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Acronyms and Abbreviations

ACF	Acute Conversion Factor
AVS	Acid Volatile Sulfide
BMR	Basal Metabolic Rate
BW	Body Weight
CAWQS	California Ambient Water Quality Standards
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CC	Clipper Creek
CCC	Criterion Continuous Concentration
CCF	Chronic Conversion Factor
CCME	Canadian Council of Ministers of the Environment
COPEC	Compounds of Potential Ecological Concern
CMC	Criterion Maximum Concentration
CSM	Conceptual Site Model
DOE	U.S. Department of Energy
DQO	Data Quality Objectives
DTSC	California Department of Toxic Substances Control
EC_{50}	Median Effective Concentration
EC_{100}	Concentration at which 100 percent of test individuals experience the measured effect
ED_{20}	Dose at which 20 percent of test individuals experience the measured effect
EPA	U.S. Environmental Protection Agency
ERA	Ecological Risk Assessment
ER-L	Effects Range-Low
FIR	Food Ingestion Rate
GE	Gross Energy

FS	Feasibility Study
HBI	Hilsenoff Biotic Index
HQ	Hazard Quotient
ISQG	Interim Freshwater Sediment Quality Guidelines
LC_{50}	Median Lethal Concentration
LCC	Little Clipper Creek
LCV	Lowest Chronic Value
LGC	Little Greenhorn Creek
LOAEL	Lowest Observed Adverse Effects Level
LOEC	Lowest Observed Effects Concentration
MBS	Metabolic Body Size
ME	Metabolizable Energy
NAWQC	National Ambient Water Quality Criteria
NCP	National Contingency Plan
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effects Level
NOEC	No Observed Effects Concentration
NPL	National Priorities List
ORNL	Oak Ridge National Laboratory
PCC	Potential Cleanup Concentrations
PEC	Probable Effects Concentration
PEL	Probable Effects Level
RBP	Rapid Bioassessment Protocol
RI	Remedial Investigation
SQG	Sediment Quality Guideline
STD	Standard Deviation
TEC	Threshold Effects Concentration
TEL	Thresholds Effects Level
TRV	Toxicity Reference Value

UCL	Upper Confidence Limit
UET	Upper Effects Level
WIR	Water Ingestion Rate
WQC	Water Quality Criteria

SECTION 1

Executive Summary

Mining activities from 1861 to 1943 at the Lava Cap Mine, and the subsequent partial collapse of the tailings log dam in 1997, have resulted in contamination by cyanide and various metals at the Lava Cap Mine Superfund Site. Contamination extends downstream of the mine along the Little Clipper Creek (LCC)/Clipper Creek (CC) drainage south to its confluence with Little Greenhorn Creek (LGC). This preliminary ecological risk assessment represents one component of the Remedial Investigation and Feasibility Study (RI/FS) that the United States Environmental Protection Agency (EPA) is conducting to address contamination at the Lava Cap Mine site. Results of this assessment are intended to help EPA determine whether cleanup actions are warranted for the affected soil, sediment, and surface water at the Lava Cap Mine site.

Potential risks to fish, sediment biota (benthic invertebrates), amphibians (e.g. red-legged frog), terrestrial plants, soil invertebrates (earthworms), soil microbial processes, and birds and mammals (e.g. American dipper, red-tailed hawk, green heron, California quail, mink, ornate shrew, California vole, and long-tailed weasel) from site-related contamination in surface water, sediment, and soil in four areas at the Lava Cap Mine site have been evaluated. Conservative estimates of exposure for each receptor were compared to literature-derived ecotoxicity screening values, as well as to site-specific toxicity thresholds as available. Results of site-specific ambient media toxicity bioassays and biological surveys were used as additional lines of evidence in the evaluation. It is assumed there is potential for ecological receptors to experience adverse effects if estimated exposure to Chemicals of Potential Ecological Concern (COPECs) exceeded ecotoxicity screening or site-specific toxicity values and were above reference concentrations. The results of these comparisons were then evaluated against biological survey data or life-history parameters (e.g. home range size) to determine if a COPEC should be retained as a risk driver.

The results of this preliminary ecological risk assessment are presented below by subarea and receptor within the Lava Cap Mine site. All the conclusions are tentative at this time since most of the screening values are literature-derived benchmarks and many of the benchmarks are not conservative enough to assure protection of individual special-status species such as the red-legged frog. The benchmarks also, in certain cases, conflict with site-specific bioassays and bioassessments. However, COPEC concentrations in site-specific bioassay media generally do not represent maximum concentrations found on site.

Lava Cap Mine Area - this area encompasses all areas at the mine itself exclusive of the source areas (i.e. the historic mine buildings and the waste rock/tailings pile). Sampling focused on areas adjacent to or in close proximity to the source areas. Samples of surface soil, surface water, sediment, groundwater, air, and biota were collected. Surface water and sediment were collected in a seasonally-ponded portion of LCC channel located northeast of the waste-rock/tailings and from a pond near the new residence located northwest of the historic mining operations.

Fish, considered to be sensitive receptors due to their complete exposure to surface water, may be at risk from silver, arsenic, barium, beryllium, cadmium, cobalt, copper, cyanide, lead, manganese, mercury, nickel, antimony, and zinc. Amphibians, also identified as a receptor sensitive to COPECs in surface water, are potentially at risk from silver, arsenic, copper, mercury, manganese, nickel, lead and zinc. Sediment biota may be at risk from silver, arsenic, cadmium, copper, mercury, lead, antimony and selenium. Terrestrial plants may be at risk from silver, arsenic, cadmium, cyanide, cobalt, copper, mercury, lead, antimony, zinc and selenium; earthworms from the same COPECs as terrestrial plants with the addition of nickel; and microbes from silver, arsenic, cadmium, copper, nickel, lead, and zinc.

A number of birds and mammals were also selected to represent the major trophic levels which may feed and live on the Mine Area and are assumed to forage in close association with affected media. The American dipper, a bird that feeds on aquatic biota, has a small home range and is maximally exposed to sediment and surface water, may be at risk from arsenic, cobalt, copper, mercury, manganese, lead, and selenium. The green heron, which feeds on a wide variety of aquatic and terrestrial biota and may have a small home range depending on the site, may be at risk from arsenic. The California quail, which feeds on herbaceous material and occasional arthropods and has a small home range, may be at risk from arsenic. The California vole, a small mammal herbivore with a small home range, may be at risk from arsenic, cyanide, and lead. The mink, a small mammal that preys on a wide variety of terrestrial and aquatic biota, may be at risk from arsenic. The ornate shrew, assumed to be sensitive due to its close association with soil, small home range and a high ingestion rate as compared to a small body weight, preys on a wide variety of invertebrates and may be at risk from arsenic, cyanide, lead and antimony. The long-tailed weasel, a small terrestrial carnivore with a high ingestion rate and a small home range, may be at risk from arsenic. Exposure was also estimated for the red-tailed hawk but due to a comparatively large home range compared to the site, this receptor was not found to be at potential risk from any of the COPECs at any of the subareas. See Table 1-1 for a visual representation of potential risk.

Midgradient - this area encompasses the Little Clipper Creek drainage below the mine which serves as the link between the contaminant source area and the primary downstream deposition and accumulation areas, including Lost Lake. The creek has a steep gradient in this area and significant tailings deposition occurs only in isolated areas. This section is approximately one mile long. Samples of surface soil and water, sediment, groundwater and biota were collected.

Fish may be at risk from arsenic, barium, cadmium, cyanide, lead and zinc. Amphibians may be at risk from arsenic. Sediment biota may be at risk from silver and lead. Terrestrial plants may be at risk from silver, arsenic, cadmium, mercury, antimony and zinc. Earthworms may be at risk from mercury and microbes may be at risk from arsenic. The American dipper may be at risk from arsenic and selenium. The California vole, ornate shrew, mink and the long-tailed weasel may be at risk from arsenic. See Table 1-2 for a visual representation of potential risk.

Deposition Area and Lost Lake - the deposition area encompasses the large, relatively flat flood plain area present between the confluence of LCC and CC and Lost Lake. This is where the largest amount of tailings was deposited after the dam failure one mile above.

The Lost Lake area is defined as the two lobes (north and south) of the lake and the lake shoreline. The deposition area is well vegetated and presents considerable wildlife habitat and an attractive human recreational area. Lost Lake provides habitat for fish, wildlife, plants and invertebrates and recreational opportunities for humans. Samples of surface soil and water, subsurface soil, sediment, groundwater and biota were collected.

Fish may be at risk from arsenic, barium, beryllium, cadmium, cyanide, cobalt, copper, manganese, and zinc. Amphibians may be at risk from arsenic. Microbes may be at risk from arsenic, copper and zinc. Terrestrial plants may be at risk from silver, arsenic, cadmium, cobalt, copper, mercury, antimony, zinc and selenium. Earthworms may be at risk from cadmium, cobalt, copper, selenium, and zinc.

The American dipper may be at risk from arsenic and selenium and the California vole, ornate shrew, mink, and long-tailed weasel from arsenic. See Table 1-3 for a visual representation of potential risk.

Downgradient from Lost Lake Area - this subarea consists of the CC drainage below Lost Lake to the confluence with Little Greenhorn Creek and extends a short distance down Little Greenhorn Creek. Samples of soil, surface water, sediment, and biota were collected from along the CC drainage downgradient of Lost Lake.

Fish may be at risk from arsenic, barium, cobalt, manganese, and zinc, and amphibians and microbes from arsenic alone. Terrestrial plants may be at risk from silver, arsenic, mercury, and zinc, and earthworms from mercury.

The American dipper may be at risk from arsenic, cobalt, manganese and selenium; the California vole, mink, and long-tailed weasel from arsenic; and the ornate shrew from arsenic, mercury, manganese and selenium. See Table 1-4 for a visual representation of potential risk.

TABLE 1-1
Potential Risk to Ecological Receptors from COPECs Present in the Lava Cap Mine Area

	Ag	As	Ba	Be	Cd	CN	Co	Cu	Hg	Mn	Ni	Pb	Sb	Se	Zn
Fish	X	X	X	X	X	X	X	X	X	X	X	X	X		X
Amphibians	X	X						X	X	X	X	X			X
Sediment Biota	X	X			X			X	X			X	X	X	
Terrestrial Plants	X	X			X	X	X	X	X			X	X	X	X
Earthworms	X	X			X	X	X	X	X			X	X	X	X
Microbes	X	X			X			X			X	X			X
American Dipper		X					X	X	X	X		X		X	
Green Heron		X													
California Quail		X													
California Vole		X				X						X			
Mink		X													
Ornate Shrew		X				X						X	X		
Long-Tailed Weasel		X													

TABLE 1-2
Potential Risk to Ecological Receptors from COPECs Present in the Midgradient Area

	Ag	As	Ba	Be	Cd	CN	Co	Cu	Hg	Mn	Ni	Pb	Sb	Se	Zn
Fish		X	X		X	X						X			X
Amphibians		X													
Sediment Biota	X											X			
Terrestrial Plants	X	X			X				X				X		X
Earthworms									X						
Microbes		X													
American Dipper		X												X	
California Vole		X													
Mink		X													
Ornate Shrew		X													
Long-Tailed Weasel		X													

TABLE 1-3
Potential Risk to Ecological Receptors from COPECs Present in the Deposition Area and Lost Lake

	Ag	As	Ba	Be	Cd	CN	Co	Cu	Hg	Mn	Ni	Pb	Sb	Se	Zn
Fish		X	X	X	X	X	X	X		X					X
Amphibians		X													
Microbes		X						X							X
Terrestrial Plants	X	X			X		X	X	X				X	X	X
Earthworms					X		X	X						X	X
American Dipper		X												X	
California Vole		X													
Mink		X													
Ornate Shrew		X													
Long-Tailed Weasel		X													

TABLE 1-4
Potential Risk to Ecological Receptors from COPECs Present in the Downgradient from Lost Lake Area

	Ag	**As**	**Ba**	**Be**	**Cd**	**CN**	**Co**	**Cu**	**Hg**	**Mn**	**Ni**	**Pb**	**Sb**	**Se**	**Zn**
Fish		X	X				X			X					X
Amphibians		X													
Microbes		X													
Terrestrial Plants	X	X							X						X
Earthworms									X						
American Dipper		X					X			X				X	
California Vole		X													
Mink		X													
Ornate Shrew		X							X	X				X	
Long-Tailed Weasel		X													

SECTION 2

Introduction

The EPA is conducting a Remedial Investigation (RI) and Feasibility Study (FS), or RI/FS, to address contamination associated with the Lava Cap Mine Superfund Site in Nevada County, California. This ecological risk assessment (ERA) is a component of the RI/FS and is being conducted to evaluate the potential risks to aquatic and terrestrial wildlife of the Lava Cap Mine vicinity. Concurrently, a separate risk assessment is being performed that addresses risk to human receptors. The results of this ERA will be used to help EPA determine if cleanup actions are warranted for the affected soil, sediments, and surface water at the Lava Cap Mine Site. Possible remedial actions in areas that have unacceptable risks will be addressed in the FS.

EPA retained CH2M HILL to perform the ERA at the Lava Cap Mine Superfund Site as a component of the Statement of Work for Work Assignment No. 21-RICO-093Y under EPA Contract No. 68-W-98-225.

2.1 Approach

The procedures used in conducting the ERA at the Lava Cap Mine Site are consistent with those described in the following guidance documents:

- *Ecological Risk Assessment Guidance for Superfund* (EPA, 1997)
- *Framework for Ecological Risk Assessment* (EPA, 1992a)
- *Guidance for Ecological Risk Assessment at Hazardous Waste Sites and Permitted Facilities* (Department of Toxic Substances Control [DTSC], 1997)

Initial data indicated exceedingly high concentrations of arsenic suggesting the presence of significant ecological risks. As the screening ecological risk assessment was expected to support this assumption, a formal screening was not performed. Instead, data collection to support a baseline ERA was conducted and a baseline ERA was completed using this information. This process serves to expedite the remedial decision process.

Ecological risks were evaluated on a weight-of-evidence basis, utilizing whole data distributions and multiple toxicity values. The ERA is built upon the preliminary conceptual site model (CSM) developed in the field sampling work plan for the remedial investigation (EPA, 1999b) and data collected as part of the RI field program, as presented in the RI report. Additional information concerning the ecology of the Lava Cap Mine Site and the resident biota was obtained from available literature and from biological sampling of fish and other aquatic biota, birds, mammals, and plants in the Lava Cap Mine Site vicinity conducted by CH2M HILL. (See Section 3.6 for a description of these sampling events.)

2.2 Report Organization

This report is organized following the ecological risk assessment framework (EPA, 1992a), with sections addressing problem formulation (Section 3); analysis, including characterization of exposure and characterization of ecological effects in Sections 4 and 5, respectively; and risk characterization, including uncertainty analysis (Section 6). Additional sections include references (Section 7) and a glossary of terms (Section 8).

SECTION 3

Problem Formulation

Problem formulation, which is one of the most critical components of any risk assessment, involves identifying the problem and chemicals to be addressed, describing the affected site (both physical and ecological aspects), selecting assessment and measurement endpoints (or measures), and developing a site conceptual model and data quality objectives. Problem formulation serves to provide direction and focus to the assessment process and to ensure that only data suitable to address the problem is collected.

3.1 Site Description

The location, description, and history of Lava Cap Mine, as well as the physical and ecological setting of the mine and downgradient areas and results of previous investigations, are summarized in the following sections. This information is summarized to provide a context for the ERA, but is described in greater detail in Section 2 of the RI Report.

3.1.1 Site Location, Description, and History

The Lava Cap Mine occupies approximately 30 acres in a rural residential area of the Sierra Nevada foothills. The location of the Lava Cap Mine is illustrated in Figure 3-1. The Lava Cap Mine vicinity and watershed basins are shown in Figure 3-2, and an aerial map of the Lava Cap Mine Site features is shown in Figure 3-3. The mine is bordered in all directions by forest and low-density residential areas. There are several structures on the mine property, including the former mill, the former cyanide treatment facility, a number of miscellaneous old mine buildings, and several residences.

Gold and silver mining activities began at the site in 1861. From 1861 to 1918, processing of the ore and disposal of the waste rock, overburden, and tailings reportedly occurred at the Banner Mine, located approximately 1.5 miles north of the Lava Cap Mine. After a 16-year hiatus from 1918 to 1934, activities were resumed and a flotation plant was built to process the ore at the Lava Cap Mine property. In 1940, a cyanide plant was built to recover the concentrates onsite. From 1941 to 1943, the cyanide plant only handled the middlings and tailings (these are intermediate products generated during processing of the source rock into ore-containing concentrates), as opposed to the higher-grade ore-containing concentrates, from the flotation plant. The middlings and tailings were ground to a very fine size (i.e., able to pass through a 400-mesh screen). Slurries from the flotation and cyanidation processes were deposited in a ravine on the Lava Cap Mine property. Where the ravine steepened and narrowed, a log dam approximately 30 feet high was built to hold the tailings in place. The timing of log dam construction is unknown. The waste rock and overburden were also deposited on the mine property, in two piles located between the mine shaft and the tailings pond that formed above the log dam. In 1943, Lava Cap Mine was closed due to World War II.

During a major winter storm in January 1997, the upper half of the log dam collapsed, releasing more than 10,000 cubic yards of tailings into Little Clipper Creek (LCC). In May 1997, staff from DTSC, the California Department of Fish and Game, and the Nevada County Department of Environmental Health inspected the mine and Downgradient areas. Extensive deposits of tailings were observed in LCC, in Clipper Creek (CC) below the confluence with LCC, and Lost Lake (approximately 1.25 miles downstream of the Lava Cap Mine). The tailings were also observed in wetland areas contiguous with these water bodies, in some cases completely covering the vegetation.

In October 1997, the EPA Region IX Emergency Response Office determined that conditions associated with the tailings release from the Lava Cap Mine met the National Contingency Plan (NCP) section 300.415(b)(2) criteria for a removal action. In 1997 and 1998, 4,000 cubic yards of tailings were removed from just upstream of the damaged log dam. These tailings were stockpiled on the waste rock pile immediately to the north of the tailings pile, and then the entire pile was covered with a clay cap.

In 1998, EPA evaluated the potential risk to human health and the environment posed by the Lava Cap Mine Site. Based on this evaluation, EPA formally listed the Lava Cap Mine Site on the National Priorities List (NPL) in February 1999 allowing Superfund funding to be spent on investigation and cleanup of the site.

3.1.2 Physical Setting

This section includes a brief summary of the surface water conditions and climate in the Lava Cap Mine vicinity. This information, along with details on the soils, geology, and hydrogeology, is reported in greater detail in the RI report.

The Lava Cap Mine is located on the southern slope of Banner Ridge at the 2,840-foot elevation. Lava Cap Mine property is entirely within the LCC drainage basin. LCC is the dominant surface water drainage to the south from the Lava Cap Mine. The upper reaches of LCC are seasonally dry (ephemeral) and become perennial about halfway across the mine property where the creek is fed by discharge from the mine. Rainfall and mine drainage percolate through the Lava Cap Mine waste rock and tailings prior to flowing into LCC below the onsite log dam. EPA created stream diversions around the tailings pile during 1997 that reduce the amount of mine drainage and LCC flows that percolate through the waste rock and tailings piles. LCC flows into CC approximately one mile downgradient from Lava Cap Mine. CC, after passing through Lost Lake, joins Little Greenhorn Creek (LGC). LGC then joins Greenhorn Creek, which flows into Rollins Reservoir (Figure 3-2) (Cole / Mills Associates, 1985).

Annual precipitation is approximately 53 inches (based on 100-year average) in Nevada City, California. Approximately 90 percent of this precipitation (normally rainfall with occasional snowfall) falls during the 6-month period between November and April. Because the Lava Cap Mine is about 700 feet higher in elevation than Nevada City, the annual precipitation at the mine may be about 10 percent higher (58 inches per year) (Cole / Mills Associates, 1985). Average temperature in Nevada City is around 55 degrees F with maximum summer temperatures in the 90s and average minimum winter temperatures in the 30s and 40s.

