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# FINAL
# Terrestrial Baseline Ecological Risk Assessment Work Plan

## Bonita Peak Mining District and Durango Reach
## San Juan County, CO
## La Plata County, CO

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## List of Acronyms and Abbreviations

| | |
|---|---|
| ATSDR | Agency for Toxic Substances and Disease Registry |
| ATV | All-terrain vehicle |
| AUF | Area use factor |
| BERA | Baseline ecological risk assessment |
| BPMD | Bonita Peak Mining District |
| BTAG | Biological Technical Assistance Group |
| BW | Body weight |
| CDPHE | Colorado Department of Public Health and Environment |
| COPEC | Contaminant of potential ecological concern |
| CPW | Colorado Parks and Wildlife |
| CSM | Conceptual site model |
| CTE | Central tendency exposure |
| DRC | Dose-response category |
| DW | Dry-weight |
| EcoSSL | Ecological soil screening level |
| EDD | Estimated daily dose |
| EPA | United States Environmental Protection Agency |
| EPC | Exposure point concentration |
| ESA | Endangered Species Act |
| ESAT | Environmental Services Assistance Team |
| ESV | Exposure screening value |
| EU | Exposure unit |
| FH | High-level floodplain sampling area exposure equation parameter |
| FIR | Food ingestion rate |
| FL | Low-level floodplain sampling area exposure equation parameter |
| FM | Mid-level floodplain sampling area exposure equation parameter |
| FP | Floodplain sampling area (combined) exposure equation parameter |
| FR | Reference floodplain sampling area exposure equation parameter |
| FV | Floodplain sampling area vegetation (combined) equation parameter |
| GIS | Geographic Information System |
| HAM | Halo area model |
| HH | High-level halo area exposure equation parameter |
| HL | Low-level halo area exposure equation parameter |
| HM | Mid-level halo area exposure equation parameter |
| HQ | Hazard quotient |
| LANL | Los Alamos National Laboratory |
| LOAEL | Lowest Observable Adverse Effect Level |
| LWA | Length-weighted average |
| MDL | Minimum detection limit |
| NOAEL | No Observable Adverse Effect Level |
| NPL | National Priorities List |
| ORNL | Oak Ridge National Laboratory |
| QA/QC | Quality Assurance/Quality Control |
| RI/FS | Remedial Investigation/Feasibility Study |

| | |
|---|---|
| RME | Reasonable maximum exposure |
| SAP/QAPP | Sampling and Analysis and Quality Assurance Project Plan |
| SERAS | Scientific, Engineering, Response & Analytical Services |
| SIR | Soil ingestion rate |
| SLERA | Screening-level ecological risk assessment |
| SPLP | Synthetic precipitation leaching procedure |
| SW | Surface water |
| T&E | Threatened and endangered |
| TRV | Toxicity reference value |
| UCL | Upper confidence level |
| USDOI | United States Department of the Interior |
| USFWS | United States Fish and Wildlife Service |
| VG | Vegetated upland area exposure equation parameter |
| WHO | World Health Organization |
| WIR | Water ingestion rate |
| WP | Work Plan |
| XRF | X-ray fluorescence |

# SECTION 1: GENERAL INTRODUCTION

This document presents a Work Plan (WP) to conduct a terrestrial Baseline Ecological Risk Assessment (BERA) for areas potentially affected by historical Bonita Peak Mining District (BPMD) mining operations. The BPMD is located in southwest Colorado, unincorporated San Juan County, within the headwaters of the Animas River. Select BPMD mine features were added to the National Priorities List in (NPL) April 2016 (United States Environmental Protection Agency [EPA], 2016b) due to the potential for ongoing releases of hazardous substances into the environment and impacts to human and ecological health. Now designated as a Superfund site, EPA has the authority to investigate and remediate contamination sources to lessen or eliminate impacts to human health and the environment occurring in BPMD. EPA uses information obtained from human health and ecological risk assessments to help guide risk management decisions on selecting and implementing cleanup actions as part of the Remedial Investigation/Feasibility Study (RI/FS) process.

A BERA WP is drafted to clearly define the scope of work before data are collected to assess the nature and extent of risks at complex Superfund sites. WPs are also used to recommend additional data collection activities needed to address risk assessment endpoints (EPA, 1992).

## 1.1 Work plan scope and goals

This WP describes the analysis steps and procedures that EPA will use to complete a terrestrial BERA for the BPMD Superfund site. The major goal of this BPMD BERA WP will be to build upon the terrestrial Screening-Level Ecological Risk Assessment (SLERA) to refine risk estimates and characterize current and potential terrestrial ecological threats to support RI/FS risk management decisions at the site (EPA, 1994b; 1997). The specific goals of this WP are as follows:

- Describe current conditions of the BPMD terrestrial assessment area, including recent history, habitats, wildlife, and potential non-mining impacts.
- Identify Contaminants of Potential Ecological Concern (COPECs)
- Identify sources of mining-related contamination, COPECs, semi-aquatic and terrestrial ecological receptors, and exposure pathways.
- Develop a terrestrial Conceptual Site Model (CSM) to identify complete exposure pathways and target receptors.
- Derive site-specific BERA assessment endpoints that are explicit expressions of ecological resources to be protected from harm.
- Provide measurement endpoints that will be used to evaluate the assessment endpoints.
- Identify procedures that will be used to assess toxicity and exposure to target receptors.
- Summarize the risk characterization and the uncertainty analysis approaches.

## 1.2 Stakeholder cooperation and role of the Biological Technical Assistance Group

The terrestrial BERA planning activities described herein are conducted with input from stakeholders and members of the BPMD Biological Technical Assistance Group (BTAG). Such input is crucial so that risk characterization and management decisions reflect and support the needs of the affected ecosystems (EPA, 1992). Stakeholders may include members of the local community, industry representatives, agency liaisons, and other parties that have an interest in participating in risk assessment activities. The BTAG consists of natural resource specialists who provide guidance and local insight to risk assessors and managers.

EPA is responsible for providing BTAG members with information on the site, including site history, suspected or known COPECs, and the RI/FS process (EPA, 1992). EPA will provide the BTAG this information during regular meetings so that any issues can be discussed among group members, risk assessors, and risk managers. As such, EPA fielded recommendations and comments from the BTAG during development of this WP. Draft BERA WP BTAG comments and EPA responses are provided in **Attachment 1**. BTAG members may also be notified and invited to comment on interim work products, such as draft Sampling and Analysis and Quality Assurance Project Plans (SAP/QAPPs), sample analysis reports, and risk assessment reports.

### 1.3 Work plan organization

This BERA WP is organized as follows:

- Section 2: Site description and history
- Section 3: Summary of the BPMD terrestrial SLERA and COPEC selection
- Section 4: CSM
- Section 5: Assessment and measurement endpoints
- Section 6: Characterization of effects
- Section 7: Exposure analysis
- Section 8: Risk characterization
- Section 9: References

# SECTION 2: SITE DESCRIPTION AND HISTORY

## 2.1 Site history

The BPMD Superfund site consists of 48 historic mining impacted sites (**Figure 2.1**). The sites are located in the upper reaches of the Animas River watershed near Silverton in San Juan County, Colorado. Individual mine sites are located in or just outside of the extensively mineralized Silverton Caldera basin. Geologic resources in this basin contain large amounts of metals (Storosh, 2013). The area has been subject to both large and small mining operations in boom and bust fashion from 1871 to 1991. Ore extraction activities ended after 1991, after which numerous reclamation and restoration projects were implemented.

