4.36E-05	-	-
Antimony	-	1.00E-02	2.35E-09	-	8.00E-05	-	1.01E-09	-	-	-
Arsenic	2.44E+01	3.00E-02	7.05E-09	1.72E-07	2.85E-04	6.03E-04	3.02E-09	7.37E-08	1.58E+00	1.16E-07
Cadmium	-	1.00E-02	2.35E-09	-	2.50E-05	-	1.01E-09	-	-	-
Chromium III	3.99E+01	1.00E-02	2.35E-09	9.37E-08	3.00E-01	3.12E-07	1.01E-09	4.02E-08	-	-
Copper	1.21E+01	1.00E-02	2.35E-09	2.84E-08	7.40E-03	3.84E-06	1.01E-09	1.22E-08	-	-
Cyanide	-	1.00E-02	2.35E-09	-	4.00E-03	-	1.01E-09	-	-	-
Lead	9.40E+00	1.00E-02	2.35E-09	2.21E-08	-	-	1.01E-09	9.46E-09	-	-
Manganese	2.06E+02	1.00E-02	2.35E-09	4.84E-07	2.80E-02	1.73E-05	1.01E-09	2.07E-07	-	-
Mercury	1.10E-01	1.00E-02	2.35E-09	2.58E-10	6.00E-05	4.31E-06	1.01E-09	1.11E-10	-	-
Nickel	2.10E+01	1.00E-02	2.35E-09	4.93E-08	4.00E-03	1.23E-05	1.01E-09	2.11E-08	-	-
Selenium	1.90E-01	1.00E-02	2.35E-09	4.46E-10	1.00E-03	4.46E-07	1.01E-09	1.91E-10	-	-
Silver	1.00E-01	1.00E-02	2.35E-09	2.35E-10	1.00E-03	2.35E-07	1.01E-09	1.01E-10	-	-
Zinc	6.77E+01	1.00E-02	2.35E-09	1.59E-07	6.00E-02	2.65E-06	1.01E-09	6.81E-08	-	-
					Hazard Index =	1.15E-03			Total Cancer Risk =	1.16E-07

AREA 1 (UPGRADIENT WETLAND)
INHALATION (PARTICULATE MATTER) - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg day)-1	Cancer Risk
Aluminum	4.33E+04	7.12E-13	3.08E-08	1.40E-03	2.20E-05	3.05E-13	1.32E-08	-	-
Antimony	-	7.12E-13	-	-	-	3.05E-13	-	-	-
Arsenic	2.44E+01	7.12E-13	1.74E-11	-	-	3.05E-13	7.44E-12	1.50E+01	1.12E-10
Cadmium	-	7.12E-13	-	-	-	3.05E-13	-	6.30E+00	-
Chromium III	3.99E+01	7.12E-13	2.84E-11	-	-	3.05E-13	1.22E-11	-	-
Copper	1.21E+01	7.12E-13	8.61E-12	-	-	3.05E-13	3.69E-12	-	-
Cyanide	-	7.12E-13	-	-	-	3.05E-13	-	-	-
Lead	9.40E+00	7.12E-13	6.69E-12	-	-	3.05E-13	2.87E-12	-	-
Manganese	2.06E+02	7.12E-13	1.47E-10	1.40E-05	1.05E-05	3.05E-13	6.28E-11	-	-
Mercury	1.10E-01	7.12E-13	7.83E-14	8.60E-05	9.10E-10	3.05E-13	3.35E-14	-	-
Nickel	2.10E+01	7.12E-13	1.49E-11	-	-	3.05E-13	6.40E-12	8.40E-01	5.38E-12
Selenium	1.90E-01	7.12E-13	1.35E-13	-	-	3.05E-13	5.79E-14	-	-
Silver	1.00E-01	7.12E-13	7.12E-14	-	-	3.05E-13	3.05E-14	-	-
Zinc	6.77E+01	7.12E-13	4.82E-11	-	-	3.05E-13	2.06E-11	-	-
				Hazard Index =	3.25E-05			Cancer Risk =	1.17E-10

AREA 1 (UPGRADIENT WETLAND)
SURFACE WATER INGESTION - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ($(mg/kg\text{-}day)^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF $(mg/kg\text{-}day)^{-1}$	Cancer Risk
Aluminum	1.53E-01	9.39E-04	1.44E-04	1.00E+00	1.44E-04	4.03E-04	6.16E-05	-	-
Antimony	-	9.39E-04	-	4.00E-04	-	4.03E-04	-	-	-
Arsenic	-	9.39E-04	-	3.00E-04	-	4.03E-04	-	1.50E+00	-
Cadmium	-	9.39E-04	-	1.00E-03	-	4.03E-04	-	-	-
Chromium III	-	9.39E-04	-	1.50E+00	-	4.03E-04	-	-	-
Copper	1.70E-03	9.39E-04	1.60E-06	3.70E-02	4.32E-05	4.03E-04	6.84E-07	-	-
Cyanide	2.10E-03	9.39E-04	1.97E-06	2.00E-02	9.86E-05	4.03E-04	8.45E-07	-	-
Lead	1.00E-03	9.39E-04	9.39E-07	-	-	4.03E-04	4.03E-07	-	-
Manganese-w	7.20E-03	9.39E-04	6.76E-06	4.70E-02	1.44E-04	4.03E-04	2.90E-06	-	-
Mercury	-	9.39E-04	-	3.00E-04	-	4.03E-04	-	-	-
Nickel	-	9.39E-04	-	2.00E-02	-	4.03E-04	-	-	-
Selenium	-	9.39E-04	-	5.00E-03	-	4.03E-04	-	-	-
Silver	-	9.39E-04	-	5.00E-03	-	4.03E-04	-	-	-
Zinc	-	9.39E-04	-	3.00E-01	-	4.03E-04	-	-	-
				Hazard Index =	4.29E-04			Cancer Risk =	0.00E+00

AREA 1 (UPGRADIENT WETLAND)
SURFACE WATER DERMAL - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	PC	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.53E-01	1.00E-03	9.39E-06	1.44E-06	2.00E-01	7.19E-06	4.03E-06	6.16E-07	-	-
Antimony	-	1.00E-03	9.39E-06	-	8.00E-05	-	4.03E-06	-	-	-
Arsenic	-	1.00E-03	9.39E-06	-	2.85E-04	-	4.03E-06	-	1.58E+00	-
Cadmium	-	1.00E-03	9.39E-06	-	2.50E-05	-	4.03E-06	-	-	-
Chromium III	-	1.00E-03	9.39E-06	-	3.00E-01	-	4.03E-06	-	-	-
Copper	1.70E-03	1.00E-03	9.39E-06	1.60E-08	7.40E-03	2.16E-06	4.03E-06	6.84E-09	-	-
Cyanide	2.10E-03	1.00E-03	9.39E-06	1.97E-08	4.00E-03	4.93E-06	4.03E-06	8.45E-09	-	-
Lead	1.00E-03	1.00E-04	9.39E-07	9.39E-10	-	-	4.03E-07	4.03E-10	-	-
Manganese-w	7.20E-03	1.00E-03	9.39E-06	6.76E-08	9.40E-03	7.19E-06	4.03E-06	2.90E-08	-	-
Mercury	-	1.00E-03	9.39E-06	-	6.00E-05	-	4.03E-06	-	-	-
Nickel	-	2.00E-04	1.88E-06	-	4.00E-03	-	8.05E-07	-	-	-
Selenium	-	1.00E-03	9.39E-06	-	1.00E-03	-	4.03E-06	-	-	-
Silver	-	6.00E-04	5.64E-06	-	1.00E-03	-	2.42E-06	-	-	-
Zinc	-	1.00E-03	9.39E-06	-	6.00E-02	-	4.03E-06	-	-	-
					Hazard Index =	2.15E-05			Cancer Risk =	0.00E+00

AREA 1 (KEYWAY WETLAND)
SOIL INGESTION - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.30E+04	3.13E-07	4.07E-03	1.00E+00	4.07E-03	4.47E-09	5.81E-05	-	-
Antimony	3.33E+02	3.13E-07	1.04E-04	4.00E-04	2.61E-01	4.47E-09	1.49E-06	-	-
Arsenic	6.34E+02	3.13E-07	1.19E-04	3.00E-04	3.79E-01	4.47E-09	1.70E-06	1.50E+00	2.55E-06
Cadmium	-	3.13E-07	-	1.00E-03	-	4.47E-09	-	-	-
Chromium III	7.10E+00	3.13E-07	2.22E-06	1.50E+00	1.48E-06	4.47E-09	3.18E-08	-	-
Copper	1.96E+01	3.13E-07	6.14E-06	3.70E-02	1.66E-04	4.47E-09	8.77E-08	-	-
Cyanide	2.70E-01	3.13E-07	8.45E-08	2.00E-02	4.23E-06	4.47E-09	1.21E-09	-	-
Lead	4.78E+01	3.13E-07	1.50E-05	-		4.47E-09	2.14E-07	-	-
Manganese	2.33E+02	3.13E-07	7.30E-05	1.40E-01	5.21E-04	4.47E-09	1.04E-06	-	-
Mercury	8.90E-01	3.13E-07	2.79E-07	3.00E-04	9.29E-04	4.47E-09	3.98E-09	-	-
Nickel	5.90E+00	3.13E-07	1.85E-06	2.00E-02	9.24E-05	4.47E-09	2.64E-08	-	-
Selenium	5.20E-01	3.13E-07	1.63E-07	5.00E-03	3.26E-05	4.47E-09	2.33E-09	-	-
Silver	2.80E+00	3.13E-07	8.77E-07	5.00E-03	1.75E-04	4.47E-09	1.25E-08	-	-
Zinc	4.09E+01	3.13E-07	1.28E-05	3.00E-01	4.27E-05	4.47E-09	1.83E-07	-	-
				Hazard Index =	6.64E-01			Total Cancer Risk =	2.55E-06

[1] Chemical intake for arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

AREA 1 (KEYWAY WETLAND)
SOIL DERMAL - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	ABS	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.30E+04	1.00E-02	1.57E-08	2.04E-04	2.00E-01	1.02E-03	2.24E-10	2.91E-06	-	-
Antimony	3.33E+02	1.00E-02	1.57E-08	5.21E-06	8.00E-05	6.52E-02	2.24E-10	7.45E-08	-	-
Arsenic	6.34E+02	3.00E-02	4.70E-08	2.98E-05	2.85E-04	1.04E-01	6.71E-10	4.25E-07	1.58E+00	6.72E-07
Cadmium	-	1.00E-02	1.57E-08	-	2.50E-05	-	2.24E-10	-	-	-
Chromium III	7.10E+00	1.00E-02	1.57E-08	1.11E-07	3.00E-01	3.71E-07	2.24E-10	1.59E-09	-	-
Copper	1.96E+01	1.00E-02	1.57E-08	3.07E-07	7.40E-03	4.15E-05	2.24E-10	4.38E-09	-	-
Cyanide	2.70E-01	1.00E-02	1.57E-08	4.23E-09	4.00E-03	1.06E-06	2.24E-10	6.04E-11	-	-
Lead	4.78E+01	1.00E-02	1.57E-08	7.48E-07	-		2.24E-10	1.07E-08	-	-
Manganese	2.33E+02	1.00E-02	1.57E-08	3.65E-06	2.80E-02	1.30E-04	2.24E-10	5.21E-08	-	-
Mercury	8.90E-01	1.00E-02	1.57E-08	1.39E-08	6.00E-05	2.32E-04	2.24E-10	1.99E-10	-	-
Nickel	5.90E+00	1.00E-02	1.57E-08	9.24E-08	4.00E-03	2.31E-05	2.24E-10	1.32E-09	-	-
Selenium	5.20E-01	1.00E-02	1.57E-08	8.14E-09	1.00E-03	8.14E-06	2.24E-10	1.16E-10	-	-
Silver	2.80E+00	1.00E-02	1.57E-08	4.38E-08	1.00E-03	4.38E-05	2.24E-10	6.26E-10	-	-
Zinc	4.09E+01	1.00E-02	1.57E-08	6.40E-07	6.00E-02	1.07E-05	2.24E-10	9.15E-09	-	-
					Hazard Index =	1.71E-01			Total Cancer Risk =	6.72E-07

AREA 1 (KEYWAY WETLAND)
INHALATION (PARTICULATE MATTER) - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)$^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)$^{-1}$	Cancer Risk
Aluminum	1.30E+04	8.30E-11	1.08E-06	1.40E-03	7.71E-04	1.19E-12	1.54E-08	-	-
Antimony	3.33E+02	8.30E-11	2.76E-08	-	-	1.19E-12	3.95E-10	-	-
Arsenic	6.34E+02	8.30E-11	5.26E-08	-	-	1.19E-12	7.52E-10	1.50E+01	1.13E-08
Cadmium	-	8.30E-11	-	-	-	1.19E-12	-	6.30E+00	-
Chromium III	7.10E+00	8.30E-11	5.89E-10	-	-	1.19E-12	8.42E-12	-	-
Copper	1.96E+01	8.30E-11	1.63E-09	-	-	1.19E-12	2.32E-11	-	-
Cyanide	2.70E-01	8.30E-11	2.24E-11	-	-	1.19E-12	3.20E-13	-	-
Lead	4.78E+01	8.30E-11	3.97E-09	-	-	1.19E-12	5.67E-11	-	-
Manganese	2.33E+02	8.30E-11	1.93E-08	1.40E-05	1.38E-03	1.19E-12	2.76E-10	-	-
Mercury	8.90E-01	8.30E-11	7.39E-11	8.60E-05	8.59E-07	1.19E-12	1.06E-12	-	-
Nickel	5.90E+00	8.30E-11	4.90E-10	-	-	1.19E-12	7.00E-12	8.40E-01	5.88E-12
Selenium	5.20E-01	8.30E-11	4.32E-11	-	-	1.19E-12	6.17E-13	-	-
Silver	2.80E+00	8.30E-11	2.32E-10	-	-	1.19E-12	3.32E-12	-	-
Zinc	4.09E+01	8.30E-11	3.40E-09	-	-	1.19E-12	4.85E-11	-	-
				Hazard Index =	2.15E-03			Cancer Risk =	1.13E-08

AREA 1 (KEYWAY WETLAND)
SURFACE WATER INGESTION - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.20E-01	1.25E-05	1.50E-06	1.00E+00	1.50E-06	1.79E-07	2.15E-08	-	-
Antimony	1.27E-01	1.25E-05	1.59E-06	4.00E-04	3.98E-03	1.79E-07	2.27E-08	-	-
Arsenic	4.63E-01	1.25E-05	5.80E-06	3.00E-04	1.93E-02	1.79E-07	8.28E-08	1.50E+00	1.24E-07
Cadmium	-	1.25E-05	-	1.00E-03	-	1.79E-07	-	-	-
Chromium III	-	1.25E-05	-	1.50E+00	-	1.79E-07	-	-	-
Copper	-	1.25E-05	-	3.70E-02	-	1.79E-07	-	-	-
Cyanide	5.60E-03	1.25E-05	7.01E-08	2.00E-02	3.51E-06	1.79E-07	1.00E-09	-	-
Lead	-	1.25E-05	-	-	-	1.79E-07	-	-	-
Manganese-w	7.85E-01	1.25E-05	9.83E-06	4.70E-02	2.09E-04	1.79E-07	1.40E-07	-	-
Mercury	1.18E-04	1.25E-05	1.48E-09	3.00E-04	4.93E-06	1.79E-07	2.11E-11	-	-
Nickel	-	1.25E-05	-	2.00E-02	-	1.79E-07	-	-	-
Selenium	-	1.25E-05	-	5.00E-03	-	1.79E-07	-	-	-
Silver	-	1.25E-05	-	5.00E-03	-	1.79E-07	-	-	-
Zinc	4.40E-03	1.25E-05	5.51E-08	3.00E-01	1.84E-07	1.79E-07	7.87E-10	-	-
				Hazard Index =	2.35E-02			Cancer Risk =	1.24E-07

AREA 1 (KEYWAY WETLAND)
SURFACE WATER DERMAL- RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	PC	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.20E-01	1.00E-03	6.26E-05	7.51E-06	2.00E-01	3.76E-05	8.95E-07	1.07E-07	-	
Antimony	1.27E-01	1.00E-03	6.26E-05	7.95E-06	8.00E-05	9.94E-02	8.95E-07	1.14E-07	-	
Arsenic	4.63E-01	1.00E-03	6.26E-05	2.90E-05	2.85E-04	1.02E-01	8.95E-07	4.14E-07	1.58E+00	6.54E-07
Cadmium	-	1.00E-03	6.26E-05	-	2.50E-05	-	8.95E-07	-	-	
Chromium III	-	1.00E-03	6.26E-05	-	3.00E-01	-	8.95E-07	-	-	
Copper	-	1.00E-03	6.26E-05	-	7.40E-03	-	8.95E-07	-	-	
Cyanide	5.60E-03	1.00E-03	6.26E-05	3.51E-07	4.00E-03	8.77E-05	8.95E-07	5.01E-09	-	
Lead	-	1.00E-04	6.26E-06	-	-	-	8.95E-08	-	-	
Manganese-w	7.85E-01	1.00E-03	6.26E-05	4.92E-05	9.40E-03	5.23E-03	8.95E-07	7.02E-07	-	
Mercury	1.18E-04	1.00E-03	6.26E-05	7.39E-09	6.00E-05	1.23E-04	8.95E-07	1.06E-10	-	
Nickel	-	2.00E-04	1.25E-05	-	4.00E-03	-	1.79E-07	-	-	
Selenium	-	1.00E-03	6.26E-05	-	1.00E-03	-	8.95E-07	-	-	
Silver	-	6.00E-04	3.76E-05	-	1.00E-03	-	5.37E-07	-	-	
Zinc	4.40E-03	1.00E-03	6.26E-05	2.76E-07	6.00E-02	4.59E-06	8.95E-07	3.94E-09	-	
					Hazard Index =	2.07E-01			Cancer Risk =	6.54E-07

AREA 1 (KEYWAY WETLAND)
SOIL INGESTION - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.30E+04	5.87E-09	7.63E-05	1.00E+00	7.63E-05	2.52E-09	3.27E-05	-	-
Antimony	3.33E+02	5.87E-09	1.95E-06	4.00E-04	4.89E-03	2.52E-09	8.38E-07	-	-
Arsenic	6.34E+02	5.87E-09	2.23E-06	3.00E-04	7.44E-03	2.52E-09	9.57E-07	1.50E+00	1.44E-06
Cadmium	-	5.87E-09	-	1.00E-03	-	2.52E-09	-	-	-
Chromium III	7.10E+00	5.87E-09	4.17E-08	1.50E+00	2.78E-08	2.52E-09	1.79E-08	-	-
Copper	1.96E+01	5.87E-09	1.15E-07	3.70E-02	3.11E-06	2.52E-09	4.93E-08	-	-
Cyanide	2.70E-01	5.87E-09	1.59E-09	2.00E-02	7.93E-08	2.52E-09	6.79E-10	-	-
Lead	4.78E+01	5.87E-09	2.81E-07	-	-	2.52E-09	1.20E-07	-	-
Manganese	2.33E+02	5.87E-09	1.37E-06	1.40E-01	9.77E-06	2.52E-09	5.86E-07	-	-
Mercury	8.90E-01	5.87E-09	5.23E-09	3.00E-04	1.74E-05	2.52E-09	2.24E-09	-	-
Nickel	5.90E+00	5.87E-09	3.46E-08	2.00E-02	1.73E-06	2.52E-09	1.48E-08	-	-
Selenium	5.20E-01	5.87E-09	3.05E-09	5.00E-03	6.11E-07	2.52E-09	1.31E-09	-	-
Silver	2.80E+00	5.87E-09	1.64E-08	5.00E-03	3.29E-06	2.52E-09	7.05E-09	-	-
Zinc	4.09E+01	5.87E-09	2.40E-07	3.00E-01	8.00E-07	2.52E-09	1.03E-07	-	-
				Hazard Index =	1.24E-02			Total Cancer Risk =	1.44E-06

[1] Chemical intake for arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

AREA 1 (KEYWAY WETLAND)
SOIL DERMAL - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	ABS	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.30E+04	1.00E-02	2.35E-09	3.05E-05	2.00E-01	1.53E-04	1.01E-09	1.31E-05	-	-
Antimony	3.33E+02	1.00E-02	2.35E-09	7.82E-07	8.00E-05	9.77E-03	1.01E-09	3.35E-07	-	-
Arsenic	6.34E+02	3.00E-02	7.05E-09	4.47E-06	2.85E-04	1.57E-02	3.02E-09	1.91E-06	1.58E+00	3.02E-06
Cadmium	-	1.00E-02	2.35E-09	-	2.50E-05	-	1.01E-09	-	-	-
Chromium III	7.10E+00	1.00E-02	2.35E-09	1.67E-08	3.00E-01	5.56E-08	1.01E-09	7.15E-09	-	-
Copper	1.96E+01	1.00E-02	2.35E-09	4.60E-08	7.40E-03	6.22E-06	1.01E-09	1.97E-08	-	-
Cyanide	2.70E-01	1.00E-02	2.35E-09	6.34E-10	4.00E-03	1.59E-07	1.01E-09	2.72E-10	-	-
Lead	4.78E+01	1.00E-02	2.35E-09	1.12E-07	-		1.01E-09	4.81E-08	-	-
Manganese	2.33E+02	1.00E-02	2.35E-09	5.47E-07	2.80E-02	1.95E-05	1.01E-09	2.34E-07	-	-
Mercury	8.90E-01	1.00E-02	2.35E-09	2.09E-09	6.00E-05	3.48E-05	1.01E-09	8.96E-10	-	-
Nickel	5.90E+00	1.00E-02	2.35E-09	1.39E-08	4.00E-03	3.46E-06	1.01E-09	5.94E-09	-	-
Selenium	5.20E-01	1.00E-02	2.35E-09	1.22E-09	1.00E-03	1.22E-06	1.01E-09	5.23E-10	-	-
Silver	2.80E+00	1.00E-02	2.35E-09	6.58E-09	1.00E-03	6.58E-06	1.01E-09	2.82E-09	-	-
Zinc	4.09E+01	1.00E-02	2.35E-09	9.60E-08	6.00E-02	1.60E-06	1.01E-09	4.12E-08	-	-
					Hazard Index =	2.57E-02			Total Cancer Risk =	3.02E-06

AREA 1 (KEYWAY WETLAND)
INHALATION (PARTICULATE MATTER) - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.30E+04	7.12E-13	9.25E-09	1.40E-03	6.61E-06	3.05E-13	3.96E-09	-	-
Antimony	3.33E+02	7.12E-13	2.37E-10	-	-	3.05E-13	1.02E-10	-	-
Arsenic	6.34E+02	7.12E-13	4.51E-10	-	-	3.05E-13	1.93E-10	1.50E+01	2.90E-09
Cadmium	-	7.12E-13	-	-	-	3.05E-13	-	6.30E+00	-
Chromium III	7.10E+00	7.12E-13	5.05E-12	-	-	3.05E-13	2.17E-12	-	-
Copper	1.96E+01	7.12E-13	1.39E-11	-	-	3.05E-13	5.98E-12	-	-
Cyanide	2.70E-01	7.12E-13	1.92E-13	-	-	3.05E-13	8.23E-14	-	-
Lead	4.78E+01	7.12E-13	3.40E-11	-	-	3.05E-13	1.46E-11	-	-
Manganese	2.33E+02	7.12E-13	1.66E-10	1.40E-05	1.18E-05	3.05E-13	7.11E-11	-	-
Mercury	8.90E-01	7.12E-13	6.33E-13	8.60E-05	7.36E-09	3.05E-13	2.71E-13	-	-
Nickel	5.90E+00	7.12E-13	4.20E-12	-	-	3.05E-13	1.80E-12	8.40E-01	1.51E-12
Selenium	5.20E-01	7.12E-13	3.70E-13	-	-	3.05E-13	1.59E-13	-	-
Silver	2.80E+00	7.12E-13	1.99E-12	-	-	3.05E-13	8.54E-13	-	-
Zinc	4.09E+01	7.12E-13	2.91E-11	-	-	3.05E-13	1.25E-11	-	-
				Hazard Index =	1.85E-05			Cancer Risk =	2.90E-09

AREA 1 (KEYWAY WETLAND)
SURFACE WATER INGESTION - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.20E-01	9.39E-04	1.13E-04	1.00E+00	1.13E-04	4.03E-04	4.83E-05	-	-
Antimony	1.27E-01	9.39E-04	1.19E-04	4.00E-04	2.98E-01	4.03E-04	5.11E-05	-	-
Arsenic	4.63E-01	9.39E-04	4.35E-04	3.00E-04	1.45E+00	4.03E-04	1.86E-04	1.50E+00	2.80E-04
Cadmium	-	9.39E-04	-	1.00E-03	-	4.03E-04	-	-	-
Chromium III	-	9.39E-04	-	1.50E+00	-	4.03E-04	-	-	-
Copper	-	9.39E-04	-	3.70E-02	-	4.03E-04	-	-	-
Cyanide	5.60E-03	9.39E-04	5.26E-06	2.00E-02	2.63E-04	4.03E-04	2.25E-06	-	-
Lead	-	9.39E-04	-	-		4.03E-04	-	-	-
Manganese-w	7.85E-01	9.39E-04	7.37E-04	4.70E-02	1.57E-02	4.03E-04	3.16E-04	-	-
Mercury	1.18E-04	9.39E-04	1.11E-07	3.00E-04	3.69E-04	4.03E-04	4.75E-08	-	-
Nickel	-	9.39E-04	-	2.00E-02	-	4.03E-04	-	-	-
Selenium	-	9.39E-04	-	5.00E-03	-	4.03E-04	-	-	-
Silver	-	9.39E-04	-	5.00E-03	-	4.03E-04	-	-	-
Zinc	4.40E-03	9.39E-04	4.13E-06	3.00E-01	1.38E-05	4.03E-04	1.77E-06	-	-
				Hazard Index =	1.76E+00			Cancer Risk =	2.80E-04

AREA 1 (KEYWAY WETLAND)
SURFACE WATER DERMAL - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	PC	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.20E-01	1.00E-03	9.39E-06	1.13E-06	2.00E-01	5.64E-06	4.03E-06	4.83E-07	-	
Antimony	1.27E-01	1.00E-03	9.39E-06	1.19E-06	8.00E-05	1.49E-02	4.03E-06	5.11E-07	-	
Arsenic	4.63E-01	1.00E-03	9.39E-06	4.35E-06	2.85E-04	1.53E-02	4.03E-06	1.86E-06	1.58E+00	2.94E-06
Cadmium	-	1.00E-03	9.39E-06	-	2.50E-05	-	4.03E-06	-	-	
Chromium III	-	1.00E-03	9.39E-06	-	3.00E-01	-	4.03E-06	-	-	
Copper	-	1.00E-03	9.39E-06	-	7.40E-03	-	4.03E-06	-	-	
Cyanide	5.60E-03	1.00E-03	9.39E-06	5.26E-08	4.00E-03	1.32E-05	4.03E-06	2.25E-08	-	
Lead	-	1.00E-04	9.39E-07	-	-		4.03E-07	-	-	
Manganese-w	7.85E-01	1.00E-03	9.39E-06	7.37E-06	9.40E-03	7.84E-04	4.03E-06	3.16E-06	-	
Mercury	1.18E-04	1.00E-03	9.39E-06	1.11E-09	6.00E-05	1.85E-05	4.03E-06	4.75E-10	-	
Nickel	-	2.00E-04	1.88E-06	-	4.00E-03	-	8.05E-07	-	-	
Selenium	-	1.00E-03	9.39E-06	-	1.00E-03	-	4.03E-06	-	-	
Silver	-	6.00E-04	5.64E-06	-	1.00E-03	-	2.42E-06	-	-	
Zinc	4.40E-03	1.00E-03	9.39E-06	4.13E-08	6.00E-02	6.89E-07	4.03E-06	1.77E-08	-	
					Hazard Index =	3.10E-02			Cancer Risk =	2.94E-06

AREA 1 (MEADOW CREEK FORESTED WETLAND)
SOIL INGESTION - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)-1	Cancer Risk
Aluminum	3.42E+04	3.13E-07	1.07E-02	1.00E+00	1.07E-02	4.47E-09	1.53E-04	-	
Antimony	1.55E+03	3.13E-07	4.85E-04	4.00E-04	1.21E+00	4.47E-09	6.93E-06	-	
Arsenic	1.23E+03	3.13E-07	2.31E-04	3.00E-04	7.70E-01	4.47E-09	3.30E-06	1.50E+00	4.95E-06
Cadmium	1.30E-01	3.13E-07	4.07E-08	1.00E-03	4.07E-05	4.47E-09	5.81E-10	-	
Chromium III	1.43E+01	3.13E-07	4.48E-06	1.50E+00	2.98E-06	4.47E-09	6.40E-08	-	
Copper	6.88E+01	3.13E-07	2.15E-05	3.70E-02	5.82E-04	4.47E-09	3.08E-07	-	
Cyanide	-	3.13E-07	-	2.00E-02	-	4.47E-09	-	-	
Lead	1.60E+02	3.13E-07	5.01E-05	-		4.47E-09	7.16E-07	-	
Manganese	1.99E+02	3.13E-07	6.23E-05	1.40E-01	4.45E-04	4.47E-09	8.90E-07	-	
Mercury	3.10E+00	3.13E-07	9.71E-07	3.00E-04	3.24E-03	4.47E-09	1.39E-08	-	
Nickel	8.00E+00	3.13E-07	2.50E-06	2.00E-02	1.25E-04	4.47E-09	3.58E-08	-	
Selenium	5.30E+00	3.13E-07	1.66E-06	5.00E-03	3.32E-04	4.47E-09	2.37E-08	-	
Silver	1.96E+01	3.13E-07	6.14E-06	5.00E-03	1.23E-03	4.47E-09	8.77E-08	-	
Zinc	7.09E+01	3.13E-07	2.22E-05	3.00E-01	7.40E-05	4.47E-09	3.17E-07	-	
				Hazard Index =	2.00E+00			Total Cancer Risk =	4.95E-06