3.1.3 Ecological Setting

The ecological setting of the Lava Cap Mine vicinity is briefly described here. As the scope of the ERA only includes wild vegetation and biota, risk to domestic plants, animals, or pets will not be evaluated. Latin names for aquatic and terrestrial species are listed in Table 3-1.

3.1.3.1 Vegetation

The predominant vegetation type throughout the project area is the Ponderosa Pine vegetation type (Mayer and Laudenslayer, 1988). This vegetation type is characterized by a dominant overstory tree species of ponderosa pine with lesser amounts of Douglas fir, incense cedar, and scattered interior live oak. The shrub layer in the project area includes poison oak, silk tassel bush, manzanita, honeysuckle, and the invasive Scotch broom. Timber resources are a primary component of the vegetation within the Tahoe and Toiyabe National Forests, which account for 28 percent of Nevada County's land area.

The riparian corridors associated with LCC, CC, and LGC are representative of the Valley Foothill Riparian vegetation type (Mayer and Laudenslayer, 1988) and have similar overstory trees as described above in addition to cottonwood, Oregon ash, and alder. Major floristic differences between upland areas and riparian corridors were seen within the shrub and ground cover layers. The riparian shrubs are characterized by various willow species, blackberry, Pacific dogwood, and bigleaf maple. The Deposition Area just upstream from Lost Lake (also a riparian zone) has a scattered tree overstory of cottonwood, Douglas fir, and incense cedar. Ground cover along the creeks consists of various hydrophytic ferns, grasses, rushes, and sedges. Limited areas of fresh emergent wetlands, characterized by dense stands of cattails and tule, are found along the edge of Lost Lake that faces the Deposition Area and in portions of the north side of the lake.

Another natural vegetation type observed in the site vicinity, but outside of areas potentially affected by the mine tailing releases, is mixed chaparral (Mayer and Laudenslayer, 1988). This type was observed on the hill slopes above CC near the confluence with LGC and along Raccoon Mountain Road and is characterized by predominantly shrub vegetation including manzanita, silk tassel bush, along with different kinds of oaks, chamise, and toyon.

Other areas not specifically observed for vegetation are the landscaped plantings associated with the residential properties. These areas have been classified as urban habitats according to Mayer and Laudenslayer (1988).

3.1.3.2 Fish

The aquatic habitats of the Lava Cap Mine Site vicinity are characteristic of the Central Valley foothills environment in being able to support both coldwater and warmwater fish. The creeks (Clipper, Little Clipper, Little Greenhorn) are all dominated by trout. Most individuals are small rainbow trout (*Oncorhynchus mykiss*), with occasional larger brown trout (*Salmo trutta*) also present. CC below Lost Lake has a small number of bluegills (*Lepomis macrochirus*) in addition to trout, showing the influence of warmwater flows or fish washed from the lake. Lost Lake is dominated by introduced warmwater fish species. Mosquitofish (*Gambusia affinis*), bluegill, and green sunfish (*Lepomis cyanellus*) dominate the shore zone and weedbeds, while largemouth bass (*Micropterus salmoides*) are found in deeper water and next to overhanging tree cover.

3.1.3.3 Amphibians and Reptiles

California red-legged frog, a federally listed threatened species, was observed in an onsite wetland by a biologist in 1985 (Bechtel, 1994). Other amphibians observed in the project area include California newt and bullfrog. Other amphibians that may occur onsite but were not observed during the sampling period include long-toed salamander, ensatina, and yellow-legged frog. Common reptiles observed during the sampling were western skink and gopher snake. Other reptiles that may occur onsite include western pond turtle, rubber boa, ringneck snake, striped racer, California mountain kingsnake, and common and western aquatic garter snake.

3.1.3.4 Birds

A variety of bird species can be found in the different habitat types within the project area. Water-associated birds found in the reservoir and riparian areas include wading birds, such as great blue heron and great egret; waterfowl, such as wood duck, mallard, cinnamon teal, hooded and common mergansers, and ruddy duck; and fish-eating birds, such as osprey and bald eagles. Other birds that may occur in the forested habitats are sharp-shinned hawks, Cooper's hawk, northern goshawk blue grouse, mountain quail, band-tailed pigeon, mourning dove, long-eared owl, northern flicker, willow flycatcher, yellow warbler, California towhee, dark-eyed junco, and others. Many birds use open areas in the forests for foraging. These species include merlin, California quail, loggerhead shrike, and song sparrow.

3.1.3.5 Mammals

The project area is within the range of many small and large mammals. Little brown myotis, Yuma myotis, western red bat, spotted bat, Townsend's big-eared bat, pallid bat, and western mastiff bat are species of bats that may occur in the project area. Common small mammals include Virginia opossum, vagrant and ornate shrews, broad-footed mole, black-tailed jackrabbit, western gray squirrel, Douglas' squirrel, deer mouse, dusky-footed woodrat, California vole, and common muskrat. Small and large mammal predators that may use the project area include coyote, gray fox, black bear, ringtail, American martin, fisher, ermine, long-tailed weasel, American mink, western spotted skunk, striped skunk, mountain lion, and bobcat. Wild pig and mule deer may also occur onsite.

3.1.3.6 Special-Status Species

Several plant and wildlife special-status species potentially may occur at or near the Lava Cap Mine Site. The wildlife special-status species are listed in Table 3-2 and the plants in Table 3-3. Although many special-status species have the potential to occur on the site, most of those listed in Tables 3-2 and 3-3 have not been observed in the area. Special-status species that have been observed at the Lava Cap Mine Site include the red-legged frog, California newt, western skink, and gopher snake.

3.2 Chemicals of Potential Ecological Concern

Chemicals of potential ecological concern (COPECs) are those chemicals that are present at the site in concentrations that may exceed toxicity thresholds for ecological receptors. These chemicals are identified by the evaluation of known site practices or analytical results.

Descriptions of the Lava Cap Mine Site and reference areas are given in Section 3.3. For the purposes of this assessment, metals and cyanide concentrations in surface soil (Table 3-4), surface sediment (Table 3-5), and surface water (Table 3-6) from areas at the Lava Cap Mine Site were statistically compared to concentrations in pooled samples from three reference areas. The results of these comparisons are presented in Table 3-7.

Chemicals with concentrations significantly greater than reference, as determined by Wilcoxon Rank-Sum tests (DTSC, 1997), were identified as COPECs. For some chemicals, significant differences were observed between concentrations in pooled reference samples and concentrations from onsite or downgradient locations, with reference concentrations exceeding onsite concentrations. Results of the Wilcoxon Rank-Sum tests (Table 3-7), coupled with visual comparisons of boxplots of the distributions of chemical concentrations in soil, sediment, and water (Appendix A), were used to identify chemicals whose onsite concentrations were consistent with or below reference. Those chemicals for which concentrations in soil, sediment, and surface water in all onsite or downgradient locations did not differ significantly from, or were significantly lower than, reference concentrations were excluded as COPECs. Only aluminum, chromium, and vanadium were excluded based on this analysis. All other chemicals (shown in Table 3-7) were retained as COPECs. No organic COPECs other than cyanide were identified.

3.3 Conceptual Site Model and Potential Exposure Pathways

The CSM is a written description and visual presentation of predicted relationships between ecological receptors and the COPECs to which they might be exposed (Figure 3-4 [Conceptual Site Model]).

An exposure pathway can be described as the physical course that a COPEC takes from the point of release to a receptor. An exposure pathway is complete (i.e., there is exposure) if there is a way for the receptor to take in chemicals through ingestion, inhalation, or dermal absorption. To be complete, an exposure pathway must have all the following components:

- A chemical source
- A mechanism for chemical release
- An environmental transport medium
- An exposure point
- A feasible route of intake

In the absence of any of these components, an exposure pathway is considered incomplete, and, by definition, there can be no risk associated with that particular exposure pathway. Exposure can occur when chemicals migrate from their source to an exposure point (i.e., a location where receptors can come into contact with the chemicals) or when a receptor moves into direct contact with chemicals or contaminated media.

For purposes of this investigation, the mine area, the tailings piles behind the partially collapsed log dam, as well as the waste rock piles are considered the primary sources of COPECs. Infiltration / percolation and discharge, mass wasting, water erosion, and wind erosion are the major release mechanisms, with surface discharge from groundwater, dilution, and deposition being secondary release mechanisms. The Lava Cap Mine and downgradient drainage were divided into four areas for evaluation purposes: 1) Mine Area, which includes the Lava Cap Mine and adjacent affected areas upstream of the log dam; 2) Midgradient Area, which extends from below the log dam to the start of the deposition area, upstream of Lost Lake; 3) Lake Area, which includes the deposition area and property surrounding Lost Lake; and 4) Downgradient Area, which extends from below the Lost Lake Dam to the confluence of Clipper Creek with Little Greenhorn Creek. Three reference areas were selected for comparison: 1) Reference 1 is along Little Clipper Creek upgradient of the mine, 2) Reference 2 is Clipper Creek upstream of the confluence with Little Clipper Creek, and 3) Reference 3 is Little Greenhorn Creek upstream of the Clipper Creek confluence. The locations of the four mine areas and three reference areas are illustrated in Figure 3-2. The affected media include soil, sediment, surface water, and groundwater. Receptors are potentially exposed via root and/or foliar uptake, dermal contact, inhalation, direct ingestion, and ingestion of prey items.

A wide variety of wildlife is supported by Nevada County's mix of habitats. The riparian habitats along the rivers and streams are essential in supporting terrestrial and aquatic wildlife. Both terrestrial and aquatic routes of exposure to COPECs exist.

Contaminants in soil may be directly bioaccumulated by terrestrial plants or soil invertebrates resident in mine site and downgradient depositional areas. Terrestrial wildlife (e.g., herbivores, omnivores, soil invertebrate feeders, and predators) may be exposed directly to contaminants in soil by incidental soil ingestion, by dermal contact, or by the inhalation of wind-borne particles. Wildlife may also receive contaminant exposure through food-web transfer of chemicals from lower trophic levels (e.g., plants to herbivores, plants and prey animals to omnivores, etc.). Because contaminated source soils may also be transported by wind to adjacent habitats, the preliminary conceptual model outlined above is also applicable to habitats adjacent to each of the areas.

These exposure pathways are illustrated in Figure 3-5 and are the primary focus of this ERA.

3.4 Assessment and Measurement Endpoint Selection

A complete problem formulation also includes selection of assessment and measurement endpoints (referred to as measures under some regulatory guidelines). The identification of these endpoints enables the risk manager and the risk assessor to focus on the critical aspects of the study that will have an impact on exposure, and thus potential risk to the environment. Utilizing the endpoint process, resources are focused on the most critical elements necessary to address the environmental problem (EPA, 1992a and 1997).

Assessment endpoints are “explicit expressions of the environmental value that is to be protected” (EPA, 1992a), and are used to define ecological values that may be impacted by the COPECs present at a site. Measurement endpoints are the measures that are evaluated to provide an indication of whether adverse effects to assessment endpoints have occurred or are likely to occur.

Complete definitions of an assessment endpoint have three components (Suter et al., 2000): the entity, the attribute, and a level of effect. Entities evaluated at the Lava Cap Mine Site include fish, benthic invertebrate, terrestrial plant, and soil invertebrate communities, soil processes, and amphibian, bird, and mammal populations. Attributes include growth, reproduction, or survival for communities and populations and individual health and survival for special-status species. The level of effect selected was determined by the attribute, with populations and communities having an effect level of 20 percent compared to no acceptable effect for special-status species.

EPA (1992a) identifies four considerations when selecting assessment endpoints. These considerations and their relationship to the assessment endpoints for the Lava Cap Mine Site are summarized below:

- Ecological relevance: fish, benthic invertebrates, amphibians, terrestrial plants, soil invertebrates, soil microbial processes, mammals, and birds are integral components of the ecosystem of riparian and upland habitats in the Sierra Nevada.
- Susceptibility to the stressor: research has shown that plants, fish, aquatic and soil invertebrates, soil microbial processes, birds, mammals, amphibians, and reptiles may be adversely affected by exposure to metals such as those detected in samples from the Lava Cap Mine Site (e.g., arsenic, cadmium, lead). Characteristics that may be affected by COPECs include growth, reproduction, or survival of communities and populations.
- Environmental policy goals: protection of endangered species is consistent with policy goals as stated through federal legislation (i.e., the Endangered Species Act). Policy goals may also focus on the preservation of the ecosystem, aesthetic considerations, and commercially or recreationally important populations (e.g., waterfowl).
- Societal value: endangered species have been identified as valued to society by protection under federal legislation (i.e., the Endangered Species Act).

Assessment endpoints for the Lava Cap Mine Site are presented in Table 3-8.

Receptors representative of assessment endpoints were selected based on several criteria, with selected receptors fulfilling as many of the following selection criteria as possible:

- Receptor is a special-status species (e.g., threatened or endangered).
- Receptor has a small home range.
- Receptor is representative of an ecological guild.
- Receptor is susceptible to bioaccumulation/biomagnification of COPECs (e.g., higher trophic-level predators).
- Receptor is likely to be exposed to contaminants.
- Receptor occurs at the site.
- Receptor is known or suspected to be sensitive to contaminants.
- Receptor is ecologically significant.

Specific amphibian, mammalian, and avian receptors selected to represent the assessment endpoints include the red-legged frog, California vole, ornate shrew, mink, long-tailed weasel, California quail, American dipper, green heron, and red-tailed hawk. Relevant characteristics used for selection of receptors are outlined in Table 3-8.

As a threatened species (protected by the Endangered Species Act), any adverse effect on the health or survival of individual red-legged frogs is unacceptable. A 20 percent effect level was selected for all avian and mammalian receptor populations, as well as for soil microbial processes within the ecosystem, and fish, benthic invertebrate, terrestrial plant, and soil invertebrate communities. This level was selected based on the discussion in Suter et al. (2000). It should be noted that selection of a 20 percent effect level is not intended to imply that a 20 percent effect is acceptable. It is simply a measure of the effect level at which differences between exposed and non-exposed populations may be discerned with any degree of confidence.

Although all receptors are not expected to occur in all areas (i.e., because of inappropriate habitat), all receptors were carried through the assessment because they are assumed to be indicators (or surrogates) of other related species that could be present in these areas.

Measurement endpoints available for this ERA include site-specific abiotic and biotic sampling, biological survey, and ambient media toxicity bioassay data, as well as non-site-specific literature-based toxicity data. The measurement endpoints for each receptor are outlined in Table 3-8. For example, only literature-derived, single-chemical toxicity data are available for birds and mammals, while single-chemical toxicity data and site-specific ambient media toxicity test data are available for soil invertebrates. The available measurement endpoints and their use in the ERA are described in Sections 3.6 and 5, respectively.

3.5 Data Quality Objectives

The data quality objectives (DQO) process is a formalized approach for focusing data collection on those data that best address the assessment concerns. The process builds on the other components of the problem formulation. Data collected based on well-defined and appropriate DQOs should be suitable to address the risk management problem stated at the beginning of the problem formulation. The DQO process consists of seven steps and is presented in EPA documents (1993a and 1994). Additional information concerning the application of the DQO process to ERAs is presented in U.S. Department of Energy (DOE 1997). The seven steps in the DQO process and ecological DQOs as they relate to the Lava Cap Mine Site are outlined in Table 3-9.

3.6 Summaries of Available Data

Data used in the ERA includes site-specific abiotic and biotic sampling, biological survey and ambient media toxicity bioassay data, as well as non-site-specific literature-based data.

The remedial investigation field effort included three rounds of data collection (summarized in Table 3-1 of the RI).

1. October and November 1999 – Surface soil, subsurface soil, sediment, air, surface water, and groundwater; also, terrestrial and aquatic habitats were characterized.

2. January 2000 - resampling of all surface water locations and monitoring wells and surface soil sampling.

3. May and June 2000 – Collection of bioassay and biota samples, resampling of surface water and monitoring and residual wells.

Sampling locations are shown on Figures 3-1 to 3-6 of the RI. The data collected are summarized below:

Abiotic Sampling. Limited abiotic sampling was conducted in the Lava Cap Mine Site area prior to the more comprehensive RI field effort performed by EPA. Relevant sampling events are summarized here but a more detailed description of each investigation is presented in the RI Report. Summary statistics for abiotic media, based on the results of the RI sampling effort, are presented in Tables 3-4 to 3-6 for surface soil, surface sediment, and surface water, respectively.

Aquatic Biological Sampling. Aquatic organisms at the Lava Cap Mine Site were sampled by CH2M HILL in May 2000 (Appendix B). Samples of fish and aquatic invertebrates were collected as dietary items for bird and mammal receptors. Fish were collected from streams, lakes, and wetlands in the Midgradient, Lake, and Downgradient areas of the Lava Cap Mine Site drainages, as well as from Reference Area 3. Aquatic invertebrates were also collected from these three Lava Cap Mine Site areas and from all three reference areas. During the October 1999 sampling event, frogs and pollywogs were collected from the adit drainage in the Mine Area. Summary statistics for COPEC concentrations measured in fish, aquatic invertebrates, and amphibians are presented by location in Tables 3-10 through 3-12.

Aquatic Biological Survey. To determine whether the aquatic invertebrate community varied in relation to exposure to mine wastes, Rapid Bioassessment Protocol (RBP) analyses were performed at two locations downgradient of (and potentially affected by) the mine(Lake and Downgradient areas), and at two reference locations (Reference Areas 2 and 3). RBP analyses were performed using the point source sampling design protocols outlined in *California Stream Bioassessment Procedure* (California Department of Fish and Game, 1999b) and are presented in Appendix B.

Terrestrial Biological Sampling. Terrestrial biota were sampled by CH2M HILL in May 2000 (Appendix C). Plants, invertebrates, and small mammals identified as food chain items were collected for analyses from areas identified during the previous RI field tasks. Plant samples were collected to assess the potential for uptake of site-related contaminants and exposure of herbivores to those COPECs. Invertebrate samples were collected as food chain items for birds and mammals to assess the potential uptake through the diet. Summary statistics for COPEC concentrations measured in terrestrial plants, terrestrial invertebrates, and small mammals are presented in Tables 3-13 through 3-15.

Ambient Media Toxicity Bioassays. Ambient media toxicity tests were conducted using water, sediment, and soil from the Lava Cap Mine vicinity (Appendix D). These tests included 48- and 96-hour freshwater bioassays on a cerodaphnid (*Ceriodaphnia dubia*) and on fathead minnows (*Pimephales promelas*), respectively; 10-day freshwater sediment bioassays on amphipods (*Hyalella azteca*); and 14-day upland soil bioassays on earthworms (*Eisenia foetida*) and lettuce seed (*Lactuca sativa*). Summaries of the aquatic biota, earthworm, and lettuce seed bioassay results are presented in Tables 3-16 through 3-18.

Non-Site-Specific Literature-Derived Data. Site-specific toxicity data and avian and mammalian life-history parameters used for exposure estimates (e.g., body weight, ingestion rates of food and water, dietary components) were not available for all receptors. Toxicity data for each receptor group were obtained from many sources, including published benchmarks from data compiled by MacDonald et al. (2000), the Oak Ridge National Laboratory (Efroymson et al., 1997a and 1997b; Suter and Tsao, 1996; Sample et al., 1996), and the EPA (EPA, 2000 and 2001). Additional toxicity data were derived from published studies as needed. The sources and use of literature-derived toxicity data are discussed in Section 5.1. Life-history parameters for avian and mammalian receptors also were derived from the literature, and these values are discussed in Section 4.7.

SECTION 4

Exposure Characterization

In the exposure characterization, the nature and magnitude of the interaction between COPECs in environmental media and ecological receptors are described and quantified. In this assessment, exposure estimates were calculated for all eight bird and mammal receptor species, as well as for fish, benthic invertebrates, amphibians, terrestrial plants and invertebrates, and soil microbial processes. Avian and mammalian ecological receptor populations selected in Section 3 include the California quail, American dipper, green heron, red-tailed hawk, California vole, ornate shrew, mink, and long-tailed weasel. The red-legged frog was selected as the amphibian receptor. The methods for and results of exposure estimation are outlined below.