The discovery of gold and silver brought miners to the area in the early 1870's. The discovery of silver in the base-metal ores was the major factor in establishing Silverton, CO as a permanent settlement. Between 1870 and 1889, rich lead-silver galena ore deposits were discovered and mined, mostly using hand tools (Jones, 2007). During this period, all but the highest grade ores were cast aside in surface mine waste dumps or left in underground mine workings in a process called high grading. High grading was conducted in part due to the difficulties with bringing ore up from and out of the mine workings. The Greene & Co. Smelter opened in Silverton in 1875, which stimulated additional mining activities in the area. The Denver & Rio Grande Railway's San Juan Extension arrived in Durango in July 1881 and Silverton in July 1882. Mining operations greatly expanded with the introduction of rail transportation which allowed ore to get out of and supplies to get into the BPMD.

A serious attempt was made during the 1880s and 1890s to mine and concentrate the low-grade ore bodies (Jones, 2007). This was a time when gravity milling became widespread to process low-grade ores into high-grade concentrates. Stamping presses and gravity mills were built across the mining district. Mills used water to separate ores, whereas untreated metal-laden wastes were discharged into streams, rivers, and lakes of the region. Use of aerial trams and new rail lines greatly improved the efficiency of mine-to-mill ore transportation. By 1897, more than 160 mines were documented to be operating in San Juan County (Jones, 2007).

Mining and milling operations slowed down around 1905 and many mines were either permanently closed or consolidated into fewer and larger operations. This is the time when mines, such as Silver Lake and Sunnyside, grew into very large operations and employed up to 400 laborers who worked several thousand linear feet of underground drifts and tunnels. These large, complex mines also excavated long haulage tunnels in lower-elevation mine workings to alleviate water infiltration issues. Haulage tunnels, such as the Unity and Terry tunnels, intercepted and discharged groundwater and left higher-elevation mining workings relatively dry.

The next major expansion in the BPMD occurred during World War I in response to increased war-time demand for zinc. This is also the time when new ball-mill grinding and floatation milling technologies were developed to more efficiently process ores of the region. Sunnyside Mine was the largest zinc ore producing mine in the country and by 1918 produced 600 short tons per day. The postwar recession hit in 1921, causing most mines and mills in the district to be closed by 1925. The Shenandoah-Dives Mine and Mayflower Mill in Silverton were the only major and consistent ore producers in the BPMD by the end of 1930. The mid-1930s also brought on new regulations that required mill tailings to be impounded and water to be clarified before it could be discharged (Storosh, 2013). Many of these tailings impoundments were poorly constructed and often breached, releasing metals-contaminated water and tailings into local waterways (Thompson, 2015).

From 1942 to 1953, wars and government strategic metal reserve programs periodically increased demand for base-metals. During this time frame, the Shenandoah-Dives Mining Company and other small mines began to re-mine old underground waste rock and surface dumps left by previous mine operators. A substantial volume of ore was recovered, which likely reduced the amount and footprint of potentially toxic materials in the environment. In 1958, the Shenandoah-Dives Mining Company became the Marcy-Shenandoah Corporation and obtained the leases for the Gold King Mill and the Sunnyside Mine. In 1960, the Marcy-Shenandoah-Dives Mining Company was purchased by Standard Metals Corporation which assumed its leases and the Mayflower Mill. Soon thereafter, Standard Metals Corporation renovated and expanded the Gold King Mill level tunnel at Gladstone toward and under the existing Sunnyside Mine workings. The haulage tunnel, which was renamed the American Tunnel, successfully drained underground mine workings in the area. The American Tunnel discharged water into Cement Creek while Sunnyside Mine workings were expanded.

Continuous mining only occurred at Sunnyside Mine from 1960 to 1991. However, additional mining and mineral explorations occurred during periods of high metals prices; most notably at Old Hundred Mine/Pride of the West Mill site where more than 15,000 linear feet of new tunnels were excavated. The waste dump from this venture was processed at the Pride of the West Mill periodically from 1970 to 1990 at times when metals prices were high. Lake Emma broke through a Sunnyside Mine in June 1978, catastrophically flooding mine workings with an estimated 5 to 10 million gallons of water and black metals-laden mud. Most of the muddy water exited from the Gladstone portal of the American Tunnel before flowing into Cement Creek and the Animas River. By 1991, approximately 1,500 mining related sites and deeded mining claims came to be located in the area (Lyon *et al*., 2003).

Sunnyside Gold Corporation, formerly Standard Metals Corporation, ended production in August 1991 after exhausting all of the higher-grade ore deposits and recovery of milled mine-waste dumps. This event marked the end of mining activities in the BPMD. However, Sunnyside Gold Corporation continued with reclamation work for 12 more years. This effort included removing tailing deposits along the Animas River between Eureka and Howardsville, removing mine dumps at Longfellow Mine and Koehler Tunnel, rerouting surface water runoff around tailings piles and plugging numerous portals and adits. Sunnyside Gold Corporation also operated a water treatment plant at the Gladstone portal on Cement Creek up until the winter of 2004. In August 2015, EPA contactors triggered a release of about 3 million gallons of metals-laden water from the Gold King Mine adit in Cement Creek near Gladstone (EPA, 2015a). The accidental release occurred when an excavator was assessing the on-going releases of water from the mine. Since the Gold King adit spill, EPA has responded by monitoring downstream water chemistry and quality, installing an interim water treatment plant in Gladstone, and working with various stakeholders to develop monitoring and preparedness plans (EPA, 2016c). EPA listed 48 BPMD mine features on the NPL soon after the Gold King adit spill. This action designated the group of BPMD mine features as Superfund site and initiated the 8-step ecological risk assessment process.

## 2.2 Climate

The BPMD watershed is mountainous with elevations ranging from about 9,300 feet at Silverton to more than 13,800 feet above sea level at some of the highest peaks. The basin receives a mean annual precipitation ranging from 24 to 40 inches/year; most of which falls as snow. Winters are long and cold with extensive snow accumulation occurring between November and April. The heavy snows and extended cold season contribute to average snowpack depth that ranges from 10 to 20 feet (Storosh, 2013). The deepest snowpack accumulates in the valleys and forests as prevailing westerly winds tend to strip most of the snow from the upper peaks and canyons. Snow begins to melt in May, but may remain in shaded, sheltered areas throughout the summer. Temperatures are mild during spring and summer, with average high temperatures ranging from 57 to 73˚F between May and September (US Climate Data, 2016). Late summer brings heavy monsoonal thunder storms but early fall tends to be dry and sunny (Lyon *et al*., 2003).

## 2.3 Habitats and wildlife

The BPMD is located in the San Juan Mountain range in San Juan County. The mountain range is dominated by rugged peaks and hanging valleys carved out during the last glaciation. The highest elevations are treeless and contain alpine habitats. Alpine areas quickly drop into steep valleys with extensive areas of exposed rock and talus supporting sparse vegetation. Sub-alpine Engelmann spruce and fir forests and high-altitude meadows are common as valley walls widen and become less steep. In most locations, valley bottoms contain relatively narrow riparian floodplain habitats with high-gradient creeks. Both paved and dirt roads and residential and commercial building sites occur throughout the BPMD. This diversity of habitats, in turn supports a rich assemblage of flora and fauna. **Appendix A** lists the major wildlife species found in San Juan County.

Alpine habitats include dry meadows, wet meadows, dwarf shrub lands, fellfields and ice fields that occur above tree line (Lyon *et al*., 2003). This high-altitude environment is characterized by high winds, low temperatures, shallow nutrient-poor soils and short growing seasons (Hanophy and Teitelbaum, 2003; Blair, 1996). Despite these inhospitable conditions, alpine environments provide habitat for a diverse assemblage of plants, invertebrates, and wildlife. Highly-adapted perennial vegetation take advantage of the lack of snow cover during the short summer growing season. Vegetation species have developed unique traits, such as ground hugging shapes (curly sedge, *Carex rupestris* and alpine sagebrush, *Artemisia scopulorum*) for protection from the elements and long tap roots (moss champion, *Silene acaulis* and alpine dusty maiden, *Chaenactis douglasii var alpina*) to make the most of what little resources area available (Rottman and Hartman, 1985; Hanophy and Teitelbaum, 2003; Schneider, 2016).