[1] Chemical intake for arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

AREA 1 (MEADOW CREEK FORESTED WETLAND)
SOIL DERMAL - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Absorption Factor	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	3.42E+04	1.00E-02	1.57E-06	5.35E-04	2.00E-01	2.68E-03	2.24E-08	7.65E-06	-	-
Antimony	1.55E+03	1.00E-02	1.57E-06	2.43E-05	8.00E-05	3.03E-01	2.24E-08	3.47E-07	-	-
Arsenic	1.23E+03	3.00E-02	1.57E-06	5.78E-05	2.85E-04	2.03E-01	2.24E-08	8.25E-07	1.58E+00	1.30E-06
Cadmium	1.30E-01	1.00E-02	1.57E-06	2.04E-09	2.50E-05	8.14E-05	2.24E-08	2.91E-11	-	-
Chromium III	1.43E+01	1.00E-02	1.57E-06	2.24E-07	3.00E-01	7.46E-07	2.24E-08	3.20E-09	-	-
Copper	6.88E+01	1.00E-02	1.57E-06	1.08E-06	7.40E-03	1.46E-04	2.24E-08	1.54E-08	-	-
Cyanide	-	1.00E-02	1.57E-06	-	4.00E-03	-	2.24E-08	-	-	-
Lead	1.60E+02	1.00E-02	1.57E-06	2.50E-06	-	-	2.24E-08	3.58E-08	-	-
Manganese	1.99E+02	1.00E-02	1.57E-06	3.12E-06	2.80E-02	1.11E-04	2.24E-08	4.45E-08	-	-
Mercury	3.10E+00	1.00E-02	1.57E-06	4.85E-08	6.00E-05	8.09E-04	2.24E-08	6.93E-10	-	-
Nickel	8.00E+00	1.00E-02	1.57E-06	1.25E-07	4.00E-03	3.13E-05	2.24E-08	1.79E-09	-	-
Selenium	5.30E+00	1.00E-02	1.57E-06	8.30E-08	1.00E-03	8.30E-05	2.24E-08	1.19E-09	-	-
Silver	1.96E+01	1.00E-02	1.57E-06	3.07E-07	1.00E-03	3.07E-04	2.24E-08	4.38E-09	-	-
Zinc	7.09E+01	1.00E-02	1.57E-06	1.11E-06	6.00E-02	1.85E-05	2.24E-08	1.59E-08	-	-
					Hazard Index =	5.10E-01			Total Cancer Risk =	1.30E-06

AREA 1 (MEADOW CREEK FORESTED WETLAND)
INHALATION (PARTICULATE MATTER) - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)$^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg day)$^{-1}$	Cancer Risk
Aluminum	3.42E+04	8.30E-11	2.84E-06	1.40E-03	2.03E-03	1.19E-12	4.06E-08	-	-
Antimony	1.55E+03	8.30E-11	1.29E-07	-		1.19E-12	1.84E-09	-	-
Arsenic	1.23E+03	8.30E-11	1.02E-07	-		1.19E-12	1.46E-09	1.50E+01	2.19E-08
Cadmium	1.30E-01	8.30E-11	1.08E-11	-		1.19E-12	1.54E-13	6.30E+00	9.71E-13
Chromium III	1.43E+01	8.30E-11	1.19E-09	-		1.19E-12	1.70E-11	-	-
Copper	6.88E+01	8.30E-11	5.71E-09	-		1.19E-12	8.16E-11	-	-
Cyanide	-	8.30E-11	-	-		1.19E-12	-	-	-
Lead	1.60E+02	8.30E-11	1.33E-08	-		1.19E-12	1.90E-10	-	-
Manganese	1.99E+02	8.30E-11	1.65E-08	1.40E-05	1.18E-03	1.19E-12	2.36E-10	-	-
Mercury	3.10E+00	8.30E-11	2.57E-10	8.60E-05	2.99E-06	1.19E-12	3.68E-12	-	-
Nickel	8.00E+00	8.30E-11	6.64E-10	-		1.19E-12	9.49E-12	8.40E-01	7.97E-12
Selenium	5.30E+00	8.30E-11	4.40E-10	-		1.19E-12	6.29E-12	-	-
Silver	1.96E+01	8.30E-11	1.63E-09	-		1.19E-12	2.32E-11	-	-
Zinc	7.09E+01	8.30E-11	5.89E-09	-		1.19E-12	8.41E-11	-	-
				Hazard Index =	3.21E-03			Cancer Risk =	2.19E-08

AREA 1 (MEADOW CREEK FORESTED WETLAND)
SOIL INGESTION - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)-1	Cancer Risk
Aluminum	3.42E+04	5.87E-09	2.01E-04	1.00E+00	2.01E-04	2.52E-09	8.60E-05	-	-
Antimony	1.55E+03	5.87E-09	9.10E-06	4.00E-04	2.27E-02	2.52E-09	3.90E-06	-	-
Arsenic	1.23E+03	5.87E-09	4.33E-06	3.00E-04	1.44E-02	2.52E-09	1.86E-06	1.50E+00	2.79E-06
Cadmium	1.30E-01	5.87E-09	7.63E-10	1.00E-03	7.63E-07	2.52E-09	3.27E-10	-	-
Chromium III	1.43E+01	5.87E-09	8.40E-08	1.50E+00	5.60E-08	2.52E-09	3.60E-08	-	-
Copper	6.88E+01	5.87E-09	4.04E-07	3.70E-02	1.09E-05	2.52E-09	1.73E-07	-	-
Cyanide	-	5.87E-09	-	2.00E-02	-	2.52E-09	-	-	-
Lead	1.60E+02	5.87E-09	9.39E-07	-		2.52E-09	4.03E-07	-	-
Manganese	1.99E+02	5.87E-09	1.17E-06	1.40E-01	8.34E-06	2.52E-09	5.01E-07	-	-
Mercury	3.10E+00	5.87E-09	1.82E-08	3.00E-04	6.07E-05	2.52E-09	7.80E-09	-	-
Nickel	8.00E+00	5.87E-09	4.70E-08	2.00E-02	2.35E-06	2.52E-09	2.01E-08	-	-
Selenium	5.30E+00	5.87E-09	3.11E-08	5.00E-03	6.22E-06	2.52E-09	1.33E-08	-	-
Silver	1.96E+01	5.87E-09	1.15E-07	5.00E-03	2.30E-05	2.52E-09	4.93E-08	-	-
Zinc	7.09E+01	5.87E-09	4.16E-07	3.00E-01	1.39E-06	2.52E-09	1.78E-07	-	-
				Hazard Index =	3.75E-02			Total Cancer Risk =	2.79E-06

[1] Chemical intake for arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

AREA 1 (MEADOW CREEK FORESTED WETLAND)
SOIL DERMAL - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Absorptio n Factor	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	3.42E+04	1.00E-02	2.35E-07	8.03E-05	2.00E-01	4.02E-04	1.01E-07	3.44E-05	-	-
Antimony	1.55E+03	1.00E-02	2.35E-07	3.64E-06	8.00E-05	4.55E-02	1.01E-07	1.56E-06	-	-
Arsenic	1.23E+03	3.00E-02	2.35E-07	8.67E-06	2.85E-04	3.04E-02	1.01E-07	3.71E-06	1.58E+00	5.86E-06
Cadmium	1.30E-01	1.00E-02	2.35E-07	3.05E-10	2.50E-05	1.22E-05	1.01E-07	1.31E-10	-	-
Chromium III	1.43E+01	1.00E-02	2.35E-07	3.36E-08	3.00E-01	1.12E-07	1.01E-07	1.44E-08	-	-
Copper	6.88E+01	1.00E-02	2.35E-07	1.62E-07	7.40E-03	2.18E-05	1.01E-07	6.92E-08	-	-
Cyanide	-	1.00E-02	2.35E-07	-	4.00E-03	-	1.01E-07	-	-	-
Lead	1.60E+02	1.00E-02	2.35E-07	3.76E-07	-	-	1.01E-07	1.61E-07	-	-
Manganese	1.99E+02	1.00E-02	2.35E-07	4.67E-07	2.80E-02	1.67E-05	1.01E-07	2.00E-07	-	-
Mercury	3.10E+00	1.00E-02	2.35E-07	7.28E-09	6.00E-05	1.21E-04	1.01E-07	3.12E-09	-	-
Nickel	8.00E+00	1.00E-02	2.35E-07	1.88E-08	4.00E-03	4.70E-06	1.01E-07	8.05E-09	-	-
Selenium	5.30E+00	1.00E-02	2.35E-07	1.24E-08	1.00E-03	1.24E-05	1.01E-07	5.33E-09	-	-
Silver	1.96E+01	1.00E-02	2.35E-07	4.60E-08	1.00E-03	4.60E-05	1.01E-07	1.97E-08	-	-
Zinc	7.09E+01	1.00E-02	2.35E-07	1.66E-07	6.00E-02	2.77E-06	1.01E-07	7.14E-08	-	-
					Hazard Index =	7.65E-02			Total Cancer Risk =	5.86E-06

AREA 1 (MEADOW CREEK FORESTED WETLAND)
INHALATION (PARTICULATE MATTER) - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg day)-1	Cancer Risk
Aluminum	3.42E+04	7.12E-13	2.43E-08	1.40E-03	1.74E-05	3.05E-13	1.04E-08	-	-
Antimony	1.55E+03	7.12E-13	1.10E-09	-	-	3.05E-13	4.73E-10	-	-
Arsenic	1.23E+03	7.12E-13	8.75E-10	-	-	3.05E-13	3.75E-10	1.50E+01	5.63E-09
Cadmium	1.30E-01	7.12E-13	9.25E-14	-	-	3.05E-13	3.96E-14	6.30E+00	2.50E-13
Chromium III	1.43E+01	7.12E-13	1.02E-11	-	-	3.05E-13	4.36E-12	-	-
Copper	6.88E+01	7.12E-13	4.90E-11	-	-	3.05E-13	2.10E-11	-	-
Cyanide	-	7.12E-13	-	-	-	3.05E-13	-	-	-
Lead	1.60E+02	7.12E-13	1.14E-10	-	-	3.05E-13	4.88E-11	-	-
Manganese	1.99E+02	7.12E-13	1.42E-10	1.40E-05	1.01E-05	3.05E-13	6.07E-11	-	-
Mercury	3.10E+00	7.12E-13	2.21E-12	8.60E-05	2.57E-08	3.05E-13	9.45E-13	-	-
Nickel	8.00E+00	7.12E-13	5.69E-12	-	-	3.05E-13	2.44E-12	8.40E-01	2.05E-12
Selenium	5.30E+00	7.12E-13	3.77E-12	-	-	3.05E-13	1.62E-12	-	-
Silver	1.96E+01	7.12E-13	1.39E-11	-	-	3.05E-13	5.98E-12	-	-
Zinc	7.09E+01	7.12E-13	5.05E-11	-	-	3.05E-13	2.16E-11	-	-
				Hazard Index =	2.75E-05			Cancer Risk =	5.63E-09

SOUTHEAST DUMP AND MIDNIGHT CREEK
SOIL INGESTION - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ($(mg/kg\text{-}day)^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF $(mg/kg\text{-}day)^{-1}$	Cancer Risk
Aluminum	4.74E+03	3.13E-07	1.48E-03	1.00E+00	1.48E-03	4.47E-09	2.12E-05	-	-
Antimony	7.00E-01	3.13E-07	2.19E-07	4.00E-04	5.48E-04	4.47E-09	3.13E-09	-	-
Arsenic	4.97E+03	3.13E-07	9.34E-04	3.00E-04	3.11E+00	4.47E-09	1.33E-05	1.50E+00	2.00E-05
Cadmium	-	3.13E-07	-	1.00E-03	-	4.47E-09	-	-	-
Chromium III	5.70E+00	3.13E-07	1.78E-06	1.50E+00	1.19E-06	4.47E-09	2.55E-08	-	-
Copper	7.27E+00	3.13E-07	2.28E-06	3.70E-02	6.15E-05	4.47E-09	3.25E-08	-	-
Cyanide	-	3.13E-07	-	2.00E-02	-	4.47E-09	-	-	-
Lead	1.15E+01	3.13E-07	3.60E-06	-	-	4.47E-09	5.14E-08	-	-
Manganese	5.61E+02	3.13E-07	1.76E-04	1.40E-01	1.25E-03	4.47E-09	2.51E-06	-	-
Mercury	2.51E+00	3.13E-07	7.86E-07	3.00E-04	2.62E-03	4.47E-09	1.12E-08	-	-
Nickel	3.89E+00	3.13E-07	1.22E-06	2.00E-02	6.09E-05	4.47E-09	1.74E-08	-	-
Selenium	-	3.13E-07	-	5.00E-03	-	4.47E-09	-	-	-
Silver	5.40E-01	3.13E-07	1.69E-07	5.00E-03	3.38E-05	4.47E-09	2.42E-09	-	-
Zinc	5.39E+01	3.13E-07	1.69E-05	3.00E-01	5.63E-05	4.47E-09	2.41E-07	-	-
				Hazard Index =	3.12E+00			Total Cancer Risk =	2.00E-05

1. Chemical Intake for Arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

SOUTHEAST DUMP AND MIDNIGHT CREEK
SOIL DERMAL - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	ABS	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	4.74E+03	1.00E-02	1.57E-08	7.42E-05	2.00E-01	3.71E-04	2.24E-10	1.06E-06	-	-
Antimony	7.00E-01	1.00E-02	1.57E-08	1.10E-08	8.00E-05	1.37E-04	2.24E-10	1.57E-10	-	-
Arsenic	4.97E+03	3.00E-02	4.70E-08	2.33E-04	2.85E-04	8.19E-01	6.71E-10	3.33E-06	1.58E+00	5.27E-06
Cadmium	-	1.00E-02	1.57E-08	-	2.50E-05	-	2.24E-10	-	-	-
Chromium III	5.70E+00	1.00E-02	1.57E-08	8.92E-08	3.00E-01	2.97E-07	2.24E-10	1.27E-09	-	-
Copper	7.27E+00	1.00E-02	1.57E-08	1.14E-07	7.40E-03	1.54E-05	2.24E-10	1.63E-09	-	-
Cyanide	-	1.00E-02	1.57E-08	-	4.00E-03	-	2.24E-10	-	-	-
Lead	1.15E+01	1.00E-02	1.57E-08	1.80E-07	-	-	2.24E-10	2.57E-09	-	-
Manganese	5.61E+02	1.00E-02	1.57E-08	8.78E-06	2.80E-02	3.14E-04	2.24E-10	1.25E-07	-	-
Mercury	2.51E+00	1.00E-02	1.57E-08	3.93E-08	6.00E-05	6.55E-04	2.24E-10	5.61E-10	-	-
Nickel	3.89E+00	1.00E-02	1.57E-08	6.09E-08	4.00E-03	1.52E-05	2.24E-10	8.70E-10	-	-
Selenium	-	1.00E-02	1.57E-08	-	1.00E-03	-	2.24E-10	-	-	-
Silver	5.40E-01	1.00E-02	1.57E-08	8.45E-09	1.00E-03	8.45E-06	2.24E-10	1.21E-10	-	-
Zinc	5.39E+01	1.00E-02	1.57E-08	8.44E-07	6.00E-02	1.41E-05	2.24E-10	1.21E-08	-	-
					Hazard Index =	8.21E-01			Total Cancer Risk =	5.27E-06

SOUTHEAST DUMP AND MIDNIGHT CREEK
INHALATION (PARTICULATE MATTER) - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ($(\text{mg/kg-day})^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)$^{-1}$	Cancer Risk
Aluminum	4.74E+03	8.30E-11	3.94E-07	1.40E-03	2.81E-04	1.19E-12	5.62E-09	-	-
Antimony	7.00E-01	8.30E-11	5.81E-11	-	-	1.19E-12	8.30E-13	-	-
Arsenic	4.97E+03	8.30E-11	4.13E-07	-	-	1.19E-12	5.89E-09	1.50E+01	8.84E-08
Cadmium	-	8.30E-11	-	-	-	1.19E-12	-	6.30E+00	-
Chromium III	5.70E+00	8.30E-11	4.73E-10	-	-	1.19E-12	6.76E-12	-	-
Copper	7.27E+00	8.30E-11	6.04E-10	-	-	1.19E-12	8.62E-12	-	-
Cyanide	-	8.30E-11	-	-	-	1.19E-12	-	-	-
Lead	1.15E+01	8.30E-11	9.55E-10	-	-	1.19E-12	1.36E-11	-	-
Manganese	5.61E+02	8.30E-11	4.66E-08	1.40E-05	3.33E-03	1.19E-12	6.65E-10	-	-
Mercury	2.51E+00	8.30E-11	2.08E-10	8.60E-05	2.42E-06	1.19E-12	2.98E-12	-	-
Nickel	3.89E+00	8.30E-11	3.23E-10	-	-	1.19E-12	4.61E-12	8.40E-01	3.88E-12
Selenium	-	8.30E-11	-	-	-	1.19E-12	-	-	-
Silver	5.40E-01	8.30E-11	4.48E-11	-	-	1.19E-12	6.40E-13	-	-
Zinc	5.39E+01	8.30E-11	4.47E-09	-	-	1.19E-12	6.39E-11	-	-
				Hazard Index =	3.61E-03			Cancer Risk =	8.84E-08

SOUTHEAST DUMP AND MIDNIGHT CREEK
SEDIMENT INGESTION - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ($(mg/kg\text{-}day)^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Sediment Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF $(mg/kg\text{-}day)^{-1}$	Cancer Risk
Aluminum	-	1.25E-07	-	1.00E+00	-	1.79E-09	-	-	-
Antimony	1.89E+01	1.25E-07	2.37E-06	4.00E-04	5.92E-03	1.79E-09	3.38E-08	-	-
Arsenic	5.64E+01	1.25E-07	4.24E-06	3.00E-04	1.41E-02	1.79E-09	6.05E-08	1.50E+00	9.08E-08
Cadmium	1.03E+00	1.25E-07	1.29E-07	1.00E-03	1.29E-04	1.79E-09	1.84E-09	-	-
Chromium III	3.00E+00	1.25E-07	3.76E-07	1.50E+00	2.50E-07	1.79E-09	5.37E-09	-	-
Copper	2.18E+00	1.25E-07	2.73E-07	3.70E-02	7.38E-06	1.79E-09	3.90E-09	-	-
Cyanide	-	1.25E-07	-	2.00E-02	-	1.79E-09	-	-	-
Lead	3.45E+00	1.25E-07	4.32E-07	-	-	1.79E-09	6.17E-09	-	-
Manganese	-	1.25E-07	-	1.40E-01	-	1.79E-09	-	-	-
Mercury	1.43E-01	1.25E-07	1.79E-08	3.00E-04	5.97E-05	1.79E-09	2.56E-10	-	-
Nickel	-	1.25E-07	-	2.00E-02	-	1.79E-09	-	-	-
Selenium	2.37E+00	1.25E-07	2.97E-07	5.00E-03	5.94E-05	1.79E-09	4.24E-09	-	-
Silver	-	1.25E-07	-	5.00E-03	-	1.79E-09	-	-	-
Zinc	1.30E+01	1.25E-07	1.63E-06	3.00E-01	5.43E-06	1.79E-09	2.33E-08	-	-
				Hazard Index =	2.03E-02			Cancer Risk =	9.08E-08

1. Chemical Intake for Arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

SOUTHEAST DUMP AND MIDNIGHT CREEK
SURFACE WATER INGESTION - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	7.90E-02	1.25E-05	9.89E-07	1.00E+00	9.89E-07	1.79E-07	1.41E-08	-	-
Antimony	3.92E-02	1.25E-05	4.91E-07	4.00E-04	1.23E-03	1.79E-07	7.01E-09	-	-
Arsenic	5.77E-02	1.25E-05	7.23E-07	3.00E-04	2.41E-03	1.79E-07	1.03E-08	1.50E+00	1.55E-08
Cadmium	-	1.25E-05	-	1.00E-03	-	1.79E-07	-	-	-
Chromium III	-	1.25E-05	-	1.50E+00	-	1.79E-07	-	-	-
Copper	-	1.25E-05	-	3.70E-02	-	1.79E-07	-	-	-
Cyanide	2.10E-03	1.25E-05	2.63E-08	2.00E-02	1.32E-06	1.79E-07	3.76E-10	-	-
Lead	4.60E-03	1.25E-05	5.76E-08	-	-	1.79E-07	8.23E-10	-	-
Manganese-w	1.54E-02	1.25E-05	1.93E-07	4.70E-02	4.10E-06	1.79E-07	2.76E-09	-	-
Mercury	1.31E-04	1.25E-05	1.64E-09	3.00E-04	5.47E-06	1.79E-07	2.34E-11	-	-
Nickel	-	1.25E-05	-	2.00E-02	-	1.79E-07	-	-	-
Selenium	-	1.25E-05	-	5.00E-03	-	1.79E-07	-	-	-
Silver	-	1.25E-05	-	5.00E-03	-	1.79E-07	-	-	-
Zinc	1.59E-02	1.25E-05	1.99E-07	3.00E-01	6.64E-07	1.79E-07	2.84E-09	-	-
				Hazard Index =	3.65E-03			Cancer Risk =	1.55E-08

SOUTHEAST DUMP AND MIDNIGHT CREEK
SURFACE WATER DERMAL- RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	PC	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	7.90E-02	1.00E-03	6.26E-05	4.95E-06	2.00E-01	2.47E-05	8.95E-07	7.07E-08	-	-
Antimony	3.92E-02	1.00E-03	6.26E-05	2.45E-06	8.00E-05	3.07E-02	8.95E-07	3.51E-08	-	-
Arsenic	5.77E-02	1.00E-03	6.26E-05	3.61E-06	2.85E-04	1.27E-02	8.95E-07	5.16E-08	1.58E+00	8.15E-08
Cadmium	-	1.00E-03	6.26E-05	-	2.50E-05	-	8.95E-07	-	-	-
Chromium III	-	1.00E-03	6.26E-05	-	3.00E-01	-	8.95E-07	-	-	-
Copper	-	1.00E-03	6.26E-05	-	7.40E-03	-	8.95E-07	-	-	-
Cyanide	2.10E-03	1.00E-03	6.26E-05	1.32E-07	4.00E-03	3.29E-05	8.95E-07	1.88E-09	-	-
Lead	4.60E-03	1.00E-04	6.26E-06	2.88E-08	-	-	8.95E-08	4.12E-10	-	-
Manganese-w	1.54E-02	1.00E-03	6.26E-05	9.64E-07	9.40E-03	1.03E-04	8.95E-07	1.38E-08	-	-
Mercury	1.31E-04	1.00E-03	6.26E-05	8.20E-09	6.00E-05	1.37E-04	8.95E-07	1.17E-10	-	-
Nickel	-	2.00E-04	1.25E-05	-	4.00E-03	-	1.79E-07	-	-	-
Selenium	-	1.00E-03	6.26E-05	-	1.00E-03	-	8.95E-07	-	-	-
Silver	-	6.00E-04	3.76E-05	-	1.00E-03	-	5.37E-07	-	-	-
Zinc	1.59E-02	1.00E-03	6.26E-05	9.96E-07	6.00E-02	1.66E-05	8.95E-07	1.42E-08	-	-
					Hazard Index =	4.37E-02			Cancer Risk =	8.15E-08

SOUTHEAST DUMP AND MIDNIGHT CREEK
SOIL INGESTION - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)$^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)$^{-1}$	Cancer Risk
Aluminum	4.74E+03	5.87E-09	2.78E-05	1.00E+00	2.78E-05	2.52E-09	1.19E-05	-	-
Antimony	7.00E-01	5.87E-09	4.11E-09	4.00E-04	1.03E-05	2.52E-09	1.76E-09	-	-
Arsenic	4.97E+03	5.87E-09	1.75E-05	3.00E-04	5.84E-02	2.52E-09	7.50E-06	1.50E+00	1.13E-05
Cadmium	-	5.87E-09	-	1.00E-03	-	2.52E-09	-	-	-
Chromium III	5.70E+00	5.87E-09	3.35E-08	1.50E+00	2.23E-08	2.52E-09	1.43E-08	-	-
Copper	7.27E+00	5.87E-09	4.27E-08	3.70E-02	1.15E-06	2.52E-09	1.83E-08	-	-
Cyanide	-	5.87E-09	-	2.00E-02	-	2.52E-09	-	-	-
Lead	1.15E+01	5.87E-09	6.75E-08	-	-	2.52E-09	2.89E-08	-	-
Manganese	5.61E+02	5.87E-09	3.29E-06	1.40E-01	2.35E-05	2.52E-09	1.41E-06	-	-
Mercury	2.51E+00	5.87E-09	1.47E-08	3.00E-04	4.91E-05	2.52E-09	6.32E-09	-	-
Nickel	3.89E+00	5.87E-09	2.28E-08	2.00E-02	1.14E-06	2.52E-09	9.79E-09	-	-
Selenium	-	5.87E-09	-	5.00E-03	-	2.52E-09	-	-	-
Silver	5.40E-01	5.87E-09	3.17E-09	5.00E-03	6.34E-07	2.52E-09	1.36E-09	-	-
Zinc	5.39E+01	5.87E-09	3.16E-07	3.00E-01	1.05E-06	2.52E-09	1.36E-07	-	-
				Hazard Index =	5.85E-02			Total Cancer Risk =	1.13E-05

1. Chemical Intake for Arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

SOUTHEAST DUMP AND MIDNIGHT CREEK
SOIL DERMAL - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	ABS	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	4.74E+03	1.00E-02	2.35E-09	1.11E-05	2.00E-01	5.57E-05	1.01E-09	4.77E-06	-	-
Antimony	7.00E-01	1.00E-02	2.35E-09	1.64E-09	8.00E-05	2.05E-05	1.01E-09	7.05E-10	-	-
Arsenic	4.97E+03	3.00E-02	7.05E-09	3.50E-05	2.85E-04	1.23E-01	3.02E-09	1.50E-05	1.58E+00	2.37E-05
Cadmium	-	1.00E-02	2.35E-09	-	2.50E-05	-	1.01E-09	-	-	-
Chromium III	5.70E+00	1.00E-02	2.35E-09	1.34E-08	3.00E-01	4.46E-08	1.01E-09	5.74E-09	-	-
Copper	7.27E+00	1.00E-02	2.35E-09	1.71E-08	7.40E-03	2.31E-06	1.01E-09	7.32E-09	-	-
Cyanide	-	1.00E-02	2.35E-09	-	4.00E-03	-	1.01E-09	-	-	-
Lead	1.15E+01	1.00E-02	2.35E-09	2.70E-08	-	-	1.01E-09	1.16E-08	-	-
Manganese	5.61E+02	1.00E-02	2.35E-09	1.32E-06	2.80E-02	4.71E-05	1.01E-09	5.65E-07	-	-
Mercury	2.51E+00	1.00E-02	2.35E-09	5.89E-09	6.00E-05	9.82E-05	1.01E-09	2.53E-09	-	-
Nickel	3.89E+00	1.00E-02	2.35E-09	9.14E-09	4.00E-03	2.28E-06	1.01E-09	3.92E-09	-	-
Selenium	-	1.00E-02	2.35E-09	-	1.00E-03	-	1.01E-09	-	-	-
Silver	5.40E-01	1.00E-02	2.35E-09	1.27E-09	1.00E-03	1.27E-06	1.01E-09	5.43E-10	-	-
Zinc	5.39E+01	1.00E-02	2.35E-09	1.27E-07	6.00E-02	2.11E-06	1.01E-09	5.42E-08	-	-
					Hazard Index =	1.23E-01			Total Cancer Risk =	2.37E-05

SOUTHEAST DUMP AND MIDNIGHT CREEK
INHALATION (PARTICULATE MATTER) - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)$^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)$^{-1}$	Cancer Risk
Aluminum	4.74E+03	7.12E-13	3.37E-09	1.40E-03	2.41E-06	3.05E-13	1.45E-09	-	-
Antimony	7.00E-01	7.12E-13	4.98E-13	-	-	3.05E-13	2.13E-13	-	-
Arsenic	4.97E+03	7.12E-13	3.54E-09	-	-	3.05E-13	1.52E-09	1.50E+01	2.27E-08
Cadmium	-	7.12E-13	. -	-	-	3.05E-13	-	6.30E+00	-
Chromium III	5.70E+00	7.12E-13	4.06E-12	-	-	3.05E-13	1.74E-12	-	-
Copper	7.27E+00	7.12E-13	5.17E-12	-	-	3.05E-13	2.22E-12	-	-
Cyanide	-	7.12E-13	-	-	-	3.05E-13	-	-	-
Lead	1.15E+01	7.12E-13	8.18E-12	-	-	3.05E-13	3.51E-12	-	-
Manganese	5.61E+02	7.12E-13	3.99E-10	1.40E-05	2.85E-05	3.05E-13	1.71E-10	-	-
Mercury	2.51E+00	7.12E-13	1.79E-12	8.60E-05	2.08E-08	3.05E-13	7.65E-13	-	-
Nickel	3.89E+00	7.12E-13	2.77E-12	-	-	3.05E-13	1.19E-12	8.40E-01	9.97E-13
Selenium	-	7.12E-13	-	-	-	3.05E-13	-	-	-
Silver	5.40E-01	7.12E-13	3.84E-13	-	-	3.05E-13	1.65E-13	-	-
Zinc	5.39E+01	7.12E-13	3.84E-11	-	-	3.05E-13	1.64E-11	-	-
				Hazard Index =	3.09E-05			Cancer Risk =	2.27E-08