4.1 Fish

Fish and other aquatic organisms may experience both water-mediated and body-burden-based exposures although they are not typically described as separate pathways. Water-mediated exposure occurs as a consequence of living in a contaminated medium. Uptake of metals can be through the skin (dermal), through the gills, or through the diet, including ingestion of contaminated food, water, and possibly sediment. Body-burden-based exposures are measured as concentrations of chemicals in tissues including whole body, muscle, kidney, and liver. Each of these exposure types is described below.

Water-Mediated Exposures

Water-mediated exposure to fish and other aquatic organisms is measured as a function of the concentration of contaminants in surface water (micrograms chemical per liter of water [µg/L]). Exposure can also be sediment-mediated and measured as a function of the concentration of contaminants in sediment (milligrams chemical per kilogram sediment [mg/kg]); however, sediment-mediated exposure to fish will not be evaluated in this assessment. Water-mediated exposure is used because most information on the effects of contaminants on fish (described in Section 5.1) has been obtained from experiments where the exposure to contaminants was reported as a function of the concentrations of contaminants in water absent significant exposure through food ingestion. Therefore, the focus of the exposure characterization for water-mediated exposures is the derivation of waterborne exposure point concentrations.

The 95 percent upper confidence limit of the arithmetic mean concentration (95 percent UCL) (Table 3-6) was selected as the representation of exposure point concentrations for surface water. Because fish are mobile, moving and foraging throughout a medium in which concentrations may vary both temporally and spatially, their exposure is best represented by the average concentration within areas they inhabit. The 95 percent UCL provides a conservative, upper bound estimate of this value. Summary statistics for concentrations of COPECs in surface water are presented in Table 3-6 and are grouped by location as described in Section 3.3.

Exposure for fish is generally evaluated using filtered water. Filtering of water removes particle-bound contaminants, which, due to physical and chemical properties, are unlikely to be bioavailable and therefore do not contribute significantly to overall exposure for fish. Filtered water samples were not available for the Lava Cap area – all water samples consist of total or unfiltered samples. Consequently, the chemical concentrations measured in these samples provide a highly conservative measure of fish exposure.

Body-Burden-Based Exposures

Concentrations of COPECs in tissues of receptor animals may exert adverse effects through various mechanisms, including toxicity to the target organ (e.g., liver or kidneys where metabolism and excretion occur) or release from tissue reserves during episodic events (e.g., mobilization of contaminants from fat during winter or spawning). Thus body burden data provide a measure of exposure. Body-burden-based exposure data for fish consist of measured whole-body concentrations of COPECs in fish collected from Lava Cap Mine Site water bodies (Table 3-10). These data can be compared to available literature information for whole-body concentrations of chemicals associated with adverse effects in fish.

4.2 Benthic Invertebrates

Benthic invertebrates may experience both sediment-mediated and body-burden-based exposures. Sediment-mediated exposure occurs as a consequence of living in a contaminated medium. Uptake of metals can be through the skin (dermal) or through the diet, including ingestion of contaminated food, water, and most importantly, sediment. Body-burden-based exposures are measured as concentrations of chemicals in whole body tissue. Only sediment-mediated exposure was estimated, and is described below.

Sediment-mediated exposure to benthic invertebrates is measured as a function of the concentration of contaminants in sediment (mg/kg). This type of measurement is used because most information on effects of contaminants on benthic organisms (described in Section 5.1) has been obtained in experiments where the exposures to contaminants were reported as a function of the concentrations of contaminants in sediment absent significant exposure through food ingestion. As such, the focus of the exposure characterization for sediment-mediated exposures is the derivation of the exposure point (sediment) concentrations.

Most effects of sediment-mediated contaminant exposure have been measured as integrated exposures to sediment, associated pore water, and contaminated food that may be present in the contaminated sediment. Effects are generally reported as concentrations of contaminants in sediment. The exposure point concentrations for sediment are reported as total metals in sediment. Because mobility of benthic invertebrates is very limited, the exposure point concentration used for this receptor group was the maximum sediment concentration. Summary statistics for metals concentrations for COPECs in sediment are presented in Table 3-5. These summary statistics are based on sediment samples collected from lakes, streams, and wetlands and are grouped by location as described in Section 3.3.

4.3 Amphibians

Exposure estimates for amphibians consist only of water-mediated exposure. These receptors are similar to aquatic organisms in that exposure is measured as a function of concentrations of contaminants in abiotic media (e.g., surface water). Although amphibians may also be exposed through sediment and the food web, these exposure pathways were not evaluated due to the lack of corresponding toxicity data. Like fish, exposure for amphibians is best described using the mean concentration. However, because the amphibian receptor being evaluated (the red-legged frog) is a special status species, additional protection for adverse effects is desired. Therefore, the exposure point concentration selected for amphibians was the maximum surface water concentration (Table 3-6).

4.4 Terrestrial Plants

Terrestrial plants experience exposure based on concentrations in soil (i.e., exposure is soil-mediated). Because plants are not mobile, the maximum concentration was selected as the suitable exposure point concentration (see Table 3-4).

4.5 Terrestrial Invertebrates

Like plants, terrestrial invertebrates also experience soil-mediated exposure. Because mobility of terrestrial invertebrates is low, the maximum concentration was selected as the suitable exposure point concentration (see Table 3-4).

4.6 Microbial Processes

Like plants and terrestrial invertebrates, soil processes experience soil-mediated exposure. Because soil processes are immobile, the maximum concentration was selected as the suitable exposure point concentration (see Table 3-4).

4.7 Birds and Mammals

Exposures estimated for birds and mammals consist of both oral and target-organ-based exposure.

Oral Exposures

Birds and mammals experience exposure through multiple pathways including ingestion of abiotic media (soil, sediment, and surface water) and biotic media (food) as well as inhalation and dermal contact. To address this multiple pathway exposure, modeling is required. The necessary input parameters to the exposure model are outlined below. Exposure estimates for each representative species were generated based on model assumptions, life history parameters, measured concentrations in exposure media (soil, sediment, and surface water), and measured or modeled concentrations in food sources as described below.

The end product or exposure estimate for birds and mammals is a dosage (amount of chemical per kilogram receptor body weight per day [mg/kg/d]) rather than a media concentration as is the case for the other receptor groups (fish, benthic invertebrates, amphibians, terrestrial plants, terrestrial invertebrates, and soil microbial processes). This is a function of both the multiple pathway approach as well as the typical methods used in toxicity testing for birds and mammals (as described in Section 5.1). Summaries of total (i.e., sum over all pathways) and partial (pathway-specific) exposure estimates are presented and compared to toxicity values in Section 5.1.

Model. The general form of the model (Suter et al., 2000) used to estimate exposure of birds and mammals to COPECs in soil, sediment, surface water, and food items is as follows:

$$E_t = E_o + E_d + E_i$$

Where:

E_t = the total chemical exposure experienced by wildlife

E_o, E_d, and E_i = oral, dermal, and inhalation exposure, respectively

Oral exposure occurs through the consumption of contaminated food, water, or soil-sediment. Dermal exposure occurs when contaminants are absorbed directly through the skin. Inhalation exposure occurs when volatile compounds or fine particulates are inhaled into the lungs.

Although methods are available for assessing dermal exposure to humans (EPA, 1992b), data necessary to estimate dermal exposure are generally not available for wildlife (EPA, 1993b). Similarly, methods and data necessary to estimate wildlife inhalation exposure are poorly developed or generally not available (EPA, 1993b). Therefore, for the purposes of this assessment, both dermal and inhalation exposure are assumed to be negligible. As a consequence, most exposure must be attributed to the oral exposure pathway. By replacing E_o with a generalized exposure model modified from Suter et al. (2000), the previous equation was rewritten as follows:

$$E_j = \left[Soil_j \times P_s \times FIR\right] + \left[\sum_{i=1}^{N} B_{ij} \times P_i \times FIR\right] + \left[Water_j \times WIR\right]$$

Where:

E_j = total exposure (mg/kg/d)

$Soil_j$ = concentration of chemical (j) in soil (mg/kg)

P_s = soil ingestion rate as proportion of diet

FIR = species-specific food ingestion rate (kg food/kg body weight/d, wet weight)

B_{ij} = concentration of chemical (j) in biota type (i) (mg/kg, wet weight)

P_i = proportion of biota type (i) in diet

$Water_j$ = concentration of chemical (j) in water (mg/L)

WIR = species-specific water ingestion rate (L/kg body weight/d)

Assumptions. To establish parameters for the exposure model, various assumptions were necessary. These assumptions are outlined below.

Exposure Point Concentrations. Because wildlife are mobile, traveling and experiencing exposure over the range of habitats they occupy, their exposure is best described by mean chemical concentrations in areas they inhabit (Suter et al., 2000). To be conservative, exposure point concentrations for soil, sediment, and surface water incorporated into the exposure model consisted of the 95 percent UCL concentrations (Tables 3-4 through 3-6).

Life History Parameters. The specific life history parameters required to estimate exposure of each receptor to COPECs include body weight, ingestion rates of food and water, dietary components and percentage of the overall diet represented by each major food type, and approximate amount of soil and/or sediment that may be incidentally ingested based on feeding habits. These parameters, as well as foraging range information, were obtained from the literature and are presented in Table 4-1. Life-history profiles for each receptor are included in Appendix E.

Bioaccumulation Models. Measurements of concentrations of COPECs in wildlife foods are a critical component for the estimation of oral exposure of birds and mammals. The most preferred data are direct measurements of concentrations in samples collected from the field. Available data for concentrations of COPECs in wildlife foods collected from the Lava Cap Mine Site are summarized in Tables 3-10 through 3-15. Not all food types consumed by the selected avian and mammalian receptors, nor all areas of the Lava Cap Mine Site, are represented. Measured COPEC concentrations in biota were used to calculate exposure in birds and mammals when available for an area, otherwise these data were estimated. To estimate concentrations of COPECs in wildlife foods, bioaccumulation models for each wildlife food type were developed based on site-specific data. These models are summarized in Appendix F and include whole body bioaccumulation in small mammals, fish, terrestrial plants, aquatic and terrestrial invertebrates, and amphibians. In the absence of measured COPEC concentrations in biota, concentrations were estimated using site-specific bioaccumulation regression models or using 90th percentile bioaccumulation factors (BAFs) as appropriate

Water Content of Wildlife Foods. Concentrations of COPECs in wildlife foods (e.g., small mammals, fish) were reported in dry weight concentrations (Tables 3-10 to 3-15). However, wet weight biota concentrations are required for the exposure calculation. Percent water content in biota are outlined in EPA (1993b). For use in this assessment, values of 69, 68, 85, 80, and 75 percent were chosen for terrestrial invertebrates, mammals, herpetiles, aquatic invertebrates, and fish, respectively. The water content of plants varied by receptor. California quail primarily eat seeds; therefore, a water content of 9.3 percent for seeds was selected. In contrast, California voles and mink feed on leaves or emergent vegetation which have a water content of 85 percent (EPA, 1993b).

Bioavailability. COPECs present in media consumed by wildlife receptors are not absorbed with perfect (100 percent) efficiency. To assume so would overestimate both exposure and risk. The absorption efficiency or bioavailability of a chemical varies as a function of many factors. These factors include the chemical form of the COPEC, the medium in which the COPEC is present, interactions with other COPECs, interactions with ingested food, the environment within the receptor's gastrointestinal tract, etc. To account for the bioavailability of COPECs at the Lava Cap Mine Site being less than 100 percent, total exposure estimates were adjusted by bioavailability fractions specific for each COPEC.

U.S. EPA Region X guidance for human health risk assessment recommends that arsenic resulting from mining activities be assumed to be 60 percent available through oral ingestion (EPA Region X, 2000). This value was developed from mammal data for human health. Because data for birds were not available, the bioavailable fraction for mammals was also assumed to be representative of birds.

In a review of bioavailability of various forms of cadmium in mammals, Hrudey et al. (1995) found oral bioavailability to vary from less than 1 to 9 percent. Data for birds was not located. For the purposes of this assessment, bioavailability of cadmium to birds and mammals was assumed to be 9 percent.

In mammals, oral absorption of copper decreases as intake increases (Hrudey et al., 1995). The highest rates of copper absorption (71 percent) were observed when copper deficiency in the diet was present. Absorption of copper was 20 to 40 percent when present at daily-required levels. Data for birds was not located. For the purposes of this assessment, bioavailability of copper to birds and mammals was assumed to be 40 percent.

Bioavailability studies conducted in the Coeur d'Alene River Basin (another area affected by mining activities) were available for lead in both birds and mammals. Maddaloni et al. (1998) evaluated lead bioavailability in the Coeur d'Alene Basin by dosing human volunteers with lead-contaminated soil. Whereas fasted individuals absorbed 26.2 percent of ingested lead, only 2.52 percent was absorbed by individuals who had eaten prior to ingesting lead. For the purposes of this assessment, lead bioavailability for mammals was assumed to be 26.2 percent. Hoffman et al., (2000) fed mallard ducklings diets containing lead-contaminated sediments from the Coeur d'Alene Basin and an equivalent concentration of lead acetate for six weeks. Concentrations of lead in blood, liver, and kidney were measured in both sets of birds. Lead concentrations in all three tissues were 2.01 to 2.25 times higher in birds exposed to lead acetate as compared to those exposed to contaminated sediments. This indicates that the bioavailability of lead in sediment is approximately 50 percent relative to lead acetate. For the purposes of this assessment, lead bioavailability for birds was assumed to be 50 percent.

Whereas bioavailability of inorganic mercury is low, that for organic mercury (i.e., methylmercury) is high. Owen (1990) reports oral bioavailability for inorganic mercury in mammals to be approximately 15 percent while that for organic mercury was 95 percent. Bioavailability data for birds was not located. In the environment, inorganic forms of mercury dominate in abiotic media while organic forms dominate in biota (Wren et al., 1995; Eisler, 2000). Therefore for the purposes of this assessment, mercury in soil, sediment, and water was assumed to be inorganic with bioavailability of 15 percent and all mercury in biota was assumed to be organic with bioavailability of 95 percent. Mercury bioavailability for birds was assumed to be equal to that for mammals.

Finally, Owen (1990) reports the oral bioavailability of barium, selenium, and zinc in mammals to be 10, 60, and 50 percent, respectively. Data for birds was unavailable. Therefore for the purposes of this assessment, bioavailability of barium, selenium, and zinc to birds and mammals was assumed to be 10, 60, and 50 percent, respectively.

Target-Organ-Based Exposures

Target-organ-based exposures consist of concentrations of COPECs in tissues of receptor species that are the focus of contaminant toxicity. These concentrations may be measured directly from field-collected birds and/or mammals or they may be modeled using site-specific or literature-derived information. They can then be compared to available literature information for concentrations of chemicals in specific tissues that are associated with adverse effects. This provides another measure of the potential nature and magnitude of effects that birds and mammals may experience at the Lava Cap Mine.

Models for estimation of COPEC concentrations in blood and organs of birds and mammals were developed based on literature-derived data. The models developed for application to receptors at the Lava Cap Mine Site included literature-based American dipper and small mammal models. The models are presented here with supporting information presented in Appendix F.

American Dipper Models. Models to estimate COPEC concentrations in the blood and liver of American dippers were developed using data collected by the USFWS (unpublished data) from the Arkansas River basin in Colorado (data concerning accumulation of COPECs from diet by American dippers were not collected from the Lava Cap Mine Site areas). The data from Colorado were considered applicable to the Lava Cap area. The raw data from the Arkansas River are presented in Appendix F, Table F-7.

Concentrations of cadmium, copper, mercury, lead, and zinc were measured in aquatic invertebrates (prey of American dippers) and blood and liver of American dippers from multiple locations within the Arkansas River basin of Colorado. Loglinear regression analyses were performed on these data to estimate COPEC concentrations in blood and liver to dippers at Lava Cap (Appendix F, Table F-8). Significant model fits were obtained for cadmium and lead for blood, and for cadmium, lead, and zinc for liver (Appendix F, Table F-8). However, the r-square values were sufficiently high (>0.2) to warrant application of the models for predictive purposes only for lead in blood, and cadmium and lead in liver.

The resulting diet-to-tissue American dipper models were coupled with site-specific sediment-to-aquatic invertebrate models (Appendix F, Table F-4) to create a sediment-to-tissue model for American dippers:

$$\text{Tissue (mg/kg wet wt.)} = e^{\left[M_1 (M_2 [\ln C_s] + b_2) + b_1\right]}$$

Where:

M_1 = slope from the diet-to-tissue regression model

M_2 = slope from the sediment-to-aquatic invertebrate regression model

C_s = COPEC concentration in sediment (mg/kg dry)

b_1 = intercept from the diet-to-tissue regression model

b_2 = intercept from the sediment-to-aquatic invertebrate regression model

These models were applied to sediment data from the Lava Cap Mine Site areas to generate estimated concentrations of cadmium and lead in tissues of American dippers (Table 4-2).

Small Mammal Models. Previous research has shown that concentrations of chemicals in small mammal tissues may be estimated based on soil concentrations (Sample et al. 1998, Shore 1995). Thus, soil-to-liver and soil-to-kidney bioaccumulation models were developed for small mammals based on literature-derived data. Using an approach comparable to that employed in Sample et al. (1998), co-located soil and small mammal organ concentration data were extracted from published studies. Appendix F, Tables F-9 and F-10 provide a summary of data used for model development. Log-linear regression models were developed for all small mammals combined, and for specific trophic guilds (e.g., insectivores, herbivores, and omnivores). Tables F-11 and F-12 in Appendix F summarize soil-to-kidney and soil-to-liver regression models, respectively.

Models with r-square values of 0.2 or greater were applied to soil data from the Lava Cap area to generate estimated concentrations of cadmium, lead, and zinc in tissues of insectivorous and herbivorous small mammals (Table 4-3). Estimates for insectivorous small mammals are assumed to be representative of ornate shrews. Estimates for herbivorous small mammals are assumed to be representative of California voles.

SECTION 5

Ecological Effects Characterization

In the effects assessment, potential adverse effects associated with varying levels of exposure to COPECs are documented. Effects data may consist of results from site-specific biological field surveys and toxicity tests of ambient media or of literature-derived, single-chemical toxicity data. For this assessment, literature-derived, single-chemical toxicity data, ambient media toxicity tests, and biological field surveys were available.

5.1 Single-Chemical Toxicity Data

5.1.1 Fish

Water-Mediated Exposures

Aquatic toxicity values for this assessment were derived from the California Ambient Water Quality Standards (CAWQS) document (EPA, 2000), the National Ambient Water Quality Criteria (NAWQC) document (EPA, 1999a), the national update for Cadmium NAWQCs (EPA, 2001) and the Oak Ridge National Laboratory (ORNL) aquatic organism benchmarks (Suter and Tsao, 1996) that complement the promulgated CAWQS and NAWQC. These values are summarized in Table 5-1. The ORNL benchmarks include acute and chronic Tier II values and lowest chronic values (LCVs) for aquatic organisms (e.g., fish, daphnids, non-daphnid invertebrates, aquatic plants, and all species). Toxicity of some COPECs varies as a function of water hardness. Consequently, CAWQS and NAWQC values for cadmium, copper, lead, nickel, silver, and zinc were adjusted for site-specific water hardness (Table 5-2) using models presented by the EPA (2000 and 2001).

Benchmarks were established based on adverse growth, reproductive, and survival effects in aquatic organisms. Although these concentrations represent levels at which adverse effects were observed in individual test aquatic organisms, reduction in growth, reproduction, or survival of individuals is likely to reduce the growth, reproduction, or survival of aquatic organism communities.

Body-Burden-Based Exposures

Body-burden-based exposures consist of measured concentrations of COPECs in tissues (e.g., whole body) of receptor fish. Whole-body concentrations measured in fish collected from Lava Cap Mine Site areas and one reference area are presented in Table 3-10. Whole-body concentrations of COPECs in fish that have been associated with effects in field or laboratory animals are used to evaluate body-burden-based exposure data. Table 5-3 summarizes body-burden-based effects concentration data derived from published studies described in Jarvinen and Ankley (1999). When 10 or more values for a chemical were available, 10th Percentile No Observed Effects Concentrations (NOECs) and Lowest Observed Effects Concentrations (LOECs) were calculated from the data in Table 5-3. If there were 10 or fewer values for a chemical, then the lowest whole-body concentration in fish with no observed effects was selected for the NOEC and the lowest whole-body concentration in which adverse effects were observed was selected for the LOEC. Data was available to determine body-burden-based NOECs and LOECs for aluminum, arsenic, cadmium, copper, mercury, lead, antimony, selenium, vanadium, and zinc, whereas only a NOEC could be determined for silver (Table 5-4). Effects concentrations presented in Jarvinen and Ankley (1999) are in wet weight units; therefore, these values were converted to dry weight using a water content of 75 percent (EPA, 1993b) for comparison to the measured dry weight data in Table 3-10.