Invertebrates such as black flies play an important ecological role as alpine plant pollinators. Birds such as rosy finch (*Leucosticte australis*) and American pippit (*Anthus rubescens*) take advantage of this abundant food source, only to migrate to lower elevations or warmer regions in the fall. The ground-dwelling white-tailed ptarmigan (*Lagopus leucurus*) inhabits alpine and subalpine zones throughout the year. This species changes its plumage from barred grayish brown to white in the winter. The white-tailed ptarmigan also changes its diet in the winter to one of the only vegetation sources available; willow buds (*Salix* spp.). The mountain bluebird (*Sialia currucoides*) is a ubiquitous seasonal resident commonly found throughout the BPMD. This species uses many BPMD habitats, foraging for ground-dwelling and flying insects when abundant.

Alpine wildlife species have also developed unique adaptations that enable them to thrive throughout the year or as seasonal residents. Year-round resident herbivores, such as the American pika (*Ochotona princeps*), use unique feeding strategies to survive long winters. Pika gather grasses and forbs and pile them into haystacks near their rocky dens for winter forage when vegetation is scarce. This species also has relatively small appendages that prevent heat loss and are less likely to freeze in extreme cold temperatures (Hanophy and Teitelbaum, 2003). Other species, such as the yellow-bellied marmot (*Marmota flaviventris*), spend most of their short wakening summer months gorging on vegetation only to hibernate for most of the rest of the year. Marmot can also lower their body temperature and heartbeat during hibernation to conserve fat reserves. Avian predators, such as the red-tailed hawk (*Buteo jamaicensis*) and golden eagle (*Aquila chrysaetos*), prowl steep canyons, rock piles and outcrops in search of pika and marmot. Alpine meadows also provide seasonally-abundant vegetation and mineral-rich soils for large game animals such as American elk (*Cervus elaphus*) and mule deer (*Odocoileus hemionus*) that may move through the region. Dangerous rocky cliffs and unstable talus fields provide unlikely habitat for surefooted species such as the mountain goat (*Oreamnos americanus*) and bighorn sheep (*Ovis canadensis*) that require such habitats for safe refuge.

Engelmann spruce (*Picea engelmannii*) is a hardy and predominant evergreen species that occurs at and below tree line in areas within the BPMD (Lyon *et al*., 2003). At tree line, this species contributes to the formation of krummholz microhabitats. Krummholz are twisted, shrubby, crooked masses of tortured trunks and branches. Krummholz provide complex structures where plants and wildlife can seek refuge from the weather and relentless winds. These are important refugia for white-tailed ptarmigan and provide nesting habitat for rosy finches. Mixed sub-alpine spruce and fir conifer forests occur below the tree line (Blair, 1996). Similar to alpine ecosystems, sub-alpine plants and wildlife endure much of the same extreme high-altitude conditions, including extended periods of cold temperatures and heavy snow cover.

Slow tree growth and perilous conditions have deterred logging in much of the region which has contributed to the preservation of late-succession forests. These forests are characterized by thick, dark spruce stands with abundant deadfall. Complex understory provides refuge for small animals such as the snowshoe hare (*Lepus americanus*), red squirrel (*Tamiasciurus hudsonicus*), and dusky grouse (*Dendragapus obscurus*). These species provide prey for predators such as red fox (*Vulpes vulpes*), coyote (*Canis latrans*), pine martin (*Martes americana*) and Canada lynx (*Lynx canadensis*). The Canada lynx was once extirpated from Colorado, but reintroduction efforts have contributed to their survival in the region (Interagency Lynx Biology Team, 2013). Although very rarely encountered by humans, a pair of adult Canada lynx was spotted near the BPMD on Molas Pass between Silverton and Durango in January 2013 (Linhard, 2013). Since then, a few more lynx sightings have occurred between Molas Pass and Ouray **(Figure 2.2)**. The most recent sighting occurred on March 7, 2017 (Benjamin, 2017; Hildebrand, 2016; Esper, 2015).

Sub-alpine forests in physically-disturbed habitats occur as early successional stage forests or are replaced by sub-alpine meadow (Blair, 1996). These thinner forest and meadow ecological settings provide habitat diversity and support species that are more adapted to open areas or require diverse habitat types. Common sub-alpine forest and meadow plant species include subalpine fir (*Abies lasiocarpa*), quaking aspen (*Populus tremuloides*), sun sedge (*Carex heliophila*), bunch grasses (*Festuca spp.*), and whortleberry (*Vaccinium myrtillus*; Lyon *et al*., 2003). Large mammals, such as American elk, mule deer, moose (*Alces americanus*) and black bear (*Ursus americanus*), often thrive in these habitats. Avian species, such as broad-tailed hummingbird (*Selasphorus platycercus*), chipping sparrow (*Spizella passerina*), dark-eyed Junco (*Junco hyemalis*), and prairie falcon (*Falco mexicanus*), also take advantage of forage and refuge resources found in diverse sub-alpine open forests and meadows.

Although not typically considered prime wildlife habitat, the numerous mine sites and developed residential and recreational lands do provide habitat for species adapted to thrive in disturbed areas. For example, mine adits and relic mining and mill structures might be attractive roosting and nesting sites for fringed myotis bat (*Myotis thysanodes*), cliff swallow (*Petrochelidon pyrrh*), and rosy-finch (Hayes and Adams, 2014; Brown and Brown, 1995; Johnson *et al*., 2000). American pika and marmot might also use rock mine waste piles and tunnels for refuge. Other species, such as the American robin (*Turdus migratorius*) and Steller's jay (*Cyanocitta stelleri*), often thrive in residential areas where maintained parks, gardens, and lawns provide foraging habitat (Greene *et al*., 1998; Sallabanks and James, 1999). Other unexpected animals, such as American elk and mule deer, may also benefit from residential areas that may be used for refuge, especially during hunting seasons. Coyote (*Canis latrans*) has a broad range of habitat preferences and is another wildlife species commonly observed in disturbed areas (Tesky, 1995).

Riparian habitats that occur in the BPMD are used by semi-aquatic and terrestrial wildlife as foraging, nesting or resting areas. The riparian vegetation in the region can be dominated by dense growths of willows (*Salix* spp.), seepwillow (*Baccharis* sp.), or other shrubs and medium-sized trees. An overstory of cottonwood (*Populus* sp.) or other large trees may be present at lower elevations. Riparian habitats in some disturbed areas may be dominated by tamarisk (*Tamarix* spp.) and Russian olive (*Eleagnus angustifolia*). Wildlife species, such as American beaver (*Castor canadensis*) and common muskrat (*Ondatra zibethicus*), are found throughout the BPMD lower riparian corridors. Other species, such as moose, can also be found grazing on willows and other aquatic vegetation along BPMD ponds, creeks, and rivers.

Iron fens are infrequent but locally-important wetland habitats that occur in some BPMD riparian corridors. These wetlands support a unique assemblage of acid- and metals-tolerant species; including bog birch (*Betula glandulosa*), water sedge (*Carex aquatilis*), fine bogmoss (*Sphagnum angustifolium*) and patches of Engelmann spruce (Lyon *et al*., 2003). Iron fens are most often supported by fractured bedrock and talus groundwater springs rich with sulfates and iron pyrite. Over time, iron fens accumulate thick layers of limonite which are hydrated iron oxides precipitated into cemented peat. These localized iron-cemented, hardened peat formations can be meters thick and persist as limonite ledges. The complex and productive wetland habitat associated with iron fens attracts both herbivorous and insectivorous wildlife. Iron fens and similar wetland systems also play an important role in storing and cycling carbon and regulating hydrological process that provide stable base flows in local creeks.