SOUTHEAST DUMP AND MIDNIGHT CREEK
SEDIMENT INGESTION - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)$^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Sediment Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)$^{-1}$	Cancer Risk
Aluminum	-	1.17E-08	-	1.00E+00	-	5.03E-09	-	-	-
Antimony	1.89E+01	1.17E-08	2.22E-07	4.00E-04	5.55E-04	5.03E-09	9.51E-08	-	-
Arsenic	5.64E+01	1.17E-08	3.97E-07	3.00E-04	1.32E-03	5.03E-09	1.70E-07	1.50E+00	2.55E-07
Cadmium	1.03E+00	1.17E-08	1.21E-08	1.00E-03	1.21E-05	5.03E-09	5.18E-09	-	-
Chromium III	3.00E+00	1.17E-08	3.52E-08	1.50E+00	2.35E-08	5.03E-09	1.51E-08	-	-
Copper	2.18E+00	1.17E-08	2.56E-08	3.70E-02	6.92E-07	5.03E-09	1.10E-08	-	-
Cyanide	-	1.17E-08	-	2.00E-02	-	5.03E-09	-	-	-
Lead	3.45E+00	1.17E-08	4.05E-08	-	-	5.03E-09	1.74E-08	-	-
Manganese	-	1.17E-08	-	1.40E-01	-	5.03E-09	-	-	-
Mercury	1.43E-01	1.17E-08	1.68E-09	3.00E-04	5.60E-06	5.03E-09	7.20E-10	-	-
Nickel	-	1.17E-08	-	2.00E-02	-	5.03E-09	-	-	-
Selenium	2.37E+00	1.17E-08	2.78E-08	5.00E-03	5.57E-06	5.03E-09	1.19E-08	-	-
Silver	-	1.17E-08	-	5.00E-03	-	5.03E-09	-	-	-
Zinc	1.30E+01	1.17E-08	1.53E-07	3.00E-01	5.09E-07	5.03E-09	6.54E-08	-	-
				Hazard Index =	1.90E-03			Total Cancer Risk =	2.55E-07

1. Chemical Intake for Arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

SOUTHEAST DUMP AND MIDNIGHT CREEK
SURFACE WATER INGESTION - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	7.90E-02	9.39E-04	7.42E-05	1.00E+00	7.42E-05	4.03E-04	3.18E-05	-	-
Antimony	3.92E-02	9.39E-04	3.68E-05	4.00E-04	9.21E-02	4.03E-04	1.58E-05	-	-
Arsenic	5.77E-02	9.39E-04	5.42E-05	3.00E-04	1.81E-01	4.03E-04	2.32E-05	1.50E+00	3.48E-05
Cadmium	-	9.39E-04	-	1.00E-03	-	4.03E-04	-	-	-
Chromium III	-	9.39E-04	-	1.50E+00	-	4.03E-04	-	-	-
Copper	-	9.39E-04	-	3.70E-02	-	4.03E-04	-	-	-
Cyanide	2.10E-03	9.39E-04	1.97E-06	2.00E-02	9.86E-05	4.03E-04	8.45E-07	-	-
Lead	4.60E-03	9.39E-04	4.32E-06	-		4.03E-04	1.85E-06	-	-
Manganese-w	1.54E-02	9.39E-04	1.45E-05	4.70E-02	3.08E-04	4.03E-04	6.20E-06	-	-
Mercury	1.31E-04	9.39E-04	1.23E-07	3.00E-04	4.10E-04	4.03E-04	5.27E-08	-	-
Nickel	-	9.39E-04	-	2.00E-02	-	4.03E-04	-	-	-
Selenium	-	9.39E-04	-	5.00E-03	-	4.03E-04	-	-	-
Silver	-	9.39E-04	-	5.00E-03	-	4.03E-04	-	-	-
Zinc	1.59E-02	9.39E-04	1.49E-05	3.00E-01	4.98E-05	4.03E-04	6.40E-06	-	-
				Hazard Index =	2.74E-01			Cancer Risk =	3.48E-05

SOUTHEAST DUMP AND MIDNIGHT CREEK
SURFACE WATER DERMAL - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	PC	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	7.90E-02	1.00E-03	9.39E-06	7.42E-07	2.00E-01	3.71E-06	4.03E-06	3.18E-07	-	-
Antimony	3.92E-02	1.00E-03	9.39E-06	3.68E-07	8.00E-05	4.60E-03	4.03E-06	1.58E-07	-	-
Arsenic	5.77E-02	1.00E-03	9.39E-06	5.42E-07	2.85E-04	1.90E-03	4.03E-06	2.32E-07	1.58E+00	3.67E-07
Cadmium	-	1.00E-03	9.39E-06	-	2.50E-05	-	4.03E-06	-	-	-
Chromium III	-	1.00E-03	9.39E-06	-	3.00E-01	-	4.03E-06	-	-	-
Copper	-	1.00E-03	9.39E-06	-	7.40E-03	-	4.03E-06	-	-	-
Cyanide	2.10E-03	1.00E-03	9.39E-06	1.97E-08	4.00E-03	4.93E-06	4.03E-06	8.45E-09	-	-
Lead	4.60E-03	1.00E-04	9.39E-07	4.32E-09	-	-	4.03E-07	1.85E-09	-	-
Manganese-w	1.54E-02	1.00E-03	9.39E-06	1.45E-07	9.40E-03	1.54E-05	4.03E-06	6.20E-08	-	-
Mercury	1.31E-04	1.00E-03	9.39E-06	1.23E-09	6.00E-05	2.05E-05	4.03E-06	5.27E-10	-	-
Nickel	-	2.00E-04	1.88E-06	-	4.00E-03	-	8.05E-07	-	-	-
Selenium	-	1.00E-03	9.39E-06	-	1.00E-03	-	4.03E-06	-	-	-
Silver	-	6.00E-04	5.64E-06	-	1.00E-03	-	2.42E-06	-	-	-
Zinc	1.59E-02	1.00E-03	9.39E-06	1.49E-07	6.00E-02	2.49E-06	4.03E-06	6.40E-08	-	-
					Hazard Index =	6.55E-03			Cancer Risk =	3.67E-07

SOUTHEAST DUMP AND MIDNIGHT CREEK
FISH INGESTION - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)$^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Fish Tissue Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)$^{-1}$	Cancer Risk
Aluminum	-	9.39E-05	-	1.00E+00	-	4.03E-05	-	-	-
Antimony	-	9.39E-05	-	4.00E-04	-	4.03E-05	-	-	-
Arsenic	7.28E-02	9.39E-05	6.84E-06	3.00E-04	2.28E-02	4.03E-05	2.93E-06	1.50E+00	4.40E-06
Cadmium	-	9.39E-05	-	1.00E-03	-	4.03E-05	-	-	-
Chromium III	-	9.39E-05	-	1.50E+00	-	4.03E-05	-	-	-
Copper	-	9.39E-05	-	3.70E-02	-	4.03E-05	-	-	-
Cyanide	-	9.39E-05	-	2.00E-02	-	4.03E-05	-	-	-
Lead	-	9.39E-05	-	-	-	4.03E-05	-	-	-
Manganese	5.99E-01	9.39E-05	5.63E-05	1.40E-01	4.02E-04	4.03E-05	2.41E-05	-	-
Mercury	-	9.39E-05	-	3.00E-04	-	4.03E-05	-	-	-
Methyl mercury	2.18E-01	9.39E-05	2.05E-05	1.00E-04	2.05E-01	4.03E-05	8.78E-06	-	-
Nickel	-	9.39E-05	-	2.00E-02	-	4.03E-05	-	-	-
Selenium	7.06E-01	9.39E-05	6.63E-05	5.00E-03	1.33E-02	4.03E-05	2.84E-05	-	-
Silver	-	9.39E-05	-	5.00E-03	-	4.03E-05	-	-	-
Zinc	7.05E+00	9.39E-05	6.62E-04	3.00E-01	2.21E-03	4.03E-05	2.84E-04	-	-
				Hazard Index =	2.43E-01			Cancer Risk =	4.40E-06

GLORY HOLE, NORTHWEST DUMP AND EFSFSR
SOIL INGESTION - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)$^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)$^{-1}$	Cancer Risk
Aluminum	7.92E+03	3.13E-07	2.48E-03	1.00E+00	2.48E-03	4.47E-09	3.54E-05	-	-
Antimony	3.68E+02	3.13E-07	1.15E-04	4.00E-04	2.88E-01	4.47E-09	1.65E-06	-	-
Arsenic	2.72E+03	3.13E-07	5.10E-04	3.00E-04	1.70E+00	4.47E-09	7.29E-06	1.50E+00	1.09E-05
Cadmium	-	3.13E-07	-	1.00E-03	-	4.47E-09	-	-	-
Chromium III	1.09E+01	3.13E-07	3.41E-06	1.50E+00	2.28E-06	4.47E-09	4.88E-08	-	-
Copper	9.49E+00	3.13E-07	2.97E-06	3.70E-02	8.03E-05	4.47E-09	4.24E-08	-	-
Cyanide	-	3.13E-07	-	2.00E-02	-	4.47E-09	-	-	-
Lead	6.51E+00	3.13E-07	2.04E-06	-	-	4.47E-09	2.91E-08	-	-
Manganese	2.53E+02	3.13E-07	7.92E-05	1.40E-01	5.66E-04	4.47E-09	1.13E-06	-	-
Mercury	1.39E+00	3.13E-07	4.35E-07	3.00E-04	1.45E-03	4.47E-09	6.22E-09	-	-
Nickel	5.97E+00	3.13E-07	1.87E-06	2.00E-02	9.35E-05	4.47E-09	2.67E-08	-	-
Selenium	3.16E-01	3.13E-07	9.89E-08	5.00E-03	1.98E-05	4.47E-09	1.41E-09	-	-
Silver	2.52E+00	3.13E-07	7.89E-07	5.00E-03	1.58E-04	4.47E-09	1.13E-08	-	-
Zinc	4.05E+01	3.13E-07	1.27E-05	3.00E-01	4.23E-05	4.47E-09	1.81E-07	-	-
				Hazard Index =	1.99E+00			Total Cancer Risk =	1.09E-05

1. Chemical Intake for Arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

GLORY HOLE, NORTHWEST DUMP AND EFSFSR
SOIL DERMAL - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	ABS	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	7.92E+03	1.00E-02	1.57E-08	1.24E-04	2.00E-01	6.20E-04	2.24E-10	1.77E-06	-	-
Antimony	3.68E+02	1.00E-02	1.57E-08	5.76E-06	8.00E-05	7.20E-02	2.24E-10	8.23E-08	-	-
Arsenic	2.72E+03	3.00E-02	4.70E-08	1.28E-04	2.85E-04	4.48E-01	6.71E-10	1.82E-06	1.58E+00	2.88E-06
Cadmium	-	1.00E-02	1.57E-08	-	2.50E-05	-	2.24E-10	-	-	-
Chromium III	1.09E+01	1.00E-02	1.57E-08	1.71E-07	3.00E-01	5.69E-07	2.24E-10	2.44E-09	-	-
Copper	9.49E+00	1.00E-02	1.57E-08	1.49E-07	7.40E-03	2.01E-05	2.24E-10	2.12E-09	-	-
Cyanide	-	1.00E-02	1.57E-08	-	4.00E-03	-	2.24E-10	-	-	-
Lead	6.51E+00	1.00E-02	1.57E-08	1.02E-07	-	-	2.24E-10	1.46E-09	-	-
Manganese	2.53E+02	1.00E-02	1.57E-08	3.96E-06	2.80E-02	1.41E-04	2.24E-10	5.66E-08	-	-
Mercury	1.39E+00	1.00E-02	1.57E-08	2.18E-08	6.00E-05	3.63E-04	2.24E-10	3.11E-10	-	-
Nickel	5.97E+00	1.00E-02	1.57E-08	9.35E-08	4.00E-03	2.34E-05	2.24E-10	1.34E-09	-	-
Selenium	3.16E-01	1.00E-02	1.57E-08	4.95E-09	1.00E-03	4.95E-06	2.24E-10	7.07E-11	-	-
Silver	2.52E+00	1.00E-02	1.57E-08	3.95E-08	1.00E-03	3.95E-05	2.24E-10	5.64E-10	-	-
Zinc	4.05E+01	1.00E-02	1.57E-08	6.34E-07	6.00E-02	1.06E-05	2.24E-10	9.06E-09	-	-
					Hazard Index =	5.21E-01			Total Cancer Risk =	2.88E-06

GLORY HOLE, NORTHWEST DUMP AND EFSFSR
INHALATION (PARTICULATE MATTER) - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)$^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)$^{-1}$	Cancer Risk
Aluminum	7.92E+03	8.30E-11	6.58E-07	1.40E-03	4.70E-04	1.19E-12	9.39E-09	-	-
Antimony	3.68E+02	8.30E-11	3.06E-08	-	-	1.19E-12	4.36E-10	-	-
Arsenic	2.72E+03	8.30E-11	2.26E-07	-	-	1.19E-12	3.22E-09	1.50E+01	4.83E-08
Cadmium	-	8.30E-11	-	-	-	1.19E-12	-	6.30E+00	-
Chromium III	1.09E+01	8.30E-11	9.05E-10	-	-	1.19E-12	1.29E-11	-	-
Copper	9.49E+00	8.30E-11	7.88E-10	-	-	1.19E-12	1.13E-11	-	-
Cyanide	-	8.30E-11	-	-	-	1.19E-12	-	-	-
Lead	6.51E+00	8.30E-11	5.40E-10	-	-	1.19E-12	7.72E-12	-	-
Manganese	2.53E+02	8.30E-11	2.10E-08	1.40E-05	1.50E-03	1.19E-12	3.00E-10	-	-
Mercury	1.39E+00	8.30E-11	1.15E-10	8.60E-05	1.34E-06	1.19E-12	1.65E-12	-	-
Nickel	5.97E+00	8.30E-11	4.96E-10	-	-	1.19E-12	7.08E-12	8.40E-01	5.95E-12
Selenium	3.16E-01	8.30E-11	2.62E-11	-	-	1.19E-12	3.75E-13	-	-
Silver	2.52E+00	8.30E-11	2.09E-10	-	-	1.19E-12	2.99E-12	-	-
Zinc	4.05E+01	8.30E-11	3.36E-09	-	-	1.19E-12	4.80E-11	-	-
				Hazard Index =	1.97E-03			Cancer Risk =	4.83E-08

GLORY HOLE, NORTHWEST DUMP AND EFSFSR
SEDIMENT INGESTION - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ($(\text{mg/kg-day})^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Sediment Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)$^{-1}$	Cancer Risk
Aluminum	8.85E+03	1.25E-07	1.11E-03	1.00E+00	1.11E-03	1.79E-09	1.58E-05	-	-
Antimony	1.28E+02	1.25E-07	1.60E-05	4.00E-04	4.01E-02	1.79E-09	2.29E-07	-	-
Arsenic	1.52E+03	1.25E-07	1.14E-04	3.00E-04	3.81E-01	1.79E-09	1.63E-06	1.50E+00	2.45E-06
Cadmium	4.04E+01	1.25E-07	5.06E-06	1.00E-03	5.06E-03	1.79E-09	7.23E-08	-	-
Chromium III	9.20E+00	1.25E-07	1.15E-06	1.50E+00	7.68E-07	1.79E-09	1.65E-08	-	-
Copper	7.30E+00	1.25E-07	9.14E-07	3.70E-02	2.47E-05	1.79E-09	1.31E-08	-	-
Cyanide	-	1.25E-07	-	2.00E-02	-	1.79E-09	-	-	-
Lead	1.06E+01	1.25E-07	1.33E-06	-	-	1.79E-09	1.90E-08	-	-
Manganese	5.62E+02	1.25E-07	7.04E-05	1.40E-01	5.03E-04	1.79E-09	1.01E-06	-	-
Mercury	1.83E+00	1.25E-07	2.29E-07	3.00E-04	7.64E-04	1.79E-09	3.27E-09	-	-
Nickel	7.06E+00	1.25E-07	8.84E-07	2.00E-02	4.42E-05	1.79E-09	1.26E-08	-	-
Selenium	3.45E+00	1.25E-07	4.32E-07	5.00E-03	8.64E-05	1.79E-09	6.17E-09	-	-
Silver	1.56E+00	1.25E-07	1.95E-07	5.00E-03	3.91E-05	1.79E-09	2.79E-09	-	-
Zinc	3.16E+01	1.25E-07	3.96E-06	3.00E-01	1.32E-05	1.79E-09	5.65E-08	-	-
				Hazard Index =	4.29E-01			Cancer Risk =	2.45E-06

1. Chemical Intake for Arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

GLORY HOLE, NORTHWEST DUMP AND EFSFSR
SURFACE WATER INGESTION - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	4.70E-02	1.25E-05	5.89E-07	1.00E+00	5.89E-07	1.79E-07	8.41E-09	-	-
Antimony	2.67E-02	1.25E-05	3.34E-07	4.00E-04	8.36E-04	1.79E-07	4.78E-09	-	-
Arsenic	5.90E-02	1.25E-05	7.39E-07	3.00E-04	2.46E-03	1.79E-07	1.06E-08	1.50E+00	1.58E-08
Cadmium	-	1.25E-05	-	1.00E-03	-	1.79E-07	-	-	-
Chromium III	-	1.25E-05	-	1.50E+00	-	1.79E-07	-	-	-
Copper	-	1.25E-05	-	3.70E-02	-	1.79E-07	-	-	-
Cyanide	-	1.25E-05	-	2.00E-02	-	1.79E-07	-	-	-
Lead	3.20E-04	1.25E-05	4.01E-09	-	-	1.79E-07	5.73E-11	-	-
Manganese-w	2.82E-02	1.25E-05	3.53E-07	4.70E-02	7.51E-06	1.79E-07	5.05E-09	-	-
Mercury	3.90E-04	1.25E-05	4.88E-09	3.00E-04	1.63E-05	1.79E-07	6.98E-11	-	-
Nickel	1.44E-02	1.25E-05	1.80E-07	2.00E-02	9.02E-06	1.79E-07	2.58E-09	-	-
Selenium	-	1.25E-05	-	5.00E-03	-	1.79E-07	-	-	-
Silver	1.29E-04	1.25E-05	1.62E-09	5.00E-03	3.23E-07	1.79E-07	2.31E-11	-	-
Zinc	3.85E-03	1.25E-05	4.82E-08	3.00E-01	1.61E-07	1.79E-07	6.89E-10	-	-
				Hazard Index =	3.33E-03			Cancer Risk =	1.58E-08

GLORY HOLE, NORTHWEST DUMP AND EFSFSR
SURFACE WATER DERMAL- RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	PC	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	4.70E-02	1.00E-03	6.26E-05	2.94E-06	2.00E-01	1.47E-05	8.95E-07	4.20E-08	-	-
Antimony	2.67E-02	1.00E-03	6.26E-05	1.67E-06	8.00E-05	2.09E-02	8.95E-07	2.39E-08	-	-
Arsenic	5.90E-02	1.00E-03	6.26E-05	3.69E-06	2.85E-04	1.30E-02	8.95E-07	5.28E-08	1.58E+00	8.33E-08
Cadmium	-	1.00E-03	6.26E-05	-	2.50E-05	-	8.95E-07	-	-	-
Chromium III	-	1.00E-03	6.26E-05	-	3.00E-01	-	8.95E-07	-	-	-
Copper	-	1.00E-03	6.26E-05	-	7.40E-03	-	8.95E-07	-	-	-
Cyanide	-	1.00E-03	6.26E-05	-	4.00E-03	-	8.95E-07	-	-	-
Lead	3.20E-04	1.00E-04	6.26E-06	2.00E-09	-	-	8.95E-08	2.86E-11	-	-
Manganese-w	2.82E-02	1.00E-03	6.26E-05	1.77E-06	9.40E-03	1.88E-04	8.95E-07	2.52E-08	-	-
Mercury	3.90E-04	1.00E-03	6.26E-05	2.44E-08	6.00E-05	4.07E-04	8.95E-07	3.49E-10	-	-
Nickel	1.44E-02	2.00E-04	1.25E-05	1.80E-07	4.00E-03	4.51E-05	1.79E-07	2.58E-09	-	-
Selenium	-	1.00E-03	6.26E-05	-	1.00E-03	-	8.95E-07	-	-	-
Silver	1.29E-04	6.00E-04	3.76E-05	4.85E-09	1.00E-03	4.85E-06	5.37E-07	6.92E-11	-	-
Zinc	3.85E-03	1.00E-03	6.26E-05	2.41E-07	6.00E-02	4.02E-06	8.95E-07	3.44E-09	-	-
					Hazard Index =	3.45E-02			Cancer Risk =	8.33E-08

GLORY HOLE, NORTHWEST DUMP AND EFSFSR
SOIL INGESTION - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ($(mg/kg\text{-}day)^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF $(mg/kg\text{-}day)^{-1}$	Cancer Risk
Aluminum	7.92E+03	5.87E-09	4.65E-05	1.00E+00	4.65E-05	2.52E-09	1.99E-05	-	-
Antimony	3.68E+02	5.87E-09	2.16E-06	4.00E-04	5.40E-03	2.52E-09	9.26E-07	-	-
Arsenic	2.72E+03	5.87E-09	9.57E-06	3.00E-04	3.19E-02	2.52E-09	4.10E-06	1.50E+00	6.15E-06
Cadmium	-	5.87E-09	-	1.00E-03	-	2.52E-09	-	-	-
Chromium III	1.09E+01	5.87E-09	6.40E-08	1.50E+00	4.27E-08	2.52E-09	2.74E-08	-	-
Copper	9.49E+00	5.87E-09	5.57E-08	3.70E-02	1.51E-06	2.52E-09	2.39E-08	-	-
Cyanide	-	5.87E-09	-	2.00E-02	-	2.52E-09	-	-	-
Lead	6.51E+00	5.87E-09	3.82E-08	-	-	2.52E-09	1.64E-08	-	-
Manganese	2.53E+02	5.87E-09	1.49E-06	1.40E-01	1.06E-05	2.52E-09	6.37E-07	-	-
Mercury	1.39E+00	5.87E-09	8.16E-09	3.00E-04	2.72E-05	2.52E-09	3.50E-09	-	-
Nickel	5.97E+00	5.87E-09	3.50E-08	2.00E-02	1.75E-06	2.52E-09	1.50E-08	-	-
Selenium	3.16E-01	5.87E-09	1.86E-09	5.00E-03	3.71E-07	2.52E-09	7.95E-10	-	-
Silver	2.52E+00	5.87E-09	1.48E-08	5.00E-03	2.96E-06	2.52E-09	6.34E-09	-	-
Zinc	4.05E+01	5.87E-09	2.38E-07	3.00E-01	7.93E-07	2.52E-09	1.02E-07	-	-
				Hazard Index =	3.74E-02			Total Cancer Risk =	6.15E-06

1. Chemical Intake for Arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

GLORY HOLE, NORTHWEST DUMP AND EFSFSR
SOIL DERMAL - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	ABS	Intake Factor (kg/kg day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day) 1	Cancer Risk
Aluminum	7.92E+03	1.00E-02	2.35E-09	1.86E-05	2.00E-01	9.30E-05	1.01E-09	7.97E-06	-	-
Antimony	3.68E+02	1.00E-02	2.35E-09	8.64E-07	8.00E-05	1.08E-02	1.01E-09	3.70E-07	-	-
Arsenic	2.72E+03	3.00E-02	7.05E-09	1.91E-05	2.85E-04	6.72E-02	3.02E-09	8.20E-06	1.58E+00	1.30E-05
Cadmium	-	1.00E-02	2.35E-09	-	2.50E-05	-	1.01E-09	-	-	-
Chromium III	1.09E+01	1.00E-02	2.35E-09	2.56E-08	3.00E-01	8.53E-08	1.01E-09	1.10E-08	-	-
Copper	9.49E+00	1.00E-02	2.35E-09	2.23E-08	7.40E-03	3.01E-06	1.01E-09	9.55E-09	-	-
Cyanide	-	1.00E-02	2.35E-09	-	4.00E-03	-	1.01E-09	-	-	-
Lead	6.51E+00	1.00E-02	2.35E-09	1.53E-08	-	-	1.01E-09	6.55E-09	-	-
Manganese	2.53E+02	1.00E-02	2.35E-09	5.94E-07	2.80E-02	2.12E-05	1.01E-09	2.55E-07	-	-
Mercury	1.39E+00	1.00E-02	2.35E-09	3.26E-09	6.00E-05	5.44E-05	1.01E-09	1.40E-09	-	-
Nickel	5.97E+00	1.00E-02	2.35E-09	1.40E-08	4.00E-03	3.50E-06	1.01E-09	6.01E-09	-	-
Selenium	3.16E-01	1.00E-02	2.35E-09	7.42E-10	1.00E-03	7.42E-07	1.01E-09	3.18E-10	-	-
Silver	2.52E+00	1.00E-02	2.35E-09	5.92E-09	1.00E-03	5.92E-06	1.01E-09	2.54E-09	-	-
Zinc	4.05E+01	1.00E-02	2.35E-09	9.51E-08	6.00E-02	1.59E-06	1.01E-09	4.08E-08	-	-
					Hazard Index =	7.81E-02			Total Cancer Risk =	1.30E-05

GLORY HOLE, NORTHWEST DUMP AND EFSFSR
INHALATION (PARTICULATE MATTER) - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)$^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)$^{-1}$	Cancer Risk
Aluminum	7.92E+03	7.12E-13	5.64E-09	1.40E-03	4.03E-06	3.05E-13	2.42E-09	-	-
Antimony	3.68E+02	7.12E-13	2.62E-10	-	-	3.05E-13	1.12E-10	-	-
Arsenic	2.72E+03	7.12E-13	1.93E-09	-	-	3.05E-13	8.29E-10	1.50E+01	1.24E-08
Cadmium	-	7.12E-13	-	-	-	3.05E-13	-	6.30E+00	-
Chromium III	1.09E+01	7.12E-13	7.76E-12	-	-	3.05E-13	3.32E-12	-	-
Copper	9.49E+00	7.12E-13	6.75E-12	-	-	3.05E-13	2.89E-12	-	-
Cyanide	-	7.12E-13	-	-	-	3.05E-13	-	-	-
Lead	6.51E+00	7.12E-13	4.63E-12	-	-	3.05E-13	1.99E-12	-	-
Manganese	2.53E+02	7.12E-13	1.80E-10	1.40E-05	1.29E-05	3.05E-13	7.72E-11	-	-
Mercury	1.39E+00	7.12E-13	9.89E-13	8.60E-05	1.15E-08	3.05E-13	4.24E-13	-	-
Nickel	5.97E+00	7.12E-13	4.25E-12	-	-	3.05E-13	1.82E-12	8.40E-01	1.53E-12
Selenium	3.16E-01	7.12E-13	2.25E-13	-	-	3.05E-13	9.64E-14	-	-
Silver	2.52E+00	7.12E-13	1.79E-12	-	-	3.05E-13	7.69E-13	-	-
Zinc	4.05E+01	7.12E-13	2.88E-11	-	-	3.05E-13	1.24E-11	-	-
				Hazard Index =	1.69E-05			Cancer Risk =	1.24E-08

GLORY HOLE, NORTHWEST DUMP AND EFSFSR
SEDIMENT INGESTION - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)$^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Sediment Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)$^{-1}$	Cancer Risk
Aluminum	8.85E+03	1.17E-08	1.04E-04	1.00E+00	1.04E-04	5.03E-09	4.45E-05	-	-
Antimony	1.28E+02	1.17E-08	1.50E-06	4.00E-04	3.76E-03	5.03E-09	6.44E-07	-	-
Arsenic	1.52E+03	1.17E-08	1.07E-05	3.00E-04	3.57E-02	5.03E-09	4.60E-06	1.50E+00	6.89E-06
Cadmium	4.04E+01	1.17E-08	4.74E-07	1.00E-03	4.74E-04	5.03E-09	2.03E-07	-	-
Chromium III	9.20E+00	1.17E-08	1.08E-07	1.50E+00	7.20E-08	5.03E-09	4.63E-08	-	-
Copper	7.30E+00	1.17E-08	8.57E-08	3.70E-02	2.32E-06	5.03E-09	3.67E-08	-	-
Cyanide	-	1.17E-08	-	2.00E-02	-	5.03E-09	-	-	-
Lead	1.06E+01	1.17E-08	1.24E-07	-	-	5.03E-09	5.33E-08	-	-
Manganese	5.62E+02	1.17E-08	6.60E-06	1.40E-01	4.71E-05	5.03E-09	2.83E-06	-	-
Mercury	1.83E+00	1.17E-08	2.15E-08	3.00E-04	7.16E-05	5.03E-09	9.21E-09	-	-
Nickel	7.06E+00	1.17E-08	8.29E-08	2.00E-02	4.14E-06	5.03E-09	3.55E-08	-	-
Selenium	3.45E+00	1.17E-08	4.05E-08	5.00E-03	8.10E-06	5.03E-09	1.74E-08	-	-
Silver	1.56E+00	1.17E-08	1.83E-08	5.00E-03	3.66E-06	5.03E-09	7.85E-09	-	-
Zinc	3.16E+01	1.17E-08	3.71E-07	3.00E-01	1.24E-06	5.03E-09	1.59E-07	-	-
				Hazard Index =	4.02E-02			Total Cancer Risk =	6.89E-06