Effects considered include reductions in growth, survival, reproduction, and egg hatchability (Table 5-3 and 5-4). Although these concentrations represent levels at which adverse effects were observed in individual test fish, it is likely that the reduction in growth, reproduction, or survival of individuals will also reduce the growth, reproduction, or survival of fish communities.

5.1.2 Benthic Invertebrates

Currently, there are no EPA sediment criteria for metals in sediment. In general, it is difficult to predict sediment concentrations at which toxicity occurs because the type and form of the sediment and the water chemistry of the overlying water affect metal speciation and bioavailability. For example, the bioavailability of metals in sediment is influenced by the amount of organic carbon, Fe-oxyhydroxides, and acid volatile sulfides (AVS) in sediments (see Di Toro et al., 1990; Di Toro et al., 1992; Tessier et al., 1993). However, sediment guidelines have been derived for metals based on the relationship between the bulk metal concentration in the sediment, the metal concentration in the pore water, and measured biological effects (e.g., Ingersoll et al., 1996; Long and Morgan, 1990; Long et al., 1995). These sediment guidelines provide an initial benchmark for predicting the potential for adverse effects due to elevated metal concentrations in sediment.

MacDonald et al. (2000) evaluated the agreement among various published sediment benchmarks and developed consensus-based Sediment Quality Guidelines (SQGs) for freshwater sediment. These SQGs consist of consensus-based Threshold Effects Concentrations (TECs) which reflect concentrations below which effects are unlikely to be observed and consensus-based Probable Effects Concentrations (PECs) which reflect concentrations above which harmful effects are likely to be observed. Effects considered included reductions in growth, reproduction, or survival of test species, which is consistent with assessment endpoints identified for the Lava Cap Mine Site (Table 3-8). The TECs and PECs used in this assessment are summarized in Table 5-5.

5.1.3 Amphibians

Toxicity values for amphibians were derived from a single document that compiled toxicity data from numerous sources: *Amphibian Toxicity Data for Water Quality Criteria Chemicals* (Schuytema and Nebeker, 1996). Specific toxicity values were not selected for each COPEC. Rather, cumulative distributions of toxicity values reported in each source (e.g., NOECs and LOECs) were developed. In this way, the full distribution of available toxicity data could be compared to the distribution of COPEC concentrations in water to determine the magnitude of exceedance. This approach provides more information concerning the nature and magnitude of risks that may be present. Because Schuytema and Nebeker (1996) present data by embryo and larval life stages, separate distributions were developed for each. The

10th percentile NOECs and LOECs for amphibians are summarized in Table 5-6. Effects considered included reductions in growth, reproduction (e.g., hatchability of eggs), or survival of test species, which is consistent with assessment endpoints identified for the Lava Cap Mine Site (Table 3-8). All data in Schuytema and Nebeker (1996) are expressed as concentrations in water (µg/L).

The rationale for the use of a 10th percentile benchmark value has been discussed in Efroymson et al. (1997a and 1997b). Briefly, estimation of concentrations that constitute thresholds for toxic effects on biota at particular sites based on published toxicity studies is impossible. This is because of the diversity of media, species, chemical forms, and test procedures represented in the literature. Therefore, National Oceanic and Atmospheric Administration (NOAA) developed a procedure to derive Effects Range Low (ER-L) values (Long and Morgan, 1990), which consists of taking the 10th percentile of the distribution of various toxic effects thresholds for various media-associated biota.

Use of 10th percentile benchmarks for the Lava Cap Mine Site ERA is justified by assuming that the toxicity of a chemical in abiotic media is a random variate, the toxicity of contaminated media at the site is drawn from the same distribution, and protection of 90 percent of media-associated biota is certain. Although biases in the data set would mediate against these assumptions, the most significant bias is related to the use of soluble salts of metals in toxicity tests, which are likely to be more toxic than the metal forms at the Lava Cap Mine Site. However, this bias will make the benchmarks more conservative and is unlikely to reduce protection of biota.

5.1.4 Terrestrial Plants

Toxicity values for terrestrial plants were derived from the ORNL plant benchmarks (Efroymson et al., 1997a). The 10th percentile NOECs and LOECs for plants are summarized in Table 5-7. See Section 5.1.3 for a discussion on the benefits of using NOECs and LOECs and for justification of the use of 10th percentile benchmarks.

The protection of terrestrial plant communities from a 20 percent reduction in growth, reproduction, or survival is an assessment endpoint in the Lava Cap Mine Site ERA (Table 3-8). Therefore, benchmarks used to determine risk to this receptor group must be based on adverse effects related to these endpoints. The ORNL plant benchmarks were developed from studies that demonstrated at least a 20 percent reduction in the growth or yield of test plant species, which is consistent with the goals of the ERA. Additionally, growth and yield are important to plant populations and to the ability of the vegetation to support higher trophic levels; therefore, these are ecologically significant responses (Efroymson et al., 1997a).

5.1.5 Terrestrial Invertebrates

Single-chemical toxicity values for terrestrial invertebrates, represented primarily by earthworms, were derived from ORNL soil invertebrate benchmarks (Efroymson et al., 1997b). The 10th percentile NOECs and LOECs for terrestrial invertebrates are summarized in Table 5-7. See Section 5.1.3 for a discussion on the benefits of using NOECs and LOECs and for the justification of the use of 10th percentile benchmarks.

The protection of terrestrial invertebrate communities from a 20 percent reduction in growth, reproduction, or survival is an assessment endpoint in the Lava Cap Mine Site ERA (Table 3-8). Therefore, benchmarks used to determine risk to this receptor group must be based on adverse effects related to these endpoints. The ORNL soil invertebrate benchmarks were developed from studies that demonstrated at least a 20 percent reduction in the growth or survival of test invertebrate species, which is consistent with the goals of the ERA.

5.1.6 Soil Microbial Processes

Single-chemical toxicity values for soil microbial processes were derived from the ORNL soil microbial processes benchmarks (Efroymson et al., 1997b). The 10th percentile NOECs and LOECs for soil microbial processes are summarized in Table 5-7. See Section 5.1.3 for a discussion on the benefits of using NOECs and LOECs and for the justification of the use of 10th percentile benchmarks.

The protection of soil microbial processes from a 20 percent reduction in growth, reproduction, or survival is an assessment endpoint in the Lava Cap Mine Site ERA (Table 3-8). Therefore, benchmarks used to determine risk to this receptor group must be based on adverse effects related to these endpoints. The ORNL soil microbial processes benchmarks were developed from studies that demonstrated at least a 20 percent reduction in the growth or activity of microbial populations, which is consistent with the goals of the ERA.

5.1.7 Birds and Mammals

Oral Exposures

Single-chemical toxicity data for birds and mammals consist of NOAELs (No Observed Adverse Effects Level) or LOAELs (Lowest Observed Adverse Effects Level) derived from toxicity studies reported in the literature. The selection of studies was based on an extensive search of primary literature, review papers, and electronic databases. Appropriate studies were selected based on several criteria:

- Studies were of chronic exposures or exposures during a critical life-stage (i.e., reproduction).
- Exposure was oral through food, to ensure data were representative of oral exposures expected for wildlife in the field.
- Emphasis was placed on studies of reproductive impacts, to ensure relevancy to population-level effects.
- Studies presented adequate information to evaluate and determine the magnitude of exposure and effects (or no effects) concentrations.

Data were extracted from original sources to verify levels of effects, quality of study design, magnitude of dose, and other study parameters. Secondary sources were not considered, except as a source for identification of primary literature.

Because NOAELs and LOAELs are statistically derived measures of effects, they are a function of the quality of the design of the toxicity study, and do not provide any information concerning the magnitude of effects associated with a given exposure, dose-response functions were also developed for all studies for which data were adequate. A modeling approach derived from the Benchmark dose methodology (Crump, 1984) was used. The model is of the form:

$$y = a_0 + \frac{(a_1 - a_0)}{1 + e^{b_0 + b_1 x}}$$

where

y	= response
x	= dose or transformed dose (e.g., log)
a_0	= minimum expected value for response (y)
a_1	= maximum expected value for response (y)
b_0, b_1	= slope and inflection parameters

The model is a 2-, 3-, or 4-parameter logistic-type model that may be applied to either binary (e.g., survival) or continuous (e.g., growth, reproduction, etc.) data. The number of parameters is determined by the attributes of the dose-response data. Initial estimates of a_0 and a_1 are based on the minimum and maximum response data. Initial estimates of b_0 and b_1 are obtained by regressing:

$$z = \ln\left[\frac{(\hat{a}_1 - y)}{(y - \hat{a}_0)}\right]$$

on x**.** The slope and intercept are the initial estimates of b_1 and b_0, respectively. Using the above initial estimates, the NLIN procedure (non-linear regression; SAS, 1989) is used to obtain the weighted least-squares estimates of the parameters and their associated standard errors. Weights are based on response standard errors. The resulting model is then used to define the dose level (and 95 percent confidence limits) that corresponds with selected standardized effect levels (e.g., ED_5 to ED_{50}).

Avian and mammalian toxicity data are summarized in Table 5-8. Information concerning assumptions made as part of the extraction of data from each study is presented in Appendix G.

Multiple toxicity studies were available for both birds and mammals for each analyte. Toxicity studies were selected to serve as the primary toxicity value if exposure was chronic or during reproduction, the dosing regime was sufficient to identify both a NOAEL and a LOAEL and allow for dose-response curve-fitting, and the study considered ecologically relevant effects (i.e., reproduction, mortality, growth). If multiple studies for a given COPEC met these criteria, the study generating the lowest reliable toxicity value was selected to be the primary toxicity value. Primary toxicity values were used for all initial evaluations of the exposure estimates and are highlighted in Table 5-8. Although selected toxicity values represent levels at which adverse effects were observed in individual test species, it is likely that reduction in the growth, reproduction, or survival of individuals will also reduce the growth, reproduction or survival of receptor populations.

NOAELs and LOAELs for mammalian and avian receptors were estimated from literature data using allometric scaling methods presented in Sample et al. (1996) and Sample and Arenal (1999). Using the following equation, no (or lowest) observed adverse effects levels for wildlife ($NOAEL_w$ or $LOAEL_w$) were determined for each species:

$$NOAEL_w = NOAEL_t\left(\frac{BW_t}{BW_w}\right)^{1-b} \text{ or } LOAEL_w = LOAEL_t\left(\frac{BW_t}{BW_w}\right)^{1-b}$$

where:

$NOAEL_t$	=	the NOAEL for a test species (obtained from the literature),
$LOAEL_t$	=	the LOAEL for a test species (obtained from the literature),
BW_t and BW_w	=	the body weights (in kg) for the test and wildlife species, respectively, and
b	=	the class-specific allometric scaling factor.

Scaling factors of 0.94 and 1.2 were applied for mammals and birds, respectively (Sample and Arenal, 1999). These receptor-specific NOAELs and LOAELs are presented in Table 5-9.

Target-Organ-Based Exposures

Target-organ-based exposures consist of measured or estimated concentrations of COPECs in target organs (e.g., blood, liver, or kidney) of receptor birds. Concentrations of COPECs in these target organs that have been associated with effects in field or laboratory animals are used to evaluate target-organ-based exposure data. Target organ effects concentration data were derived from published studies.

Table 5-10 summarizes target organ effect concentrations derived from published sources. Table 5-11 presents effects values for concentrations of lead in blood and liver. Effects considered include reductions in survival, weight loss, and clinical toxicity (Tables 5-10 and 5-11). Effects such as weight loss and clinical toxic symptoms are likely to reduce the survival of affected individuals in the field. Therefore, these are ecologically relevant endpoints. Although the published target organ effect concentrations represent levels at which adverse effects were observed in individual test species, it is likely that these adverse effects on individuals will reduce the growth, reproduction, or survival of receptor populations.

5.2 Ambient Media Toxicity Data

Ambient media toxicity tests were conducted using water, sediment, and soil from the Lava Cap Mine vicinity (Appendix D). These tests included 48- and 96-hour freshwater bioassays with *Ceriodaphnia* and fathead minnows, respectively; 10-day freshwater sediment bioassays with amphipods; and 14-day upland soil bioassays with earthworms and lettuce. Results of these analyses are described below.

5.2.1 Amphipods

Results of the 10-day freshwater sediment bioassay are presented in Table 3-16. Only one of 15 sediment samples caused a significant reduction in amphipod survival; this was the single sample collected in the Mine Area.

Site-specific sediment NOECs and LOECs were derived by evaluating the range of concentrations of COPECs associated with the sample in which adverse effects were observed and in those samples in which no effects were observed. The highest concentration of an individual COPEC in samples where no effects were observed was considered to be the benthic invertebrate NOEC for that COPEC. The LOEC for sediment was based on the concentration of each analyte in the sample where effects were observed. In cases where the COPEC concentration in this sample was less than concentrations in one or more samples that caused no observed effects, no LOEC was determined, and the highest concentration of the COPEC in samples with no observed effects was considered the NOEC. Site-specific NOECs and LOECs for sediment are presented in Table 5-5.

5.2.2 Ceriodaphnia and Fathead Minnows

Results of the 48-hour freshwater bioassays are presented in Table 3-16. No effects on survival of *Ceriodaphnia* or fathead minnows were observed in any of the samples from any location. Therefore, the highest COPEC concentration in any tested sample was considered the site-specific aquatic NOEC for that COPEC. Site-specific LOECs could not be determined. Site-specific NOECs for surface water are presented in Table 5-1.

5.2.3 Earthworms

Results of the 14-day upland soil bioassay are presented in Table 3-17. Earthworms were raised in serial dilutions (i.e., 6.25 percent, 12.5 percent, 25 percent, 50 percent, and 100 percent concentration) of samples of soil from 12 locations. Significant effects were observed within bioassays from only one of 12 locations. Survival was significantly reduced among earthworms raised in soil consisting of 25, 50, and 100 percent of the single sample collected from the Mine Area. Although weight loss was highly variable and was greatest in the bioassays performed on the Mine Area soil sample, no significant differences were observed for any sample or dilution (Table 3-17).

Correlation analyses were performed between concentrations of COPECs in soil and earthworm response to determine which COPECs were most associated with the observed responses. Of 19 COPECs, 12 were highly negatively correlated ($p<0.001$) with mortality, and the same 12 were highly positively correlated ($p<0.001$) with weight loss (Table 5-12). Aluminum, barium, beryllium, chromium, manganese, thallium, and vanadium were either non-correlated or poorly correlated with earthworm responses.

Site-specific soil NOECs and LOECs were derived by evaluating the range of concentrations of COPECs associated with the sample in which adverse effects were observed and in those samples in which no effects were observed. The highest concentration of an individual COPEC in samples where no effects were observed was considered the NOEC for soil invertebrates for that COPEC. The LOEC was based on the lowest concentration of each analyte in the three sample dilutions (25, 50, or 100 percent) in which effects were observed. In cases where the COPEC concentration in any of these dilutions was less than concentrations in one or more samples that caused no observed effects, no LOEC was determined, and the highest concentration of the COPEC in samples with no observed effects was considered the NOEC. Dose-response curves were also fit to the growth and survival data using the logistic model outlined in Section 5.1.7. LC_{50}s and EC_{50}s were derived for each analyte for which significant correlations were obtained (Table 5-12). Plots of the COPEC-specific dose-response relationships for earthworms are presented in Appendix H.

5.2.4 Lettuce

Percent germination of lettuce seed and the above-ground biomass per plant were also measured in the upland soil bioassay. These results are presented in Table 3-18. As with earthworms, the tests were conducted at dilutions of 6.25, 12.5, 25, 50, and 100 percent of each soil sample. Significant reductions in seed germination and above-ground biomass per plant were observed in soil from 10 of the 12 locations sampled. Effects were seen in all dilutions, although most were observed in the 25, 50, and 100 percent sample dilutions (i.e., 20, 50, or 100 percent field-collected soil). In multiple instances, statistically significant reductions in germination or growth were observed at higher dilution rates (i.e., lower concentrations, such as 50 percent site soil), but not at the next lower dilution rate (i.e., higher concentrations such as 100 percent site soil).

Correlation analyses were performed between concentrations of COPECs in soil and lettuce response to determine which COPECs were most associated with the observed responses. Correlation coefficients were lower for lettuce for all COPECs than for earthworms. Of 19 COPECs, 14 were highly negatively correlated ($p<0.001$) with germination and 3 highly negatively correlated ($p<0.001$) with growth (Table 5-13). Aluminum, barium, cyanide (for growth), thallium, and vanadium were either non-correlated or poorly correlated with lettuce responses.

Due to the discontinuous distribution of responses and poorer correlation between COPEC concentrations and lettuce responses, defining reliable LOECs and NOECs was not possible. Instead, EC_{100}s based on percent germination results and EC_{50}s based on above-ground biomass per plant results were determined. EC_{100}s for percent seed germination were determined visually from scatterplots of dose-response data for each COPEC. The concentration at which 100 percent of seeds failed to germinate and at which there was no overlap with lesser magnitude effects on seed germination was defined as the EC_{100}. Above-ground biomass per plant was also regressed against COPEC concentration, and the EC_{50} was statistically determined from the resulting regression line.

Due to the large degree of variability in the biomass data and the poor correlations between growth and COPEC concentrations, the lettuce growth EC_{50}s were considered to be highly uncertain and of marginal utility for risk estimation. Moreover, use of EC_{100}s for risk estimation is likely to underestimate risk, therefore no COPECs were excluded based on the EC_{100} data. However, if a COPEC concentration exceeded the EC_{100} value, it was retained as a potential risk driver, even if it did not exceed literature-derived toxicity values.

5.3 Biological Surveys

Biological survey data were available only for benthic invertebrates.

The benthic invertebrate RBP analyses (see Section 3.6, Appendix B) were performed at two affected locations (within the Deposition Area, upstream of Lost Lake [Lake Area], and in Clipper Creek, downstream of the Lost Lake Dam [Downgradient Area]) and two reference locations (Clipper Creek, upstream of the confluence with Little Clipper Creek [Reference 2], and Greenhorn Creek, upstream of the confluence with Clipper Creek [Reference 3]). Although overall density was lower in the affected areas, abundance and diversity do not show clear evidence of impairment in the affected areas. When considered alone, the decreased density of invertebrates in general would be considered evidence for impairment in affected areas. However, the other RBP metrics (e.g., evenness, Hilsenoff Biotic Index [HBI], total number of invertebrate families) are either neutral or indicative of better conditions in the affected areas. Therefore, there is no consistent trend in the RBP metrics.

SECTION 6

Risk Characterization

In the risk characterization, the exposure and effects analyses are integrated to provide an estimate of risk (e.g., the likelihood of adverse effects given the exposure). To facilitate management decisions, the risk characterization is presented by receptor (Section 6.1) and by Lava Cap Mine Site Area (Section 6.2). Because multiple types of information (i.e., lines of evidence) were available, risks to ecological receptors at Lava Cap Mine were evaluated using a weight-of-evidence approach (i.e., Sample and Suter, 1999; Suter et al., 2000). In a weight-of-evidence approach, each available line of evidence for each assessment endpoint and receptor is evaluated individually to provide a conclusion concerning the presence or absence of risk based on that line of evidence. Once all lines of evidence have been evaluated, they are considered jointly to determine whether the combined weight-of-evidence supports a conclusion of risk.