In summary, the BPMD contains a diverse assemblage of semi-aquatic and terrestrial habitats that range from alpine meadows, sub-alpine forests, and wetlands to developed areas. The diversity of habitats attracts and supports a diverse assemblage of wildlife. Many wildlife species are highly adapted to survive the extreme conditions often present in the high-altitude habitats of the region. Some species take advantage of forage and refuge resources that are seasonally available throughout the year, store food reserves for the winter, or hibernate. Other wildlife species only use BPMD habitats when resources are seasonally abundant, which is usually during the short summer and fall months when plant and insect communities are most productive. Afterwards, most bird and mammal species migrate to lower elevations or warmer regions. **Appendix B** provides a list of BPMD-specific wildlife species with key ecological attributes that were considered when developing this WP.

## 2.4 Non-mining impacts

The rich cultural and natural history and abundance and accessibility of public land attract many visitors to the BPMD throughout the year. Summer and fall recreation activities include All-Terrain Vehicle (ATV) use, camping, wildlife viewing, hiking, biking, fishing, and hunting. The relic mining site structures provide unique viewing areas for visitors interested in the region's rich mining heritage (River Protection Workgroup, 2013). Some summer recreation activities, such as ATV use, have a high potential to impact wildlife that are sensitive to human disturbances. Some sensitive species, such as large game species, may not spend much time or use habitats and regions with high levels of human use.

Seasonal sheep grazing occurs in alpine meadow habitats throughout upper BPMD basins. Some flocks may contain up to a couple hundred sheep and it's common to see multiple flocks grazing in upper Animas River basins during the summer. Sheep and associated guard dogs have potential to impact vegetation communities, increase erosion, and displace native wildlife.

Winter activities include heli-skiing, Silverton Mountain backcountry skiing, and snowmobiling. While few wildlife species are present during the winter months, some species, such as the mountain goat and ptarmigan, could be present. Mountain goats, in particular, can be disturbed by heli-skiing activities that often target the same terrain used for winter refuge (Wilson and Shackleton, 2001).

Climate-change impacts can be potentially catastrophic for alpine wildlife (Nydick and Crawford, 2008; United States Forest Service, 2013). For example, many alpine species such as pika are adapted to low-temperature conditions and may experience heat stress during the warm summer months. Given this situation, climate change has the potential to increase stress to some alpine wildlife species. Little opportunity exists to escape to cooler conditions when the weather gets too hot since alpine habitats are already at the highest-available altitudes in the region. Many alpine areas often support high numbers of endemic species because they are geographically isolated. Habitat isolation creates a scenario where endemic wildlife species cannot migrate to new areas, which increases the risk of extinction. Climate change can also influence snow pack cover and duration, which can impact alpine and sub alpine habitats and the species they support.

## 2.5 Special status species

A Threatened and Endangered (T&E) species list for the upper Animas River watershed above the Mineral Creek confluence was obtained from the United States Fish Wildlife Service ([USFWS]; 2017) iPAC environmental conservation online system. State T&E species information was obtained from Colorado Parks and Wildlife ([CPW]; 2016). The Canada lynx and North American wolverine (*Gulo gulo*) are two mammal species identified in the iPAC list for the Animas River watershed. The Canada lynx is listed as federally threatened and state endangered, while the North American wolverine is listed as state endangered. The North American wolverine federal listing under the Endangered Species Act (ESA) is currently under review (USFWS, 2016b). The southwestern willow flycatcher (*Empidonax traillii extimus*) was identified in the iPAC list and is a federal- and state-endangered bird species. The iPAC list also contained the Uncompahgre fritillary butterfly (*Boloria acrocnema*). This butterfly is a highly-endemic and federally-endangered insect species. The boreal toad (*Bufo boreas boreas*) was not identified in the iPAC list, but is listed as a state-endangered amphibian species. Currently USFWS is reviewing the listing status of the boreal toad under the ESA (USFWS, 2011).

Lynx have been observed near Silverton over the last couple years even though this species is considered rare in Colorado. Given these sightings and availability of late-succession forest habitat, it is considered likely that lynx may occur within the BPMD. The wolverine has rarely been seen in Colorado since 1919 and is reported to be extirpated from San Juan County (CPW, 2017). The chance that the wolverine exists in the BPMD is considered highly unlikely given the current distribution and status of this species. The southwestern willow flycatcher may be present in the BPMD even though it was listed as uncommon in San Juan County by USFWS (**Appendix A**). Although found in San Juan Country, the only Uncompahgre fritillary butterfly colonies that are known to exist occur on Mount Uncompahgre and Redcloud Peak. Both areas are located just to the northeast of the BPMD (USFWS, 2009). Although the boreal toad has been documented in nearby Mineral, Saguache, western Rio Grande and Conejos Counties, a dedicated survey did not report any sightings of this species in San Juan County watersheds (Keinath and McGee, 2005). Note that the historic range of boreal toad extended into San Juan County and the BPMD; see F*igure 1 Boreal toad distribution in USDA Forest Service Region 2* in Keinath and McGee (2005). BLM (2006) suggested that, although suitable habitat exists within portions of the BPMD, boreal toads are not found in the area due to chemical and physical impacts of metals and acidity. Of all the T&E listed species, only the southwestern willow flycatcher and Canada lynx are plausibly associated with the BPMD. The southwestern willow flycatcher was assessed in the aquatic BERA prepared for the BPMD (TechLaw, 2016a), whereas the lynx will be evaluated in the terrestrial BERA outlined in this WP.

# SECTION 3: SUMMARY OF THE TERRESTRIAL BPMD SLERA

A terrestrial SLERA was drafted to assess the ecological risk to terrestrial plants, soil invertebrates, birds, and mammals potentially exposed to mine-impacted soils within the BPMD (TechLaw, 2017b). A major goal of the SLERA was to identify COPECs for use in the terrestrial BERA and to rank mining-related features for their potential to cause ecological harm. A SLERA is typically drafted prior to the BERA and used to justify whether or not a BERA is needed. In the case of the BPMD Superfund site, EPA sped up the RI/FS process and performed the SLERA and drafted this BERA WP at the same time.

The terrestrial SLERA used recently-collected soil analytical data collected in 2015 and 2016 from three separate groups of exposure areas, namely mine waste and tailings piles, overbank areas associated with floodplain habitats, and public campsites located throughout the BPMD (TechLaw 2016b; 2017a). Hazard Quotients (HQs) were used to identify COPECs for each of the four terrestrial receptor groups (i.e., plants, invertebrates, birds, and mammals) and to rank the cumulative risks of exposure by the COPECs between and among exposure areas. HQs were obtained by dividing maximum metals concentrations in each exposure area by soil-based no-effect Ecological Screening Values (ESVs). Most of the ESVs consisted of EPA Ecological Soil Screening Levels (EcoSSLs) developed for four receptor groups; plants, soil invertebrates, birds, and mammals. No-effect soil ESVs developed by Los Alamos National Laboratory (LANL), EPA Region 4, and Oak Ridge National Laboratory (ORNL) were used to fill in missing values (Efroymson *et al*. 1997a,b,c; EPA, 2015b; LANL, 2016). The remainder of this section summarizes the SLERA findings and identifies the COPECs that will be considered in the terrestrial BERA.

## 3.1 Mine wastes

EPA collected mine waste rock and tailings soil samples from 35 of the BPMD NPL mine sites during the summer of 2015 and 2016. As noted in the terrestrial SLERA, waste rock may still have monetary value and is considered the personal property of claim owners. The use of the generic term “waste rock” throughout this terrestrial BERA WP does not mean that this geologic material has no value.