1. Chemical Intake for Arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

GLORY HOLE, NORTHWEST DUMP AND EFSFSR
SURFACE WATER INGESTION - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	4.70E-02	9.39E-04	4.41E-05	1.00E+00	4.41E-05	4.03E-04	1.89E-05	-	-
Antimony	2.67E-02	9.39E-04	2.51E-05	4.00E-04	6.27E-02	4.03E-04	1.07E-05	-	-
Arsenic	5.90E-02	9.39E-04	5.54E-05	3.00E-04	1.85E-01	4.03E-04	2.38E-05	1.50E+00	3.56E-05
Cadmium	-	9.39E-04	-	1.00E-03	-	4.03E-04	-	-	-
Chromium III	-	9.39E-04	-	1.50E+00	-	4.03E-04	-	-	-
Copper	-	9.39E-04	-	3.70E-02	-	4.03E-04	-	-	-
Cyanide	-	9.39E-04	-	2.00E-02	-	4.03E-04	-	-	-
Lead	3.20E-04	9.39E-04	3.01E-07	-	-	4.03E-04	1.29E-07	-	-
Manganese-w	2.82E-02	9.39E-04	2.65E-05	4.70E-02	5.64E-04	4.03E-04	1.14E-05	-	-
Mercury	3.90E-04	9.39E-04	3.66E-07	3.00E-04	1.22E-03	4.03E-04	1.57E-07	-	-
Nickel	1.44E-02	9.39E-04	1.35E-05	2.00E-02	6.76E-04	4.03E-04	5.80E-06	-	-
Selenium	-	9.39E-04	-	5.00E-03	-	4.03E-04	-	-	-
Silver	1.29E-04	9.39E-04	1.21E-07	5.00E-03	2.42E-05	4.03E-04	5.19E-08	-	-
Zinc	3.85E-03	9.39E-04	3.62E-06	3.00E-01	1.21E-05	4.03E-04	1.55E-06	-	-
				Hazard Index =	2.50E-01			Cancer Risk =	3.56E-05

GLORY HOLE, NORTHWEST DUMP AND EFSFSR
SURFACE WATER DERMAL - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	PC	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	4.70E-02	1.00E-03	9.39E-06	4.41E-07	2.00E-01	2.21E-06	4.03E-06	1.89E-07	-	-
Antimony	2.67E-02	1.00E-03	9.39E-06	2.51E-07	8.00E-05	3.14E-03	4.03E-06	1.07E-07	-	-
Arsenic	5.90E-02	1.00E-03	9.39E-06	5.54E-07	2.85E-04	1.94E-03	4.03E-06	2.38E-07	1.58E+00	3.75E-07
Cadmium	-	1.00E-03	9.39E-06	-	2.50E-05	-	4.03E-06	-	-	-
Chromium III	-	1.00E-03	9.39E-06	-	3.00E-01	-	4.03E-06	-	-	-
Copper	-	1.00E-03	9.39E-06	-	7.40E-03	-	4.03E-06	-	-	-
Cyanide	-	1.00E-03	9.39E-06	-	4.00E-03	-	4.03E-06	-	-	-
Lead	3.20E-04	1.00E-04	9.39E-07	3.01E-10	-	-	4.03E-07	1.29E-10	-	-
Manganese-w	2.82E-02	1.00E-03	9.39E-06	2.65E-07	9.40E-03	2.82E-05	4.03E-06	1.14E-07	-	-
Mercury	3.90E-04	1.00E-03	9.39E-06	3.66E-09	6.00E-05	6.11E-05	4.03E-06	1.57E-09	-	-
Nickel	1.44E-02	2.00E-04	1.88E-06	2.71E-08	4.00E-03	6.76E-06	8.05E-07	1.16E-08	-	-
Selenium	-	1.00E-03	9.39E-06	-	1.00E-03	-	4.03E-06	-	-	-
Silver	1.29E-04	6.00E-04	5.64E-06	7.27E-10	1.00E-03	7.27E-07	2.42E-06	3.12E-10	-	-
Zinc	3.85E-03	1.00E-03	9.39E-06	3.62E-08	6.00E-02	6.03E-07	4.03E-06	1.55E-08	-	-
					Hazard Index =	5.18E-03			Cancer Risk =	3.75E-07

GLORY HOLE, NORTHWEST DUMP AND EFSFSR
FISH INGESTION - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ($(mg/kg\text{-}day)^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Fish Tissue Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF $(mg/kg\text{-}day)^{-1}$	Cancer Risk
Aluminum	-	9.39E-05	-	1.00E+00	-	4.03E-05		-	-
Antimony	-	9.39E-05	-	4.00E-04	-	4.03E-05		-	-
Arsenic	7.39E-02	9.39E-05	6.94E-06	3.00E-04	2.31E-02	4.03E-05	2.98E-06	1.50E+00	4.46E-06
Cadmium	-	9.39E-05	-	1.00E-03	-	4.03E-05		-	-
Chromium III	-	9.39E-05	-	1.50E+00	-	4.03E-05		-	-
Copper	-	9.39E-05	-	3.70E-02	-	4.03E-05		-	-
Cyanide	-	9.39E-05	-	2.00E-02	-	4.03E-05		-	-
Lead	4.20E-02	9.39E-05	3.95E-06	-	-	4.03E-05	1.69E-06	-	-
Manganese	3.53E-01	9.39E-05	3.32E-05	1.40E-01	2.37E-04	4.03E-05	1.42E-05	-	-
Mercury	0.00E+00	9.39E-05	0.00E+00	3.00E-04	0.00E+00	4.03E-05	0.00E+00	-	-
Methyl mercury	1.17E-01	9.39E-05	1.10E-05	1.00E-04	1.10E-01	4.03E-05	4.71E-06	-	-
Nickel	-	9.39E-05	-	2.00E-02	-	4.03E-05		-	-
Selenium	6.15E-01	9.39E-05	5.78E-05	5.00E-03	1.16E-02	4.03E-05	2.48E-05	-	-
Silver	-	9.39E-05	-	5.00E-03	-	4.03E-05		-	-
Zinc	7.83E+00	9.39E-05	7.35E-04	3.00E-01	2.45E-03	4.03E-05	3.15E-04	-	-
				Hazard Index =	1.47E-01			Cancer Risk =	4.46E-06

NORTHEAST DUMP AND SUGAR CREEK
SOIL INGESTION - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.10E+04	3.13E-07	3.44E-03	1.00E+00	3.44E-03	4.47E-09	4.92E-05	-	-
Antimony	1.91E+01	3.13E-07	5.98E-06	4.00E-04	1.50E-02	4.47E-09	8.54E-08	-	-
Arsenic	5.63E+03	3.13E-07	1.06E-03	3.00E-04	3.53E+00	4.47E-09	1.51E-05	1.50E+00	2.27E-05
Cadmium	-	3.13E-07	-	1.00E-03	-	4.47E-09	-	-	-
Chromium III	1.62E+01	3.13E-07	5.07E-06	1.50E+00	3.38E-06	4.47E-09	7.25E-08	-	-
Copper	1.11E+01	3.13E-07	3.48E-06	3.70E-02	9.39E-05	4.47E-09	4.97E-08	-	-
Cyanide	-	3.13E-07	-	2.00E-02	-	4.47E-09	-	-	-
Lead	8.56E+00	3.13E-07	2.68E-06	-	-	4.47E-09	3.83E-08	-	-
Manganese	3.59E+02	3.13E-07	1.12E-04	1.40E-01	8.03E-04	4.47E-09	1.61E-06	-	-
Mercury	1.52E+00	3.13E-07	4.76E-07	3.00E-04	1.59E-03	4.47E-09	6.80E-09	-	-
Nickel	1.71E+01	3.13E-07	5.35E-06	2.00E-02	2.68E-04	4.47E-09	7.65E-08	-	-
Selenium	2.48E-01	3.13E-07	7.77E-08	5.00E-03	1.55E-05	4.47E-09	1.11E-09	-	-
Silver	1.95E+00	3.13E-07	6.11E-07	5.00E-03	1.22E-04	4.47E-09	8.72E-09	-	-
Zinc	3.00E+01	3.13E-07	9.39E-06	3.00E-01	3.13E-05	4.47E-09	1.34E-07	-	-
				Hazard Index =	3.55E+00			Total Cancer Risk =	2.27E-05

[1] Chemical intake for arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

NORTHEAST DUMP AND SUGAR CREEK
SOIL DERMAL - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	ABS	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.10E+04	1.00E-02	1.57E-08	1.72E-04	2.00E-01	8.61E-04	2.24E-10	2.46E-06	-	-
Antimony	1.91E+01	1.00E-02	1.57E-08	2.99E-07	8.00E-05	3.74E-03	2.24E-10	4.27E-09	-	-
Arsenic	5.63E+03	3.00E-02	4.70E-08	2.64E-04	2.85E-04	9.28E-01	6.71E-10	3.78E-06	1.58E+00	5.96E-06
Cadmium	-	1.00E-02	1.57E-08	-	2.50E-05	-	2.24E-10	-	-	-
Chromium III	1.62E+01	1.00E-02	1.57E-08	2.54E-07	3.00E-01	8.45E-07	2.24E-10	3.62E-09	-	-
Copper	1.11E+01	1.00E-02	1.57E-08	1.74E-07	7.40E-03	2.35E-05	2.24E-10	2.48E-09	-	-
Cyanide	-	1.00E-02	1.57E-08	-	4.00E-03	-	2.24E-10	-	-	-
Lead	8.56E+00	1.00E-02	1.57E-08	1.34E-07	-	-	2.24E-10	1.91E-09	-	-
Manganese	3.59E+02	1.00E-02	1.57E-08	5.62E-06	2.80E-02	2.01E-04	2.24E-10	8.03E-08	-	-
Mercury	1.52E+00	1.00E-02	1.57E-08	2.38E-08	6.00E-05	3.97E-04	2.24E-10	3.40E-10	-	-
Nickel	1.71E+01	1.00E-02	1.57E-08	2.68E-07	4.00E-03	6.69E-05	2.24E-10	3.82E-09	-	-
Selenium	2.48E-01	1.00E-02	1.57E-08	3.88E-09	1.00E-03	3.88E-06	2.24E-10	5.55E-11	-	-
Silver	1.95E+00	1.00E-02	1.57E-08	3.05E-08	1.00E-03	3.05E-05	2.24E-10	4.36E-10	-	-
Zinc	3.00E+01	1.00E-02	1.57E-08	4.70E-07	6.00E-02	7.83E-06	2.24E-10	6.71E-09	-	-
					Hazard Index =	9.33E-01			Total Cancer Risk =	5.96E-06

NORTHEAST DUMP AND SUGAR CREEK
INHALATION (PARTICULATE MATTER) - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ($(mg/kg\text{-}day)^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg day)$^{-1}$	Cancer Risk
Aluminum	1.10E+04	8.30E-11	9.13E-07	1.40E-03	6.52E-04	1.19E-12	1.30E-08	-	-
Antimony	1.91E+01	8.30E-11	1.59E-09	-	-	1.19E-12	2.27E-11	-	-
Arsenic	5.63E+03	8.30E-11	4.67E-07	-	-	1.19E-12	6.68E-09	1.50E+01	1.00E-07
Cadmium	-	8.30E-11	-	-	-	1.19E-12	-	6.30E+00	-
Chromium III	1.62E+01	8.30E-11	1.34E-09	-	-	1.19E-12	1.92E-11	-	-
Copper	1.11E+01	8.30E-11	9.22E-10	-	-	1.19E-12	1.32E-11	-	-
Cyanide	-	8.30E-11	-	-	-	1.19E-12	-	-	-
Lead	8.56E+00	8.30E-11	7.11E-10	-	-	1.19E-12	1.02E-11	-	-
Manganese	3.59E+02	8.30E-11	2.98E-08	1.40E-05	2.13E-03	1.19E-12	4.26E-10	-	-
Mercury	1.52E+00	8.30E-11	1.26E-10	8.60E-05	1.47E-06	1.19E-12	1.80E-12	-	-
Nickel	1.71E+01	8.30E-11	1.42E-09	-	-	1.19E-12	2.03E-11	8.40E-01	1.70E-11
Selenium	2.48E-01	8.30E-11	2.06E-11	-	-	1.19E-12	2.94E-13	-	-
Silver	1.95E+00	8.30E-11	1.62E-10	-	-	1.19E-12	2.31E-12	-	-
Zinc	3.00E+01	8.30E-11	2.49E-09	-	-	1.19E-12	3.56E-11	-	-
				Hazard Index =	2.78E-03			Cancer Risk =	1.00E-07

NORTHEAST DUMP AND SUGAR CREEK
SEDIMENT INGESTION - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Sediment Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)-1	Cancer Risk
Aluminum	-	1.25E-07	-	1.00E+00	-	1.79E-09	-	-	-
Antimony	5.90E-01	1.25E-07	7.39E-08	4.00E-04	1.85E-04	1.79E-09	1.06E-09	-	-
Arsenic	3.79E+01	1.25E-07	2.85E-06	3.00E-04	9.49E-03	1.79E-09	4.07E-08	1.50E+00	6.10E-08
Cadmium	1.13E+00	1.25E-07	1.42E-07	1.00E-03	1.42E-04	1.79E-09	2.02E-09	-	-
Chromium III	4.00E+00	1.25E-07	5.01E-07	1.50E+00	3.34E-07	1.79E-09	7.16E-09	-	-
Copper	2.22E+00	1.25E-07	2.78E-07	3.70E-02	7.51E-06	1.79E-09	3.97E-09	-	-
Cyanide	-	1.25E-07	-	2.00E-02	-	1.79E-09	-	-	-
Lead	4.52E+00	1.25E-07	5.66E-07	-	-	1.79E-09	8.09E-09	-	-
Manganese	-	1.25E-07	-	1.40E-01	-	1.79E-09	-	-	-
Mercury	9.14E+00	1.25E-07	1.14E-06	3.00E-04	3.82E-03	1.79E-09	1.64E-08	-	-
Nickel	-	1.25E-07	-	2.00E-02	-	1.79E-09	-	-	-
Selenium	1.80E+00	1.25E-07	2.25E-07	5.00E-03	4.51E-05	1.79E-09	3.22E-09	-	-
Silver	-	1.25E-07	-	5.00E-03	-	1.79E-09	-	-	-
Zinc	1.96E+01	1.25E-07	2.45E-06	3.00E-01	8.18E-06	1.79E-09	3.51E-08	-	-
				Hazard Index =	1.37E-02			Cancer Risk =	6.10E-08

[1] Chemical intake for arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

NORTHEAST DUMP AND SUGAR CREEK
SURFACE WATER INGESTION - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.37E-01	1.25E-05	1.72E-06	1.00E+00	1.72E-06	1.79E-07	2.45E-08	-	-
Antimony	8.30E-03	1.25E-05	1.04E-07	4.00E-04	2.60E-04	1.79E-07	1.49E-09	-	-
Arsenic	1.20E-02	1.25E-05	1.50E-07	3.00E-04	5.01E-04	1.79E-07	2.15E-09	1.50E+00	3.22E-09
Cadmium	-	1.25E-05	-	1.00E-03	-	1.79E-07	-	-	-
Chromium III	-	1.25E-05	-	1.50E+00	-	1.79E-07	-	-	-
Copper	-	1.25E-05	-	3.70E-02	-	1.79E-07	-	-	-
Cyanide	-	1.25E-05	-	2.00E-02	-	1.79E-07	-	-	-
Lead	-	1.25E-05	-	-	-	1.79E-07	-	-	-
Manganese-w	5.00E-03	1.25E-05	6.26E-08	4.70E-02	1.33E-06	1.79E-07	8.95E-10	-	-
Mercury	2.55E-04	1.25E-05	3.19E-09	3.00E-04	1.06E-05	1.79E-07	4.56E-11	-	-
Nickel	-	1.25E-05	-	2.00E-02	-	1.79E-07	-	-	-
Selenium	-	1.25E-05	-	5.00E-03	-	1.79E-07	-	-	-
Silver	-	1.25E-05	-	5.00E-03	-	1.79E-07	-	-	-
Zinc	8.00E-03	1.25E-05	1.00E-07	3.00E-01	3.34E-07	1.79E-07	1.43E-09	-	-
				Hazard Index =	7.75E-04			Cancer Risk =	3.22E-09

NORTHEAST DUMP AND SUGAR CREEK
SURFACE WATER DERMAL- RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	PC	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.37E-01	1.00E-03	6.26E-05	8.58E-06	2.00E-01	4.29E-05	8.95E-07	1.23E-07	-	-
Antimony	8.30E-03	1.00E-03	6.26E-05	5.20E-07	8.00E-05	6.50E-03	8.95E-07	7.43E-09	-	-
Arsenic	1.20E-02	1.00E-03	6.26E-05	7.51E-07	2.85E-04	2.64E-03	8.95E-07	1.07E-08	1.58E+00	1.70E-08
Cadmium	-	1.00E-03	6.26E-05	-	2.50E-05	-	8.95E-07	-	-	-
Chromium III	-	1.00E-03	6.26E-05	-	3.00E-01	-	8.95E-07	-	-	-
Copper	-	1.00E-03	6.26E-05	-	7.40E-03	-	8.95E-07	-	-	-
Cyanide	-	1.00E-03	6.26E-05	-	4.00E-03	-	8.95E-07	-	-	-
Lead	-	1.00E-04	6.26E-06	-	-	-	8.95E-08	-	-	-
Manganese-w	5.00E-03	1.00E-03	6.26E-05	3.13E-07	9.40E-03	3.33E-05	8.95E-07	4.47E-09	-	-
Mercury	2.55E-04	1.00E-03	6.26E-05	1.60E-08	6.00E-05	2.66E-04	8.95E-07	2.28E-10	-	-
Nickel	-	2.00E-04	1.25E-05	-	4.00E-03	-	1.79E-07	-	-	-
Selenium	-	1.00E-03	6.26E-05	-	1.00E-03	-	8.95E-07	-	-	-
Silver	-	6.00E-04	3.76E-05	-	1.00E-03	-	5.37E-07	-	-	-
Zinc	8.00E-03	1.00E-03	6.26E-05	5.01E-07	6.00E-02	8.35E-06	8.95E-07	7.16E-09	-	-
					Hazard Index =	9.48E-03			Cancer Risk =	1.70E-08

NORTHEAST DUMP AND SUGAR CREEK
SOIL INGESTION - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.10E+04	5.87E-09	6.46E-05	1.00E+00	6.46E-05	2.52E-09	2.77E-05	-	-
Antimony	1.91E+01	5.87E-09	1.12E-07	4.00E-04	2.80E-04	2.52E-09	4.81E-08	-	-
Arsenic	5.63E+03	5.87E-09	1.98E-05	3.00E-04	6.61E-02	2.52E-09	8.50E-06	1.50E+00	1.27E-05
Cadmium	-	5.87E-09	-	1.00E-03	-	2.52E-09	-	-	-
Chromium III	1.62E+01	5.87E-09	9.51E-08	1.50E+00	6.34E-08	2.52E-09	4.08E-08	-	-
Copper	1.11E+01	5.87E-09	6.52E-08	3.70E-02	1.76E-06	2.52E-09	2.79E-08	-	-
Cyanide	-	5.87E-09	-	2.00E-02	-	2.52E-09	-	-	-
Lead	8.56E+00	5.87E-09	5.03E-08	-	-	2.52E-09	2.15E-08	-	-
Manganese	3.59E+02	5.87E-09	2.11E-06	1.40E-01	1.51E-05	2.52E-09	9.03E-07	-	-
Mercury	1.52E+00	5.87E-09	8.92E-09	3.00E-04	2.97E-05	2.52E-09	3.82E-09	-	-
Nickel	1.71E+01	5.87E-09	1.00E-07	2.00E-02	5.02E-06	2.52E-09	4.30E-08	-	-
Selenium	2.48E-01	5.87E-09	1.46E-09	5.00E-03	2.91E-07	2.52E-09	6.24E-10	-	-
Silver	1.95E+00	5.87E-09	1.14E-08	5.00E-03	2.29E-06	2.52E-09	4.91E-09	-	-
Zinc	3.00E+01	5.87E-09	1.76E-07	3.00E-01	5.87E-07	2.52E-09	7.55E-08	-	-
				Hazard Index =	6.65E-02			Total Cancer Risk =	1.27E-05

[1] Chemical intake for arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

NORTHEAST DUMP AND SUGAR CREEK
SOIL DERMAL - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	ABS	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.10E+04	1.00E-02	2.35E-09	2.58E-05	2.00E-01	1.29E-04	1.01E-09	1.11E-05	-	-
Antimony	1.91E+01	1.00E-02	2.35E-09	4.49E-08	8.00E-05	5.61E-04	1.01E-09	1.92E-08	-	-
Arsenic	5.63E+03	3.00E-02	7.05E-09	3.97E-05	2.85E-04	1.39E-01	3.02E-09	1.70E-05	1.58E+00	2.68E-05
Cadmium	-	1.00E-02	2.35E-09	-	2.50E-05	-	1.01E-09	-	-	-
Chromium III	1.62E+01	1.00E-02	2.35E-09	3.80E-08	3.00E-01	1.27E-07	1.01E-09	1.63E-08	-	-
Copper	1.11E+01	1.00E-02	2.35E-09	2.61E-08	7.40E-03	3.52E-06	1.01E-09	1.12E-08	-	-
Cyanide	-	1.00E-02	2.35E-09	-	4.00E-03	-	1.01E-09	-	-	-
Lead	8.56E+00	1.00E-02	2.35E-09	2.01E-08	-	-	1.01E-09	8.62E-09	-	-
Manganese	3.59E+02	1.00E-02	2.35E-09	8.43E-07	2.80E-02	3.01E-05	1.01E-09	3.61E-07	-	-
Mercury	1.52E+00	1.00E-02	2.35E-09	3.57E-09	6.00E-05	5.95E-05	1.01E-09	1.53E-09	-	-
Nickel	1.71E+01	1.00E-02	2.35E-09	4.02E-08	4.00E-03	1.00E-05	1.01E-09	1.72E-08	-	-
Selenium	2.48E-01	1.00E-02	2.35E-09	5.82E-10	1.00E-03	5.82E-07	1.01E-09	2.50E-10	-	-
Silver	1.95E+00	1.00E-02	2.35E-09	4.58E-09	1.00E-03	4.58E-06	1.01E-09	1.96E-09	-	-
Zinc	3.00E+01	1.00E-02	2.35E-09	7.05E-08	6.00E-02	1.17E-06	1.01E-09	3.02E-08	-	-
					Hazard Index =	1.40E-01			Total Cancer Risk =	2.68E-05

NORTHEAST DUMP AND SUGAR CREEK
INHALATION (PARTICULATE MATTER) - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg day)-1	Cancer Risk
Aluminum	1.10E+04	7.12E-13	7.83E-09	1.40E-03	5.59E-06	3.05E-13	3.35E-09	-	-
Antimony	1.91E+01	7.12E-13	1.36E-11	-	-	3.05E-13	5.83E-12	-	-
Arsenic	5.63E+03	7.12E-13	4.01E-09	-	-	3.05E-13	1.72E-09	1.50E+01	2.58E-08
Cadmium	-	7.12E-13	-	-	-	3.05E-13	-	6.30E+00	-
Chromium III	1.62E+01	7.12E-13	1.15E-11	-	-	3.05E-13	4.94E-12	-	-
Copper	1.11E+01	7.12E-13	7.90E-12	-	-	3.05E-13	3.39E-12	-	-
Cyanide	-	7.12E-13	-	-	-	3.05E-13	-	-	-
Lead	8.56E+00	7.12E-13	6.09E-12	-	-	3.05E-13	2.61E-12	-	-
Manganese	3.59E+02	7.12E-13	2.55E-10	1.40E-05	1.82E-05	3.05E-13	1.09E-10	-	-
Mercury	1.52E+00	7.12E-13	1.08E-12	8.60E-05	1.26E-08	3.05E-13	4.64E-13	-	-
Nickel	1.71E+01	7.12E-13	1.22E-11	-	-	3.05E-13	5.22E-12	8.40E-01	4.38E-12
Selenium	2.48E-01	7.12E-13	1.76E-13	-	-	3.05E-13	7.56E-14	-	-
Silver	1.95E+00	7.12E-13	1.39E-12	-	-	3.05E-13	5.95E-13	-	-
Zinc	3.00E+01	7.12E-13	2.13E-11	-	-	3.05E-13	9.15E-12	-	-
				Hazard Index =	2.39E-05			Cancer Risk =	2.58E-08

NORTHEAST DUMP AND SUGAR CREEK
SEDIMENT INGESTION - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Sediment Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)-1	Cancer Risk
Aluminum	-	1.17E-08	-	1.00E+00	-	5.03E-09	-	-	-
Antimony	5.90E-01	1.17E-08	6.93E-09	4.00E-04	1.73E-05	5.03E-09	2.97E-09	-	-
Arsenic	3.79E+01	1.17E-08	2.67E-07	3.00E-04	8.90E-04	5.03E-09	1.14E-07	1.50E+00	1.72E-07
Cadmium	1.13E+00	1.17E-08	1.33E-08	1.00E-03	1.33E-05	5.03E-09	5.69E-09	-	-
Chromium III	4.00E+00	1.17E-08	4.70E-08	1.50E+00	3.13E-08	5.03E-09	2.01E-08	-	-
Copper	2.22E+00	1.17E-08	2.61E-08	3.70E-02	7.05E-07	5.03E-09	1.12E-08	-	-
Cyanide	-	1.17E-08	-	2.00E-02	-	5.03E-09	-	-	-
Lead	4.52E+00	1.17E-08	5.31E-08	-	-	5.03E-09	2.27E-08	-	-
Manganese	-	1.17E-08	-	1.40E-01	-	5.03E-09	-	-	-
Mercury	9.14E+00	1.17E-08	1.07E-07	3.00E-04	3.58E-04	5.03E-09	4.60E-08	-	-
Nickel	-	1.17E-08	-	2.00E-02	-	5.03E-09	-	-	-
Selenium	1.80E+00	1.17E-08	2.11E-08	5.00E-03	4.23E-06	5.03E-09	9.06E-09	-	-
Silver	-	1.17E-08	-	5.00E-03	-	5.03E-09	-	-	-
Zinc	1.96E+01	1.17E-08	2.30E-07	3.00E-01	7.67E-07	5.03E-09	9.86E-08	-	-
				Hazard Index =	1.28E-03			Total Cancer Risk =	1.72E-07

[1] Chemical intake for arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

NORTHEAST DUMP AND SUGAR CREEK
SURFACE WATER INGESTION - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.37E-01	9.39E-04	1.29E-04	1.00E+00	1.29E-04	4.03E-04	5.52E-05	-	-
Antimony	8.30E-03	9.39E-04	7.80E-06	4.00E-04	1.95E-02	4.03E-04	3.34E-06	-	-
Arsenic	1.20E-02	9.39E-04	1.13E-05	3.00E-04	3.76E-02	4.03E-04	4.83E-06	1.50E+00	7.25E-06
Cadmium	-	9.39E-04	-	1.00E-03	-	4.03E-04	-	-	-
Chromium III	-	9.39E-04	-	1.50E+00	-	4.03E-04	-	-	-
Copper	-	9.39E-04	-	3.70E-02	-	4.03E-04	-	-	-
Cyanide	-	9.39E-04	-	2.00E-02	-	4.03E-04	-	-	-
Lead	-	9.39E-04	-	-	-	4.03E-04	-	-	-
Manganese-w	5.00E-03	9.39E-04	4.70E-06	4.70E-02	9.99E-05	4.03E-04	2.01E-06	-	-
Mercury	2.55E-04	9.39E-04	2.40E-07	3.00E-04	7.98E-04	4.03E-04	1.03E-07	-	-
Nickel	-	9.39E-04	-	2.00E-02	-	4.03E-04	-	-	-
Selenium	-	9.39E-04	-	5.00E-03	-	4.03E-04	-	-	-
Silver	-	9.39E-04	-	5.00E-03	-	4.03E-04	-	-	-
Zinc	8.00E-03	9.39E-04	7.51E-06	3.00E-01	2.50E-05	4.03E-04	3.22E-06	-	-
				Hazard Index =	5.81E-02			Cancer Risk =	7.25E-06