Weight-of-evidence concerning presence or absence of risks was determined following processes outlined in Suter et al. (2000). Data were considered to be of unequal value in the weight-of-evidence. Greater weight was given to data displaying either responses of test biota exposed in the laboratory to site-specific field-collected media or site-specific field surveys of responses of resident biota to site-contamination. Comparison of literature-based toxicity data to site-specific exposure estimates received the lowest weight. Strength-of-risk conclusions were considered high if multiple lines of evidence, including site-specific field surveys and toxicity tests, were available for a given receptor and all lines of evidence were in agreement. Risk conclusions were considered to be of moderate strength if data consisted of literature-based toxicity and one site-specific line of evidence. If only literature-based toxicity data were available to evaluate risks, the strength of risk conclusions was considered to be low.

Where available, NOECs and LOECs are used as benchmarks to give a range of risk. If the NOEC is exceeded, but not the LOEC, this indicates that risk is possible (likelihood of adverse effects occurring is considered low); however, these were not considered to present significant risk in the weight-of-evidence. In contrast, risk is probable (adverse effects are likely) if the LOEC is exceeded. For bird and mammal receptors, exposure estimates that exceeded LOAELs or ED_{20}s were considered to be an indicator of probable risk for the literature-based toxicity data line of evidence. Estimated exposures that exceeded NOAELs but not LOAELs were considered to be an indicator of possible risk; however, these were not considered to represent significant risk drivers and were not considered in the weight-of-evidence.

Uncertainties that may influence final risk conclusions are summarized in Section 6.3, and gaps in the available site-specific data are discussed in Section 6.4.

6.1 Risk Characterization by Receptor

6.1.1 Fish Community

Three lines of evidence were available to estimate risk to fish communities: single-chemical toxicity benchmarks (from EPA, 2000; EPA, 1999a; and Suter and Tsao, 1996); body-burden-based NOECs and LOECs developed from Jarvinen and Ankley (1999); and site-specific ambient media toxicity tests used to identify samples with toxic effects on aquatic organisms.

Hazard Quotients (HQ or exposure measure / effects measure) for fish were calculated based on the 95 percent UCL surface water concentration at each of the four areas within the Lava Cap Mine drainage and at each of two reference areas (Reference 1 and Reference 2) as described in Section 3.3. As available, the 95 percent UCL in water was compared to acute and chronic National Ambient Water Quality Criteria (NAWQC) (EPA, 1999a; EPA, 2001) and state water quality standards for California (CAWQS) (EPA, 2000), acute and chronic Tier II values, and LCVs for fish, daphnids, non-daphnid invertebrates, and all species combined (Suter and Tsao, 1996). Additionally, the 95 percent UCLs in water were compared to site-specific NOECs for all COPECs. Because of the lack of toxicity in the ambient media toxicity tests site-specific LOECs could not be developed. Water screening HQs are presented in Table 6-1.

HQs for fish were also calculated on the basis of median, 90th percentile, and maximum whole-body concentrations of COPECs measured in fish collected from Midgradient, Lake, Downgradient, and Reference 3 waters. As available, the median, 90th percentile, and maximum whole-body fish concentrations were compared to literature-based whole-body fish NOECs and LOECs. These body-burden-based HQs are presented in Table 6-2. Exceedance of a NOEC indicates that risk is possible, although it becomes more unlikely if only the 90th percentile or maximum concentration is exceeded. If the maximum concentration exceeds the LOEC, risk is also possible. In contrast, if the 90th percentile or median concentration exceeds the LOEC, risk is likely or high, respectively.

Water-Mediated (Single-Chemical) Toxicity Line of Evidence

The 95 percent UCL water concentrations in all areas, including reference, exceeded at least one literature-derived benchmark for at least one COPEC (Tables 6-1 and 6-3). Generally, the Mine Area had the greatest number of COPECs that exceeded benchmarks. For example, silver, arsenic, copper, lead, and zinc concentrations in the Mine Area exceeded the acute NAWQC and CAWQS benchmarks, and arsenic, cyanide, copper, lead, and zinc concentrations in this area exceeded the chronic NAWQC and CAWQS benchmarks. Cadmium exceeded the chronic CAWQS at the Mine Area and the acute and chronic NAWQCs at both the Mine and Lake Areas. Arsenic and cyanide also exceeded chronic benchmarks in Midgradient and Lake samples.

Barium concentrations in all areas exceeded Chronic Tier II values and concentrations in the Mine Area exceeded the Acute Tier II value. Manganese concentrations exceeded Chronic Tier II values in Reference 2, the Mine Area, the Lake Area, and the Downgradient Area, as well as LCVs for daphnids and all species in the Downgradient Area. Zinc exceeded the fish, daphnid, aquatic plant, and all species LCVs, cobalt exceeded the daphnid and all species LCVs, and mercury exceeded the fish and all species LCVs in the Mine Area.

COPECs that exceeded at least one literature-based toxicity value were barium at Reference 1; barium and manganese at Reference 2; silver, arsenic, barium, cadmium, cyanide, cobalt, copper, mercury, manganese, lead, and zinc at the Mine Area; arsenic, barium, and cyanide at the Midgradient Area; arsenic, barium, cadmium, cyanide, and manganese at the Lake Area; and barium and manganese at the Downgradient Area. These potential risk drivers are considered in the weight-of-evidence.

Body-Burden-Based Toxicity Line of Evidence

Median, 90th percentile, or maximum whole-body fish concentrations in all areas with available data, including reference, exceeded at least one literature-based whole-body benchmark for at least one COPEC (Tables 6-2 and 6-3). Because aluminum and vanadium concentrations in site media were not statistically different from reference in all media (Table 3-7), these chemicals were excluded from the risk characterization (Table 6-3).

Median, 90th percentile, or maximum whole body concentrations of arsenic, cadmium, selenium, and zinc exceeded the literature-based NOEC at all Lava Cap Mine Site areas with available data, and also at Reference 3. Additionally, silver, copper, and lead at the Midgradient Area, and copper at the Lake Area exceeded the NOEC. For arsenic, the median, 90th percentile, and maximum values at all Lava Cap Mine Site areas exceeded the NOEC, whereas only the 90th percentile and maximum values slightly exceeded the NOEC at Reference 3. Similarly, only the 90th percentile and maximum values of cadmium and copper at the Lake Area exceeded the NOEC, but the HQs were less than 2. Non-exceedance by the median value and low HQs for other values indicate that possible risk from arsenic at Reference 3 and cadmium and copper at the Lake Area is unlikely. Furthermore, whole-body concentrations of cadmium in fish from the Lake and Downgradient Areas and selenium in fish from the Lake Area are less than or similar to those at Reference 3 (Table 6-2). Therefore, risk from these COPECs at these areas is unlikely. Risk from exposure to all other COPECs that exceeded the NOEC is considered to be possible, although only the COPECs that exceeded both the NOEC and LOEC were carried forward to the weight-of-evidence analysis.

Median, 90th percentile, and maximum whole-body concentrations were also compared to literature-based LOECs. Exceedance of the LOEC indicates probable risk, but is also dependent on the concentration. If the maximum whole-body concentration in fish exceeds the LOEC, risk is possible, whereas exceedance of the LOEC by 90th percentile and median concentrations indicates likely and high probability of risk, respectively. Median, 90th percentile, and maximum whole-body concentrations of arsenic, selenium, and zinc exceeded the LOEC at all Lava Cap Mine Site areas with available data. HQs for cadmium and lead at the Midgradient Area were greater than 1, as were HQs for copper at the Lake Area and selenium and zinc at Reference 3. Because the LOEC for copper was only slightly exceeded by the 90th percentile and maximum values at the Lake Area, risk from copper at this area is not considered to be high. Risk from other COPECs with median fish concentrations above the LOEC is considered to be high. The values for zinc were not markedly different among sampled areas, but the HQs for the three mine areas were slightly higher than for Reference 3.

Ambient Media Toxicity Line of Evidence

Based on the site-specific bioassay results, no significant reductions in the survival of *Cerodaphnia* or fathead minnows were observed in samples from any location tested; however, because bioassays were not performed on site waters with the highest COPEC concentrations, the 95 percent UCL water concentrations did exceed the site-specific NOEC for at least one COPEC at each location, including reference. LOECs could not be developed due to the lack of observed toxicity in the water samples tested.

Comparison of 95 percent UCL water concentrations to site-specific NOECs resulted in HQs greater than 1 for all COPECs in the Mine Area (Tables 6-1 and 6-3). Furthermore, selenium concentrations at all areas (including reference) exceeded site-specific NOECs. Additional COPECs with HQs greater than 1 included beryllium, cobalt, and manganese at Reference 2; barium and cyanide at the Midgradient Area; beryllium, cadmium, cyanide, cobalt, and manganese at the Lake Area; and barium, cobalt, and manganese at the Downgradient Area.

Weight-of-Evidence

Both cyanide and selenium surface water concentrations at all on-site locations are either less than or not statistically different from reference concentrations (Table 3-7). However, because cyanide is often associated with mining activities, it was retained as a potential risk driver. Selenium was not considered to be a risk driver at any location. Surface water concentrations and whole-body fish concentrations exceeded multiple literature-based benchmarks at all Lava Cap Mine Site areas. Although site-specific ambient media toxicity tests were performed and no toxicity was observed, these tests add little to the risk conclusions because chemical concentrations in waters used for the tests were below maximum concentrations present at the site.

The weight-of-evidence for risks to the fish community (summarized in Table 6-3) indicates that multiple chemicals in surface water may pose significant risks to the growth, reproduction, or survival of fish in all areas of the Lava Cap Mine Site. This includes 14 chemicals in the Mine Area (silver, arsenic, barium, beryllium, cadmium, cyanide, cobalt, copper, mercury, manganese, nickel, lead, antimony, and zinc); 6 chemicals in the Midgradient Area (arsenic, barium, cadmium, cyanide, lead, and zinc); 9 chemicals in the Lake Area (arsenic, barium, beryllium, cadmium, cyanide, cobalt, copper, manganese, and zinc); and 5 chemicals in the Downgradient Area (arsenic, barium, cobalt, manganese, and zinc).

The strength of these risk conclusions is low due to the reliance on literature-based toxicity data. However, it should be noted that the body-burden based and single-chemical toxicity data are consistent in identifying risk to fish from exposure to arsenic at the Midgradient and Lake Areas. In addition, the NAWQC and CAWQS are intended to be protective for 95 percent of aquatic genera, and the organisms used for bioassays (*Ceriodaphnia* and fathead minnows) may not be among the more sensitive species for Lava Cap Mine Site COPECs.

6.1.2 Benthic Invertebrate Community

Three lines of evidence were available to estimate risk to benthic invertebrate communities: single-chemical toxicity benchmarks (from MacDonald et al., 2000); site-specific ambient media toxicity tests used to identify toxic effects on survival; and biological survey results.

HQs for benthic invertebrates were calculated based on the maximum sediment concentration in each of the four areas within the Lava Cap Mine Site drainages and three reference areas as described in Section 3.3. Maximum concentrations of each COPEC were compared to TECs and PECs (from MacDonald et al., 2000), as well as site-specific NOECs and LOECs as available. Sediment screening results are presented in Table 6-4.

Sediment-Mediated (Single-Chemical) Toxicity Line of Evidence

Overall, maximum sediment concentrations exceeded at least one literature-derived or site-specific benchmark for at least one COPEC in all areas, including reference. Sediment concentrations of arsenic and nickel exceeded TECs in all areas; however arsenic exceeded the PEC only at Reference 1 (HQ<2) and all Lava Cap Mine Site areas (HQs>30), and nickel exceeded the PEC only at Reference 2 and the Mine Area (HQs<2). At the Mine Area, arsenic, cadmium, copper, mercury, nickel, and zinc exceeded both the TEC and PEC benchmark, while lead exceeded only the TEC benchmark. Although cadmium, copper, mercury, nickel, lead, and zinc sediment concentrations at the Midgradient Area exceeded the TEC benchmarks, none of these chemicals exceeded the PECs. Similarly, cadmium, copper, nickel, lead and zinc concentrations at the Downgradient Area exceeded the TECs but not the PECs. At the Lake Area, arsenic, cadmium, copper, mercury, nickel, lead, and zinc exceeded the TECs, but only arsenic and zinc also exceeded the PEC benchmark. Copper concentrations at Reference 1 and Reference 2 and mercury at Reference 1 exceeded the TECs, but not the PECs.

Ambient Media Toxicity Line of Evidence

During the sediment bioassays, significantly increased mortality was observed in the only sediment sample tested from the Mine Area. Site-specific LOECs for sediment were derived from this sample.

Concentrations of beryllium and mercury at Reference 1 and beryllium, copper, and nickel at Reference 2 exceeded site-specific NOECs based on the ambient media toxicity tests. At Lava Cap Mine Site areas, silver, arsenic, beryllium, cadmium, copper, mercury, nickel, lead, antimony, and selenium at the Mine Area; silver, nickel, lead, antimony, and selenium at the Midgradient Area; silver, cadmium, mercury, nickel, lead, antimony, selenium, and zinc at the Lake Area; and arsenic, barium, cyanide, cobalt, manganese, lead, and selenium at the Downgradient Area also exceeded the NOECs. However, beryllium and nickel at Lava Cap Mine Site areas and mercury at the Lake Area did not differ statistically from concentrations of these COPECs at reference areas. Therefore, risk is considered possible for all other COPECs that exceeded site-specific NOECs except for beryllium, nickel, and mercury at these locations.

Site-specific LOEC-based HQs greater than or equal to 1 were obtained for silver, arsenic, beryllium, cadmium, copper, mercury, nickel, lead, antimony, and selenium in the Mine Area. Silver concentrations in the Midgradient Area also exceeded the site-specific LOEC, as did lead concentrations in the Midgradient, Lake, and Downgradient Areas. Nickel is the only COPEC to exceed the site-specific LOEC in a reference area (Reference 2). Risk is considered to be probable for COPECs that exceeded the LOEC, except for nickel at the Mine Area (nickel in this area did not exceed reference nickel concentrations).

COPECs that exceeded both the NOEC and LOEC are considered potential risk drivers and are carried forward in the weight-of-evidence analysis.

Biological Survey Line of Evidence

A site-specific biological survey of the benthic invertebrate community was conducted, and RBP analyses were performed. Based on these analyses no adverse effects were observed in the Lake and Downgradient Areas or in two of the three reference areas. No data were available for Reference 2 or for the Mine and Midgradient Areas.

Weight-of-Evidence

Beryllium and nickel sediment concentrations at all on-site locations were less than or did not differ significantly from reference concentrations (Table 3-7); therefore, these chemicals were not considered risk drivers at any location (Table 6-5). Despite exceedance of literature-based benchmarks, it is assumed that no risk is associated with exposure to arsenic, copper, and mercury at reference areas. The ambient media toxicity tests and the biological survey results support this conclusion. Although there was some consistency in the risk at the Lake and Downgradient Areas that was determined from literature-based benchmarks and site-specific NOECs, this risk was not considered to be significant based on the lack of support from the site-specific LOEC comparisons and the biological survey results. Risk from exposure to zinc at the Mine Area, and arsenic, cadmium, copper, mercury, nickel, and zinc at the Midgradient Area also was not supported by the site-specific toxicity tests.

The weight-of-evidence for the benthic invertebrate community (Table 6-5) indicates that sediment concentrations of silver, arsenic, cadmium, copper, mercury, lead, antimony, and selenium in the Mine Area and silver and lead in the Midgradient Area pose significant risk to benthic invertebrate communities. Sediment concentrations of COPECs in the Lake and Downgradient Areas do not pose a risk to benthic invertebrate communities. The strength of these risk conclusions is considered to be moderate because of the availability of both literature-based toxicity and at least one site-specific (bioassay results) line of evidence that supports the conclusion. Although biological survey data were available for some sites, no data were available for the Mine and Midgradient Areas; therefore, the strength of this additional line of evidence is low.

6.1.3 Amphibians

One line of evidence was available to estimate risk to amphibians, representing the endangered red-legged frog: single-chemical toxicity benchmarks. HQs for amphibians were calculated based on the maximum surface water concentration in each of the four areas within the Lava Cap Mine Site drainages and two reference areas (Reference 1 and Reference 2) as described in Section 3.3. As available, the maximum concentration in water was compared to the 10th percentile of literature-derived LOECs for embryo and larval amphibian stages. No amphibian toxicity data are available for barium, cobalt, or vanadium. Water screening HQs for amphibians are presented in Table 6-6.

Water-Mediated (Single-Chemical) Toxicity Line of Evidence

Embryo or larval HQs greater than 1 were obtained for at least one COPEC in all on-site areas. Arsenic concentrations exceeded the lower of either embryo or larval 10th percentile LOECs in all four Lava Cap Mine areas. The maximum water concentrations for silver, copper, mercury, lead, and zinc in the Mine Area exceeded embryo and larval LOECs, while manganese and nickel concentrations exceeded the embryo LOEC in this area.

Weight-of-Evidence

As described in the weight-of-evidence evaluation in Table 6-7, risks from mercury were based on comparison to methyl mercury benchmarks, which likely overestimated the risk. Results indicate that arsenic presents risk to individual amphibian (i.e., red-legged frogs) health and survival in all Lava Cap Mine areas. Additionally, silver, copper, mercury, manganese, nickel, lead, and zinc in the Mine Area present significant risk to amphibians. The strength of these risk conclusions is low because of the reliance on literature-based toxicity data.

6.1.4 Terrestrial Plants

Two lines of evidence were available to estimate risk to terrestrial plant communities: single-chemical toxicity benchmarks (from Efroymson et al., 1997a) and site-specific ambient media toxicity tests used to identify toxic effects on germination and growth.

HQs for terrestrial plants were calculated based on the maximum soil concentration in each of the four areas at the Lava Cap Mine Site and in each of two reference areas (Reference 1 and Reference 2) as described in Section 3.3. Literature-derived LOECs were available for all COPECs except cyanide and thallium, and were compared to maximum soil concentrations. Literature-derived NOECs were also available; however, these were not relied on for the risk characterization. The available plant NOEC data were highly variable, and in some cases (e.g., barium, cobalt, and mercury), the calculated 10th percentile value was greater than the calculated 10th percentile LOEC (Table 5-7). Therefore, only chemicals that exceeded the 10th percentile LOEC are carried forward as potential risk drivers in the weight-of-evidence analysis.

Maximum soil concentrations also were compared to site-specific EC_{100}s for germination. EC_{100}s were based on soil samples in which adverse effects to terrestrial plants (i.e., 100 percent failure to germinate) were observed. Although EC_{50}s for growth were developed, these are not discussed in the risk characterization because of the large degree of variability in the biomass data and the poor correlations between growth and COPEC concentrations. As described in Section 5.2.4, the use of EC_{100}s will likely underestimate risk; therefore, no COPECs were excluded as potential risk drivers based solely on this line of evidence. Soil screening results for plants are presented in Table 6-8.

Soil-Mediated (Single-Chemical) Toxicity Line of Evidence

Tenth percentile literature-derived NOECs for multiple COPECs were exceeded at all locations with available data. Arsenic, nickel, lead, selenium, and zinc at Reference 1 and arsenic, nickel, and zinc at Reference 2 had HQs greater than 1; however, these were presumed not to present a risk. Arsenic, cadmium, cobalt, nickel, lead, selenium, and zinc at the Mine Area; arsenic, cadmium, nickel, lead, and zinc at the Midgradient Area; arsenic, cadmium, nickel, lead, selenium, and zinc at the Lake Area; and arsenic, cadmium, and zinc at the Downgradient Area also exceeded the NOECs. However, concentrations of barium and nickel at Lava Cap Mine Site areas did not differ from reference areas and were assumed to represent no risk at Lava Cap Mine Site locations. It should be noted that NOEC values were not available for silver, copper, manganese, and antimony. Additionally, NOECs for barium, cobalt, and mercury were greater than literature-derived LOECs, and were therefore not relied on for the risk characterization. Risk to the plant communities was considered to be possible for all other COPECs at Lava Cap Mine Site areas that exceeded the NOEC. However, as previously indicated, these COPECs were not retained as potential risk drivers in the weight-of-evidence analysis unless the LOEC was also exceeded.