Composite soil samples were collected from each site and analyzed for total recoverable metals. The terrestrial SLERA used the maximum metals concentrations from each mine site divided by the no-effect soil ESVs to derive conservative HQs (TechLaw, 2017b). The lowest-available no-effect soil ESVs were used to identify the COPECs for each receptor group and site. Metals with HQs above 1.0 were identified as COPECs. The HQs were then used to categorize each site in one of three risk rank categories, i.e., lower-, moderate-, and higher-risk exposure areas. This simplified risk ranking approach was only intended to rank sites in terms of potential risk and not to assess actual risk at individual sites. The results of the mine site soil risk ranking analysis can be summarized as follows:

- Thirty of the 35 mine sites represented higher-risk exposure areas and five represented moderate-risk exposure areas. None of the mine sites fell into the lower-risk exposure area category.

- With a few exceptions, lead was the main risk driver, with zinc as a strong secondary risk driver. The range of lead and zinc concentrations in the higher-risk and moderate-risk categories are as follows:

    - *Higher-risk exposure areas*: lead = 2,210 mg/kg to 35,700 mg/kg; zinc = 321 mg/kg to 66,800 mg/kg.
    - *Moderate-risk exposure areas*: lead = 502 mg/kg to 2,800 mg/kg; zinc = 248 mg/kg to 1,040 mg/kg

- Arsenic was identified as the primary risk driver at Koehler Tunnel (maximum Exposure Point Concentration [EPC] = 13,700 mg/kg) and Longfellow Mine (maximum EPC = 3,160 mg/kg).

- With a few exceptions, the top three risk drivers across the two risk categories systematically account for over 70% of the total potential for ecological risk at the mine site exposure areas.

## 3.2 Overbank soils

EPA collected overbank soils from over 200 riparian sampling locations throughout the BPMD and analyzed them for total recoverable metals. Sample results were organized into 25 separate exposure areas. These exposure areas represented river and creek reaches along the major tributaries of the Animas River, Mineral Creek, Cement Creek, upper Animas River and associated gulches (**Figure 3.1**). Similar to mine site soil analyses, maximum metals concentrations in overbank soil exposure reaches were divided by no-effect soil ESVs to calculate HQs and identify the overbank soil COPECs. Overbank soil risk ranking methods were identical to those used for mine site soils. The results of the overbank soil risk ranking analysis can be summarized as follows:

- Twelve of the 25 overbank soil exposure areas represented higher-risk exposure areas, six represented moderate-risk exposure areas, and seven represented lower-risk exposure areas.

- With exceptions, lead and zinc were the two main risk drivers. The range of concentrations for these two metals in the three risk categories are as follows:

    - *Higher-risk exposure areas*: lead = 1,250 mg/kg to 10,500 mg/kg; zinc = 446 mg/kg to 30,200 mg/kg
    - *Moderate-risk exposure areas*: lead = 349 mg/kg to 1,760 mg/kg; zinc = 577 mg/kg to 4,120 mg/kg
    - *Lower-risk exposure areas*: lead = 162 mg/kg to 508 mg/kg; zinc = 176 mg/kg to 813 mg/kg

- The top three risk drivers across the three risk categories systematically accounted for over half of the total risk at the overbank soil exposure areas.

### 3.3 Campsite soils

Soil samples were collected at 12 public campsites located throughout the BPMD and assessed as individual exposure areas. These sites represent relatively flat areas that may contain mine-impacted soils associated with floodplains or nearby mines. Campsites may provide habitat for wildlife species tolerant to human activities. One composite sample was collected from each campsite. These samples were analyzed for total metals. COPEC selection and risk ranking procedures followed those used for the mine site and overbank exposure areas. The results of the public campsite soil risk ranking analysis can be summarized as follows:

- Three of the 12 public campsites represent higher-risk exposure areas, two represent moderate-risk exposure areas, and seven represent lower-risk exposure areas.

- With exceptions, lead and zinc are the two main risk drivers at the public campsites. The range of concentrations for these two metals in the three risk categories are as follows:

    - *Higher-risk exposure areas*: lead = 2,880 mg/kg to 44,200 mg/kg; zinc = 740 mg/kg to 17,300 mg/kg
    - *Moderate-risk exposure areas*: lead = 761 mg/kg to 1,330 mg/kg; zinc = 540 mg/kg to 1,520 mg/kg
    - *Lower-risk exposure areas*: lead = 73.6 mg/kg to 530 mg/kg; zinc = 74.3 mg/kg to 874 mg/kg

- The top three risk drivers across the three risk categories systematically account for over half of the total risk at the public campsite exposure areas.

### 3.4 Risk ranking and COPEC summary

The SLERA risk ranking results are summarized below:

- The mine sites have the highest proportion of exposure areas ranked in the higher-risk category (30 out of 35, or 86%), followed by the overbank soil exposure areas (12 out of 25, or 48%), and the campsite exposure areas (3 out of 12, or 25%). Hence, as an aggregate, they represented some of the highest levels of potential terrestrial ecological risk in the BPMD.

- Conversely, the public campsites have the highest proportion of exposure areas ranked in the lower-risk category (7 out of 12, or 58%), followed by the overbank soil exposure areas (7 out of 25, or 28%), and the mine site exposure areas (0 out of 35, or 0%). This evidence indicates that, as an aggregate, more of the public campsites have a lower potential for terrestrial ecological risk compared to the two other exposure area groups.

- Birds were systematically the most at risk (i.e., highest HQs) of the four terrestrial receptor groups evaluated. This situation resulted from two inter-related factors: (a) lead and zinc were the two principal risk drivers because of their high soil concentrations, and (b) the bird no-effect soil ESVs for these two COPECs were the lowest of the four receptor groups, indicating the high sensitivity of birds to these metals. This sensitivity stems from their susceptibility of exposure and biochemical dysfunctions at low doses which is reflected in the EPA (2005c) EcoSSLs.

- A relatively small number of soil COPECs, spearheaded by lead and zinc but also including to a lesser degree antimony, arsenic, cadmium, manganese, and mercury, were responsible for the vast majority of the terrestrial ecological risk identified in the three exposure area groups at the BPMD. With a few exceptions, the remaining COPECs, which consist of barium, beryllium, chromium, cobalt, copper, molybdenum, selenium, silver, thallium, and vanadium, only played a marginal role.

- While no reliable aluminum and iron no-effect soil ESVs are available, narrative toxicity statements EPA (2003a,b) indicate that plants may be at risk from exposure to these two metals at sites with low soil pH.

## 3.5 Terrestrial BERA COPEC selection

The terrestrial BERA will further evaluate the soil COPECs that were identified in the terrestrial SLERA. The SLERA COPEC selection considered risk endpoints associated with four terrestrial receptor groups and the three exposure areas. **Appendix Table C.4.** summarizes the maximum HQs for the terrestrial receptor groups and exposure areas. This table provides the underlying information used to support the terrestrial BERA soil COPEC selection process. Metals with maximum concentrations above their conservative no-effect soil ESVs (HQs>1) were identified as receptor group-specific soil COPECs, regardless of exposure area. However, mine site exposure areas largely drove COPECs selection since they had the greatest concentrations of metals.

Note that no-effect soil ESVs were not available for some of the terrestrial receptor groups analyzed in the SLERA. The missing ESVs consisted of: 1) chromium for plants; 2) cobalt, molybdenum, silver, thallium and vanadium for invertebrates; 3) antimony and beryllium for birds; and 4) aluminum and iron for all four terrestrial receptor groups. Of these potential BERA COPECs, only aluminum and iron in plants will be considered. This approach is consistent with known sensitivities of plants to these two metals as it pertains to certain soil types (EPA, 2005c).