NORTHEAST DUMP AND SUGAR CREEK
SURFACE WATER DERMAL - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	PC	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.37E-01	1.00E-03	9.39E-06	1.29E-06	2.00E-01	6.43E-06	4.03E-06	5.52E-07	-	-
Antimony	8.30E-03	1.00E-03	9.39E-06	7.80E-08	8.00E-05	9.75E-04	4.03E-06	3.34E-08	-	-
Arsenic	1.20E-02	1.00E-03	9.39E-06	1.13E-07	2.85E-04	3.96E-04	4.03E-06	4.83E-08	1.58E+00	7.63E-08
Cadmium	-	1.00E-03	9.39E-06	-	2.50E-05	-	4.03E-06	-	-	-
Chromium III	-	1.00E-03	9.39E-06	-	3.00E-01	-	4.03E-06	-	-	-
Copper	-	1.00E-03	9.39E-06	-	7.40E-03	-	4.03E-06	-	-	-
Cyanide	-	1.00E-03	9.39E-06	-	4.00E-03	-	4.03E-06	-	-	-
Lead	-	1.00E-04	9.39E-07	-	-	-	4.03E-07	-	-	-
Manganese-w	5.00E-03	1.00E-03	9.39E-06	4.70E-08	9.40E-03	5.00E-06	4.03E-06	2.01E-08	-	-
Mercury	2.55E-04	1.00E-03	9.39E-06	2.40E-09	6.00E-05	3.99E-05	4.03E-06	1.03E-09	-	-
Nickel	-	2.00E-04	1.88E-06	-	4.00E-03	-	8.05E-07	-	-	-
Selenium	-	1.00E-03	9.39E-06	-	1.00E-03	-	4.03E-06	-	-	-
Silver	-	6.00E-04	5.64E-06	-	1.00E-03	-	2.42E-06	-	-	-
Zinc	8.00E-03	1.00E-03	9.39E-06	7.51E-08	6.00E-02	1.25E-06	4.03E-06	3.22E-08	-	-
					Hazard Index =	1.42E-03			Cancer Risk =	7.63E-08

LOCATION UW-1 (UPGRADIENT WETLAND)
SOIL INGESTION - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ($(\text{mg/kg-day})^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)$^{-1}$	Cancer Risk
Aluminum	2.02E+04	1.43E-06	2.89E-02	1.00E+00	2.89E-02	5.59E-10	1.13E-05	-	-
Antimony	6.89E+02	1.43E-06	9.84E-04	4.00E-04	2.46E+00	5.59E-10	3.85E-07	-	-
Arsenic	9.83E+02	1.43E-06	3.00E-04	3.00E-04	2.81E+00	5.59E-10	3.30E-07	1.50E+00	4.95E-07
Cadmium	-	1.43E-06	-	1.00E-03	-	5.59E-10	-	-	-
Chromium III	1.01E+01	1.43E-06	1.44E-05	1.50E+00	9.62E-06	5.59E-10	5.65E-09	-	-
Copper	2.86E+02	1.43E-06	4.09E-04	3.70E-02	1.10E-02	5.59E-10	1.60E-07	-	-
Cyanide	-	1.43E-06	-	2.00E-02	-	5.59E-10	-	-	-
Lead	7.54E+02	1.43E-06	1.08E-03	-		5.59E-10	4.22E-07	-	-
Manganese	1.47E+02	1.43E-06	2.10E-04	1.40E-01	1.50E-03	5.59E-10	8.22E-08	-	-
Mercury	2.30E+00	1.43E-06	3.29E-06	3.00E-04	1.10E-02	5.59E-10	1.29E-09	-	-
Nickel	8.20E+00	1.43E-06	1.17E-05	2.00E-02	5.86E-04	5.59E-10	4.58E-09	-	-
Selenium	1.10E+00	1.43E-06	1.57E-06	5.00E-03	3.14E-04	5.59E-10	6.15E-10	-	-
Silver	2.20E+00	1.43E-06	3.14E-06	5.00E-03	6.29E-04	5.59E-10	1.23E-09	-	-
Zinc	4.82E+01	1.43E-06	6.89E-05	3.00E-01	2.30E-04	5.59E-10	2.69E-08	-	-
				Hazard Index =	5.32E+00		Total Cancer Risk =		4.95E-07

[1] Chemical intake for arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

LOCATION UW-1 (UPGRADIENT WETLAND)
SOIL DERMAL - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	ABS	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	2.02E+04	1.00E-02	7.14E-08	1.44E-03	2.00E-01	7.21E-03	2.80E-11	5.65E-07	-	-
Antimony	6.89E+02	1.00E-02	7.14E-08	4.92E-05	8.00E-05	6.15E-01	2.80E-11	1.93E-08	-	-
Arsenic	9.83E+02	3.00E-02	2.14E-07	2.11E-04	2.85E-04	7.39E-01	8.39E-11	8.24E-08	1.58E+00	1.30E-07
Cadmium	-	1.00E-02	7.14E-08	-	2.50E-05	-	2.80E-11	-	-	-
Chromium III	1.01E+01	1.00E-02	7.14E-08	7.21E-07	3.00E-01	2.40E-06	2.80E-11	2.82E-10	-	-
Copper	2.86E+02	1.00E-02	7.14E-08	2.04E-05	7.40E-03	2.76E-03	2.80E-11	8.00E-09	-	-
Cyanide	-	1.00E-02	7.14E-08	-	4.00E-03	-	2.80E-11	-	-	-
Lead	7.54E+02	1.00E-02	7.14E-08	5.39E-05	-	-	2.80E-11	2.11E-08	-	-
Manganese	1.47E+02	1.00E-02	7.14E-08	1.05E-05	2.80E-02	3.75E-04	2.80E-11	4.11E-09	-	-
Mercury	2.30E+00	1.00E-02	7.14E-08	1.64E-07	6.00E-05	2.74E-03	2.80E-11	6.43E-11	-	-
Nickel	8.20E+00	1.00E-02	7.14E-08	5.86E-07	4.00E-03	1.46E-04	2.80E-11	2.29E-10	-	-
Selenium	1.10E+00	1.00E-02	7.14E-08	7.86E-08	1.00E-03	7.86E-05	2.80E-11	3.08E-11	-	-
Silver	2.20E+00	1.00E-02	7.14E-08	1.57E-07	1.00E-03	1.57E-04	2.80E-11	6.15E-11	-	-
Zinc	4.82E+01	1.00E-02	7.14E-08	3.44E-06	6.00E-02	5.74E-05	2.80E-11	1.35E-09	-	-
					Hazard Index =	1.37E+00			Total Cancer Risk =	1.30E-07

LOCATION UW-1 (UPGRADIENT WETLAND)
INHALATION (PARTICULATE MATTER) - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ($(mg/kg\text{-}day)^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg day)$^{-1}$	Cancer Risk
Aluminum	2.02E+04	3.79E-10	7.65E-06	1.40E-03	5.47E-03	1.48E-13	2.99E-09	-	-
Antimony	6.89E+02	3.79E-10	2.61E-07	-	-	1.48E-13	1.02E-10	-	-
Arsenic	9.83E+02	3.79E-10	3.72E-07	-	-	1.48E-13	1.46E-10	1.50E+01	2.19E-09
Cadmium	-	3.79E-10	-	-	-	1.48E-13	-	6.30E+00	-
Chromium III	1.01E+01	3.79E-10	3.83E-09	-	-	1.48E-13	1.50E-12	-	-
Copper	2.86E+02	3.79E-10	1.08E-07	-	-	1.48E-13	4.24E-11	-	-
Cyanide	-	3.79E-10	-	-	-	1.48E-13	-	-	-
Lead	7.54E+02	3.79E-10	2.86E-07	-	-	1.48E-13	1.12E-10	-	-
Manganese	1.47E+02	3.79E-10	5.57E-08	1.40E-05	3.98E-03	1.48E-13	2.18E-11	-	-
Mercury	2.30E+00	3.79E-10	8.71E-10	8.60E-05	1.01E-05	1.48E-13	3.41E-13	-	-
Nickel	8.20E+00	3.79E-10	3.11E-09	-	-	1.48E-13	1.22E-12	8.40E-01	1.02E-12
Selenium	1.10E+00	3.79E-10	4.17E-10	-	-	1.48E-13	1.63E-13	-	-
Silver	2.20E+00	3.79E-10	8.33E-10	-	-	1.48E-13	3.26E-13	-	-
Zinc	4.82E+01	3.79E-10	1.83E-08	-	-	1.48E-13	7.15E-12	-	-
				Hazard Index =	9.45E-03			Cancer Risk =	2.19E-09

LOCATION UW-1 (UPGRADIENT WETLAND)
SURFACE WATER INGESTION - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	-	1.43E-04	-	1.00E+00	-	5.59E-08	-	-	-
Antimony	6.90E-02	1.43E-04	9.86E-06	4.00E-04	2.46E-02	5.59E-08	3.86E-09	-	-
Arsenic	3.16E-01	1.43E-04	4.51E-05	3.00E-04	1.50E-01	5.59E-08	1.77E-08	1.50E+00	2.65E-08
Cadmium	-	1.43E-04	-	1.00E-03	-	5.59E-08	-	-	-
Chromium III	-	1.43E-04	-	1.50E+00	-	5.59E-08	-	-	-
Copper	4.00E-03	1.43E-04	5.71E-07	3.70E-02	1.54E-05	5.59E-08	-	-	-
Cyanide	-	1.43E-04	-	2.00E-02	-	5.59E-08	-	-	-
Lead	5.30E-03	1.43E-04	7.57E-07	-	-	5.59E-08	-	-	-
Manganese-w	4.91E-02	1.43E-04	7.01E-06	4.70E-02	1.49E-04	5.59E-08	2.75E-09	-	-
Mercury	-	1.43E-04	-	3.00E-04	-	5.59E-08	-	-	-
Nickel	-	1.43E-04	-	2.00E-02	-	5.59E-08	-	-	-
Selenium	-	1.43E-04	-	5.00E-03	-	5.59E-08	-	-	-
Silver	-	1.43E-04	-	5.00E-03	-	5.59E-08	-	-	-
Zinc	-	1.43E-04	-	3.00E-01	-	5.59E-08	-	-	-
				Hazard Index =	1.75E-01			Cancer Risk =	2.65E-08

LOCATION UW-1 (UPGRADIENT WETLAND)
SURFACE WATER DERMAL- RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	PC	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	-	1.00E-03	7.14E-04	-	2.00E-01	-	2.80E-07	-	-	-
Antimony	6.90E-02	1.00E-03	7.14E-04	4.93E-05	8.00E-05	6.16E-01	2.80E-07	1.93E-08	-	-
Arsenic	3.16E-01	1.00E-03	7.14E-04	2.26E-04	2.85E-04	7.92E-01	2.80E-07	8.83E-08	1.58E+00	1.37E-07
Cadmium	-	1.00E-03	7.14E-04	-	2.50E-05	-	2.80E-07	-	-	-
Chromium III	-	1.00E-03	7.14E-04	-	3.00E-01	-	2.80E-07	-	-	-
Copper	4.00E-03	1.00E-03	7.14E-04	2.86E-06	7.40E-03	3.86E-04	2.80E-07	1.12E-09	-	-
Cyanide	-	1.00E-03	7.14E-04	-	4.00E-03	-	2.80E-07	-	-	-
Lead	5.30E-03	1.00E-04	7.14E-05	-	-	-	2.80E-08	-	-	-
Manganese-w	4.91E-02	1.00E-03	7.14E-04	3.51E-05	9.40E-03	3.73E-03	2.80E-07	1.37E-08	-	-
Mercury	-	1.00E-03	7.14E-04	-	6.00E-05	-	2.80E-07	-	-	-
Nickel	-	2.00E-04	1.43E-04	-	4.00E-03	-	5.59E-08	-	-	-
Selenium	-	1.00E-03	7.14E-04	-	1.00E-03	-	2.80E-07	-	-	-
Silver	-	6.00E-04	4.29E-04	-	1.00E-03	-	1.68E-07	-	-	-
Zinc	-	1.00E-03	7.14E-04	-	6.00E-02	-	2.80E-07	-	-	-
					Hazard Index =	1.41E+00			Cancer Risk =	1.37E-07

LOCATION UW-1 (UPGRADIENT WETLAND)
SOIL INGESTION - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	2.02E+04	1.79E-07	3.61E-03	1.00E+00	3.61E-03	6.99E-12	1.41E-07	-	-
Antimony	6.89E+02	1.79E-07	1.23E-04	4.00E-04	3.08E-01	6.99E-12	4.82E-09	-	-
Arsenic	9.83E+02	1.79E-07	1.05E-04	3.00E-04	3.51E-01	6.99E-12	4.12E-09	1.50E+00	6.18E-09
Cadmium	-	1.79E-07	-	1.00E-03	-	6.99E-12	-	-	-
Chromium III	1.01E+01	1.79E-07	1.80E-06	1.50E+00	1.20E-06	6.99E-12	7.06E-11	-	-
Copper	2.86E+02	1.79E-07	5.11E-05	3.70E-02	1.38E-03	6.99E-12	2.00E-09	-	-
Cyanide	-	1.79E-07	-	2.00E-02	-	6.99E-12	-	-	-
Lead	7.54E+02	1.79E-07	1.35E-04	-	-	6.99E-12	5.27E-09	-	-
Manganese	1.47E+02	1.79E-07	2.63E-05	1.40E-01	1.88E-04	6.99E-12	1.03E-09	-	-
Mercury	2.30E+00	1.79E-07	4.11E-07	3.00E-04	1.37E-03	6.99E-12	1.61E-11	-	-
Nickel	8.20E+00	1.79E-07	1.46E-06	2.00E-02	7.32E-05	6.99E-12	5.73E-11	-	-
Selenium	1.10E+00	1.79E-07	1.96E-07	5.00E-03	3.93E-05	6.99E-12	7.69E-12	-	-
Silver	2.20E+00	1.79E-07	3.93E-07	5.00E-03	7.86E-05	6.99E-12	1.54E-11	-	-
Zinc	4.82E+01	1.79E-07	8.61E-06	3.00E-01	2.87E-05	6.99E-12	3.37E-10	-	-
				Hazard Index =	6.65E-01			Total Cancer Risk =	6.18E-09

LOCATION UW-1 (UPGRADIENT WETLAND)
SOIL DERMAL - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	ABS	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	2.02E+04	1.00E-02	7.14E-08	1.44E-03	2.00E-01	7.21E-03	2.80E-12	5.65E-08	-	-
Antimony	6.89E+02	1.00E-02	7.14E-08	4.92E-05	8.00E-05	6.15E-01	2.80E-12	1.93E-09	-	-
Arsenic	9.83E+02	3.00E-02	2.14E-07	2.11E-04	2.85E-04	7.39E-01	8.39E-12	8.24E-09	1.58E+00	1.30E-08
Cadmium	-	1.00E-02	7.14E-08	-	2.50E-05	-	2.80E-12	-	-	-
Chromium III	1.01E+01	1.00E-02	7.14E-08	7.21E-07	3.00E-01	2.40E-06	2.80E-12	2.82E-11	-	-
Copper	2.86E+02	1.00E-02	7.14E-08	2.04E-05	7.40E-03	2.76E-03	2.80E-12	8.00E-10	-	-
Cyanide	-	1.00E-02	7.14E-08	-	4.00E-03	-	2.80E-12	-	-	-
Lead	7.54E+02	1.00E-02	7.14E-08	5.39E-05	-	-	2.80E-12	2.11E-09	-	-
Manganese	1.47E+02	1.00E-02	7.14E-08	1.05E-05	2.80E-02	3.75E-04	2.80E-12	4.11E-10	-	-
Mercury	2.30E+00	1.00E-02	7.14E-08	1.64E-07	6.00E-05	2.74E-03	2.80E-12	6.43E-12	-	-
Nickel	8.20E+00	1.00E-02	7.14E-08	5.86E-07	4.00E-03	1.46E-04	2.80E-12	2.29E-11	-	-
Selenium	1.10E+00	1.00E-02	7.14E-08	7.86E-08	1.00E-03	7.86E-05	2.80E-12	3.08E-12	-	-
Silver	2.20E+00	1.00E-02	7.14E-08	1.57E-07	1.00E-03	1.57E-04	2.80E-12	6.15E-12	-	-
Zinc	4.82E+01	1.00E-02	7.14E-08	3.44E-06	6.00E-02	5.74E-05	2.80E-12	1.35E-10	-	-
					Hazard Index =	1.37E+00			Total Cancer Risk =	1.30E-08

LOCATION UW-1 (UPGRADIENT WETLAND)
INHALATION (PARTICULATE MATTER) - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg day)-1	Cancer Risk
Aluminum	2.02E+04	2.16E-11	4.37E-07	1.40E-03	3.12E-04	8.47E-16	1.71E-11	-	-
Antimony	6.89E+02	2.16E-11	1.49E-08	-	-	8.47E-16	5.84E-13	-	-
Arsenic	9.83E+02	2.16E-11	2.13E-08	-	-	8.47E-16	8.33E-13	1.50E+01	1.25E-11
Cadmium	-	2.16E-11	-	-	-	8.47E-16	-	6.30E+00	-
Chromium III	1.01E+01	2.16E-11	2.19E-10	-	-	8.47E-16	8.56E-15	-	-
Copper	2.86E+02	2.16E-11	6.19E-09	-	-	8.47E-16	2.42E-13	-	-
Cyanide	-	2.16E-11	-	-	-	8.47E-16	-	-	-
Lead	7.54E+02	2.16E-11	1.63E-08	-	-	8.47E-16	6.39E-13	-	-
Manganese	1.47E+02	2.16E-11	3.18E-09	1.40E-05	2.27E-04	8.47E-16	1.25E-13	-	-
Mercury	2.30E+00	2.16E-11	4.98E-11	8.60E-05	5.79E-07	8.47E-16	1.95E-15	-	-
Nickel	8.20E+00	2.16E-11	1.77E-10	-	-	8.47E-16	6.95E-15	8.40E-01	5.84E-15
Selenium	1.10E+00	2.16E-11	2.38E-11	-	-	8.47E-16	9.32E-16	-	-
Silver	2.20E+00	2.16E-11	4.76E-11	-	-	8.47E-16	1.86E-15	-	-
Zinc	4.82E+01	2.16E-11	1.04E-09	-	-	8.47E-16	4.08E-14	-	-
				Hazard Index =	5.40E-04			Cancer Risk =	1.25E-11

LOCATION UW-1 (UPGRADIENT WETLAND)
SURFACE WATER INGESTION - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	-	1.43E-03	-	1.00E+00	-	5.98E-08	-	-	-
Antimony	6.90E-02	1.43E-03	9.86E-05	4.00E-04	2.46E-01	5.98E-08	3.86E-09	-	-
Arsenic	3.16E-01	1.43E-03	4.51E-04	3.00E-04	1.50E+00	5.98E-08	1.77E-08	1.50E+00	2.65E-08
Cadmium	-	1.43E-03	-	1.00E-03	-	5.98E-08	-	-	-
Chromium III	-	1.43E-03	-	1.50E+00	-	5.98E-08	-	-	-
Copper	4.00E-03	1.43E-03	5.71E-05	3.70E-02	1.54E-04	5.98E-08	2.24E-10	-	-
Cyanide	-	1.43E-03	-	2.00E-02	-	5.98E-08	-	-	-
Lead	5.30E-03	1.43E-03	7.57E-06	-	-	5.98E-08	2.96E-10	-	-
Manganese-w	4.91E-02	1.43E-03	7.01E-05	4.70E-02	1.49E-03	5.98E-08	2.75E-09	-	-
Mercury	-	1.43E-03	-	3.00E-04	-	5.98E-08	-	-	-
Nickel	-	1.43E-03	-	2.00E-02	-	5.98E-08	-	-	-
Selenium	-	1.43E-03	-	5.00E-03	-	5.98E-08	-	-	-
Silver	-	1.43E-03	-	5.00E-03	-	5.98E-08	-	-	-
Zinc	-	1.43E-03	-	3.00E-01	-	5.98E-08	-	-	-
				Hazard Index =	1.75E+00			Cancer Risk =	2.65E-08

LOCATION UW-1 (UPGRADIENT WETLAND)
SURFACE WATER DERMAL - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	PC	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	-	1.00E-03	1.43E-04	-	2.00E-01	-	5.59E-09	-	-	-
Antimony	6.90E-02	1.00E-03	1.43E-04	9.86E-06	8.00E-05	1.23E-01	5.59E-09	3.86E-10	-	-
Arsenic	3.16E-01	1.00E-03	1.43E-04	4.51E-05	2.85E-04	1.58E-01	5.59E-09	1.77E-09	1.58E+00	2.79E-09
Cadmium	-	1.00E-03	1.43E-04	-	2.50E-05	-	5.59E-09	-	-	-
Chromium III	-	1.00E-03	1.43E-04	-	3.00E-01	-	5.59E-09	-	-	-
Copper	4.00E-03	1.00E-03	1.43E-04	5.71E-07	7.40E-03	7.72E-05	5.59E-09	2.24E-11	-	-
Cyanide	-	1.00E-03	1.43E-04	-	4.00E-03	-	5.59E-09	-	-	-
Lead	5.30E-03	1.00E-04	1.43E-05	7.57E-08	-	-	5.59E-10	2.96E-12	-	-
Manganese-w	4.91E-02	1.00E-03	1.43E-04	7.01E-06	9.40E-03	2.46E-04	5.59E-09	2.75E-10	-	-
Mercury	-	1.00E-03	1.43E-04	-	6.00E-05	-	5.59E-09	-	-	-
Nickel	-	2.00E-04	2.86E-05	-	4.00E-03	-	1.12E-09	-	-	-
Selenium	-	1.00E-03	1.43E-04	-	1.00E-03	-	5.59E-09	-	-	-
Silver	-	6.00E-04	8.57E-05	-	1.00E-03	-	3.35E-09	-	-	-
Zinc	-	1.00E-03	1.43E-04	-	6.00E-02	-	5.59E-09	-	-	-
					Hazard Index =	2.82E-01			Cancer Risk =	2.79E-09

SMELTER
SOIL INGESTION - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.35E+04	1.43E-06	1.93E-02	1.00E+00	1.93E-02	5.59E-10	7.55E-06	-	-
Antimony	2.92E+02	1.43E-06	4.17E-04	4.00E-04	1.04E+00	5.59E-10	1.63E-07	-	-
Arsenic	3.75E+03	1.43E-06	3.21E-03	3.00E-04	1.07E+01	5.59E-10	1.26E-06	1.50E+00	1.89E-06
Cadmium	9.00E-02	1.43E-06	1.29E-07	1.00E-03	1.29E-04	5.59E-10	5.03E-11	-	-
Chromium III	6.10E+00	1.43E-06	8.71E-06	1.50E+00	5.81E-06	5.59E-10	3.41E-09	-	-
Copper	8.30E+00	1.43E-06	1.19E-05	3.70E-02	3.20E-04	5.59E-10	4.64E-09	-	-
Cyanide	0.00E+00	1.43E-06	0.00E+00	2.00E-02	0.00E+00	5.59E-10	0.00E+00	-	-
Lead	1.66E+01	1.43E-06	2.37E-05	-	-	5.59E-10	9.28E-09	-	-
Manganese	3.70E+02	1.43E-06	5.29E-04	1.40E-01	3.78E-03	5.59E-10	2.07E-07	-	-
Mercury	4.71E+02	1.43E-06	6.73E-04	3.00E-04	2.24E+00	5.59E-10	2.63E-07	-	-
Nickel	2.80E+00	1.43E-06	4.00E-06	2.00E-02	2.00E-04	5.59E-10	1.57E-09	-	-
Selenium	6.67E+01	1.43E-06	9.53E-05	5.00E-03	1.91E-02	5.59E-10	3.73E-08	-	-
Silver	4.10E+00	1.43E-06	5.86E-06	5.00E-03	1.17E-03	5.59E-10	2.29E-09	-	-
Zinc	4.73E+01	1.43E-06	6.76E-05	3.00E-01	2.25E-04	5.59E-10	2.64E-08	-	-
				Hazard Index =	1.40E+01			Total Cancer Risk =	1.89E-06

[1] Chemical intake for arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

SMELTER
SOIL DERMAL - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	ABS	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.35E+04	1.00E-02	7.14E-08	9.64E-04	2.00E-01	4.82E-03	2.80E-11	3.77E-07	-	-
Antimony	2.92E+02	1.00E-02	7.14E-08	2.09E-05	8.00E-05	2.61E-01	2.80E-11	8.16E-09	-	-
Arsenic	3.75E+03	3.00E-02	2.14E-07	8.04E-04	2.85E-04	2.82E+00	8.39E-11	3.15E-07	1.58E+00	4.97E-07
Cadmium	9.00E-02	1.00E-02	7.14E-08	6.43E-09	2.50E-05	2.57E-04	2.80E-11	2.52E-12	-	-
Chromium III	6.10E+00	1.00E-02	7.14E-08	4.36E-07	3.00E-01	1.45E-06	2.80E-11	1.71E-10	-	-
Copper	8.30E+00	1.00E-02	7.14E-08	5.93E-07	7.40E-03	8.01E-05	2.80E-11	2.32E-10	-	-
Cyanide	0.00E+00	1.00E-02	7.14E-08	0.00E+00	4.00E-03	0.00E+00	2.80E-11	0.00E+00	-	-
Lead	1.66E+01	1.00E-02	7.14E-08	1.19E-06	-	-	2.80E-11	4.64E-10	-	-
Manganese	3.70E+02	1.00E-02	7.14E-08	2.64E-05	2.80E-02	9.44E-04	2.80E-11	1.03E-08	-	-
Mercury	4.71E+02	1.00E-02	7.14E-08	3.36E-05	6.00E-05	5.61E-01	2.80E-11	1.32E-08	-	-
Nickel	2.80E+00	1.00E-02	7.14E-08	2.00E-07	4.00E-03	5.00E-05	2.80E-11	7.83E-11	-	-
Selenium	6.67E+01	1.00E-02	7.14E-08	4.76E-06	1.00E-03	4.76E-03	2.80E-11	1.86E-09	-	-
Silver	4.10E+00	1.00E-02	7.14E-08	2.93E-07	1.00E-03	2.93E-04	2.80E-11	1.15E-10	-	-
Zinc	4.73E+01	1.00E-02	7.14E-08	3.38E-06	6.00E-02	5.63E-05	2.80E-11	1.32E-09	-	-
					Hazard Index =	3.65E+00			Total Cancer Risk =	4.97E-07

SMELTER
INHALATION (PARTICULATE MATTER, SOIL) - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ($(\text{mg/kg-day})^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg day)$^{-1}$	Cancer Risk
Aluminum	1.35E+04	3.79E-10	5.11E-06	1.40E-03	3.65E-03	1.48E-13	2.00E-09	-	-
Antimony	2.92E+02	3.79E-10	1.11E-07	-	-	1.48E-13	4.33E-11	-	-
Arsenic	3.75E+03	3.79E-10	1.42E-06	-	-	1.48E-13	5.56E-10	1.50E+01	8.34E-09
Cadmium	9.00E-02	3.79E-10	3.41E-11	-	-	1.48E-13	1.33E-14	6.30E+00	8.41E-14
Chromium III	6.10E+00	3.79E-10	2.31E-09	-	-	1.48E-13	9.04E-13	-	-
Copper	8.30E+00	3.79E-10	3.14E-09	-	-	1.48E-13	1.23E-12	-	-
Cyanide	0.00E+00	3.79E-10	0.00E+00	-	-	1.48E-13	0.00E+00	-	-
Lead	1.66E+01	3.79E-10	6.29E-09	-	-	1.48E-13	2.46E-12	-	-
Manganese	3.70E+02	3.79E-10	1.40E-07	1.40E-05	1.00E-02	1.48E-13	5.49E-11	-	-
Mercury	4.71E+02	3.79E-10	1.78E-07	8.60E-05	2.07E-03	1.48E-13	6.98E-11	-	-
Nickel	2.80E+00	3.79E-10	1.06E-09	-	-	1.48E-13	4.15E-13	8.40E-01	3.49E-13
Selenium	6.67E+01	3.79E-10	2.53E-08	-	-	1.48E-13	9.89E-12	-	-
Silver	4.10E+00	3.79E-10	1.55E-09	-	-	1.48E-13	6.08E-13	-	-
Zinc	4.73E+01	3.79E-10	1.79E-08	-	-	1.48E-13	7.01E-12	-	-
				Hazard Index =	1.57E-02			Cancer Risk =	8.34E-09

SMELTER
ASH INGESTION - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.44E+02	1.43E-06	2.06E-04	1.00E+00	2.06E-04	5.59E-10	8.05E-08	-	-
Antimony	6.27E+03	1.43E-06	8.96E-03	4.00E-04	2.24E+01	5.59E-10	3.51E-06	-	-
Arsenic	2.04E+05	1.43E-06	1.75E-01	3.00E-04	5.83E+02	5.59E-10	6.84E-05	1.50E+00	1.03E-04
Cadmium	-	1.43E-06	-	1.00E-03	-	5.59E-10	-	-	-
Chromium III	2.90E+00	1.43E-06	4.14E-06	1.50E+00	2.76E-06	5.59E-10	1.62E-09	-	-
Copper	6.36E+01	1.43E-06	9.09E-05	3.70E-02	2.46E-03	5.59E-10	3.56E-08	-	-
Cyanide	0.00E+00	1.43E-06	0.00E+00	2.00E-02	0.00E+00	5.59E-10	0.00E+00	-	-
Lead	-	1.43E-06	-	-	-	5.59E-10	-	-	-
Manganese	1.58E+01	1.43E-06	2.26E-05	1.40E-01	1.61E-04	5.59E-10	8.83E-09	-	-
Mercury	3.10E+03	1.43E-06	4.43E-03	3.00E-04	1.48E+01	5.59E-10	1.73E-06	-	-
Nickel	0.00E+00	1.43E-06	0.00E+00	2.00E-02	0.00E+00	5.59E-10	0.00E+00	-	-
Selenium	8.69E+02	1.43E-06	1.24E-03	5.00E-03	2.48E-01	5.59E-10	4.86E-07	-	-
Silver	4.23E+01	1.43E-06	6.04E-05	5.00E-03	1.21E-02	5.59E-10	2.37E-08	-	-
Zinc	8.12E+01	1.43E-06	1.16E-04	3.00E-01	3.87E-04	5.59E-10	4.54E-08	-	-
				Hazard Index =	6.20E+02			Total Cancer Risk =	1.03E-04