Tenth percentile literature-derived LOECs for arsenic, barium, manganese, and zinc were exceeded in all areas, including reference. Additionally, silver concentrations in all four of the Lava Cap Mine Site areas exceeded the LOEC value. HQs greater than 1 were obtained for cadmium, cobalt, copper, nickel, antimony, and selenium concentrations in the Mine and Lake Areas. Nickel also exceeded the LOEC in Reference 2, and antimony exceeded the LOEC in the Midgradient Area. Mercury exceeded the LOEC in Mine Area, Midgradient Area, and Downgradient Area soils, but not in Lake Area soils. Concentrations of lead in Mine Area soil samples had an HQ greater than 1. COPECs that exceeded the LOEC were considered to represent probable risk to the plant community and are discussed as potential risk drivers in the weight-of-evidence analysis.

Ambient Media Toxicity Lines of Evidence

Significantly increased mortality and reduced growth were observed in at least one soil sample tested from each area, including reference; however, there was high variability and discontinuity in the response. Due to the large degree of variability in the biomass data and the poor correlations between growth and COPEC concentrations, the lettuce growth EC_{50}s were considered to be highly uncertain and are not discussed in the risk characterization. There was only one sample tested from the Mine Area in which 100 percent of the seeds failed to germinate, and thus 100 percent failed to grow. Site-specific EC_{100} values were developed from this data. In the Mine Area, maximum soil concentrations of 12 (silver, arsenic, cyanide, cadmium, cobalt, copper, mercury, nickel, lead, antimony, selenium, and zinc) of the 16 COPECs exceeded the EC_{100} as determined by the site-specific bioassays. Selenium is the only COPEC to exceed the EC_{100} in the reference areas, and it also exceeded the EC_{100} in the Mine and Lake Areas. (Note that this probably indicates selenium was not a causative factor for plant mortality in the sample used to derive EC_{100} values.) HQs obtained for mercury in all four of the areas were greater than 1. Cadmium and antimony concentrations at the Midgradient Area and cadmium, cobalt, copper, and zinc concentrations at the Lake Area also exceeded the EC_{100}s for these chemicals. As previously indicated, this line of evidence was not used to exclude COPECs as potential risk drivers.

Weight-of-Evidence

Barium, manganese, and nickel soil concentrations were less than or did not differ statistically from reference concentrations (Table 3-7). Therefore, these chemicals are not considered to be risk drivers at any area. Maximum arsenic and zinc concentrations at the reference areas exceeded the 10^{th} percentile LOEC; however these concentrations are presumed to present no risk to terrestrial plants at the reference areas. Although selenium concentrations in soils from reference locations marginally exceeded (HQs < 2) the site-specific EC_{100}, they are presumed to present no risk (as noted above).

The weight-of-evidence evaluation is outlined in Table 6-9. Chemicals that pose probable risk to the growth, reproduction, or survival of terrestrial plants were silver, arsenic, cyanide, cadmium, cobalt, copper, mercury, lead, antimony, selenium, and zinc in the Mine Area; silver, arsenic, cadmium, mercury, antimony, and zinc in the Midgradient Area; silver, arsenic, cadmium, cobalt, copper, mercury, antimony, selenium, and zinc in the Lake Area; and silver, arsenic, mercury, and zinc in the Downgradient Area. The strength of these risk conclusions is considered moderate because the lines of evidence include literature-based toxicity and site-specific bioassay data.

6.1.5 Terrestrial Invertebrates

Two lines of evidence were available to estimate risk to terrestrial invertebrate communities: single-chemical toxicity benchmarks (from Efroymson et al., 1997b) and site-specific ambient media toxicity tests used to identify toxic effects on survival and growth.

HQs for terrestrial invertebrates were calculated based on the maximum soil concentration in each of the four areas at the Lava Cap Mine Site and in each of two reference areas (Reference 1 and Reference 2) as described in Section 3.3. Literature-derived LOECs were available and compared to maximum soil concentrations for all COPECs except silver, barium, beryllium, cyanide, cobalt, manganese, antimony, and thallium. Literature-derived NOECs were also available, but NOECs were not relied on for the risk characterization. The literature-based terrestrial invertebrate NOEC data were highly variable, and in some cases (e.g., cadmium and mercury), the calculated 10^{th} percentile value was greater than the calculated 10^{th} percentile LOEC (Table 5-7). Therefore, only chemicals that exceeded the 10^{th} percentile LOEC are discussed as potential risk drivers in the weight-of-evidence analysis.

Maximum soil concentrations also were compared to site-specific NOECs, LOECs or LC_{50}s and to site-specific weight loss EC_{50}s. Site-specific NOECs were based on samples with no observed effects, and site-specific LOECs were based on the single soil sample from the Mine Area in which adverse effects were observed. LC_{50}s and EC_{50}s were determined from dose-response curves fit to the survival and growth data, respectively.

Maximum soil concentrations that exceeded LOECs, LC_{50}s, or EC_{50}s were considered to be indicators of probable risk (adverse effects are likely). Maximum soil concentrations that exceeded NOECs, but not LOECs, LC_{50}s, or EC_{50}s were considered to be indicators of possible risk (likelihood of adverse effects occurring is considered low); however, these were not considered to represent significant risk drivers and were not retained as risk drivers in the weight-of-evidence analysis.

Soil-Mediated (Single-Chemical) Toxicity Line of Evidence

Maximum soil concentrations of copper and zinc at all areas, including reference, exceeded the 10^{th} percentile of literature-derived NOECs (Tables 6-8 and 6-10). However, concentrations of copper and zinc at reference areas were presumed to be no risk to soil invertebrates. Additionally, copper concentrations at the Midgradient and Downgradient Areas were less than reference concentrations and therefore are presumed to present no risk. Cadmium, copper, mercury, nickel, lead, and zinc at the Mine Area and cadmium, copper, nickel, and zinc at the Lake Area, as well as zinc at the Downgradient Area had NOEC-based HQs greater than 1. It should be noted that NOEC values were not available for silver, arsenic, barium, beryllium, cyanide, cobalt, manganese, antimony, and thallium. Additionally, NOECs for cadmium and mercury were greater than literature-derived LOECs, and were therefore not relied on for the risk characterization. Risk to the terrestrial invertebrate communities was considered to be possible for all other COPECs at Lava Cap Mine Site areas that exceeded the NOEC. However, as previously indicated, these COPECs are not retained as potential risk drivers in the weight-of-evidence analysis unless the LOEC was also exceeded.

Maximum soil concentrations of arsenic and zinc in all four Lava Cap Mine Site areas exceeded the 10^{th} percentile of literature-derived LOECs (Tables 6-8 and 6-10). Copper exceeded LOECs in both of the reference areas tested, the Mine Area, and the Lake Area. Maximum soil concentrations of cadmium, mercury, nickel and lead also exceeded the LOECs but only in the Mine Area. COPECs that exceeded the LOEC were considered to represent probable risk to terrestrial invertebrates, and were carried forward as potential risk drivers in the weight-of-evidence analysis.

Ambient Media Toxicity Line of Evidence

Of the soil samples tested in the site-specific bioassays, only the single soil sample from the Mine Area caused a significant increase in earthworm mortality (Table 6-10). No statistically significant effects on mortality or weight loss were observed for samples from any other areas.

Maximum soil concentrations of barium and manganese at Reference 1 and beryllium, cobalt, copper, and nickel at Reference 2 exceeded site-specific NOECs for mortality; however, these were presumed to present no risk to terrestrial invertebrates at reference areas (Tables 6-8 and 6-10). NOEC-based HQs greater than 1 were also obtained for silver, arsenic, beryllium, cyanide, cadmium, cobalt, copper, mercury, manganese, nickel, lead, antimony, selenium, and zinc concentrations measured in soil from the Mine Area, as well as for cobalt and mercury at the Midgradient Area; beryllium, cadmium, cobalt, copper, mercury, manganese, nickel, selenium, and zinc concentrations at the Lake Area; and mercury at the Downgradient Area. Although COPECs that exceeded the site-specific NOECs are considered to represent possible risk to terrestrial invertebrates, as previously discussed, this risk is low and the COPECs are not retained as potential risk drivers in the weight-of-evidence unless the LOEC, LC_{50}, or EC_{50} is also exceeded.

LOEC- or LC_{50}-based HQs greater than 1 were obtained for silver, arsenic, cyanide, cadmium, cobalt, copper, mercury, manganese, nickel, lead, antimony, selenium, and zinc concentrations measured in soil from the Mine Area and for cadmium, cobalt, copper, manganese, and selenium concentrations measured in Lake Area soils (Tables 6-8 and 6-10). Manganese is the only COPEC in reference soil samples (Reference 1) to exceed the LOEC, and mercury is the only COPEC to exceed the LOEC in the Downgradient Area. No LOEC- or LC_{50}-based HQs greater than 1 were obtained for Reference 2 or for the Midgradient Area.

Finally, comparisons of the maximum soil concentration to the weight loss EC_{50} as determined by the site-specific bioassays were evaluated. Silver, arsenic, cyanide, cadmium, cobalt, copper, mercury, nickel, lead, antimony, selenium, and zinc concentrations measured in Mine Area soils exceeded the weight loss EC_{50}s, and cadmium, cobalt, copper, nickel, selenium, and zinc concentrations measured in Lake Area soils exceeded their EC_{50}s (Tables 6-8 and 6-10). Mercury exceeded the EC_{50} in all Lava Cap Mine areas except the Lake Area. Copper and nickel were the only COPECs to exceed EC_{50}s in samples collected from Reference 2. No chemicals exceeded the weight loss EC_{50} at Reference 1.

COPECs that exceeded both the site-specific NOEC and the site-specific LOEC, LC_{50}, or EC_{50} were carried forward as potential risk drivers in the weight-of-evidence analysis.

Weight-of-Evidence

Manganese and nickel concentrations at on-site locations were less than or did not differ statistically from reference locations, so they are not considered to be risk drivers at any locations. Additionally, maximum concentrations of copper in reference soils and in Midgradient and Downgradient Areas were similar and only marginally (HQs<2) exceeded literature-based LOECs or site-specific toxicity values. Therefore, these chemicals are not considered risk drivers at these locations. Although arsenic and zinc in the Midgradient and Downgradient Areas and arsenic in the Lake Area exceeded literature-derived LOEC values, these results were not supported by the site-specific toxicity data. Therefore, these chemicals are not considered to be risk drivers at these locations.

As indicated in the weight-of-evidence evaluation presented in Table 6-10, 11 chemicals in the Mine Area (silver, arsenic, cyanide, cadmium, cobalt, copper, mercury, lead, antimony, selenium, and zinc), and 5 chemicals in the Lake Area (cadmium, cobalt, copper, selenium, and zinc) pose a significant risk to the growth, reproduction, or survival of terrestrial invertebrates. Only mercury presents risk to terrestrial invertebrates in the Midgradient and Downgradient Areas. Because both literature-based toxicity data and one site-specific line-of-evidence were available, the strength of the risk conclusions for soil invertebrates is considered to be moderate.

6.1.6 Soil Microbial Processes

One line of evidence was available to estimate risk to soil microbial processes: single-chemical toxicity benchmarks (from Efroymson et al., 1997b). HQs for microbial processes were calculated based on the maximum soil concentration in each of the four areas at the Lava Cap Mine Site and in each of two reference areas (Reference 1 and Reference 2) as described in Section 3.3. Literature-derived LOECs were available and compared to maximum soil concentrations for all COPECs except barium, beryllium, cyanide, antimony, and thallium. Literature-derived NOECs were also available, but these were not relied on for the risk characterization. The available NOEC data for microbial processes were highly variable, and in some cases (e.g., silver and manganese), the calculated 10th percentile value was greater than the calculated 10th percentile LOEC (Table 5-7). Therefore, only chemicals that exceeded the 10th percentile LOEC are carried forward as potential risk drivers in the weight-of-evidence analysis.

Soil-Mediated (Single-Chemical) Toxicity Line of Evidence

Maximum soil concentrations of manganese and zinc at Reference 1 and manganese at Reference 2 exceeded the 10th percentile of literature-derived NOECs; however, these were presumed to be no risk to soil microbial processes (Tables 6-8 and 6-11). Cadmium, copper mercury, manganese, nickel, lead, and zinc at the Mine Area; manganese and zinc at the

Midgradient and Downgradient Areas; and cadmium, copper, manganese, nickel, and zinc at the Lake Area also had NOEC-based HQs greater than 1. However, concentrations of manganese at Lava Cap Mine Site areas did not differ from reference areas and were assumed to represent no risk at Lava Cap Mine Site locations. Nickel concentrations at the Midgradient Area were less than reference concentrations and therefore are presumed to present no risk. It should be noted that NOEC values were not available for arsenic, barium, beryllium, cyanide, cobalt, antimony, and thallium. Additionally, NOECs for silver and manganese were greater than literature-derived LOECs, and were therefore not relied on for the risk characterization. Risk to the soil microbial processes was considered to be possible for all other COPECs at Lava Cap Mine Site areas that exceeded the NOEC. However, as previously indicated, these COPECs were not retained as potential risk drivers in the weight-of-evidence analysis, unless the LOEC was also exceeded.

Maximum soil concentrations of silver, arsenic, cadmium, copper, manganese, nickel, lead, and zinc in the Mine Area exceeded the 10^{th} percentile of literature-derived LOECs for soil microbial processes (Tables 6-8 and 6-11). Manganese exceeded the LOEC in all areas. Arsenic and zinc exceeded the LOECs at all four Lava Cap Mine Site areas. Zinc also exceeded the LOEC at Reference 1. In addition to the Mine Area, maximum soil concentrations of copper at the Lake Area exceeded the LOEC. COPECs that exceeded the LOEC were considered to represent probable risk to soil microbial processes and were carried forward as potential risk drivers in the weight-of-evidence analysis.

Weight-of-Evidence

Although manganese exceeded the NOEC and LOEC at all locations, concentrations at reference locations are presumed to present no risk. Additionally, manganese concentrations at the four Lava Cap Mine Site areas were less than or statistically similar to reference concentrations. Therefore, manganese is not considered a risk driver at any location. Maximum concentrations of zinc in soils from Reference 1, the Midgradient Area, and the Downgradient Area marginally exceeded (HQs<2) literature-based LOECs. Zinc is therefore not considered a risk driver at these locations, but is retained as a risk driver at the Mine and Lake Areas (HQs>10).

The weight-of-evidence (summarized in Table 6-11) indicates that seven chemicals in the Mine Area (silver, arsenic, cadmium, copper, nickel, lead, and zinc) and three chemicals in the Lake Area (arsenic, copper, and zinc) pose significant risk to soil microbial processes. Only arsenic presents risk in the Midgradient and Downgradient Areas. Arsenic is a dominant risk driver in all Lava Cap Mine areas. The strength of these risk conclusions is low because of the reliance on literature-based toxicity data.

6.1.7 Birds and Mammals

A tiered approach was used in the characterization of risks based on oral exposure. Initial 95 percent UCL-based exposure estimates were compared to NOAELs, LOAELs, and ED_{20}s for each receptor and COPEC. It should be noted that no appropriate avian toxicity data were available to derive NOAEL, LOAEL, or ED_{20} values for antimony, beryllium, silver, or thallium. Thus, no HQs were calculated for avian receptors exposed to these chemicals. Although it was also not possible to derive NOAEL, LOAEL, or ED_{20} values for cyanide toxicity in birds, acute data were available and were used to calculate acute HQs (Note: This will likely underestimate chronic risk because it generally takes a higher dose to elicit an acute response.) No appropriate mammalian toxicity data were available to derive ED_{20} values for antimony, barium, beryllium, cyanide, selenium, silver, or thallium; therefore, only NOAEL and LOAEL-based HQs were calculated for mammalian receptors exposed to these chemicals. Additionally, no data were available to derive a LOAEL value for beryllium, so only the NOAEL-based HQ was calculated for mammalian receptors exposed to beryllium.

Exposure estimates that exceeded LOAELs or ED_{20}s were considered to be indicators of probable risk (adverse effects are likely). Estimated exposures that exceeded NOAELs but not LOAELs or ED_{20}s were considered to be indicators of possible risk (likelihood of adverse effects occurring is considered low); however, these were not considered to represent significant risk drivers and were not retained as potential risk drivers in the weight-of-evidence analysis.

Exposure estimates for any COPEC-receptor combination for which HQs greater than 1 were obtained were recalculated to account for the bioavailability of the COPEC. COPECs for which “percent bioavailable” data were available include arsenic (60 percent), barium (10 percent), cadmium (9 percent), copper (40 percent), lead in mammals (26.2 percent), lead in birds (50 percent), inorganic mercury (15 percent, used for media exposures), organic mercury (95 percent, used for exposure from ingestion of biota), selenium (60 percent), and zinc (50 percent). (See Section 4.7 for more detailed information.)

After adjusting exposure estimates for bioavailability, any COPEC-receptor combination for which HQs greater than 1 were obtained were evaluated to determine which pathways and assumptions were driving the risk estimate. These pathways and assumptions were then modified based on more ecologically or statistically appropriate assumptions. For example, COPECs with HQs greater than 1 in reference areas were assumed to pose no risk to birds and mammals; therefore, COPECs in any area that had HQs greater than 1, but whose exposure concentrations were equal to or less than reference exposures were excluded as risk drivers.

Risk was also characterized based on target-organ-based exposure for some American dippers, ornate shrews, and California voles. Median, 90th percentile, and maximum concentrations of lead in blood and liver and cadmium in liver were estimated for American dippers. Median, 90th percentile, and maximum concentrations of cadmium and lead in liver and kidney tissues were estimated for ornate shrews, and cadmium and lead in liver and kidney and zinc in kidney tissues were estimated for California voles. These were compared to literature-based tissue concentrations associated with adverse effects. Data were available to develop LOECs, but not NOECs for American dipper tissues. Data were not available to develop NOECs or LOECs for cadmium in mammalian liver tissue or NOECs for cadmium and zinc in mammalian kidney tissue. Exceedance of a NOEC indicates that risk is possible, although it becomes less likely if only the 90th percentile or maximum concentration exceeds the NOEC. If the maximum concentration exceeds the LOEC, risk is also possible. In contrast, if the 90th percentile or median concentration exceeds the LOEC, risk is likely or high, respectively.

The risk estimation for the four bird receptors and four mammal receptors is summarized in Table 6-15, and risk for each receptor is characterized below.

6.1.7.1 American Dipper

Two lines of evidence were available to estimate risks to American dippers: estimates of risk based on single-chemical oral exposure and target-organ-based exposure. Risk to the American dipper population was considered possible if the oral exposure exceeded the literature-based NOAEL and probable if the oral exposure exceeded either the selected LOAEL or the ED_{20}, or if the target-organ-based exposure exceeded literature-based LOECs. (Note: NOECs for target-organ-based exposures were not available.) More weight was given to exceedance of the LOAEL, ED_{20}, or LOEC.

Oral (Single-Chemical) Toxicity Line of Evidence

Oral exposure exceeded literature-derived NOAELs for multiple COPECs in all areas, including reference (Tables 6-12 and 6-15). However, HQs for several chemicals (some cases of barium, cadmium, mercury, selenium, and zinc) were reduced below the risk threshold (HQ=1) when they were recalculated to account for the bioavailability of arsenic, barium, cadmium, mercury, selenium, and zinc. As a result, cobalt, lead, and zinc had HQs greater than 1 at all reference areas, selenium had an HQ greater than 1 at Reference 1, and manganese had an HQ greater than 1 at Reference 3. Cobalt and manganese exposure at the Midgradient and Lake Areas and zinc at the Mine, Midgradient, and Lake Areas did not exceed reference exposures for these COPECs. Although COPEC exposures that exceeded NOAELs were considered to represent possible risk, these COPECs were not carried forward to the weight-of-evidence analysis unless either the LOAEL or ED_{20} were exceeded.

Oral exposure exceeded literature-derived LOAELs or ED_{20}s for multiple COPECs in all areas, including reference (Tables 6-12 and 6-15). However, HQs for several chemicals (all cases of barium and zinc and some cases of selenium) were reduced below the risk threshold (HQ=1) when they were recalculated to account for the bioavailability of arsenic, barium, mercury, selenium, and zinc. As a result, only cobalt had HQs greater than 1 at the reference areas. COPECs carried forward to the weight-of-evidence analysis include cobalt at the reference areas; arsenic, cobalt, copper, mercury, manganese, lead, and selenium at the Mine Area; arsenic, cobalt, and selenium at the Midgradient and Lake Areas; and arsenic, cobalt, manganese, and selenium at the Downgradient Area.