All metals with the potential to bioaccumulate will be retained as bird and mammal COPECs for further evaluation in the terrestrial BERA, regardless of SLERA HQ results. A list of potentially bioaccumulative metals was obtained from Tangahu *et al*. (2011). This COPEC-selection step only added nickel for birds and mammals, and chromium for mammals, to the list of wildlife COPECs, as all the other bioaccumulative metals were already identified in the terrestrial SLERA due to their elevated HQs. The major common cations sodium, calcium, magnesium and potassium were excluded as COPECs because they are considered to be essential micronutrients.

**Table 3.1** summarizes the receptor group-specific COPECs that will be considered in the terrestrial BERA. **Appendix C** provides tables that summarize the terrestrial SLERA COPEC-selection process and summarizes the screening-level risk analyses of the soils collected at the mine sites, overbank soil exposure areas and public campsites. Each table provides the minimum-and maximum-detected concentrations or 1/2 the Maximum Detection Limit (MDL) when a metal was not measured above its MDL. These tables also provide other information, such as the location of the minimum-detected concentration, the concentration used for screening and the no-effect soil ESVs used to calculate the HQs.

# SECTION 4: CONCEPTUAL SITE MODEL

## 4.1 Contaminant fate and transport

Available information was reviewed to determine which fate and transport mechanisms might result in complete exposure pathways to semi-aquatic and terrestrial community-level receptors that live and feed in the terrestrial habitats at the BPMD. The goal of this analysis was to identify the major elements of a complete exposure pathway, which consists of the following components:

- sources of contamination,
- release and transport mechanisms,
- contact points and exposure media,
- routes of entry,
- key receptors,
- exposure pathways.

Each of these components are discussed below.

## 4.2 Sources of contamination

The major sources of contamination in the BPMD are associated with past mining activities in the watersheds of Cement Creek, Mineral Creek, and the Animas River above Silverton. While mining has not occurred in the BPMD since 1991, mine wastes associated with past mining activities are still present in the environment. Below are summaries of the major sources of mining-related contamination in the BPMD:

**1) Mine sites including adits, waste rock piles and tailings**. Mining in the region often required advancing tunnels into mineral-rich deposits. Rock and low-value ore were dumped outside of the mine adit as tunnels advanced. The waste rock in these piles was often composed of highly-mineralized rock containing high concentrations of metals at levels great enough to be of value to claim owners. Early mine sites often used stamp mills, then floatation mills, to concentrate ore. Stamp mills were often constructed and operated at or near each mine. Most floatation mills were located in centralized areas and processed ore from surrounding mines. Milling processes produced fine-grained tailings that, up until the 1930's, were discharged untreated into local waterways. Waste tailings contained high concentrations of metals because the milling processes were not efficient at removing all metals from the ore. Tailings accumulated downgradient from mills and filled local floodplains with fine-grained, metal-enriched deposits.

**2) Mill waste repositories.** Mills were required after the mid-1930's to impound tailings wastes on-site so that fine-grained materials could settle out before water was re-used or discharged to local waterways. These fine-grained tailings accumulated in waste repositories which were poorly constructed and often failed. Repositories filled with mill wastes are still present in some areas of the BPMD.

**3) Haul roads, railroads, and aerial tramways.** Different types of transportation routes were constructed and used to bring ore from the mines to processing and shipping facilities. Waste rock and other mine wastes were readily available and were ideal base materials to build roads and rail lines. Spills and other unintentional releases of metal-rich ore or waste materials from trucks, trains, and trams had the potential to contaminate areas near transportation routes. Most of the major transportation routes were located along valley bottoms, in or near floodplain habitats (Jones, 2007).

**4) Smelter sites and emissions deposition areas.** Around 10 smelters operated within the BPMD mostly prior to 1900, after which ore was transported by rail down the valley to several Durango smelters (Jones, 2007). The former smelters in the BPMD are potential sources of metals contamination. They produced slag-related waste by-products containing high levels of metals that were disposed of on-site. Smelting processes also had the potential to create large amounts of air pollution. Particulate and volatized metals found in smelter emissions have potentially contaminated areas downwind of these smelters. Smelters were mostly located next to creeks and rivers of the region near major transportation routes.

**5) Naturally mineralized soils and rock.** Soils and rock within the BPMD naturally contain high levels of metals. These geologic materials weather and erode into waterways. They likely contribute to a relatively metals-rich baseline or reference condition within natural areas of the BPMD assessment area.

## 4.3 <u>Release and transport mechanisms</u>

The potential release and transport of mine-related contamination from the sources to points of contact with semi-aquatic and terrestrial receptors depends on several physical and chemical processes which dictate the concentrations and spatial distribution of metals. The following release and transport mechanisms may potentially be present throughout the BPMD:

- Erosion of metals-rich rock and soil by wind and gravity from mine and mill waste sources to surrounding depositional, lower-elevation areas;

- Transport of metals adsorbed to soil, waste rock and tailings particles via surface water runoff;

- Dissolution and leaching of metals from mine waste, host rock, or vein rock into soil solutions, pore water, and groundwater;

- Migration of metals in pore- and groundwater to floodplain soils, sediment and surface water in adjacent surface water features, and subsequent attenuation by dilution, dispersion, and sorption;

- Transport of dissolved and particulate metals in surface water to downstream instream reaches and floodplains;

- Areal deposition of metals-laden mine waste dust and emissions from smelters to surrounding upland and floodplain soils, and;

- Uptake, accumulation, then trophic transfer of metals incorporated in tissues of semi-aquatic and terrestrial plant, invertebrate, and wildlife food chains.

## 4.4 Contact point and exposure media

Exposure units (EUs) are specific exposure areas with analytical data that are used to derive EPCs. EUs represent the points of contact to be evaluated in the terrestrial BERA. EUs will be specific to each ecological receptor or receptor groups under evaluation. Concentrations of metals in exposure media from within each EU will be used to calculate EPCs. Ecologically-relevant exposure media to be evaluated in the terrestrial BERA consists of terrestrial upland and floodplain soils, surface water, and tissues of plants, invertebrates, and small mammals. Section 7 of this terrestrial BERA WP provides more information on the EU selection process and the EPC-derivation methods.

## 4.5 Routes of entry

The major routes of entry for metals in soils, surface waters, and dietary items within the BPMD to the receptors retained for evaluation in the terrestrial BERA are as follows:

- Direct contact of plants with surface soils
- Direct contact of invertebrates with surface soils
- Ingestion of contaminated food items by semi-aquatic and terrestrial wildlife receptors
- Incidental ingestion of contaminated soil by wildlife receptors
- Ingestion of surface water by semi-aquatic and terrestrial wildlife receptors

Although the following routes of entry may occur, they are expected to be minor (most metals are not readily absorbed), are difficult to characterize (no established exposure models or toxicity evaluations), and will not be assessed in the terrestrial BERA. This methodology is consistent with EPA (2007e) guidance on conducting metals-based risk assessments.

- Ingestion of contaminated plants and invertebrates by invertebrates
- Direct contact of semi-aquatic wildlife receptors with surface water
- Direct contact of dust (soil particles) by terrestrial plants and invertebrates
- Direct contact to or inhalation of dust (soil particles) by ground-dwelling wildlife receptors

## 4.6 Key receptor groups

The terrestrial BERA will evaluate exposures and risks to semi-aquatic and terrestrial ecological receptors that are relevant to the site, are culturally or ecologically important, and have high likelihood of exposure. Terrestrial plants and soil invertebrates will be evaluated as community-level receptor groups, instead of individual species. On the other hand, specific species of birds and mammals will be selected and evaluated for risk. Year-round residents, seasonal residents and migratory wildlife species were considered when selecting wildlife receptors. The selected bird and mammal species will act as surrogates representing wider feeding guilds (e.g., avian insectivores or mammalian carnivores). The terrestrial BERA will assume that BPMD habitats can support the ecological receptors listed below:

- Plant communities that reside in alpine and sub-alpine meadows and forests and floodplain soils.
- Soil invertebrates that live on soil or within the soil substrate.
- Semi-aquatic herbivorous, insectivorous, and omnivorous wildlife species that spend the most of their life within riparian and floodplain habitats feeding on both terrestrial and floodplain food items.
- Terrestrial herbivorous, insectivorous, and carnivorous wildlife species that reside and forage in upland alpine and sub-alpine meadow and forest habitats.