[1] Chemical intake for arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

SMELTER
INHALATION (PARTICULATE MATTER, ASH) - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ($(mg/kg\text{-}day)^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg day)$^{-1}$	Cancer Risk
Aluminum	1.44E+02	3.79E-10	5.45E-08	1.40E-03	3.90E-05	1.48E-13	2.13E-11	-	-
Antimony	6.27E+03	3.79E-10	2.38E-06	-	-	1.48E-13	9.30E-10	-	-
Arsenic	2.04E+05	3.79E-10	7.73E-05	-	-	1.48E-13	3.02E-08	1.50E+01	4.54E-07
Cadmium	-	3.79E-10	-	-	-	1.48E-13	-	6.30E+00	-
Chromium III	2.90E+00	3.79E-10	1.10E-09	-	-	1.48E-13	4.30E-13	-	-
Copper	6.36E+01	3.79E-10	2.41E-08	-	-	1.48E-13	9.43E-12	-	-
Cyanide	-	3.79E-10	-	-	-	1.48E-13	-	-	-
Lead	-	3.79E-10	-	-	-	1.48E-13	-	-	-
Manganese	1.58E+01	3.79E-10	5.98E-09	1.40E-05	4.27E-04	1.48E-13	2.34E-12	-	-
Mercury	3.10E+03	3.79E-10	1.17E-06	8.60E-05	1.37E-02	1.48E-13	4.60E-10	-	-
Nickel	-	3.79E-10	-	-	-	1.48E-13	-	8.40E-01	-
Selenium	8.69E+02	3.79E-10	3.29E-07	-	-	1.48E-13	1.29E-10	-	-
Silver	4.23E+01	3.79E-10	1.60E-08	-	-	1.48E-13	6.27E-12	-	-
Zinc	8.12E+01	3.79E-10	3.08E-08	-	-	1.48E-13	1.20E-11	-	-
				Hazard Index =	1.41E-02			Cancer Risk =	4.54E-07

SMELTER
ASH DERMAL - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	ABS	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.44E+02	1.00E-02	7.14E-08	1.03E-05	2.00E-01	5.14E-05	2.80E-11	4.03E-09	-	-
Antimony	6.27E+03	1.00E-02	7.14E-08	4.48E-04	8.00E-05	5.60E+00	2.80E-11	1.75E-07	-	-
Arsenic	2.04E+05	3.00E-02	2.14E-07	4.37E-02	2.85E-04	1.53E+02	8.39E-11	1.71E-05	1.58E+00	2.70E-05
Cadmium	-	1.00E-02	7.14E-08	-	2.50E-05	-	2.80E-11	-	-	-
Chromium III	2.90E+00	1.00E-02	7.14E-08	2.07E-07	3.00E-01	6.90E-07	2.80E-11	8.11E-11	-	-
Copper	6.36E+01	1.00E-02	7.14E-08	4.54E-06	7.40E-03	6.14E-04	2.80E-11	1.78E-09	-	-
Cyanide	0.00E+00	1.00E-02	7.14E-08	0.00E+00	4.00E-03	0.00E+00	2.80E-11	0.00E+00	-	-
Lead	-	1.00E-02	7.14E-08	-	-	-	2.80E-11	-	-	-
Manganese	1.58E+01	1.00E-02	7.14E-08	1.13E-06	2.80E-02	4.03E-05	2.80E-11	4.42E-10	-	-
Mercury	3.10E+03	1.00E-02	7.14E-08	2.21E-04	6.00E-05	3.69E+00	2.80E-11	8.67E-08	-	-
Nickel	0.00E+00	1.00E-02	7.14E-08	0.00E+00	4.00E-03	0.00E+00	2.80E-11	0.00E+00	-	-
Selenium	8.69E+02	1.00E-02	7.14E-08	6.21E-05	1.00E-03	6.21E-02	2.80E-11	2.43E-08	-	-
Silver	4.23E+01	1.00E-02	7.14E-08	3.02E-06	1.00E-03	3.02E-03	2.80E-11	1.18E-09	-	-
Zinc	8.12E+01	1.00E-02	7.14E-08	5.80E-06	6.00E-02	9.67E-05	2.80E-11	2.27E-09	-	-
					Hazard Index =	1.63E+02			Total Cancer Risk =	2.70E-05

SMELTER
WOOD INGESTION - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)-1	Cancer Risk
Aluminum	2.34E+02	1.43E-06	3.34E-04	1.00E+00	3.34E-04	5.59E-10	1.31E-07	-	-
Antimony	6.69E+02	1.43E-06	9.56E-04	4.00E-04	2.39E+00	5.59E-10	3.74E-07	-	-
Arsenic	2.20E+03	1.43E-06	1.89E-03	3.00E-04	6.29E+00	5.59E-10	7.38E-07	1.50E+00	1.11E-06
Cadmium	2.70E-01	1.43E-06	3.86E-07	1.00E-03	3.86E-04	5.59E-10	1.51E-10	-	-
Chromium III	8.90E-01	1.43E-06	1.27E-06	1.50E+00	8.48E-07	5.59E-10	4.98E-10	-	-
Copper	9.90E+00	1.43E-06	1.41E-05	3.70E-02	3.82E-04	5.59E-10	5.54E-09	-	-
Cyanide	-	1.43E-06	-	2.00E-02	-	5.59E-10	-	-	-
Lead	4.90E+00	1.43E-06	7.00E-06	-	-	5.59E-10	2.74E-09	-	-
Manganese	1.96E+01	1.43E-06	2.80E-05	1.40E-01	2.00E-04	5.59E-10	1.10E-08	-	-
Mercury	6.30E+00	1.43E-06	9.00E-06	3.00E-04	3.00E-02	5.59E-10	3.52E-09	-	-
Nickel	-	1.43E-06	-	2.00E-02	-	5.59E-10	-	-	-
Selenium	3.60E+00	1.43E-06	5.14E-06	5.00E-03	1.03E-03	5.59E-10	2.01E-09	-	-
Silver	0.00E+00	1.43E-06	0.00E+00	5.00E-03	0.00E+00	5.59E-10	0.00E+00	-	-
Zinc	1.95E+01	1.43E-06	2.79E-05	3.00E-01	9.29E-05	5.59E-10	1.09E-08	-	-
				Hazard Index =	8.71E+00			Total Cancer Risk =	1.11E-06

[1] Chemical intake for arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

SMELTER
INHALATION (PARTICULATE MATTER, WOOD) - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)$^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg day)$^{-1}$	Cancer Risk
Aluminum	2.34E+02	3.79E-10	8.86E-08	1.40E-03	6.33E-05	1.48E-13	3.47E-11	-	-
Antimony	6.69E+02	3.79E-10	2.53E-07	-	-	1.48E-13	9.92E-11	-	-
Arsenic	2.20E+03	3.79E-10	8.33E-07	-	-	1.48E-13	3.26E-10	1.50E+01	4.89E-09
Cadmium	2.70E-01	3.79E-10	1.02E-10	-	-	1.48E-13	4.00E-14	6.30E+00	2.52E-13
Chromium III	8.90E-01	3.79E-10	3.37E-10	-	-	1.48E-13	1.32E-13	-	-
Copper	9.90E+00	3.79E-10	3.75E-09	-	-	1.48E-13	1.47E-12	-	-
Cyanide	-	3.79E-10	-	-	-	1.48E-13	-	-	-
Lead	4.90E+00	3.79E-10	1.86E-09	-	-	1.48E-13	7.26E-13	-	-
Manganese	1.96E+01	3.79E-10	7.42E-09	1.40E-05	5.30E-04	1.48E-13	2.91E-12	-	-
Mercury	6.30E+00	3.79E-10	2.39E-09	8.60E-05	2.77E-05	1.48E-13	9.34E-13	-	-
Nickel	-	3.79E-10	-	-	-	1.48E-13	-	8.40E-01	-
Selenium	3.60E+00	3.79E-10	1.36E-09	-	-	1.48E-13	5.34E-13	-	-
Silver	0.00E+00	3.79E-10	0.00E+00	-	-	1.48E-13	0.00E+00	-	-
Zinc	1.95E+01	3.79E-10	7.39E-09	-	-	1.48E-13	2.89E-12	-	-
				Hazard Index =	6.21E-04			Cancer Risk =	4.89E-09

SMELTER
WOOD DERMAL - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	ABS	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	2.34E+02	1.00E-02	7.14E-08	1.67E-05	2.00E-01	8.36E-05	2.80E-11	6.54E-09	-	-
Antimony	6.69E+02	1.00E-02	7.14E-08	4.78E-05	8.00E-05	5.97E-01	2.80E-11	1.87E-08	-	-
Arsenic	2.20E+03	3.00E-02	2.14E-07	4.71E-04	2.85E-04	1.65E+00	8.39E-11	1.85E-07	1.58E+00	2.91E-07
Cadmium	2.70E-01	1.00E-02	7.14E-08	1.93E-08	2.50E-05	7.71E-04	2.80E-11	7.55E-12	-	-
Chromium III	8.90E-01	1.00E-02	7.14E-08	6.36E-08	3.00E-01	2.12E-07	2.80E-11	2.49E-11	-	-
Copper	9.90E+00	1.00E-02	7.14E-08	7.07E-07	7.40E-03	9.56E-05	2.80E-11	2.77E-10	-	-
Cyanide	-	1.00E-02	7.14E-08	-	4.00E-03	-	2.80E-11	-	-	-
Lead	4.90E+00	1.00E-02	7.14E-08	3.50E-07	-	-	2.80E-11	1.37E-10	-	-
Manganese	1.96E+01	1.00E-02	7.14E-08	1.40E-06	2.80E-02	5.00E-05	2.80E-11	5.48E-10	-	-
Mercury	6.30E+00	1.00E-02	7.14E-08	4.50E-07	6.00E-05	7.50E-03	2.80E-11	1.76E-10	-	-
Nickel	-	1.00E-02	7.14E-08	-	4.00E-03	-	2.80E-11	-	-	-
Selenium	3.60E+00	1.00E-02	7.14E-08	2.57E-07	1.00E-03	2.57E-04	2.80E-11	1.01E-10	-	-
Silver	0.00E+00	1.00E-02	7.14E-08	0.00E+00	1.00E-03	0.00E+00	2.80E-11	0.00E+00	-	-
Zinc	1.95E+01	1.00E-02	7.14E-08	1.39E-06	6.00E-02	2.32E-05	2.80E-11	5.45E-10	-	-
					Hazard Index =	2.26E+00			Total Cancer Risk =	2.91E-07

SMELTER
SOIL INGESTION - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.35E+04	1.79E-07	2.41E-03	1.00E+00	2.41E-03	6.99E-12	9.44E-08	-	-
Antimony	2.92E+02	1.79E-07	5.21E-05	4.00E-04	1.30E-01	6.99E-12	2.04E-09	-	-
Arsenic	3.75E+03	1.79E-07	4.02E-04	3.00E-04	1.34E+00	6.99E-12	1.57E-08	1.50E+00	2.36E-08
Cadmium	9.00E-02	1.79E-07	1.61E-08	1.00E-03	1.61E-05	6.99E-12	6.29E-13	-	-
Chromium III	6.10E+00	1.79E-07	1.09E-06	1.50E+00	7.26E-07	6.99E-12	4.26E-11	-	-
Copper	8.30E+00	1.79E-07	1.48E-06	3.70E-02	4.01E-05	6.99E-12	5.80E-11	-	-
Cyanide	0.00E+00	1.79E-07	0.00E+00	2.00E-02	0.00E+00	6.99E-12	0.00E+00	-	-
Lead	1.66E+01	1.79E-07	2.96E-06	-	-	6.99E-12	1.16E-10	-	-
Manganese	3.70E+02	1.79E-07	6.61E-05	1.40E-01	4.72E-04	6.99E-12	2.59E-09	-	-
Mercury	4.71E+02	1.79E-07	8.41E-05	3.00E-04	2.80E-01	6.99E-12	3.29E-09	-	-
Nickel	2.80E+00	1.79E-07	5.00E-07	2.00E-02	2.50E-05	6.99E-12	1.96E-11	-	-
Selenium	6.67E+01	1.79E-07	1.19E-05	5.00E-03	2.38E-03	6.99E-12	4.66E-10	-	-
Silver	4.10E+00	1.79E-07	7.32E-07	5.00E-03	1.46E-04	6.99E-12	2.87E-11	-	-
Zinc	4.73E+01	1.79E-07	8.45E-06	3.00E-01	2.82E-05	6.99E-12	3.31E-10	-	-
				Hazard Index =	1.76E+00			Total Cancer Risk =	2.36E-08

[1] Chemical intake for arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

SMELTER
SOIL DERMAL - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	ABS	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.35E+04	1.00E-02	7.14E-08	9.64E-04	2.00E-01	4.82E-03	2.80E-12	3.77E-08	-	-
Antimony	2.92E+02	1.00E-02	7.14E-08	2.09E-05	8.00E-05	2.61E-01	2.80E-12	8.16E-10	-	-
Arsenic	3.75E+03	3.00E-02	2.14E-07	8.04E-04	2.85E-04	2.82E+00	8.39E-12	3.15E-08	1.58E+00	4.97E-08
Cadmium	9.00E-02	1.00E-02	7.14E-08	6.43E-09	2.50E-05	2.57E-04	2.80E-12	2.52E-13	-	-
Chromium III	6.10E+00	1.00E-02	7.14E-08	4.36E-07	3.00E-01	1.45E-06	2.80E-12	1.71E-11	-	-
Copper	8.30E+00	1.00E-02	7.14E-08	5.93E-07	7.40E-03	8.01E-05	2.80E-12	2.32E-11	-	-
Cyanide	0.00E+00	1.00E-02	7.14E-08	0.00E+00	4.00E-03	0.00E+00	2.80E-12	0.00E+00	-	-
Lead	1.66E+01	1.00E-02	7.14E-08	1.19E-06	-	-	2.80E-12	4.64E-11	-	-
Manganese	3.70E+02	1.00E-02	7.14E-08	2.64E-05	2.80E-02	9.44E-04	2.80E-12	1.03E-09	-	-
Mercury	4.71E+02	1.00E-02	7.14E-08	3.36E-05	6.00E-05	5.61E-01	2.80E-12	1.32E-09	-	-
Nickel	2.80E+00	1.00E-02	7.14E-08	2.00E-07	4.00E-03	5.00E-05	2.80E-12	7.83E-12	-	-
Selenium	6.67E+01	1.00E-02	7.14E-08	4.76E-06	1.00E-03	4.76E-03	2.80E-12	1.86E-10	-	-
Silver	4.10E+00	1.00E-02	7.14E-08	2.93E-07	1.00E-03	2.93E-04	2.80E-12	1.15E-11	-	-
Zinc	4.73E+01	1.00E-02	7.14E-08	3.38E-06	6.00E-02	5.63E-05	2.80E-12	1.32E-10	-	-
					Hazard Index =	3.65E+00			Total Cancer Risk =	4.97E-08

SMELTER
INHALATION (PARTICULATE MATTER, Soil) - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg day)-1	Cancer Risk
Aluminum	1.35E+04	2.16E-11	2.92E-07	1.40E-03	2.09E-04	8.47E-16	1.14E-11	-	-
Antimony	2.92E+02	2.16E-11	6.32E-09	-	-	8.47E-16	2.47E-13	-	-
Arsenic	3.75E+03	2.16E-11	8.12E-08	-	-	8.47E-16	3.18E-12	1.50E+01	4.77E-11
Cadmium	9.00E-02	2.16E-11	1.95E-12	-	-	8.47E-16	7.62E-17	6.30E+00	4.80E-16
Chromium III	6.10E+00	2.16E-11	1.32E-10	-	-	8.47E-16	5.17E-15	-	-
Copper	8.30E+00	2.16E-11	1.80E-10	-	-	8.47E-16	7.03E-15	-	-
Cyanide	0.00E+00	2.16E-11	0.00E+00	-	-	8.47E-16	0.00E+00	-	-
Lead	1.66E+01	2.16E-11	3.59E-10	-	-	8.47E-16	1.41E-14	-	-
Manganese	3.70E+02	2.16E-11	8.01E-09	1.40E-05	5.72E-04	8.47E-16	3.13E-13	-	-
Mercury	4.71E+02	2.16E-11	1.02E-08	8.60E-05	1.19E-04	8.47E-16	3.99E-13	-	-
Nickel	2.80E+00	2.16E-11	6.06E-11	-	-	8.47E-16	2.37E-15	8.40E-01	1.99E-15
Selenium	6.67E+01	2.16E-11	1.44E-09	-	-	8.47E-16	5.65E-14	-	-
Silver	4.10E+00	2.16E-11	8.87E-11	-	-	8.47E-16	3.47E-15	-	-
Zinc	4.73E+01	2.16E-11	1.02E-09	-	-	8.47E-16	4.01E-14	-	-
				Hazard Index =	8.99E-04			Cancer Risk =	4.77E-11

SMELTER
ASH INGESTION - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.44E+02	1.79E-07	2.57E-05	1.00E+00	2.57E-05	6.99E-12	1.01E-09	-	-
Antimony	6.27E+03	1.79E-07	1.12E-03	4.00E-04	2.80E+00	6.99E-12	4.38E-08	-	-
Arsenic	2.04E+05	1.79E-07	2.19E-02	3.00E-04	7.29E+01	6.99E-12	8.55E-07	1.50E+00	1.28E-06
Cadmium	-	1.79E-07	-	1.00E-03	-	6.99E-12	-	-	-
Chromium III	2.90E+00	1.79E-07	5.18E-07	1.50E+00	3.45E-07	6.99E-12	2.03E-11	-	-
Copper	6.36E+01	1.79E-07	1.14E-05	3.70E-02	3.07E-04	6.99E-12	4.45E-10	-	-
Cyanide	0.00E+00	1.79E-07	0.00E+00	2.00E-02	0.00E+00	6.99E-12	0.00E+00	-	-
Lead	-	1.79E-07	-	-	-	6.99E-12	-	-	-
Manganese	1.58E+01	1.79E-07	2.82E-06	1.40E-01	2.02E-05	6.99E-12	1.10E-10	-	-
Mercury	3.10E+03	1.79E-07	5.54E-04	3.00E-04	1.85E+00	6.99E-12	2.17E-08	-	-
Nickel	0.00E+00	1.79E-07	0.00E+00	2.00E-02	0.00E+00	6.99E-12	0.00E+00	-	-
Selenium	8.69E+02	1.79E-07	1.55E-04	5.00E-03	3.10E-02	6.99E-12	6.07E-09	-	-
Silver	4.23E+01	1.79E-07	7.55E-06	5.00E-03	1.51E-03	6.99E-12	2.96E-10	-	-
Zinc	8.12E+01	1.79E-07	1.45E-05	3.00E-01	4.83E-05	6.99E-12	5.68E-10	-	-
				Hazard Index =	7.75E+01			Total Cancer Risk =	1.28E-06

[1] Chemical intake for arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

SMELTER
ASH DERMAL - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	ABS	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	1.44E+02	1.00E-02	7.14E-08	1.03E-05	2.00E-01	5.14E-05	2.80E-12	4.03E-10	-	-
Antimony	6.27E+03	1.00E-02	7.14E-08	4.48E-04	8.00E-05	5.60E+00	2.80E-12	1.75E-08	-	-
Arsenic	2.04E+05	3.00E-02	2.14E-07	4.37E-02	2.85E-04	1.53E+02	8.39E-12	1.71E-06	1.58E+00	2.70E-06
Cadmium	-	1.00E-02	7.14E-08	-	2.50E-05	-	2.80E-12	-	-	-
Chromium III	2.90E+00	1.00E-02	7.14E-08	2.07E-07	3.00E-01	6.90E-07	2.80E-12	8.11E-12	-	-
Copper	6.36E+01	1.00E-02	7.14E-08	4.54E-06	7.40E-03	6.14E-04	2.80E-12	1.78E-10	-	-
Cyanide	0.00E+00	1.00E-02	7.14E-08	0.00E+00	4.00E-03	0.00E+00	2.80E-12	0.00E+00	-	-
Lead	-	1.00E-02	7.14E-08	-	-	-	2.80E-12	-	-	-
Manganese	1.58E+01	1.00E-02	7.14E-08	1.13E-06	2.80E-02	4.03E-05	2.80E-12	4.42E-11	-	-
Mercury	3.10E+03	1.00E-02	7.14E-08	2.21E-04	6.00E-05	3.69E+00	2.80E-12	8.67E-09	-	-
Nickel	0.00E+00	1.00E-02	7.14E-08	0.00E+00	4.00E-03	0.00E+00	2.80E-12	0.00E+00	-	-
Selenium	8.69E+02	1.00E-02	7.14E-08	6.21E-05	1.00E-03	6.21E-02	2.80E-12	2.43E-09	-	-
Silver	4.23E+01	1.00E-02	7.14E-08	3.02E-06	1.00E-03	3.02E-03	2.80E-12	1.18E-10	-	-
Zinc	8.12E+01	1.00E-02	7.14E-08	5.80E-06	6.00E-02	9.67E-05	2.80E-12	2.27E-10	-	-
					Hazard Index =	1.63E+02			Total Cancer Risk =	2.70E-06

SMELTER
INHALATION (PARTICULATE MATTER, ASH) - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg day)-1	Cancer Risk
Aluminum	1.44E+02	2.16E-11	3.12E-09	1.40E-03	2.23E-06	8.47E-16	1.22E-13	-	-
Antimony	6.27E+03	2.16E-11	1.36E-07	-	-	8.47E-16	5.31E-12	-	-
Arsenic	2.04E+05	2.16E-11	4.42E-06	-	-	8.47E-16	1.73E-10	1.50E+01	2.59E-09
Cadmium	-	2.16E-11	-	-	-	8.47E-16	-	6.30E+00	-
Chromium III	2.90E+00	2.16E-11	6.28E-11	-	-	8.47E-16	2.46E-15	-	-
Copper	6.36E+01	2.16E-11	1.38E-09	-	-	8.47E-16	5.39E-14	-	-
Cyanide	0.00E+00	2.16E-11	0.00E+00	-	-	8.47E-16	0.00E+00	-	-
Lead	-	2.16E-11	-	-	-	8.47E-16	-	-	-
Manganese	1.58E+01	2.16E-11	3.42E-10	1.40E-05	2.44E-05	8.47E-16	1.34E-14	-	-
Mercury	3.10E+03	2.16E-11	6.71E-08	8.60E-05	7.80E-04	8.47E-16	2.63E-12	-	-
Nickel	0.00E+00	2.16E-11	0.00E+00	-	-	8.47E-16	0.00E+00	8.40E-01	0.00E+00
Selenium	8.69E+02	2.16E-11	1.88E-08	-	-	8.47E-16	7.36E-13	-	-
Silver	4.23E+01	2.16E-11	9.16E-10	-	-	8.47E-16	3.58E-14	-	-
Zinc	8.12E+01	2.16E-11	1.76E-09	-	-	8.47E-16	6.88E-14	-	-
				Hazard Index =	8.07E-04			Cancer Risk =	2.59E-09

SMELTER
WOOD INGESTION - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)-1	Cancer Risk
Aluminum	2.34E+02	1.79E-07	4.18E-05	1.00E+00	4.18E-05	6.99E-12	1.64E-09	-	-
Antimony	6.69E+02	1.79E-07	1.19E-04	4.00E-04	2.99E-01	6.99E-12	4.68E-09	-	-
Arsenic	2.20E+03	1.79E-07	2.36E-04	3.00E-04	7.86E-01	6.99E-12	9.23E-09	1.50E+00	1.38E-08
Cadmium	2.70E-01	1.79E-07	4.82E-08	1.00E-03	4.82E-05	6.99E-12	1.89E-12	-	-
Chromium III	8.90E-01	1.79E-07	1.59E-07	1.50E+00	1.06E-07	6.99E-12	6.22E-12	-	-
Copper	9.90E+00	1.79E-07	1.77E-06	3.70E-02	4.78E-05	6.99E-12	6.92E-11	-	-
Cyanide	-	1.79E-07	-	2.00E-02	-	6.99E-12	-	-	-
Lead	4.90E+00	1.79E-07	8.75E-07	-	-	6.99E-12	3.42E-11	-	-
Manganese	1.96E+01	1.79E-07	3.50E-06	1.40E-01	2.50E-05	6.99E-12	1.37E-10	-	-
Mercury	6.30E+00	1.79E-07	1.13E-06	3.00E-04	3.75E-03	6.99E-12	4.40E-11	-	-
Nickel	-	1.79E-07	-	2.00E-02	-	6.99E-12	-	-	-
Selenium	3.60E+00	1.79E-07	6.43E-07	5.00E-03	1.29E-04	6.99E-12	2.52E-11	-	-
Silver	0.00E+00	1.79E-07	0.00E+00	5.00E-03	0.00E+00	6.99E-12	0.00E+00	-	-
Zinc	1.95E+01	1.79E-07	3.48E-06	3.00E-01	1.16E-05	6.99E-12	1.36E-10	-	-
				Hazard Index =	1.09E+00			Total Cancer Risk =	1.38E-08

[1] Chemical intake for arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

SMELTER
WOOD DERMAL - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	ABS	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	2.34E+02	1.00E-02	7.14E-08	1.67E-05	2.00E-01	8.36E-05	2.80E-12	6.54E-10	-	-
Antimony	6.69E+02	1.00E-02	7.14E-08	4.78E-05	8.00E-05	5.97E-01	2.80E-12	1.87E-09	-	-
Arsenic	2.20E+03	3.00E-02	2.14E-07	4.71E-04	2.85E-04	1.65E+00	8.39E-12	1.85E-08	1.58E+00	2.91E-08
Cadmium	2.70E-01	1.00E-02	7.14E-08	1.93E-08	2.50E-05	7.71E-04	2.80E-12	7.55E-13	-	-
Chromium III	8.90E-01	1.00E-02	7.14E-08	6.36E-08	3.00E-01	2.12E-07	2.80E-12	2.49E-12	-	-
Copper	9.90E+00	1.00E-02	7.14E-08	7.07E-07	7.40E-03	9.56E-05	2.80E-12	2.77E-11	-	-
Cyanide		1.00E-02	7.14E-08	-	4.00E-03	-	2.80E-12	-	-	-
Lead	4.90E+00	1.00E-02	7.14E-08	3.50E-07	-	-	2.80E-12	1.37E-11	-	-
Manganese	1.96E+01	1.00E-02	7.14E-08	1.40E-06	2.80E-02	5.00E-05	2.80E-12	5.48E-11	-	-
Mercury	6.30E+00	1.00E-02	7.14E-08	4.50E-07	6.00E-05	7.50E-03	2.80E-12	1.76E-11	-	-
Nickel	-	1.00E-02	7.14E-08	-	4.00E-03	-	2.80E-12	-	-	-
Selenium	3.60E+00	1.00E-02	7.14E-08	2.57E-07	1.00E-03	2.57E-04	2.80E-12	1.01E-11	-	-
Silver	0.00E+00	1.00E-02	7.14E-08	0.00E+00	1.00E-03	0.00E+00	2.80E-12	0.00E+00	-	-
Zinc	1.95E+01	1.00E-02	7.14E-08	1.39E-06	6.00E-02	2.32E-05	2.80E-12	5.45E-11	-	-
					Hazard Index =	2.26E+00			Total Cancer Risk =	2.91E-08

SMELTER
INHALATION (PARTICULATE MATTER, WOOD) - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg day)-1	Cancer Risk
Aluminum	2.34E+02	2.16E-11	5.06E-09	1.40E-03	3.62E-06	8.47E-16	1.98E-13	-	-
Antimony	6.69E+02	2.16E-11	1.45E-08	-	-	8.47E-16	5.67E-13	-	-
Arsenic	2.20E+03	2.16E-11	4.76E-08	-	-	8.47E-16	1.86E-12	1.50E+01	2.80E-11
Cadmium	2.70E-01	2.16E-11	5.84E-12	-	-	8.47E-16	2.29E-16	6.30E+00	1.44E-15
Chromium III	8.90E-01	2.16E-11	1.93E-11	-	-	8.47E-16	7.54E-16	-	-
Copper	9.90E+00	2.16E-11	2.14E-10	-	-	8.47E-16	8.39E-15	-	-
Cyanide		2.16E-11	-	-	-	8.47E-16	-	-	-
Lead	4.90E+00	2.16E-11	1.06E-10	-	-	8.47E-16	4.15E-15	-	-
Manganese	1.96E+01	2.16E-11	4.24E-10	1.40E-05	3.03E-05	8.47E-16	1.66E-14	-	-
Mercury	6.30E+00	2.16E-11	1.36E-10	8.60E-05	1.59E-06	8.47E-16	5.34E-15	-	-
Nickel	-	2.16E-11	-	-	-	8.47E-16	-	8.40E-01	-
Selenium	3.60E+00	2.16E-11	7.79E-11	-	-	8.47E-16	3.05E-15	-	-
Silver	0.00E+00	2.16E-11	0.00E+00	-	-	8.47E-16	0.00E+00	-	-
Zinc	1.95E+01	2.16E-11	4.22E-10	-	-	8.47E-16	1.65E-14	-	-
				Hazard Index =	3.55E-05			Cancer Risk =	2.80E-11