Target-Organ Toxicity Line of Evidence

Lead and cadmium did not exceed target-organ-based thresholds at any location (Tables 6-13 and 6-15).

Weight-of-Evidence

Exposures to cobalt in reference areas were presumed to pose no risk to receptors. Furthermore, cobalt was excluded as a risk driver from the Midgradient and Lake Areas because of non-exceedance of reference exposures, but was retained as a potential risk driver at the Mine and Downgradient Areas. Because American dippers have small home ranges (0.55-0.77 km of stream), it is reasonable to assume that individuals may reside and forage exclusively within each on-site area. Therefore, all chemicals not excluded after the bioavailability adjustment or when compared to reference exposures were retained as risk drivers.

The weight-of-evidence as described in Table 6-15 is that multiple chemicals pose significant risk to the growth, reproduction, or survival of American dippers in the Mine, Midgradient, Lake, and Downgradient Areas. Arsenic, cobalt, copper, mercury, manganese, lead, and selenium are risk drivers in the Mine Area. Arsenic and selenium are risk drivers in the Midgradient and Lake Areas, and arsenic, cobalt, manganese, and selenium are risk drivers in the Downgradient Area. The strength of these risk conclusions is low because of reliance on literature-based toxicity data.

6.1.7.2 Red-Tailed Hawk

The only line of evidence available to estimate risks to red-tailed hawks was estimates of risk based on single-chemical oral exposure. As with American dippers, risk to the red-tailed hawk population was considered possible if the oral exposure exceeded the literature-based NOAEL and probable if the oral exposure exceeded either the selected LOAEL or the ED_{20}.

Oral (Single-Chemical) Toxicity Line of Evidence

Estimated oral exposure for at least one COPEC at all areas except Reference 2 and 3 exceeded literature-derived NOAELs (Tables 6-12 and 6-15). After exposure was adjusted to include bioavailability data for arsenic, lead, and zinc, no COPECs exceeded NOAELs at reference areas or at the Midgradient, Lake, and Downgradient areas. Arsenic and lead at the Mine Area had NOAEL-based HQs greater than 1 after the bioavailability recalculation. However, only arsenic at the Mine Area carried forward to the weight–of-evidence analysis because exposure to this COPEC exceeded the NOAEL and the LOAEL or ED_{20}.

Weight-of-Evidence

Arsenic in the Mine Area was the only chemical to exceed literature-derived thresholds, and was retained as a potential risk driver after recalculation to account for the bioavailability of arsenic (Tables 6-12 and 6-15). However, because of the large size of the foraging range of red-tailed hawks (930 ha) compared to the small size of the Mine Area (~5 ha), less than 1 percent of the food of a typical red-tailed hawk would be expected to be obtained from the Mine Area. Therefore, arsenic was not retained as a risk driver.

As outlined in Table 6-15, the weight-of-evidence is that no chemicals in any of the Lava Cap Mine Site areas presents risk to the growth, reproduction, or survival of red-tailed hawks. The strength of these risk conclusions is low because of reliance on literature-based toxicity data.

6.1.7.3 Green Heron

Estimates of risk based on single-chemical oral exposure were the only line of evidence available to estimate risks to green herons. Risk to the green heron population was considered possible if the oral exposure exceeded the literature-based NOAEL and probable if the oral exposure exceeded either the selected LOAEL or the ED_{20}.

Oral (Single-Chemical) Toxicity Line of Evidence

Oral exposure exceeded literature-derived NOAELs in all areas, except Reference 3 (Tables 5-12 and 5-15). However, HQs for several chemicals (all cases of cadmium and selenium and some cases of lead and zinc) were reduced below the risk threshold (NOAEL-based HQ=1) when they were recalculated to account for the bioavailability of arsenic, cadmium, lead, mercury, selenium, and zinc. As a result, no COPECs were considered possible risk at Reference 1 or Reference 3. Lead at Reference 2; arsenic, cobalt, lead, and zinc at the Mine Area; cobalt, manganese, and lead at the Downgradient Area; and lead at the Midgradient and Lake areas had NOAEL-based HQs greater than 1 after the bioavailability adjustment. COPECs at the reference areas were assumed to pose no risk. Additionally, exposures of lead at the Midgradient and Lake areas were less than exposures of this COPEC at reference areas. Although COPEC exposures that exceeded NOAELs were considered to represent possible risk, these COPECs were not carried forward to the weight-of-evidence analysis unless either the LOAEL or ED_{20} were exceeded.

Oral exposure exceeded literature-derived LOAELs or ED_{20}s for multiple COPECs in all areas except the reference areas (Tables 6-12 and 6-15). However, HQs for several chemicals (all cases of selenium and some cases of arsenic) were reduced below the risk threshold (LOAEL-based HQ=1) when they were recalculated to account for the bioavailability of arsenic and selenium. As a result, only arsenic exceeded literature-based toxicity thresholds at the Mine Area and was carried forward to the weight-of-evidence analysis.

Weight-of-Evidence

Although home range data for green herons are lacking, green herons are known to be territorial. Therefore, it is reasonable to assume that individuals may reside and forage exclusively within each on-site area. Thus, all chemicals not excluded after the bioavailability adjustment were retained as potential risk drivers.

The weight-of-evidence evaluation presented in Table 6-15 indicates that only arsenic poses risk to growth, reproduction, or survival of green herons in the Mine Area. Only arsenic is a risk driver in the Midgradient and Lake Areas. The strength of these risk conclusions is low because of reliance on literature-based toxicity data.

6.1.7.4 California Quail

One line of evidence was available to estimate risks to California quail: estimates of risk based on single-chemical oral exposure. As with the other avian receptors, risk to the California quail population was considered possible if the oral exposure exceeded the literature-based NOAEL and probable if the oral exposure exceeded either the selected LOAEL or the ED_{20}.

Oral (Single-Chemical) Toxicity Line of Evidence

Estimated oral exposure for at least one COPEC at all areas, except Reference 3, exceeded literature-derived NOAELs. After exposure was adjusted to include bioavailability data for arsenic, barium, cadmium, lead, and zinc, only lead had an HQ greater than 1 at Reference 1 and 2. Arsenic, lead, and zinc at the Mine Area; lead and zinc at the Midgradient and Downgradient Areas; and cadmium, lead, and zinc at the Lake Area had NOAEL-based HQs greater than 1 after the bioavailability recalculation. Lead exposures at reference areas are presumed to pose no risk to California quail. Moreover, lead exposure at the Lake Area was less than exposure at reference areas and lead exposure at Midgradient and Downgradient Areas was not markedly different from reference areas. Although COPEC exposures that exceeded NOAELs were considered to represent possible risk, these COPECs were not carried forward to the weight-of-evidence analysis unless either the LOAEL or ED_{20} were exceeded.

Arsenic, cadmium, lead, and zinc exposures at the Mine Area and cadmium exposures at the Midgradient and Lake Areas had HQs greater than 1. However, only arsenic at the Mine Area was retained after accounting for the bioavailability of cadmium, lead, and zinc. Because exposure to this COPEC exceeded the NOAEL and the LOAEL or ED_{20}, it was carried forward to the weight-of-evidence analysis.

Weight-of-Evidence

Based on the above results and consideration of the small home-range sizes of California quail (1.2 to less than 20 ha), the weight-of-evidence is that arsenic poses risk to the growth, reproduction, or survival of California quail in the Mine Area (Table 6-15). The strength of these risk conclusions is low because of reliance on literature-based toxicity data.

6.1.7.5 Mink

One line of evidence was available to estimate risks to mink: estimates of risk based on single-chemical oral exposure. Risk to the mink population was considered possible if the oral exposure exceeded the literature-based NOAEL and probable if the oral exposure exceeded either the selected LOAEL or ED_{20}.

Oral (Single-Chemical) Toxicity Line of Evidence

Estimated oral exposure for at least one COPEC exceeded literature-derived NOAELs at all four of the Lava Cap Mine Site areas (Tables 6-12 and 6-15). These included arsenic and zinc at the Mine Site Area; arsenic at the Midgradient and Lake areas; and arsenic, barium, and manganese at the Downgradient Area. After adjusting exposure to account for the bioavailability of arsenic, barium, and zinc, arsenic and zinc at the Mine Area; arsenic at the Midgradient and Lake areas; and arsenic and manganese at the Downgradient Area had NOAEL-based HQs greater than 1. Risk due to exposures to these COPECs was considered to be possible, but only COPECs that also exceeded the LOAEL or ED_{20} were retained in the weight-of-evidence analysis.

Estimated arsenic exposure exceeded literature-derived LOAELs and ED_{20}s in all four of the Lava Cap Mine Site areas (Tables 6-12 and 6-15). Manganese exposure in the Downgradient Area also exceeded toxicity thresholds. When these exposures were recalculated to account for bioavailability, arsenic at the Mine, Midgradient, and Lake areas, as well as arsenic and manganese at the Downgradient Area were retained as potential risk drivers and were carried forward to the weight-of-evidence analysis. These COPECs were considered to pose probable risk to mink at these locations.

Weight-of-Evidence

Because of the large home-range sizes of mink (1-5 km of stream) compared to the small size of the Lava Cap Mine Site areas (<5 ha each), it is unlikely that individuals will forage exclusively, and therefore be exposed exclusively, within a single area. The manganese HQ (3.12) at the Downgradient Area only nominally exceeded the risk threshold (HQ=1) and was therefore not retained as a risk driver. Arsenic was retained as a risk driver at all four Lava Cap Mine Site areas.

The weight-of-evidence, as outlined in Table 6-15, is that arsenic presents risk to the growth, reproduction, or survival of mink populations in the Mine, Midgradient, Lake, and

Downgradient areas. The strength of these risk conclusions is low because of reliance on literature-based toxicity data.

6.1.7.6 Ornate Shrew

Two lines of evidence were available to estimate risks to ornate shrews: estimates of risk based on single-chemical oral exposure and target-organ-based exposure. Risk to the ornate shrew population was considered possible if the oral exposure exceeded the literature-based NOAEL or if the target-organ-based exposure exceeded the literature-based NOECs. Risk was considered to be probable if the oral exposure exceeded either the selected LOAEL or the ED_{20}, or if the target-organ-based exposure exceeded literature-based LOECs. More weight was given to exceedance of the LOAEL, ED_{20}, or LOEC.

Oral (Single-Chemical) Toxicity Line of Evidence

Oral exposure exceeded literature-derived NOAELs for multiple COPECs in all areas, including Reference 1 and 2 (Tables 6-12 and 6-15). However, HQs for several chemicals (all cases of barium and copper, and some cases of mercury and selenium) were reduced below the risk threshold (NOAEL-based HQ=1) when they were recalculated to account for bioavailability. COPEC exposures exceeding NOAELs at reference areas were presumed to pose no risk. Moreover, barium and cobalt exposures at all Lava Cap Mine Site areas were less than reference exposures, as were manganese at the Mine, Midgradient, and Lake areas and thallium at the Mine, Midgradient, and Downgradient areas. All other COPECs that exceeded literature-derived NOAELs were considered to represent possible risk to ornate shrews; however, as previously discussed, these COPECs were not discussed in the weight-of-evidence analysis unless either the LOAELs or ED_{20} were also exceeded.

Oral exposure exceeded literature-derived LOAELs or ED_{20}s for multiple COPECs in all areas, including Reference 1 and 2 (Tables 6-12 and 6-15). However, HQs for several chemicals (all cases of barium, zinc, and copper and some cases of mercury) were reduced below the risk threshold (LOAEL- or ED_{20}-based HQ=1) when they were recalculated to account for bioavailability. COPECs retained as potential risk drivers and carried forward to the weight-of-evidence analysis included arsenic and manganese at Reference 1; arsenic, manganese, and selenium at Reference 2; arsenic, cyanide, and antimony at the Mine Area; arsenic and manganese at the Midgradient and Lake areas; and arsenic, mercury, manganese, and selenium at the Downgradient Area. These COPECs were considered to pose probable risk to ornate shrews at these locations.

Target-Organ Toxicity Line of Evidence

Maximum and 90^{th} percentile concentrations of lead in liver and kidney tissue exceeded the literature-based NOEC at the Mine Area (Tables 6-14 and 6-15). This indicates that risk, although possible, is low because the median concentration of lead in liver or kidney tissue was not exceeded. The literature-based LOEC for lead was exceeded by the maximum concentration in liver tissue and the 90^{th} percentile and maximum concentration in kidney tissue. Because the median concentration did not exceed the LOEC, risk from exposure to lead based on this line of evidence is considered likely but not high.

Weight-of-Evidence

Exposures to arsenic, manganese, and selenium in reference areas were presumed to pose no risk to ornate shrews. Furthermore, manganese at the Midgradient and Lake areas was excluded as a risk driver due to non-exceedance of reference exposures. Although home range data for ornate shrews are lacking, ranges are assumed to be comparable to those for other small mammals (<1 ha). Therefore, it is reasonable to assume that individuals may reside and forage exclusively within each on-site area. Thus, all chemicals not excluded after the bioavailability adjustment or when compared to reference exposures were retained as risk drivers. Lead was also retained as a risk driver because of exceedance of the target-organ-based toxicity thresholds for liver and kidney.

As described in Table 6-15, the weight-of-evidence is that multiple chemicals present risks to the growth, reproduction, or survival of ornate shrews in the Mine, Midgradient, Lake, and Downgradient areas. Arsenic, cyanide, lead, and antimony are risk drivers in the Mine Area. In the Midgradient and Lake Areas, arsenic is a risk driver and arsenic, mercury, manganese, and selenium are risk drivers in the Downgradient Area. The strength of these risk conclusions is low because of reliance on literature-based toxicity data.

6.1.7.7 California Vole

Two lines of evidence were available to estimate risks to California voles: estimates of risk based on single-chemical oral exposure and target-organ-based exposure. Risk to the California vole population was considered possible if the oral exposure exceeded the literature-based NOAEL or if the target-organ-based exposure exceeded the literature-based NOECs. Risk was considered probable if the oral exposure exceeded either the selected LOAEL or the ED_{20}, or if the target-organ-based exposure exceeded literature-based LOECs. More weight was given to exceedance of the LOAEL, ED_{20}, or LOEC.

Oral (Single-Chemical) Toxicity Line of Evidence

Oral exposure exceeded literature-derived NOAELs for multiple COPECs in all areas, including Reference 1 and 2 (Tables 6-12 and 6-15). However, HQs for several chemicals (all cases of barium and cadmium and some cases of zinc) were reduced below the risk threshold (NOAEL-based HQ=1) when they were recalculated to account for bioavailability. Arsenic, cyanide, antimony, and zinc exposures at the Mine Area; arsenic, antimony, and zinc exposures at the Midgradient Area; arsenic, manganese, and zinc at the Lake Area; and arsenic and zinc at the Downgradient Area exceeded the NOAEL after adjusting for bioavailability. COPEC exposures exceeding NOAELs at reference areas (thallium at Reference 1) were presumed to pose no risk. All other COPECs that exceeded literature-derived NOAELs were considered to represent possible risk to California voles; however, as previously discussed, these COPECs were not considered in the weight-of-evidence analysis unless either the LOAELs or ED_{20} were also exceeded.

Oral exposure exceeded literature-derived LOAELs or ED_{20}s for multiple COPECs in all four Lava Cap Mine Site areas and for one COPEC (barium) at Reference 1. No COPECs exceeded thresholds at Reference 2 and 3 (Tables 6-12 and 6-15). HQs for several chemicals (all cases of barium, cadmium, and zinc) were reduced below the risk threshold (LOAEL- or ED_{20}-based HQ=1) when they were recalculated to account for bioavailability. As a result, no COPECs exceeded literature-based LOAELs or ED_{20}s at any of the reference areas.

COPECs retained as potential risk drivers and carried forward to the weight-of-evidence analysis included arsenic and cyanide at the Mine Area, and arsenic at the Midgradient, Lake, and Downgradient areas. These COPECs were considered to pose probable risk to California voles at these locations.

Target-Organ Toxicity Line of Evidence

Maximum concentrations of lead in liver tissue and maximum and 90th percentile concentrations of lead in kidney tissue exceeded the literature-based NOEC at the Mine Area (Tables 6-14 and 6-15). This indicates that risk, although possible, is low because the median concentration of lead in liver or kidney tissue was not exceeded. The literature based LOEC for lead was exceeded by the maximum concentration in liver. Because the median concentration did not exceed the LOEC, risk from exposure to lead based on this line of evidence is considered possible (only the maximum concentration exceeded the LOEC) but not high.

Weight-of-Evidence

Because of the small home-range sizes of California voles (68-231 m^2) compared to the size of the Lava Cap Mine Site areas (<5 ha each), it is reasonable to assume that individuals may reside and forage exclusively within each on-site area. Thus, all chemicals not excluded after the bioavailability adjustment were retained as risk drivers. Lead was also retained as a risk driver due to exceedance of the target-organ-based toxicity thresholds for kidney, although this risk is considered to be relatively low because only the estimated maximum concentration in liver tissue exceeded the LOEC.

As described in Table 6-15, the weight-of-evidence is that arsenic, cyanide, and lead present risks to the growth, reproduction, or survival of California voles in the Mine Area, and arsenic presents risk in the Midgradient, Lake, and Downgradient areas. The strength of these risk conclusions is low due to reliance on literature-based toxicity data.

6.1.7.8 Long-Tailed Weasel

One line of evidence was available to estimate risks to long-tailed weasels: estimates of risk based on single-chemical oral exposure. Risk to the long-tailed weasel population was considered possible if the oral exposure exceeded the literature-based NOAEL and probable if the oral exposure exceeded either the selected LOAEL or ED_{20}.

Oral (Single-Chemical) Toxicity Line of Evidence

Estimated oral exposure for multiple COPECs exceeded literature-derived NOAELs at all four Lava Cap Mine Site areas and at Reference 1 and 2 (Tables 6-12 and 6-15). These included arsenic and zinc at all Lava Cap Mine Site areas; cyanide and antimony at the Mine Area; and barium at the Lake and Downgradient areas. Barium and zinc exposure at Reference 1 and Reference 2 also exceeded the NOAELs. Exposure was adjusted to account for the bioavailability of arsenic, barium, and zinc. This resulted in NOAEL-based HQs greater than 1 for arsenic, cyanide, antimony, and zinc at the Mine Area, arsenic at the Midgradient and Lake areas, and arsenic and zinc at the Downgradient Area. No COPECs at reference areas had HQs greater than 1.0. Risk due to exposures to these COPECs was considered to be possible, but only COPECs that also exceeded the LOAEL or ED_{20} were retained in the weight-of-evidence analysis.

Arsenic was the only COPEC to exceed literature-derived LOAELs or ED_{20}s in all four Lava Cap Mine Site areas. Toxicity thresholds were not exceeded at the reference areas for any COPEC (Tables 6-12 and 6-15). When these were recalculated to account for the bioavailability of arsenic, arsenic at the Mine, Midgradient, Lake, and Downgradient areas was retained as a potential risk driver.

Weight-of-Evidence

Because of the large home-range sizes of long-tailed weasels (5-121 ha) compared to the small size of the Lava Cap Mine Site areas (<5 ha each), it is unlikely that individuals will forage exclusively, and therefore be exposed exclusively, within a single area. However, arsenic exposure at all four Lava Cap Mine Site areas was sufficient to retain arsenic as a risk driver.

The weight-of-evidence, as outlined in Table 6-15, is that arsenic presents significant risk to the growth, reproduction, or survival of long-tailed weasels in the Mine, Midgradient, Lake, and Downgradient areas. The strength of these risk conclusions is low because of reliance on literature-based toxicity data.

6.2 Risk Characterization by Lava Cap Mine Site Area

For risk management purposes, it is useful to consider risk at each defined area (Mine, Midgradient, Lake, and Downgradient; see Section 3.3 for description) at the Lava Cap Mine Site. Only risk, as determined by the weight-of-evidence analyses in Section 6.1, is discussed in this section because these analyses represent COPECs that are likely to cause adverse effects to receptors. Overall, risk to at lease one receptor from at least one COPEC is probable at all areas with arsenic being the primary risk driver across all areas. The weight-of-evidence conclusions are summarized by assessment endpoint and Lava Cap Mine Site area in Table 6-16 and are described below.