## 4.7 Exposure pathways

Exposure pathways are the means by which contaminants can be transferred from a contaminated medium to the target receptors. The terrestrial BERA will evaluate the following exposure pathways:

- **Plants.** Direct contact with terrestrial and floodplain soils
- **Soil invertebrates**. Direct contact with terrestrial and floodplain soils.
- **Semi-aquatic herbivorous wildlife**. Ingestion of terrestrial plants and surface water; incidental ingestion of floodplain soils
- **Semi-aquatic insectivorous wildlife**. Ingestion of terrestrial invertebrates and surface water; incidental ingestion of floodplain soils
- **Semi-aquatic omnivorous wildlife**. Ingestion of terrestrial plants, terrestrial invertebrates, and surface water; incidental ingestion of floodplain soils
- **Terrestrial herbivorous wildlife**. Ingestion of terrestrial plants and surface water; incidental ingestion of upland soils
- **Terrestrial insectivorous wildlife**. Ingestion of terrestrial invertebrates and surface water; incidental ingestion of upland soils
- **Terrestrial omnivorous wildlife**. Ingestion of terrestrial plants, terrestrial invertebrates, and surface water; incidental ingestion of upland soils
- **Carnivorous wildlife**. Ingestion of terrestrial small mammals, and surface water; incidental ingestion of upland and floodplain soil[1]

The terrestrial BERA will expand upon the above wildlife exposure pathways using species-specific intake rates and proportions of each dietary item within a balanced diet (Section 7).

[1] Carnivorous wildlife have large home-ranges that encompass both upland and floodplain habitats. Therefore, are not separated with respect to semi-aquatic and terrestrial exposure pathways.

## 4.8 Conceptual site model

The CSM is the culmination of the problem formulation process. The model shows how mining-related COPECs are expected to move from their source(s) to the various receptor groups of concern via the release and transport mechanisms, contact points and exposure media, and routes of entry. **Figure 4.1** provides the terrestrial CSM for the BPMD assessment area.

# SECTION 5: ASSESSMENT AND MEASUREMENT ENDPOINTS

## 5.1 Introduction

Risk assessment endpoints represent explicit expressions of the key ecological resources to be protected from mining-related contaminants. They are generally associated with sensitive populations, communities, or trophic guilds (i.e., different feeding strategies). The terrestrial BERA endpoints should:

- have ecological relevance,
- be susceptible to the stressors of concern,
- have biological, social, and/or economic value, and
- be applicable to the risk management goals for the site.

By considering these selection criteria, ecological risks identified to one or more of the assessment endpoints will support the future risk management decision process.

Risk measurement endpoints represent measurable ecological characteristics, quantified through laboratory or field studies, which can be related back to the valued ecological resources chosen as the assessment endpoints. Measurement endpoints are required because it is often not possible to directly quantify risk to an assessment endpoint. The measurement endpoints should represent the same exposure pathway(s) and mechanisms of toxicity as the assessment endpoints in order to be relevant and useful in supporting risk-based decision making.

Risk questions establish a link between assessment endpoints and their predicted responses. The risk questions summarized in this WP should provide a basis to develop the study design and evaluate the results of the site investigation in the analysis phase and during risk characterization (EPA, 1997).

## 5.2 Selecting representative assessment endpoint communities or species

It is neither practical nor possible to evaluate the potential for ecological risk to all of the individual parts of the local terrestrial ecosystems affected by the mining-related contaminants. Instead, receptor groups and key target species are identified to evaluate exposure and risk. The terrestrial BERA will evaluate exposures and risks to semi-aquatic and terrestrial ecological receptors that are relevant to the BPMD NPL site, are culturally or ecologically important, and have high likelihood of exposure. Plants and invertebrates will be evaluated as community-level groups. On the other hand, targeted species of birds and mammals are selected to represent a wider group of wildlife species.

### 5.2.1 Plants and invertebrates

Terrestrial plants are expected to live in floodplain and upland soils within the exposure areas of the BPMD. Plants are primary producers that extract energy from the sun and nutrients from soil and water. As such they are the foundation of the semi-aquatic and terrestrial food webs. Plants are directly consumed by invertebrates and wildlife. Invertebrates, bacteria, and fungi also consume plant-based organic material in soils. Plants will be included in the terrestrial BERA as a target receptor group because of the important ecological roles that they provide to their local ecosystems.

Terrestrial invertebrates may include flying insects, ground-dwelling insects, and soil invertebrates. The terrestrial BERA will only evaluate risks to soil invertebrates associated with floodplain and upland soils, since this invertebrate receptor group is in direct contact and would have the greatest exposure to soil-based contamination. Soil invertebrates are important primary consumers in semi-aquatic and terrestrial ecosystems. They are sustained by plants or plant-based organic materials in soils and in turn are fed upon by insectivorous and omnivorous wildlife. Although flying and ground-dwelling insects will not be used to directly evaluate risks, they will be used to assess wildlife receptor exposures.

### 5.2.2 Wildlife species

In addition to the two community-level terrestrial receptor groups described above (*i.e*. plants and invertebrates), the terrestrial BERA will also evaluate exposure and risks to several representative bird and mammal species. **Table 5.1** provides the list of the target wildlife receptors that were selected from the list of species developed for the BPMD. **Appendix D** summarizes the inclusion and exclusion parameters that were considered to help identify target receptor species. It is important to note that the American dipper (*Cinclus mexicanus*) is a locally important aquatic-dependent bird species that was not considered for the terrestrial BERA since it is a target receptor evaluated in the aquatic BERA (TechLaw, 2016a).

## 5.3 Endpoint selection

The following assessment endpoints will be used to evaluate the potential for terrestrial ecological risks to the community-level receptor groups and wildlife species in the BPMD. A risk question is appended to each assessment endpoint.

**Measurement endpoints:**

Assessment endpoint #1:

- **Maintain stable and healthy terrestrial plant communities**: *Are the contaminant levels in soil high enough to affect survival, growth or reproduction of terrestrial plants?*

The terrestrial BERA will use one measurement endpoint to assess the potential impacts of metals to BPMD plant communities:

- Compare the metal concentrations in BPMD assessment area soils to no-effect and low-effect soil ESVs associated with phytotoxicity.

The quality of the physical habitat to support plants will be considered when identifying plant exposure areas. For example, mine waste piles, steep rocky talus slopes, and cliffs or rocky outcrops would not be expected to support most plant species, regardless of metals contamination. Therefore, plant exposure and risks associated with these habitats will not be included in the terrestrial BERA. More information on how these areas will be identified is provided in Section 7.2.1.

Assessment endpoint #2:

- **Maintain stable and healthy soil invertebrate communities:** *Are the contaminant levels in soil high enough to affect survival, growth or reproduction of soil invertebrates?*

The terrestrial BERA will use one measurement endpoint to assess the potential impacts of metals to the soil invertebrate communities:

- Compare the metal concentrations in BPMD assessment area soils to no-effect and low-effect soil ESVs associated with soil invertebrate toxicity and adverse changes to soil invertebrate community composition.