DMEA DUMP
SOIL INGESTION - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)-1	Cancer Risk
Aluminum	4.40E+03	1.43E-06	6.29E-03	1.00E+00	6.29E-03	5.59E-10	2.46E-06	-	-
Antimony	7.40E+00	1.43E-06	1.06E-05	4.00E-04	2.64E-02	5.59E-10	4.14E-09	-	-
Arsenic	9.46E+03	1.43E-06	8.11E-03	3.00E-04	2.70E+01	5.59E-10	3.17E-06	1.50E+00	4.76E-06
Cadmium	-	1.43E-06	-	1.00E-03	-	5.59E-10	-	-	-
Chromium III	6.40E+00	1.43E-06	9.14E-06	1.50E+00	6.10E-06	5.59E-10	3.58E-09	-	-
Copper	6.30E+00	1.43E-06	9.00E-06	3.70E-02	2.43E-04	5.59E-10	3.52E-09	-	-
Cyanide	-	1.43E-06	-	2.00E-02	-	5.59E-10	-	-	-
Lead	9.20E+00	1.43E-06	1.31E-05	-		5.59E-10	5.14E-09	-	-
Manganese	8.85E+02	1.43E-06	1.26E-03	1.40E-01	9.03E-03	5.59E-10	4.95E-07	-	-
Mercury	9.90E+00	1.43E-06	1.41E-05	3.00E-04	4.71E-02	5.59E-10	5.54E-09	-	-
Nickel	-	1.43E-06	-	2.00E-02	-	5.59E-10	-	-	-
Selenium	3.50E-01	1.43E-06	5.00E-07	5.00E-03	1.00E-04	5.59E-10	1.96E-10	-	-
Silver	3.40E+00	1.43E-06	4.86E-06	5.00E-03	9.71E-04	5.59E-10	1.90E-09	-	-
Zinc	4.27E+01	1.43E-06	6.10E-05	3.00E-01	2.03E-04	5.59E-10	2.39E-08	-	-
				Hazard Index =	2.71E+01			Total Cancer Risk =	4.76E-06

[1] Chemical intake for arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

DMEA DUMP
SOIL DERMAL - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Absorption Factor	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	4.40E+03	1.00E-02	7.14E-06	3.14E-04	2.00E-01	1.57E-03	2.80E-09	1.23E-07	-	-
Antimony	7.40E+00	1.00E-02	7.14E-06	5.29E-07	8.00E-05	6.61E-03	2.80E-09	2.07E-10	-	-
Arsenic	9.46E+03	3.00E-02	7.14E-06	2.03E-03	2.85E-04	7.11E+00	2.80E-09	7.93E-07	1.58E+00	1.25E-06
Cadmium	-	1.00E-02	7.14E-06	-	2.50E-05	-	2.80E-09	-	-	-
Chromium III	6.40E+00	1.00E-02	7.14E-06	4.57E-07	3.00E-01	1.52E-06	2.80E-09	1.79E-10	-	-
Copper	6.30E+00	1.00E-02	7.14E-06	4.50E-07	7.40E-03	6.08E-05	2.80E-09	1.76E-10	-	-
Cyanide	-	1.00E-02	7.14E-06	-	4.00E-03	-	2.80E-09	-	-	-
Lead	9.20E+00	1.00E-02	7.14E-06	6.57E-07	-	-	2.80E-09	2.57E-10	-	-
Manganese	8.85E+02	1.00E-02	7.14E-06	6.32E-05	2.80E-02	2.26E-03	2.80E-09	2.47E-08	-	-
Mercury	9.90E+00	1.00E-02	7.14E-06	7.07E-07	6.00E-05	1.18E-02	2.80E-09	2.77E-10	-	-
Nickel	-	1.00E-02	7.14E-06	-	1.80E-02	-	2.80E-09	-	-	-
Selenium	3.50E-01	1.00E-02	7.14E-06	2.50E-08	1.00E-03	2.50E-05	2.80E-09	9.78E-12	-	-
Silver	3.40E+00	1.00E-02	7.14E-06	2.43E-07	1.00E-03	2.43E-04	2.80E-09	9.51E-11	-	-
Zinc	4.27E+01	1.00E-02	7.14E-06	3.05E-06	6.00E-02	5.08E-05	2.80E-09	1.19E-09	-	-
					Hazard Index =	7.14E+00			Total Cancer Risk =	1.25E-06

DMEA DUMP
INHALATION (PARTICULATE MATTER) - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ($(mg/kg\text{-}day)^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg day)$^{-1}$	Cancer Risk
Aluminum	4.40E+03	3.79E-10	1.67E-06	1.40E-03	1.19E-03	1.48E-13	6.52E-10	-	-
Antimony	7.40E+00	3.79E-10	2.80E-09	-	-	1.48E-13	1.10E-12	-	-
Arsenic	9.46E+03	3.79E-10	3.58E-06	-	-	1.48E-13	1.40E-09	1.50E+01	2.10E-08
Cadmium	-	3.79E-10	-	-	-	1.48E-13	-	6.30E+00	-
Chromium III	6.40E+00	3.79E-10	2.42E-09	-	-	1.48E-13	9.49E-13	-	-
Copper	6.30E+00	3.79E-10	2.39E-09	-	-	1.48E-13	9.34E-13	-	-
Cyanide	-	3.79E-10	-	-	-	1.48E-13	-	-	-
Lead	9.20E+00	3.79E-10	3.48E-09	-	-	1.48E-13	1.36E-12	-	-
Manganese	8.85E+02	3.79E-10	3.35E-07	1.40E-05	2.39E-02	1.48E-13	1.31E-10	-	-
Mercury	9.90E+00	3.79E-10	3.75E-09	8.60E-05	4.36E-05	1.48E-13	1.47E-12	-	-
Nickel	-	3.79E-10	-	-	-	1.48E-13	-	8.40E-01	-
Selenium	3.50E-01	3.79E-10	1.33E-10	-	-	1.48E-13	5.19E-14	-	-
Silver	3.40E+00	3.79E-10	1.29E-09	-	-	1.48E-13	5.04E-13	-	-
Zinc	4.27E+01	3.79E-10	1.62E-08	-	-	1.48E-13	6.33E-12	-	-
				Hazard Index =	2.52E-02			Cancer Risk =	2.10E-08

DMEA DUMP
SOIL INGESTION - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)-1	Cancer Risk
Aluminum	4.40E+03	1.79E-07	7.86E-04	1.00E+00	7.86E-04	6.99E-12	3.08E-08	-	-
Antimony	7.40E+00	1.79E-07	1.32E-06	4.00E-04	3.30E-03	6.99E-12	5.17E-11	-	-
Arsenic	9.46E+03	1.79E-07	1.01E-03	3.00E-04	3.38E+00	6.99E-12	3.97E-08	1.50E+00	5.95E-08
Cadmium	-	1.79E-07	-	1.00E-03	-	6.99E-12	-	-	-
Chromium III	6.40E+00	1.79E-07	1.14E-06	1.50E+00	7.62E-07	6.99E-12	4.47E-11	-	-
Copper	6.30E+00	1.79E-07	1.13E-06	3.70E-02	3.04E-05	6.99E-12	4.40E-11	-	-
Cyanide	-	1.79E-07	-	2.00E-02	-	6.99E-12	-	-	-
Lead	9.20E+00	1.79E-07	1.64E-06	-	-	6.99E-12	6.43E-11	-	-
Manganese	8.85E+02	1.79E-07	1.58E-04	1.40E-01	1.13E-03	6.99E-12	6.19E-09	-	-
Mercury	9.90E+00	1.79E-07	1.77E-06	3.00E-04	5.89E-03	6.99E-12	6.92E-11	-	-
Nickel	-	1.79E-07	-	2.00E-02	-	6.99E-12	-	-	-
Selenium	3.50E-01	1.79E-07	6.25E-08	5.00E-03	1.25E-05	6.99E-12	2.45E-12	-	-
Silver	3.40E+00	1.79E-07	6.07E-07	5.00E-03	1.21E-04	6.99E-12	2.38E-11	-	-
Zinc	4.27E+01	1.79E-07	7.63E-06	3.00E-01	2.54E-05	6.99E-12	2.98E-10	-	-
				Hazard Index =	3.39E+00			Total Cancer Risk =	5.95E-08

[1] Chemical intake for arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

DMEA DUMP
SOIL DERMAL - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Absorption Factor	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	4.40E+03	1.00E-02	7.14E-06	3.14E-04	2.00E-01	1.57E-03	2.80E-10	1.23E-08	-	-
Antimony	7.40E+00	1.00E-02	7.14E-06	5.29E-07	8.00E-05	6.61E-03	2.80E-10	2.07E-11	-	-
Arsenic	9.46E+03	3.00E-02	7.14E-06	2.03E-03	2.85E-04	7.11E+00	2.80E-10	7.93E-08	1.58E+00	1.25E-07
Cadmium	-	1.00E-02	7.14E-06	-	2.50E-05	-	2.80E-10	-	-	-
Chromium III	6.40E+00	1.00E-02	7.14E-06	4.57E-07	3.00E-01	1.52E-06	2.80E-10	1.79E-11	-	-
Copper	6.30E+00	1.00E-02	7.14E-06	4.50E-07	7.40E-03	6.08E-05	2.80E-10	1.76E-11	-	-
Cyanide	-	1.00E-02	7.14E-06	-	4.00E-03	-	2.80E-10	-	-	-
Lead	9.20E+00	1.00E-02	7.14E-06	6.57E-07	-	-	2.80E-10	2.57E-11	-	-
Manganese	8.85E+02	1.00E-02	7.14E-06	6.32E-05	2.80E-02	2.26E-03	2.80E-10	2.47E-09	-	-
Mercury	9.90E+00	1.00E-02	7.14E-06	7.07E-07	6.00E-05	1.18E-02	2.80E-10	2.77E-11	-	-
Nickel	-	1.00E-02	7.14E-06	-	1.80E-02	-	2.80E-10	-	-	-
Selenium	3.50E-01	1.00E-02	7.14E-06	2.50E-08	1.00E-03	2.50E-05	2.80E-10	9.78E-13	-	-
Silver	3.40E+00	1.00E-02	7.14E-06	2.43E-07	1.00E-03	2.43E-04	2.80E-10	9.51E-12	-	-
Zinc	4.27E+01	1.00E-02	7.14E-06	3.05E-06	6.00E-02	5.08E-05	2.80E-10	1.19E-10	-	-
					Hazard Index =	7.14E+00			Total Cancer Risk =	1.25E-07

DMEA DUMP
INHALATION (PARTICULATE MATTER) - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg day)-1	Cancer Risk
Aluminum	4.40E+03	2.16E-11	9.52E-08	1.40E-03	6.80E-05	8.47E-16	3.73E-12	-	-
Antimony	7.40E+00	2.16E-11	1.60E-10	-	-	8.47E-16	6.27E-15	-	-
Arsenic	9.46E+03	2.16E-11	2.05E-07	-	-	8.47E-16	8.01E-12	1.50E+01	1.20E-10
Cadmium	-	2.16E-11	-	-	-	8.47E-16	-	6.30E+00	-
Chromium III	6.40E+00	2.16E-11	1.39E-10	-	-	8.47E-16	5.42E-15	-	-
Copper	6.30E+00	2.16E-11	1.36E-10	-	-	8.47E-16	5.34E-15	-	-
Cyanide	-	2.16E-11	-	-	-	8.47E-16	-	-	-
Lead	9.20E+00	2.16E-11	1.99E-10	-	-	8.47E-16	7.79E-15	-	-
Manganese	8.85E+02	2.16E-11	1.92E-08	1.40E-05	1.37E-03	8.47E-16	7.50E-13	-	-
Mercury	9.90E+00	2.16E-11	2.14E-10	8.60E-05	2.49E-06	8.47E-16	8.39E-15	-	-
Nickel	-	2.16E-11	-	-	-	8.47E-16	-	8.40E-01	-
Selenium	3.50E-01	2.16E-11	7.58E-12	-	-	8.47E-16	2.97E-16	-	-
Silver	3.40E+00	2.16E-11	7.36E-11	-	-	8.47E-16	2.88E-15	-	-
Zinc	4.27E+01	2.16E-11	9.24E-10	-	-	8.47E-16	3.62E-14	-	-
				Hazard Index =	1.44E-03			Cancer Risk =	1.20E-10

LOCATION BD6 (NORTHWEST DUMP)
SOIL INGESTION - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)$^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)$^{-1}$	Cancer Risk
Aluminum	6.85E+03	1.43E-06	9.79E-03	1.00E+00	9.79E-03	5.59E-10	3.83E-06	-	-
Antimony	1.64E+04	1.43E-06	2.34E-02	4.00E-04	5.86E+01	5.59E-10	9.17E-06	-	-
Arsenic	4.79E+03	1.43E-06	4.11E-03	3.00E-04	1.37E+01	5.59E-10	1.61E-06	1.50E+00	2.41E-06
Cadmium	9.00E-02	1.43E-06	1.29E-07	1.00E-03	1.29E-04	5.59E-10	5.03E-11	-	-
Chromium III	8.57E+00	1.43E-06	1.22E-05	1.50E+00	8.16E-06	5.59E-10	4.79E-09	-	-
Copper	2.65E+01	1.43E-06	3.79E-05	3.70E-02	1.02E-03	5.59E-10	1.48E-08	-	-
Cyanide	-	1.43E-06	-	2.00E-02	-	5.59E-10	-	-	-
Lead	3.47E+01	1.43E-06	4.96E-05	-	-	5.59E-10	1.94E-08	-	-
Manganese	1.30E+02	1.43E-06	1.86E-04	1.40E-01	1.33E-03	5.59E-10	7.27E-08	-	-
Mercury	1.36E+01	1.43E-06	1.94E-05	3.00E-04	6.48E-02	5.59E-10	7.60E-09	-	-
Nickel	2.89E+00	1.43E-06	4.13E-06	2.00E-02	2.06E-04	5.59E-10	1.62E-09	-	-
Selenium	7.70E+00	1.43E-06	1.10E-05	5.00E-03	2.20E-03	5.59E-10	4.31E-09	-	-
Silver	6.79E+00	1.43E-06	9.70E-06	5.00E-03	1.94E-03	5.59E-10	3.80E-09	-	-
Zinc	1.50E+02	1.43E-06	2.14E-04	3.00E-01	7.14E-04	5.59E-10	8.39E-08	-	-
				Hazard Index =	7.23E+01			Total Cancer Risk =	2.41E-06

[1] Chemical intake for arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

LOCATION BD6 (NORTHWEST DUMP)
SOIL DERMAL - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Absorption Factor	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	6.85E+03	1.00E-02	7.14E-06	4.89E-04	2.00E-01	2.45E-03	2.80E-09	1.92E-07	-	-
Antimony	1.64E+04	1.00E-02	7.14E-06	1.17E-03	8.00E-05	1.46E+01	2.80E-09	4.58E-07	-	-
Arsenic	4.79E+03	3.00E-02	7.14E-06	1.03E-03	2.85E-04	3.60E+00	2.80E-09	4.02E-07	1.58E+00	6.34E-07
Cadmium	9.00E-02	1.00E-02	7.14E-06	6.43E-09	2.50E-05	2.57E-04	2.80E-09	2.52E-12	-	-
Chromium III	8.57E+00	1.00E-02	7.14E-06	6.12E-07	3.00E-01	2.04E-06	2.80E-09	2.40E-10	-	-
Copper	2.65E+01	1.00E-02	7.14E-06	1.89E-06	7.40E-03	2.56E-04	2.80E-09	7.41E-10	-	-
Cyanide	-	1.00E-02	7.14E-06	-	4.00E-03	-	2.80E-09	-	-	-
Lead	3.47E+01	1.00E-02	7.14E-06	2.48E-06	-	-	2.80E-09	9.70E-10	-	-
Manganese	1.30E+02	1.00E-02	7.14E-06	9.29E-06	2.80E-02	3.32E-04	2.80E-09	3.63E-09	-	-
Mercury	1.36E+01	1.00E-02	7.14E-06	9.71E-07	6.00E-05	1.62E-02	2.80E-09	3.80E-10	-	-
Nickel	2.89E+00	1.00E-02	7.14E-06	2.06E-07	4.00E-03	5.16E-05	2.80E-09	8.08E-11	-	-
Selenium	7.70E+00	1.00E-02	7.14E-06	5.50E-07	1.00E-03	5.50E-04	2.80E-09	2.15E-10	-	-
Silver	6.79E+00	1.00E-02	7.14E-06	4.85E-07	1.00E-03	4.85E-04	2.80E-09	1.90E-10	-	-
Zinc	1.50E+02	1.00E-02	7.14E-06	1.07E-05	6.00E-02	1.79E-04	2.80E-09	4.19E-09	-	-
					Hazard Index =	1.83E+01			Total Cancer Risk =	6.34E-07

LOCATION BD6 (NORTHWEST DUMP)
INHALATION (PARTICULATE MATTER) - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ($(mg/kg\text{-}day)^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg day)$^{-1}$	Cancer Risk
Aluminum	6.85E+03	3.79E-10	2.59E-06	1.40E-03	1.85E-03	1.48E-13	1.02E-09	-	-
Antimony	1.64E+04	3.79E-10	6.21E-06	-	-	1.48E-13	2.43E-09	-	-
Arsenic	4.79E+03	3.79E-10	1.81E-06	-	-	1.48E-13	7.10E-10	1.50E+01	1.07E-08
Cadmium	9.00E-02	3.79E-10	3.41E-11	-	-	1.48E-13	1.33E-14	6.30E+00	8.41E-14
Chromium III	8.57E+00	3.79E-10	3.25E-09	-	-	1.48E-13	1.27E-12	-	-
Copper	2.65E+01	3.79E-10	1.00E-08	-	-	1.48E-13	3.93E-12	-	-
Cyanide	-	3.79E-10	-	-	-	1.48E-13	-	-	-
Lead	3.47E+01	3.79E-10	1.31E-08	-	-	1.48E-13	5.14E-12	-	-
Manganese	1.30E+02	3.79E-10	4.92E-08	1.40E-05	3.52E-03	1.48E-13	1.93E-11	-	-
Mercury	1.36E+01	3.79E-10	5.15E-09	8.60E-05	5.99E-05	1.48E-13	2.02E-12	-	-
Nickel	2.89E+00	3.79E-10	1.09E-09	-	-	1.48E-13	4.28E-13	8.40E-01	3.60E-13
Selenium	7.70E+00	3.79E-10	2.92E-09	-	-	1.48E-13	1.14E-12	-	-
Silver	6.79E+00	3.79E-10	2.57E-09	-	-	1.48E-13	1.01E-12	-	-
Zinc	1.50E+02	3.79E-10	5.68E-08	-	-	1.48E-13	2.22E-11	-	-
				Hazard Index =	5.43E-03			Cancer Risk =	1.07E-08

LOCATION BD6 (NORTHWEST DUMP)
SOIL INGESTION - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ($(mg/kg\text{-}day)^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)[1]	SF (mg/kg-day)$^{-1}$	Cancer Risk
Aluminum	6.85E+03	1.79E-07	1.22E-03	1.00E+00	1.22E-03	6.99E-12	4.79E-08	-	-
Antimony	1.64E+04	1.79E-07	2.93E-03	4.00E-04	7.32E+00	6.99E-12	1.15E-07	-	-
Arsenic	4.79E+03	1.79E-07	5.13E-04	3.00E-04	1.71E+00	6.99E-12	2.01E-08	1.50E+00	3.01E-08
Cadmium	9.00E-02	1.79E-07	1.61E-08	1.00E-03	1.61E-05	6.99E-12	6.29E-13	-	-
Chromium III	8.57E+00	1.79E-07	1.53E-06	1.50E+00	1.02E-06	6.99E-12	5.99E-11	-	-
Copper	2.65E+01	1.79E-07	4.73E-06	3.70E-02	1.28E-04	6.99E-12	1.85E-10	-	-
Cyanide	-	1.79E-07	-	2.00E-02	-	6.99E-12	-	-	-
Lead	3.47E+01	1.79E-07	6.20E-06	-	-	6.99E-12	2.43E-10	-	-
Manganese	1.30E+02	1.79E-07	2.32E-05	1.40E-01	1.66E-04	6.99E-12	9.09E-10	-	-
Mercury	1.36E+01	1.79E-07	2.43E-06	3.00E-04	8.10E-03	6.99E-12	9.51E-11	-	-
Nickel	2.89E+00	1.79E-07	5.16E-07	2.00E-02	2.58E-05	6.99E-12	2.02E-11	-	-
Selenium	7.70E+00	1.79E-07	1.38E-06	5.00E-03	2.75E-04	6.99E-12	5.38E-11	-	-
Silver	6.79E+00	1.79E-07	1.21E-06	5.00E-03	2.43E-04	6.99E-12	4.75E-11	-	-
Zinc	1.50E+02	1.79E-07	2.68E-05	3.00E-01	8.93E-05	6.99E-12	1.05E-09	-	-
				Hazard Index =	9.04E+00			Total Cancer Risk =	3.01E-08

[1] Chemical intake for arsenic is adjusted by a factor of 0.6 to account for reduced ingestion of arsenic in soil compared to arsenic ingestion in water.

LOCATION BD6 (NORTHWEST DUMP)
SOIL DERMAL - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Absorption Factor	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	6.85E+03	1.00E-02	7.14E-06	4.89E-04	2.00E-01	2.45E-03	2.80E-10	1.92E-08	-	-
Antimony	1.64E+04	1.00E-02	7.14E-06	1.17E-03	8.00E-05	1.46E+01	2.80E-10	4.58E-08	-	-
Arsenic	4.79E+03	3.00E-02	7.14E-06	1.03E-03	2.85E-04	3.60E+00	2.80E-10	4.02E-08	1.58E+00	6.34E-08
Cadmium	9.00E-02	1.00E-02	7.14E-06	6.43E-09	2.50E-05	2.57E-04	2.80E-10	2.52E-13	-	-
Chromium III	8.57E+00	1.00E-02	7.14E-06	6.12E-07	3.00E-01	2.04E-06	2.80E-10	2.40E-11	-	-
Copper	2.65E+01	1.00E-02	7.14E-06	1.89E-06	7.40E-03	2.56E-04	2.80E-10	7.41E-11	-	-
Cyanide	-	1.00E-02	7.14E-06	-	4.00E-03	-	2.80E-10	-	-	-
Lead	3.47E+01	1.00E-02	7.14E-06	2.48E-06	-	-	2.80E-10	9.70E-11	-	-
Manganese	1.30E+02	1.00E-02	7.14E-06	9.29E-06	2.80E-02	3.32E-04	2.80E-10	3.63E-10	-	-
Mercury	1.36E+01	1.00E-02	7.14E-06	9.71E-07	6.00E-05	1.62E-02	2.80E-10	3.80E-11	-	-
Nickel	2.89E+00	1.00E-02	7.14E-06	2.06E-07	4.00E-03	5.16E-05	2.80E-10	8.08E-12	-	-
Selenium	7.70E+00	1.00E-02	7.14E-06	5.50E-07	1.00E-03	5.50E-04	2.80E-10	2.15E-11	-	-
Silver	6.79E+00	1.00E-02	7.14E-06	4.85E-07	1.00E-03	4.85E-04	2.80E-10	1.90E-11	-	-
Zinc	1.50E+02	1.00E-02	7.14E-06	1.07E-05	6.00E-02	1.79E-04	2.80E-10	4.19E-10	-	-
					Hazard Index =	1.83E+01			Total Cancer Risk =	6.34E-08

LOCATION BD6 (NORTHWEST DUMP)
INHALATION (PARTICULATE MATTER) - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ($(mg/kg\text{-}day)^{-1}$)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Soil Conc. (mg/kg)	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg day)$^{-1}$	Cancer Risk
Aluminum	6.85E+03	2.16E-11	1.48E-07	1.40E-03	1.06E-04	8.47E-16	5.80E-12	-	-
Antimony	1.64E+04	2.16E-11	3.55E-07	-	-	8.47E-16	1.39E-11	-	-
Arsenic	4.79E+03	2.16E-11	1.04E-07	-	-	8.47E-16	4.06E-12	1.50E+01	6.09E-11
Cadmium	9.00E-02	2.16E-11	1.95E-12	-	-	8.47E-16	7.62E-17	6.30E+00	4.80E-16
Chromium III	8.57E+00	2.16E-11	1.85E-10	-	-	8.47E-16	7.26E-15	-	-
Copper	2.65E+01	2.16E-11	5.74E-10	-	-	8.47E-16	2.24E-14	-	-
Cyanide	-	2.16E-11	-	-	-	8.47E-16	-	-	-
Lead	3.47E+01	2.16E-11	7.51E-10	-	-	8.47E-16	2.94E-14	-	-
Manganese	1.30E+02	2.16E-11	2.81E-09	1.40E-05	2.01E-04	8.47E-16	1.10E-13	-	-
Mercury	1.36E+01	2.16E-11	2.94E-10	8.60E-05	3.42E-06	8.47E-16	1.15E-14	-	-
Nickel	2.89E+00	2.16E-11	6.26E-11	-	-	8.47E-16	2.45E-15	8.40E-01	2.06E-15
Selenium	7.70E+00	2.16E-11	1.67E-10	-	-	8.47E-16	6.52E-15	-	-
Silver	6.79E+00	2.16E-11	1.47E-10	-	-	8.47E-16	5.75E-15	-	-
Zinc	1.50E+02	2.16E-11	3.25E-09	-	-	8.47E-16	1.27E-13	-	-
				Hazard Index =	3.10E-04			Cancer Risk =	6.09E-11

BAILEY TUNNEL OUTLET
SURFACE WATER INGESTION - RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	-	1.43E-04	-	1.00E+00	-	5.59E-08	-	-	-
Antimony	2.81E-01	1.43E-04	4.01E-05	4.00E-04	1.00E-01	5.59E-08	1.57E-08	-	-
Arsenic	5.35E-01	1.43E-04	7.64E-05	3.00E-04	2.55E-01	5.59E-08	2.99E-08	1.50E+00	4.49E-08
Cadmium	-	1.43E-04	-	1.00E-03	-	5.59E-08	-	-	-
Chromium III	-	1.43E-04	-	1.50E+00	-	5.59E-08	-	-	-
Copper	-	1.43E-04	-	3.70E-02	-	5.59E-08	-	-	-
Cyanide	-	1.43E-04	-	2.00E-02	-	5.59E-08	-	-	-
Lead	6.40E-03	1.43E-04	9.14E-07	-		5.59E-08	3.58E-10	-	-
Manganese-w	1.81E-01	1.43E-04	2.59E-05	4.70E-02	5.50E-04	5.59E-08	1.01E-08	-	-
Mercury	-	1.43E-04	-	3.00E-04	-	5.59E-08	-	-	-
Nickel	-	1.43E-04	-	2.00E-02	-	5.59E-08	-	-	-
Selenium	-	1.43E-04	-	5.00E-03	-	5.59E-08	-	-	-
Silver	1.06E-04	1.43E-04	1.51E-08	5.00E-03	3.03E-06	5.59E-08	5.93E-12	-	-
Zinc	7.50E-03	1.43E-04	1.07E-06	3.00E-01	3.57E-06	5.59E-08	4.19E-10	-	-
				Hazard Index =	1.42E-01			Cancer Risk =	4.49E-08

BAILEY TUNNEL OUTLET
SURFACE WATER DERMAL- RME
(RECLAMATION WORKER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	PC	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	-	1.00E-03	7.14E-04	-	2.00E-01	-	2.80E-07	-	-	-
Antimony	2.81E-01	1.00E-03	7.14E-04	2.01E-04	8.00E-05	2.51E+00	2.80E-07	7.86E-08	-	-
Arsenic	5.35E-01	1.00E-03	7.14E-04	3.82E-04	2.85E-04	1.34E+00	2.80E-07	1.50E-07	1.58E+00	2.36E-07
Cadmium	-	1.00E-03	7.14E-04	-	2.50E-05	-	2.80E-07	-	-	-
Chromium III	-	1.00E-03	7.14E-04	-	3.00E-01	-	2.80E-07	-	-	-
Copper	-	1.00E-03	7.14E-04	-	7.40E-03	-	2.80E-07	-	-	-
Cyanide	-	1.00E-03	7.14E-04	-	4.00E-03	-	2.80E-07	-	-	-
Lead	6.40E-03	1.00E-04	7.14E-05	4.57E-07	-		2.80E-08	1.79E-10	-	-
Manganese-w	1.81E-01	1.00E-03	7.14E-04	1.29E-04	9.40E-03	1.38E-02	2.80E-07	5.06E-08	-	-
Mercury	-	1.00E-03	7.14E-04	-	6.00E-05	-	2.80E-07	-	-	-
Nickel	-	2.00E-04	1.43E-04	-	4.00E-03	-	5.59E-08	-	-	-
Selenium	-	1.00E-03	7.14E-04	-	1.00E-03	-	2.80E-07	-	-	-
Silver	1.06E-04	6.00E-04	4.29E-04	4.54E-08	1.00E-03	4.54E-05	1.68E-07	1.78E-11	-	-
Zinc	7.50E-03	1.00E-03	7.14E-04	5.36E-06	6.00E-02	8.93E-05	2.80E-07	2.10E-09	-	-
					Hazard Index =	3.86E+00			Cancer Risk =	2.36E-07