6.2.1 Mine Area

Based on the weight-of-evidence, all conceptual model groups except carnivorous birds (represented by the red-tailed hawk) are at risk from exposure to at least one chemical at the Mine Area (Table 6-16). In general, media-associated endpoints (e.g., fish, benthic invertebrates, amphibians, terrestrial plants, soil invertebrates, and soil microbial processes) are at risk from the greatest number of chemicals. Silver, arsenic, copper, and lead pose probable risk to all of these endpoints, and cadmium, mercury, and zinc pose risk to four of the five media-associated endpoints. Other chemicals that pose risk to media-associated endpoints include antimony (4 endpoints); cyanide, cobalt, nickel, and selenium (3 endpoints); manganese (2 endpoints); and barium and beryllium (1 endpoint).

Bird and mammal receptors tend to have fewer risk drivers, although those most closely associated with contaminated media (i.e., aquatic insectivorous birds, such as American dippers, and burrowing insectivores, such as ornate shrews) are at risk from multiple chemicals (Table 6-16). Only the carnivorous birds (represented by red-tailed hawks) do not experience risk from estimated chemical exposures at this area. This is likely due to the large home ranges of these birds and their low association with contaminated media. Arsenic exposure presents risk to all other bird and mammal receptors. Cyanide, cobalt, copper, mercury, manganese, lead, antimony, and selenium present risk to at least one bird or mammal receptor.

6.2.2 Midgradient Area

At the Midgradient Area, all conceptual model groups, except carnivorous birds (represented by the red-tailed hawk), herbivorous birds (represented by the California quail), and piscivorous birds (represented by the green heron) are at risk from exposure to at least one chemical (Table 6-16). Fish and terrestrial plants are at risk from the greatest number of chemicals at this area, with arsenic, barium, cadmium, cyanide, lead, and zinc posing risk to the fish community and silver, arsenic, cadmium, mercury, antimony, and zinc posing risk to the terrestrial plant community. Arsenic also poses risk to the amphibians and soil microbial processes, and silver and lead pose risk to benthic invertebrates and mercury poses risk to soil invertebrates.

The carnivorous (represented by red-tailed hawks), herbivorous (represented by California quail), and piscivorous birds (represented by the green heron) do not experience risk from estimated chemical exposures at the Midgradient Area. As previously indicated, this is likely due to the large home ranges of carnivorous birds, as well as their low association with contaminated media. Herbivorous and piscivorous birds also have a low association with contaminated media. Arsenic poses risk to all of the other bird and mammal receptors, and selenium poses risk to aquatic insectivores (represented by the American dipper).

6.2.3 Lake Area

At the Lake Area, all conceptual model groups, except benthic invertebrates, carnivorous birds (represented by the red-tailed hawk), herbivorous birds (represented by the California quail),and piscivorous birds (represented by the green heron) are at risk from exposure to at least one chemical (Table 6-16). As with the Mine and Midgradient areas, media-associated endpoints (e.g., fish, amphibians, terrestrial plants, soil invertebrates, and soil microbial processes) tend to be at risk from the greatest number of chemicals. The one exception is benthic invertebrates. In this case, several COPECs exceeded literature-derived benchmarks but the site-specific biological survey and analysis (rapid bioassessment protocol) indicated no clear differences between reference and Lake Area benthic invertebrates. Therefore, adverse impacts on the benthic invertebrate community at the Lake Area are considered to be possible, but not probable. Arsenic poses risk to four of the other five media-associated endpoints and copper and zinc pose risk to three of the other five media-associated endpoints. Other chemicals that pose risk to media-associated endpoints include cadmium and cobalt (3 endpoints); selenium (2 endpoints); and barium, beryllium, cyanide, mercury, manganese, and antimony (1 endpoint).

The carnivorous (represented by red-tailed hawks), herbivorous (represented by California quail), and piscivorous birds (represented by the green heron) do not experience risk from estimated chemical exposures at the Lake Area. As previously indicated, this is likely due to the large home ranges of carnivorous birds and the low association of carnivorous, herbivorous, and picivorous birds with contaminated media. Arsenic poses risk to all of the other bird and mammal receptors and selenium poses risk to aquatic insectivores (represented by the American dipper).

6.2.4 Downgradient Area

At the Downgradient Area, all conceptual model groups, except benthic invertebrates, carnivorous birds (represented by the red-tailed hawk), herbivorous birds (represented by the California quail), and piscivorous birds (represented by the green heron) are at risk from exposure to at least one chemical (Table 6-16). As with the Midgradient and Lake areas, fish and terrestrial plants are at risk from the greatest number of chemicals at this area, with arsenic, barium, cobalt, manganese, and zinc posing risk to the fish community, and silver, arsenic, mercury, and zinc posing risk to the terrestrial plant community. Other chemicals likely to cause risk in media-associated endpoints include arsenic for amphibians and soil microbial processes, and mercury for soil invertebrates. Benthic invertebrates is the only media-associated endpoint that is not at risk. In this case, several COPECs exceeded literature-derived benchmarks but the site-specific biological survey and analysis (RBP) indicated no clear differences between reference and Downgradient Area benthic invertebrates. Therefore, adverse impacts on the benthic invertebrate community at the Downgradient Area are considered to be possible, but not probable.

Bird and mammal receptors tend to have fewer risk drivers, although those most closely associated with contaminated media (i.e., aquatic insectivorous birds such as American dippers and burrowing insectivores such as ornate shrews) are at risk from multiple chemicals (Table 6-16). The carnivorous (represented by red-tailed hawks), herbivorous (represented by California quail), and piscivorous birds (represented by the green heron) do not experience risk from estimated chemical exposures at the Downgradient Area. As previously indicated, this is likely due to the large home ranges of carnivorous birds and the low association of these receptors with contaminated media. Arsenic poses risk to all other birds and mammals, and cobalt, mercury, manganese, and selenium pose risk to at least one bird or mammal.

6.3 Uncertainties

Uncertainties are inherent in all risk assessments. The nature and magnitude of uncertainties depend on the amount and quality of data available, the degree of knowledge concerning site conditions, and the assumptions made to perform the assessment. A qualitative evaluation of the major uncertainties associated with this assessment, in no particular order of importance, is outlined below.

- Data concerning soil and or sediment ingestion rates by Lava Cap Mine Site avian and mammalian receptors were not available. As a consequence, soil and sediment ingestion rates were estimated based on assumed similarities to other species for which data were available. The suitability of these assumptions is unknown. Although this uncertainty may result in underestimation of exposure (and risk), it is more likely that exposure and risk are overestimated.
- No avian and mammalian life history data specific to the Lava Cap Mine Site drainage were available; therefore, exposure parameters were either modeled based on allometric relationships (e.g., food ingestion rates) or were based on data from the same species in other portions of its range. Because diet composition as well as food, water, and soil ingestion rates can differ among individuals and locations, published parameter values

may not accurately reflect individuals present at the site. As a consequence, risk may be either overestimated or underestimated.

- No site-specific data on COPEC concentrations in birds and reptiles were available for avian and mammalian exposure estimate calculations. Therefore, concentrations in these prey items were estimated from site-specific bioaccumulation models for mammals and amphibians. The suitability of these bioaccumulation models is unknown. As a consequence, concentrations of COPECs in actual bird and reptile prey of Lava Cap Mine Site avian and mammalian receptors may be either higher or lower than data used in this assessment.
- Gut contents were removed from collected small mammals prior to chemical analysis. Although this allows for a more accurate estimation of bioaccumulation, it likely under-represents exposure to mammlian and avian predators that consume the entire animal. Consequently, risk may be underestimated for mammal-eating predators.
- Literature-derived toxicity data based on laboratory studies were used to evaluate risk to all receptor groups, and in some cases, were the only available toxicity data. It was assumed that effects observed in laboratory species were indicative of effects that would occur in wild species. The suitability of this assumption is unknown. Consequently, risk may be either overestimated or underestimated.
- Toxicity data are not available for all COPECs considered in this assessment. As a consequence, COPECs for which toxicity data are unavailable were not evaluated. Exclusion of COPECs from evaluation underestimates aggregate risk.
- Bioavailability data were not available for all COPECs considered in this assessment. Therefore, risk for COPECs lacking bioavailability data may be overestimated.
- Available bioavailability values are not site-specific, but are based on published data from laboratory studies or other sites. Consequently, risk may be either overestimated or underestimated.
- Bioavailability in the toxicity studies used for screening is generally high because many toxicity tests are performed using soluble salts of inorganic chemicals. Therefore, risk based solely on literature-derived toxicity values may be overestimated.
- In this assessment, total metals concentrations in surface water were used to determine risk to fish and amphibians. Because the total concentration of a metal includes both the dissolved (i.e., bioavailable) and undissolved fraction, use of the total metal concentration is likely to overestimate risk.
- Because toxicity data are not available for all avian and mammalian receptor species considered in this assessment, it was necessary to extrapolate toxicity values from test species to site receptor species. Although improved class-specific scaling factors were employed (Sample and Arenal, 1999), these factors are not chemical-specific and are based on acute toxicity data. As a consequence, risk may be either overestimated or underestimated.
- In this assessment, risks from COPECs were each considered independently for many receptors (i.e., those receptors that lacked ambient media toxicity data). Because

chemicals may interact in an additive, antagonistic, or synergistic manner, evaluation of single-chemical risk may either underestimate or overestimate risks associated with chemical mixtures.

- Ambient media toxicity bioassays were conducted on a select group of laboratory species (e.g., amphipods, fathead minnows, earthworms, and lettuce seeds). It was assumed that these species are representative of the fish and other aquatic organisms, benthic invertebrates, terrestrial invertebrates, and terrestrial plants found in the Lava Cap Mine Site areas. The suitability of this assumption is unknown. Consequently, risk may be either overestimated or underestimated.
- For terrestrial plants, terrestrial invertebrates, and soil microbial processes, 10^{th} percentile NOECs and LOECs were calculated from published data. In some cases, NOECs exceeded LOECs for a particular COPEC. It was therefore assumed that the LOEC was the most appropriate value for screening as it represents the lowest concentration at which a 20 percent or greater reduction in growth, reproduction, or survival was observed. This reliance on LOEC values only may result in overestimation of risk.

6.4 Data Gaps

The availability of site-specific data provides a realistic assessment of adverse effects that are actually occurring at the site, thus strengthening the risk conclusions. Several types of site-specific data were available for the Lava Cap Mine Site, including chemical analyses of media (water, sediment, and soil) and biota (fish, aquatic invertebrates, frogs, terrestrial plants, terrestrial invertebrates, and small mammals) collected on-site; site-specific bioassays for aquatic organisms, sediment biota, and terrestrial plants; and a biological survey and analysis for benthic invertebrates conducted on-site. From this data, it was also possible to develop site-specific soil-, water-, and sediment-biota bioaccumulation models for wildlife foods. However, several gaps in the available data exist causing increased uncertainty in the risk characterization and are described below.

- Additional sit-specific bioassays with chronic endpoints using maximum and minimum values in media by area would increase the strength of this line of evidence.
- Measurement of the dissolved metal concentrations in surface water from on-site and reference areas are lacking and collection of these data would better estimate risk to aquatic organisms (e.g., fish and amphibians). Dissolved concentrations of metals in water represent the concentrations available to exposed biota, whereas the total concentrations represent both bioavailable and unavailable concentrations of metals. Therefore, use of total metals concentrations overestimates risk.
- Measurement of organic carbon in sediment is also lacking. This data would enable concentrations of the bioavailable fraction of a metal in sediment to be estimated reducing uncertainty associated with the risk characterization for benthic invertebrates.
- The collection and chemical analysis of additional media and biota samples at reference areas would better establish background concentrations of chemicals in the areas surrounding the Lava Cap Mine Site.

- Conducting water bioassays using on-site water with the maximum concentrations of cyanide or metals measured at the site would increase the strength of this line of evidence for estimating risk to fish communities. Available water bioassays did not use water with the maximum concentrations of chemicals; therefore, confidence in the finding of no effects for this bioassay was low.
- Biological surveys of plant and soil invertebrate communities and bird and mammal populations that compare Lava Cap Mine Site areas to reference areas would be useful in determining actual impacts of cyanide or metals on these receptor groups. However, this is a low priority because of the small size of the site and the lack of appropriate undisturbed reference areas, both of which limit the usefulness of biological surveys.

SECTION 7

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SECTION 8

Glossary

Abiotic: Non-living; usually applied to the physical and chemical aspects of an organism's environment.

Abundance: The number of organisms in a population, combining 'intensity' (density within inhabited areas) and 'prevalence' (number and size of inhabited areas).

Acid volatile sulfide: A reactive pool of solid-phase sulfide that is available to bind metals and that portion unavailable and nontoxic to biota.

Acute: Having a sudden onset or lasting a short time. An acute stimulus is severe enough to induce a response rapidly. The word acute can be used to define either the exposure or the response to an exposure (effect). The duration of an acute toxicity test is generally 4 days or less and mortality is the response usually measured.

Adverse effect: Negative impacts on defined measurement parameters.

Allometric (Scaling): Variation in rates of vital processes as a function of an organism's body mass.

Anaerobic: Lacking oxygen; referring to an organism, environment, or cellular process that lacks oxygen and may by poisoned by it.

Area use factor (or) site use factor: The ratio of an organism's home range, breeding range, or feeding/foraging range to the area of contamination of the site under investigation.

Assessment endpoint: An explicit expression of the environmental value to be protected. An assessment endpoint must include an entity and specific property of that entity.

Background area: Those areas believed to represent an uncontaminated or undisturbed state.

Benthic community: The community of organisms (primarily invertebrates) dwelling at the bottom of a pond, river, lake, or ocean.

Bioaccumulation: The net accumulation of a substance by an organism due to uptake from all environmental media, including food.

Bioassay: Measures of biological responses that may be used to estimate the concentration or to determine the presence of some chemical or material.

Bioassessment: A general term referring to environmental evaluations involving living organisms; can include bioassay, community analyses, etc.

Bioavailability: The extent to which the form of a chemical occurring in a medium is susceptible to being taken up by an organism. A chemical is said to be bioavailable if it is in a form that is readily taken up (e.g., dissolved) rather than a less available form (e.g., sorbed to solids or to dissolved organic matter).

Bioconcentration: The net accumulation of a substance by an organism due to uptake from aqueous solution.

Biomagnification: Result of the process of bioaccumulation and biotransfer by which tissue concentrations of chemicals in organisms at one trophic level exceed tissue concentrations in organisms at the next lower trophic level in a food chain.

Biota: The fauna and flora together; all the living organisms at a location.

Chronic: Involving a stimulus that is lingering or continues for a long time; often signifies periods from several weeks to years, depending on the reproductive life cycle of the species. Can be used to define either the exposure or the response to an exposure (effect). Chronic exposures typically induce a biological response of relatively slow progress and long duration.

Community: An assemblage of populations of different species within a specified location and time.

Concentration: Amount of substance per unit volume.

Concentration-response curve: A curve describing the relationship between exposure concentration and percent of the test population responding.

Conceptual Site Model (CSM): A representation of the hypothesized causal relationship between the source of contamination and the response of the endpoint entities.

Control: A treatment in a toxicity test that duplicates all the conditions of the exposure treatments but contains no test material. The control is used to determine the response rate expected in the test organisms in the absence of the test material.

Correlation: An estimate of the degree to which two sets of variable vary together, with no distinction between dependent and independent variables.

Data Quality Objective (DQO): U. S. EPA process, which establishes what type, quantity, and quality of environmental data, are appropriate for their intended application.

Dermal absorption: Absorption directly through the skin.

Diversity: An index of community organization that take into account both species richness (the number of different species) and their relative abundance.

Dose: A measure of exposure. Examples include (1) the amount of a chemical ingested, (2) the amount of a chemical absorbed, and (3) the product of ambient exposure concentration and the duration of exposure.

Dose-response curve: Similar to concentration-response curve except that the dose (i.e., the quantity) of the chemical administrated to the organism is known. The curve is plotted as Dose versus Response.

Downgradient area: The segment of Clipper Creek below the Lost Lake dam.

Drainage basin: Area in which water drains to a common watercourse; synonymous with watershed.

Ecological Risk Assessment (ERA): A process that evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more agents.

Ecosystem: The functional system consisting of the biotic community and abiotic environment occupying a specified location in space and time.

Endangered species: The classification provided to an animal or plant in danger of extinction within the foreseeable future throughout all or a significant portion of its range.

Exposure pathway: The physical route by which a contaminant moves from a source to a biological receptor. A pathway may involve exchange among multiple media and may include transformation of the contaminants.

Exposure point: A location of potential contact between an organism and a chemical or physical agent.

Feasibility Study (FS): The component of the CERCLA assessment process that is conducted to analyze the practicality, benefits, costs, and risks associated with remedial alternatives.

Food chain transfer: A process by which substances in the tissues of lower-trophic-level organisms are transferred to the higher-trophic-level organisms that feed on them.

Hazard Quotient (HQ): The quotient of an ambient exposure concentration divided by a toxicological effective concentration.

Hazard Index (HI): The sum of more than one hazard quotient for multiple substances and/or multiple exposure pathways. The HI is calculated separately for chronic, subchronic, and shorter-duration exposures.

Herbivore: Animal consumer of living plant material.

Home range: Including territories, the area encompassed by an animal for travel on a daily to seasonal basis, to find food, water, and shelter.

Invertebrate: An animal without a backbone

Life-history: An organism's lifetime pattern of behavior, habitat use, food habits, and growth, and reproduction.

Matrix: The substance in which an analyte is embedded or contained; the properties of a matrix depend on its constituents and form.

Measurement endpoint: A measurable ecological characteristic that is related to the valued characteristic chosen as the assessment (equivalent to measure of effect).

Microbial processes: Soil functions (nitrification, decomposition, etc.) performed by microbial communities

Midgradient area: Area of this assessment defined as below the log dam at the mine site to above the deposition area at Lost Lake.

Omnivore: An animal that consumes both plant and animal material.

Organic carbon: Burnable form found in fats, oils, carbohydrates and proteins.

Overburden: Soil and rock overlying a mineral deposit.

Population: An aggregate of interbreeding individuals of a species occupying a specific location in space and time.

Pore water: Sediment interstitial water.

Risk: The expected frequency or probability of undesirable effects reuniting from exposure to known or expected stressors.

Rapid Bioassessment Protocol (RBP): Procedures of collection and determination of the condition and health of benthic invertebrate communities.

Receptor: An organism, population or community that is exposed to contaminants. Receptors mayor may not assessment endpoint entities.

Regression: Analysis of the functional relationship between two variables; the independent variable is described on the X axis and the dependent variable is described on the Y axis (i.e., the change in Y is a function of a change in X).

Remedial Investigation (RI): The component of the CERCLA assessment process that is conducted to determine the need for remediation.

Riparian: Occurring in or by the edge of a stream or in its floodplain.

Risk manager: An individual with the authority to decide what actions will be taken in response to a risk. Usually risk managers are representatives of regulatory agencies, land managers, or other organizations.

Serial dilution: Process by which a sample is diluted to produce samples of decreasing concentration. Generally performed in a geometric series (100 percent, 50 percent, 25 percent, 12.5 percent, 6.25 percent).

Special status species: Threatened or endangered species or species protected by a treaty or other statute.

Surrogate species: Representative species.

Threatened species: The classification provided to an animal or plant likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

Toxicity threshold: The concentration of the toxic component above which some effect (or response) will be produced and below which it will not.

Medium: The specific environmental components – air, water, soil – which are the subject of regulatory concern and activities.

Trophic level: Position in the food chain assessed by the number of energy-transfer steps that reach that level.

Weight-of-evidence approach: (1) A type of analysis that considers all available evidence and reaches a conclusion based on the amount and quality of evidence supporting each alternative conclusion; (2) The result of a weight-of-evidence analysis.

Wilcoxon Rank-Sum test: A non-parametric statistical test equivalent to the t-test.