BAILEY TUNNEL OUTLET
SURFACE WATER INGESTION - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	-	1.43E-03	-	1.00E+00	-	5.59E-08	-	-	-
Antimony	2.81E-01	1.43E-03	4.01E-04	4.00E-04	1.00E+00	5.59E-08	1.57E-08	-	-
Arsenic	5.35E-01	1.43E-03	7.64E-04	3.00E-04	2.55E+00	5.59E-08	2.99E-08	1.50E+00	4.49E-08
Cadmium	-	1.43E-03	-	1.00E-03	-	5.59E-08	-	-	-
Chromium III	-	1.43E-03	-	1.50E+00	-	5.59E-08	-	-	-
Copper	-	1.43E-03	-	3.70E-02	-	5.59E-08	-	-	-
Cyanide	-	1.43E-03	-	2.00E-02	-	5.59E-08	-	-	-
Lead	6.40E-03	1.43E-03	9.14E-06	-		5.59E-08	3.58E-10	-	-
Manganese-w	1.81E-01	1.43E-03	2.59E-04	4.70E-02	5.50E-03	5.59E-08	1.01E-08	-	-
Mercury	-	1.43E-03	-	3.00E-04	-	5.59E-08	-	-	-
Nickel	-	1.43E-03	-	2.00E-02	-	5.59E-08	-	-	-
Selenium	-	1.43E-03	-	5.00E-03	-	5.59E-08	-	-	-
Silver	1.06E-04	1.43E-03	1.51E-07	5.00E-03	3.03E-05	5.59E-08	5.93E-12	-	-
Zinc	7.50E-03	1.43E-03	1.07E-05	3.00E-01	3.57E-05	5.59E-08	4.19E-10	-	-
				Hazard Index =	3.56E+00			Cancer Risk =	4.49E-08

BAILEY TUNNEL OUTLET
SURFACE WATER DERMAL - RME
(RECREATIONAL USER)

HQ = Chemical Intake / RfD
CR = Chemical Intake x SF

Where:
RfD = Reference Dose (mg/kg-day)
SF = Cancer Slope Factor ((mg/kg-day)-1)
HQ = Hazard Quotient for noncancer effects
CR = Cancer risk

Chemical of Concern	Surface Water Conc. (mg/L)	PC	Intake Factor (L/kg-day)	Chemical Intake (mg/kg-day)	RfD (mg/kg-day)	HQ	Intake Factor (kg/kg-day)	Chemical Intake (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk
Aluminum	-	1.00E-03	1.43E-04	-	2.00E-01	-	5.59E-09	-	-	-
Antimony	2.81E-01	1.00E-03	1.43E-04	4.01E-05	8.00E-05	5.02E-01	5.59E-09	1.57E-09	-	-
Arsenic	5.35E-01	1.00E-03	1.43E-04	7.64E-05	2.85E-04	2.68E-01	5.59E-09	2.99E-09	1.58E+00	4.72E-09
Cadmium	-	1.00E-03	1.43E-04	-	2.50E-05	-	5.59E-09	-	-	-
Chromium III	-	1.00E-03	1.43E-04	-	3.00E-01	-	5.59E-09	-	-	-
Copper	-	1.00E-03	1.43E-04	-	7.40E-03	-	5.59E-09	-	-	-
Cyanide	-	1.00E-03	1.43E-04	-	4.00E-03	-	5.59E-09	-	-	-
Lead	6.40E-03	1.00E-04	1.43E-05	9.14E-08	-		5.59E-10	3.58E-12	-	-
Manganese-w	1.81E-01	1.00E-03	1.43E-04	2.59E-05	9.40E-03	2.75E-03	5.59E-09	1.01E-09	-	-
Mercury	-	1.00E-03	1.43E-04	-	6.00E-05	-	5.59E-09	-	-	-
Nickel	-	2.00E-04	2.86E-05	-	4.00E-03	-	1.12E-09	-	-	-
Selenium	-	1.00E-03	1.43E-04	-	1.00E-03	-	5.59E-09	-	-	-
Silver	1.06E-04	6.00E-04	8.57E-05	9.09E-09	1.00E-03	9.09E-06	3.35E-09	3.56E-13	-	-
Zinc	7.50E-03	1.00E-03	1.43E-04	1.07E-06	6.00E-02	1.79E-05	5.59E-09	4.19E-11	-	-
					Hazard Index =	7.73E-01			Cancer Risk =	4.72E-09

APPENDIX E

TOXICITY PROFILES

TOXICITY PROFILE FOR ARSENIC

CHEMISTRY AND EXPOSURE

CHEMICAL FORMS OF ARSENIC

Arsenic is naturally occurring, and is usually found combined with elements such as oxygen or sulfur. These forms of arsenic are known as inorganic arsenic. The elemental (pure) form of arsenic is less common in the environment (ATSDR, 1998). Naturally occurring arsenic can exist in four oxidation states: -3 (arsine gas), 0 (the metallic state), +3, and +5. The most common oxidation states of arsenic in soil and water are arsenite (As^{+3}) and arsenate (As^{+5}) (Valberg et al., 1997). Trivalent forms of arsenic typically found in soil include arsenic trioxide, calcium arsenite, cupric arsenite, lead arsenite, and sodium arsenite (Naqvi et al., 1994). Pentavalent forms of arsenic in soil include arsenic pentoxide, calcium arsenate, and lead arsenate (Naqvi et al., 1994). Natural arsenic associated with ore deposits may exist in more complex forms such as enargite (Cu_3AsS_4) or arsenopyrite (FeAsS) (Valberg et al., 1997). Arsenic compounds associated with ore deposits are generally less toxic than soluble forms of arsenic, due to low uptake potential (Davis et al., 1992).

In fish and shellfish most arsenic is present as non-toxic organic forms (e.g., arsenobetaine and arsenocholine) (ATSDR, 1998). It is common practice to conservatively estimate that no more than 10% of arsenic in fish and shellfish is present as inorganic arsenic (FDA, 1993).

HUMAN EXPOSURE

Because arsenic is a natural part of the environment, it is normally present in soil, water, food, and air. Of these media, food is usually the largest source in the U.S. population. Persons in the U.S. typically ingest about 50 µg/day of total arsenic. USEPA estimates that Americans ingest approximately 18 µg/day of inorganic arsenic in food and about 5 µg/day in drinking water (USEPA, 1988; Valberg et al. 1997).

PHARMACOKINETICS

ABSORPTION

Soluble (ionic) forms of arsenate and arsenite typically found in food and water are well absorbed by the oral route. Inorganic arsenic is also well absorbed from the lungs (ATSDR, 1998).

USEPA's oral RfD and SF for arsenic were derived based on an epidemiological study of a group of people who were exposed to high levels (e.g., intake of approximately 1000 µg/day) of soluble arsenic in food and water (USEPA, 2000a). However, arsenic ingested in soil is generally less well absorbed than soluble arsenic in food and water because (1) the arsenic form may be relatively insoluble (e.g., arsenic forms at mining sites tend to be insoluble [Davis et al., 1996]; and (2) arsenic adsorbs to soil particles which makes it less available for absorption (Valberg et al., 1997). This assumption of lower bioavailability is confirmed by results from animal studies which show that soil-bound arsenic is not as bioavailable as arsenic in solution (Freeman et al., 1993; 1995; Groen et al., 1994). In addition, a number

of human studies have reported low urinary arsenic levels at sites with high arsenic in soil, probably as a result of the low oral bioavailability of arsenic in soil (Butte-Silver Bow Dept. of Public Health and Cinn. Dept. of Health, 1992; Colorado Dept. of Health and ATSDR, 1990; Hewitt et al., 1995; Huang et al., 1997; Valberg et al., 1997). Good correlations between arsenic in soil and urinary arsenic levels in human receptors were reported at a site where site-specific bioavailability adjustment factors (0.18-0.25) were used to account for lower bioavailability of arsenic in soil (Walker and Griffin, 1998). USEPA Region 10 recommends using a relative bioavailability factor of 0.6 in risk assessment to account for lower bioavailability of arsenic in soil relative to arsenic in food and water (Lorenzana, Roseanne 1998, personal communication between Roseanne Lorenzana,, EPA Region 10 risk assessor and Sharon Quiring, URS-Seattle risk assessor).

Low dermal absorption of arsenic has been reported in studies of human cadavers, Rhesus monkeys, and rats (ATSDR, 1998). ATSDR (1998) reported that "dermal uptake of arsenic appears to be sufficiently limited that other routes of exposure (oral or inhalation) would almost always be expected to be of greater concern."

METABOLISM AND EXCRETION

Once absorbed, arsenate (As+5) and arsenite (As+3) can be interconverted (ATSDR, 1998). In addition, humans efficiently metabolize inorganic arsenic forms to methylarsenic acid (MMA) and dimethyl arsenic acid (DMA), which are rapidly excreted in the urine (ATSDR, 1998). This methylation may be considered a detoxification system because methylated metabolites are less reactive with tissue, less toxic, and more rapidly excreted in the urine (Vahter et al., 1995). Most absorbed arsenic in humans is excreted in the urine within several days (ATSDR, 1998).

TOXICITY

Adverse effects from acute exposure to high levels of arsenic are relatively well understood. However, there is little consensus regarding potential toxicity (including carcinogenic potency) from chronic intake of low levels of arsenic such as those typically observed in the U.S. (i.e., ingestion of approximately 50 μg total arsenic per day). In addition, most reports of arsenic toxicity in humans so far are based on exposure to arsenic compounds in media other than soil, e.g., inhalation in occupational settings or consumption in food and drinking water (Valberg et al., 1997).

GENOTOXIC EFFECTS

Inorganic arsenicals are usually inactive or weak mutagens, but are able to produce chromosomal effects in humans and in human cells *in vitro* (ATSDR, 1998).

CANCER EFFECTS

In Humans: The International Agency for Research on Cancer (IARC), the Department of Health and Human Services, USEPA and the U.S. National Toxicology Program (NTP) have each classified inorganic arsenic as being carcinogenic to humans. Breathing inorganic arsenic increases the risk of lung cancer in

human (ATSDR, 1998). Ingesting 1000 μg/day of inorganic arsenic in food and drinking water increases the risk of a specific type of skin cancer and could be associated with tumors of the bladder and lung (ATSDR, 1998; NAS, 1999). The type of skin cancer associated with exposure to arsenic is easily treated and almost never fatal (USEPA, 1988). There is no evidence that dermal exposure to arsenic produces cancer in humans (e.g., arsenic does not induce skin cancer at the point of contact (ATSDR, 1998).

In Animals: No animal model exists for carcinogenicity of arsenic in skin and other organs after oral exposure (ATSDR, 1998). ATSDR (1998) reported that cancer studies in animals after inhalation exposure were not located and that most studies of animals exposed to arsenate or arsenite by the oral route have not yet detected any clear evidence for an increased incidence of skin cancer or other cancers.

Mechanism of Action. USEPA's *1997 Report on the Expert Panel on Arsenic Carcinogenicity: Review and Workshop* stated that the mechanism of action for carcinogenicity of arsenicals is to induce chromosome alterations which are involved in tumor formation (USEPA 1997). The process by which chromosome alterations are induced is unknown. However, the panel concluded that arsenic and its metabolites probably do not directly interact with DNA (USEPA 1997).

Based on a mechanism of action involving chromosomal alterations (without direct interaction with DNA), the dose-response curve for induction of tumors by arsenic is predicted to be non-linear at low dose levels (in other words, to exhibit a threshold). Non-linearity at low doses is also supported by experimental data (USEPA, 1997). This is an important distinction, because USEPA applied a linear model to data from Taiwanese populations exposed to high doses of arsenic to derive their oral SF for predicting cancer risk at low doses (USEPA 2000a). An USEPA expert panel on arsenic carcinogenicity recently concluded this methodology will not accurately predict cancer response at low doses (USEPA, 1997).

Humans have a mechanism for detoxifying arsenic (by methylation and excretion). It has been proposed that the risk of cancer from exposure to low doses of arsenic may be zero because, below a threshold dose, there is complete methylation and excretion of inorganic arsenic (Chappel et al., 1997). However, in deriving the slope factor, USEPA assumed that any dose no matter how small is associated with some probability of inducing cancer.

Cancer Classification and Potency of Arsenic. USEPA has classified arsenic as "A, known human carcinogen" based on increased risk of lung cancer from breathing arsenic in occupational settings and increased the risk of a specific type of skin cancer in humans ingesting arsenic in water (USEPA, 2000a).

USEPA's oral SF for arsenic of 1.5 per mg/kg-day was derived based on increased skin cancer in a Taiwanese population ingesting approximately 1000 μg/day of naturally-occurring arsenic in their food and drinking water. Data regarding cancer risk in humans exposed to much lower levels of arsenic (e.g., typical intake of 50 μg total arsenic per day observed in the U.S. population) were not available. Therefore, USEPA used cancer risk levels in the Taiwanese population exposed to very high levels of arsenic with a model to mathematically estimate cancer risk from exposure to very low doses of arsenic (USEPA, 2000a).

Regarding USEPA's oral slope factor for arsenic, ATSDR (1998) stated: "Recently it has been suggested that this slope factor may over-estimate cancer risks at low dose, since low doses may be largely 'detoxified' by in vivo methylation producing a nonlinear dose-response curve (Marcus and Rispin, 1998). Additional considerations currently under intense debate include the adequacy of the model used by EPA and the accuracy and reliability of the Taiwan exposure data (Brown et al. 1997); a number of host and environmental factors among the Taiwanese that may not be applicable elsewhere (Carlson-Lynch et al. 1999); a possible threshold for arsenic carcinogenicity and nonlinearities in the dose-response curve (Abernathy et al. 1996, Slayton et al. 1996); and the possibility of significant exposure to arsenic from sources other than the well water (Chappell et al. 1997)."

Beginning in 1997, USEPA launched a major research effort to better understand the cancer potency of arsenic ingested by humans at low doses observed in the U.S. The expectation is that, based on better information, USEPA will derive new toxicity values for arsenic without having to depend on the Taiwanese data. However, information from these studies may not be available for several years.

USEPA is currently revising the MCL for arsenic. At the request of USEPA, the National Academy of Sciences (NAS) reviewed the current state of science for estimating risks associated with arsenic in drinking water (NAS, 1999). NAS assessed the risks of skin, lung, and bladder cancer from ingestion of inorganic arsenic in drinking water, primarily using information from Taiwanese populations exposed to high doses of arsenic. The report concluded that the current EPA MCL for arsenic in drinking water of 50 ug/L does not achieve EPA's goal for public health protection, based on risk estimates for lung and bladder cancer, and requires downward revision as promptly as possible. USEPA recently proposed an MCL for arsenic in drinking water of 5 ug/L (USEPA, 2000b). USEPA plans to issue a final arsenic MCL in 2001.

NON-CANCER EFFECTS

Oral route: Ingested arsenic may produce gastrointestinal irritation, peripheral neuropathy, vascular lesions, anemia, and a group of skin diseases. Chronic lowest observable adverse effect levels (LOAELs) for humans range from about 0.001 (dermal effects only) to 0.100 mg/kg-day (approximately 70 to 7000 μg/day for an adult) (ATSDR, 1998).

The current USEPA RfD of 3E-04 mg/kg-day (intake of about 21 μg/day) is based on peripheral vascular disease leading to skin effects in a Taiwanese population exposed to 0.014 mg/kg-day arsenic (intake of about 1000 μg/day in an adult) in their food and drinking water.

Dermal route: Direct exposure to inorganic arsenic on the skin may produce local irritation or dermatitis (ATSDR, 1998). Regarding non-local effects, ATSDR (1998) reported that "dermal uptake of arsenic appears to be sufficiently limited that other routes of exposure (oral or inhalation) would almost always be expected to be of greater concern [than the dermal route]."

Inhalation Route: Respiratory irritation, nausea, and skin effects have been reported in humans exposed to inorganic arsenic by the inhalation route of exposure (ATSDR, 1998). Non-cancer effects in humans are

unlikely to occur when arsenic is below a concentration of about 100 to 1000 μg/m^3 (ATSDR, 1998). USEPA does not currently have an inhalation RfC for arsenic.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 1998. Toxicological Profile for Arsenic (Update). Draft for Public Comment, August 1998.

Abernathy, C.O., W.R. Chappell, M.E., Meek, et al. 1996. Is ingested arsenic a "threshold" carcinogen? Fund. Appl. Toxicol. 29(2): 168-175 (as cited in ATSDR, 1998).

Brown, K.G., H.-R. Guo, T.-L. Kuo, and H.L. Greene. 1997. Skin Cancer and Inorganic Arsenic: Uncertainty-Status of Risk. Risk Analysis 17(1):37-42. February (as cited in ATSDR, 1998).

Butte-Silver Bow Department of Health and University of Cincinnati Department of Environmental Health. 1992. The Butte-Silver Bow County Environmental Health Lead Study. Final report. February.

Carlson-Lynch, H., B.D. Beck, P.D. Boardman. 1994. Arsenic risk assessment. Environ. Health Perspect. 102(4): 354-356 (as cited in ATSDR, 1998).

Chappell, W. R., B.D. Beck, K.G. Brown, R. Chaney, C.R. Cothern, K.J. Irgolic, D.W. North, I. Thornton, and T.A. Tsongas. 1997. Inorganic Arsenic: A Need and an Opportunity to Improve Risk Assessment. Environmental Health Perspectives 105(10). October (as cited in ATSDR, 1998).

Colorado Department of Health Division of Disease Control and Environmental Epidemiology, University of Colorado at Denver, Center for Environmental Sciences, and Agency for Toxic Substances and Disease Registry (ATSDR). 1990. Leadville Metals Exposure Study. April.

Davis, A., M.V. Ruby, M. and P.D. Bergstrom. 1992. Bioavailability of Arsenic and Lead in Soils form the Butte, Montana, Mining District. Environ. Sci. Technol. 26 (3): 461-468.

Davis, A., M.V. Ruby, M. Bloom, R. Schoof, G. Freeman, and P.D. Bergstrom. 1996. Mineralogic Constraints on the Bioavailability of Arsenic in Smelter-Impacted Soils. Environ. Sci. Technol. 30: 392-399.

Freeman, G.B., J.D. Johnson, J.M. Killinger, S.C. Liao, A.O. Davis, M.V. Ruby, R.L. Chaney, S.C. Lovre, and P.D. Bergstrom. 1993. Bioavailability of arsenic in soil impacted by smelter activities following oral administration in rabbits. Fundam. Appl. Toxicol. 21:83-88.

Groen, K., H.A.M.G. Vaessen, J.J.G. Kliest, J.L.M. de Boer, T. van Ooik, A. Timmerman, and R.F. Vlug. 1994. Bioavailability of inorganic arsenic from bog ore-containing soil in the dog. Environmental Health Perspective 102(2):182-184.

Huang, Y.-H., R.L. Bornschein, J. Grote, W. Menrath, and S. Roda. 1997. Environmental arsenic exposure of children around a former copper smelter site. Environ. Res. 72:72-81.

Marcus, W.L. and A.S. Rispin. 1998. Threshold carcinogenicity using arsenic as an example. In: Cothern, C.R., M.A. Mehlan, W.L. Marcus, eds. Risk assessment and risk management of industrial and environmental chemicals. Vol XV. Princeton, NJ: Princeton Scientific Publishing Co., 133-158 (as cited in ATSDR, 1998).

Naqvi, S.M., C. Vaishnavi, H. Singh. 1994. Toxicity and Metabolism of Arsenic in Invertebrates. Arsenic in the Environment, Part II: Human Health and Ecosystem Effects. Edited by Jerome O. Nriagu. Published by John Wiley & Sons, Inc.

National Academy of Sciences (NAS). 1999. Arsenic in Drinking Water. National Research Council. Ed: National Academy Press. Washington, D.C.

Slayton, T.M., B.D. Beck, K.A. Reynolds, S.D. Chapnick, P.A. Valberg, L.J. Yost, R.A. Schoof, T.D. Gauthier, and L. Jones. 1996. Correspondence: Issues in arsenic cancer risk assessment. Environmental Health Perspective 104(10):1012-1013 (as cited in ATSDR, 1998).

U.S. Environmental Protection Agency (USEPA). 1988. Special Report on Ingested Inorganic Arsenic: Skin Cancer; Nutritional Essentiality. Office of Health and Environmental Assessment, Washington, DC. USEPA/625/3-87/013A. SAB Review Draft. November.

U.S. Environmental Protection Agency (USEPA). 1997. Report on the Expert Panel on Arsenic Carcinogenicity: Review and Workshop. Prepared by Eastern Research Group, Inc., USEPA Contract No. 68-C6-0041. Prepared for the National Center for Environmental Assessment. August.

U.S. Environmental Protection Agency (USEPA). 2000a. Integrated Risk Information System. Arsenic, inorganic, CASRN 7440-38-2, last revised 04/10/1998. Available online at http://www.epa.gov/iris/subst/0278.htm

U.S. Environmental Protection Agency (USEPA). 2000b. Proposed Revision to Arsenic Drinking Water Standard. Office of Groundwater and Drinking Water. 815-F-00-012. May. Available online at http://www.epa.gov/safewater/ars/proposalfs.htmlupdated.

U.S. Food and Drug Administration (FDA). 1993. Guidance Document for Arsenic in Shellfish. Center for Food Safety and Applied Nutrition. Washington, DC. January.

Vahter, M., R. Couch, B. Nermell, and R. Nilsson. 1995. Lack of Methylation of Inorganic Arsenic in the Chimpanzee. Toxicology and Applied Pharmacology 133:262-268.

Valberg, P.A., B.D. Beck, T.S. Bowers, J.L. Keating, P.D. Bergstrom, and P.D. Boardman. 1997. Issues in Setting Health-Based Cleanup Levels for Arsenic in Soil. Regulatory Toxicology and Pharmacology 26:219-229.

Walker, S. and S. Griffin. 1998. Site-specific Data Confirm Arsenic Exposure Predicted by the U.S. Environmental Protection Agency. Environmental Health Perspectives 106(3):133-139. March.

TOXICITY PROFILE FOR ANTIMONY

CHEMISTRY AND EXPOSURE

Antimony (CAS NO. 7440-36-0, Sb) is a silver-white, lustrous, hard, brittle metal with scale-like crystalline structure of dark gray, lustrous powder with an atomic weight of 121.75 g/mole (Merck, 1989). Besides the stable metal there are two allotropes: yellow crystalline and amorphous black forms (Sax, 1986). Its density is 6.684 at 25 C and it is insoluble in hot and cold water (Weast, 1988-89). Antimony reacts with hot concentrated hydrochloric acid, and when melted forms a volatile oxide (Stokinger, 1981).

Antimony exists in a variety of chemical forms, including trivalent and pentavalent states. Stibnite (Sb_2S), is the most common naturally occurring antimony compound. Antimony may also be found in the environment as the native metal, as antimonides of heavy metals, and as antimony oxides. Antimony exists in natural waters as a soluble oxide or antimonite salt. Sorption onto clay and other minerals is the primary mechanism for removal from surface waters. Antimonite salts may also react with other heavy metals in solution to form insoluble compounds that may precipitate. In bed sediments, which often provide a reducing environment, a volatile water-soluble gas known as stibine (SbH_3) is formed (Amdur et al., 1991). This gas is oxidized to SbO_3 in aerobic waters or in air. This process results in the mobilization of antimony compounds from sediments. Bioaccumulation is not an important fate process for antimony.

Antimony is often used in association with lead and arsenic in industry. The major uses of this metal include the manufacture of lead alloys, storage batteries, pewter, rubber, matches, ceramics, enamels, paints, lacquers, and textiles (Goyer, 1986). Antimony forms a volatile oxide in reaction with steam, nitric acid, or strongly oxidizing salts. When heated, antimony reacts with halogens (e.g., chlorine or bromine). Oxides, sulfides, and chlorides of antimony are the most common forms found in industry.

PHARMACOKINETICS

Antimony is slowly absorbed from the gastrointestinal tract (Amdur et al., 1991). Inhaled antimony can be absorbed from the lungs and transported to blood and tissues (Carson et al., 1986). Specific information on the dermal absorption of antimony was not located; however, most metals are poorly absorbed through the skin.

The disposition of antimony in the body differs for trivalent and pentavalent forms (Amdur et al., 1991). Trivalent antimony is concentrated in red blood cells and pentavalent antimony is found mostly in plasma. Trivalent antimony is excreted primarily in the urine, while there is greater gastrointestinal excretion of the pentavalent form.

TOXICITY

GENOTOXIC EFFECTS

Incubation of antimony salts with human lymphocytes resulted in chromosome defects (Paton and Allison, 1972). Syrian hamster embryo cells treated with antimony acetate undergo neoplastic transformation (Amdur et al., 1991).

CANCER EFFECTS

There is no evidence that antimony is carcinogenic in humans or animals. USEPA (2000) reports that antimony has not undergone a complete evaluation and determination under USEPA's IRIS program for evidence of human carcinogenic potential. Therefore, cancer classification for antimony is not available from USEPA. However, oral feeding of antimony to rats does not produce excess tumors (Amdur et al., 1991).

NON-CANCER EFFECTS

Because human occupational exposure to antimony typically also involves exposure to lead and arsenic, it is difficult to assess the toxicity of antimony alone (Sax, 1986). In general, antimony compounds are irritants at the portal of entry. Oral ingestion of antimony trioxide can cause burning stomach pains, colic, nausea, and vomiting (Amdur et al., 1991). Antimony poisoning among smelter workers occurred at atmospheric concentrations of 4.69-11.81 mg/m^3; symptoms included dermatitis, rhinitis, inflammation of the upper and lower respiratory tract, and pneumonitis (Stokinger, 1981). Exposure to antimony fumes or dust has also resulted in conjunctivitis and nasal septal ulceration (Merck, 1989). Animals exposed to the fumes of antimony oxide have developed pneumonitis, fatty degeneration of the liver, a decreased white blood cell count, and damage to the heart muscle.

Antimony compounds are irritating to the skin upon direct contact (Sax, 1986). Contact with fumes or dust containing antimony has resulted in dermatitis and keratitis (Merck, 1989). Chronic exposure to antimony by dermal contact causes pustular skin eruptions known as "antimony spots", which is a rash consisting of papules and pustules around sweat and sebaceous glands (Stokinger, 1981).

Some studies suggest that chronic occupational exposure to antimony compounds results in deleterious nervous system effects, irritability, sleeplessness, fatigue, dizziness, and muscular and neurological pain. These effects are very difficult to attribute to antimony alone, because there often is concurrent exposure to known neurotoxins (e.g., lead). Myocardial effects following chronic exposure to antimony among factory workers have been conclusively documented. Individuals exposed to antimony trisulfide at concentrations ranging from 0.58 to 5.5 mg/m^3 exhibited ECG changes and elevated blood pressure (Carson, 1986). Stokinger (1981) reported that female workers exposed to antimony experienced a higher than normal incidence of spontaneous abortions late in the pregnancy, premature births, and depressed infant weight gain. Animal studies failed to reproduce these findings (Stokinger, 1981).

The current USEPA oral RfD for antimony is based on a study in rats (Schroeder et al., 1970) exposed to potassium antimony tartrate administered in water at a dose level of 0.35 mg/kg-day which resulted in decreased longevity, decreased blood glucose levels, and altered cholesterol levels (USEPA, 2000). No increase in tumors was seen as a result of treatment. Similar effects following exposure to antimony have been reported in mice (Kanisawa and Schroeder, 1969) and in other studies on rats (Bradley and Frederick, 1941; Browning 1969).

The LOAEL of 0.35 mg/kg-day was divided by an uncertainty factor of 1000, resulting in an oral RfD of 0.0004 mg/kg-day (USEPA, 2000). The uncertainty factor of 1000 reflects large uncertainty as to the toxicity of antimony by the oral route.

There are no USEPA-verified toxicity values for inhalation exposure to antimony (USEPA, 2000).

References

Amdur, M.O., Doull, J., and C.D. Klaassen (eds), 1991. Casarett and Doull's Toxicology, The Basic Science of Poisonings. 3rd Ed. Pergamon Press, New York.

Bradley, W.R. and W.G. Frederick. 1941. The toxicity of antimony--animal studies. Ind. Med. 10 Ind. Hyg. Sec. 2: 15-22.

Browning, E. 1969. Antimony. In: Toxicity of Industrial Metals, 2nd ed. Appleton-Century-Craft, New York. p. 23-38

Carson, B.L., Ellis, H.V., and McCann, J.L., eds. 1986. Toxicology and biological monitoring of metals in humans. Lewis Publishers Inc., Michigan.

Chappell, W. R., B.D. Beck, K.G. Brown, R. Chaney, C.R. Cothern, K.J. Irgolic, D.W. North, I. Thornton,

Excerpted from: "Toxicological Profile for Antimony", ATSDR, 10/90.

Goyer, R.A. 1986. Toxic Effects of Metals. In: Casarett and Doull's Toxicology: The Basic Science of Poisons. 3rd Ed. Edited by C.D. Klaassen, M.O. Amdur, and J. Doull. MacMillan, New York.

Kanisawa, M. and H.A. Schroeder. 1969. Life term studies on the effect of trace elements on spontaneous tumor in mice and rats. Cancer Res. 29: 892-895.

Sax, N.I. 1986. Dangerous Properties of Industrial Materials. Van Nostrand Reinhold. New York.

Schroeder, H.A., M. Mitchner and A.P. Nasor. 1970. Zirconium, niobium, antimony, vanadium and lead in rats: Life term studies. J. Nutrition. 100: 59-66.

The Merck Index, 11th Edison, Merck & Co., Inc., 1989.

U.S. Environmental Protection Agency (USEPA). 2000. Integrated Risk Information System. On-line database.

Weast, J. Handbook of Chemistry and Physics, 69th Ed. 1988-1989.