Similar to the plant measurement endpoint, the quality of the physical habitat to support stable and healthy soil invertebrate communities will also be considered when selecting terrestrial exposure areas. Specifically, only areas that support plants (food base for most invertebrates) will be included in the terrestrial BERA.

Assessment endpoint #3:

- **Maintain stable and healthy herbivorous bird populations**: *Are the contaminant levels in soils, surface water, and plants high enough to affect survival, growth, or reproduction in herbivorous birds?*

The terrestrial BERA will use one measurement endpoint to assess the potential impact of metals ingested by this receptor group:

- Use metal levels measured in BPMD assessment area soils, surface water, and plant tissues in a food chain model to calculate metal-specific Estimated Daily Doses (EDDs) for comparison against avian no-effect and low-effect Toxicity Reference Values (TRVs) for adverse effects on survival, growth, or reproduction. If site-specific plant tissue residual data are deemed unreliable[2], metals concentrations may be estimated using published soil-to-plant uptake factors or regression equations and measured soil concentrations.

Assessment endpoint #4:

[2] Plant tissue sample results will be deemed unreliable when analytical data are generated outside Quality Assurance, Quality Control (QA/QC) requirements. This may include, but are not limited to improper sample handling, storage and chain of custody, matrix interferences during analysis, and not meeting project-specified analytical QA/QC limits. If used, published soil-to-tissue uptake factors and equations will be obtained from EPA (2007e) *Table 4a. Uptake Equations for Inorganics* and sources cited in the same table.

- **Maintain stable and healthy herbivorous mammal populations**: *Are the contaminant levels in soils, surface water, and plants high enough to affect survival, growth, or reproduction in herbivorous mammals?*

The terrestrial BERA will use one measurement endpoint to assess the potential impact of metals ingested by this receptor group:

- Use metal levels measured in BPMD assessment area soils, surface water, and plant tissues in a food chain model to calculate metal-specific EDDs for comparison against mammal no-effect and low-effect TRVs for adverse effects on survival, growth, or reproduction. If site-specific plant tissue residual data are unavailable or deemed unreliable, metals concentrations may be estimated using published soil-to-plant uptake factors or regression equations and measured soil concentrations.

<u>Assessment endpoint #5:</u>

- **Maintain stable and healthy insectivorous bird populations**: *Are the contaminant levels in soils, surface water, and terrestrial invertebrates high enough to affect survival, growth, or reproduction in insectivorous birds?*

The terrestrial BERA will use one measurement endpoint to assess the potential impact of metals ingested by this receptor group:

- Use metal levels measured in BPMD assessment area soils, surface water, and terrestrial invertebrates (flying insects, ground-dwelling insects, and/or soil invertebrates) in a food chain model to calculate metal-specific EDDs for comparison against avian no-effect and low-effect TRVs for adverse effects on survival, growth, or reproduction. If site-specific invertebrate tissue residual data are deemed unreliable, metals concentrations may be estimated using published soil-to-invertebrate uptake factors or regression equations and measured soil concentrations.

<u>Assessment endpoint #6:</u>

- **Maintain stable and healthy insectivorous mammal populations**: *Are the contaminant levels in soils, surface water, and terrestrial invertebrates high enough to affect survival, growth, or reproduction in insectivorous mammals?*

The terrestrial BERA will use one measurement endpoint to assess the potential impact of metals ingested by this receptor group:

- Use metal levels measured in BPMD assessment area floodplain and upland soils, surface water, and terrestrial invertebrates (flying insects, ground-dwelling insects, and/or soil invertebrates) in a food chain model to calculate metal-specific EDDs for comparison against mammal no-effect and low-effect TRVs for adverse effects on survival, growth, or reproduction. If site-specific invertebrate tissue residual data are deemed unreliable, metals concentrations may be estimated using published soil-to-invertebrate uptake factors or regression equations and measured soil concentrations.

Assessment endpoint #7:

- **Maintain stable and healthy omnivorous bird populations**: *Are the contaminant levels in soils, surface water, terrestrial invertebrates, and plants high enough to affect survival, growth, or reproduction in omnivorous birds?*

The terrestrial BERA will use one measurement endpoint to assess the potential impact of metals ingested by this receptor group:

- Use metal levels measured in BPMD assessment area soils, surface water, terrestrial invertebrates (flying insects, ground -dwelling insects, and/or soil invertebrates), and plants in a food chain model to calculate metal-specific EDDs for comparison against avian no-effect and low-effect TRVs for adverse effects on survival, growth, or reproduction. If site-specific dietary item tissue residual data are deemed unreliable, metals concentrations may be estimated using published soil-to-biota uptake factors or regression equations and measured soil concentrations.

Assessment endpoint #8:

- **Maintain stable and healthy omnivorous mammal populations**: *Are the contaminant levels in soils, surface water, terrestrial invertebrates, and plants high enough to affect survival, growth, or reproduction in omnivorous mammals?*

The terrestrial BERA will use one measurement endpoint to assess the potential impact of metals ingested by this receptor group:

- Use metal levels measured in BPMD assessment area soils, surface water, terrestrial invertebrates (flying insects, ground-dwelling insects, and/or soil invertebrates), and plants in a food chain model to calculate metal-specific EDDs for comparison against mammal no-effect and low-effect TRVs for adverse effects on survival, growth, or reproduction. If site-specific dietary item tissue residual data are deemed unreliable, metals concentrations may be estimated using published soil-to-biota uptake factors or regression equations and measured soil concentrations.

Assessment endpoint #9:

- **Maintain stable and healthy carnivorous bird populations**: *Are the contaminant levels in soils, surface water, and small mammal tissues high enough to affect survival, growth, or reproduction in carnivorous birds?*

The terrestrial BERA will use one measurement endpoint to assess the potential impact of metals ingested by this receptor group:

- Use metal levels in BPMD assessment area soils, surface water, and small mammal tissues in a food chain model to calculate metal-specific EDDs for comparison against avian no-effect and low-effect TRVs for adverse effects on survival, growth, or reproduction. Small mammal tissue metals concentrations will be estimated using soil-to-biota uptake factors or regression equations and measured soil concentrations. Note that, in addition to small mammals, carnivorous birds might also prey upon smaller birds. Bird tissue data are unavailable and will not be collected. Therefore, only small mammal tissue concentrations will be used to assess dietary exposure in carnivorous birds.

Assessment endpoint #10:

- **Maintain stable and healthy carnivorous mammal populations**: *Are the contaminant levels in soils, surface water, and small mammal tissues high enough to affect survival, growth, or reproduction in carnivorous mammals?*

The terrestrial BERA will use one measurement endpoint to assess the potential impact of metals ingested by this receptor group:

- Use metal levels in BPMD assessment area soils, surface water, and small mammal tissues in a food chain model to calculate metal-specific EDDs for comparison against mammal no-effect and low-effect TRVs for adverse effects on survival, growth, or reproduction. Small mammal tissue metals concentrations will be estimated using soil-to-biota uptake factors or regression equations and measured soil concentrations. Carnivorous mammals might also prey upon small birds. However, bird tissue data are unavailable and will not be collected. Therefore, only small mammal tissue concentrations will be used to assess dietary exposure in carnivorous mammals.

**Table 5.2** summarizes exposure pathways and respective target receptors associated with each of the 10 assessment endpoints.

# SECTION 6: CHARACTERIZATION OF EFFECTS

## 6.1 Introduction

The characterization of effects consists of quantifying the toxicity of the COPECs to the various terrestrial receptors under different exposure conditions. **Table 6.1** summarizes adverse sublethal effects in wildlife receptors from exposure to select COPECs as reported in the literature.

The terrestrial BERA will use a HQ approach to characterize the potential risk of the COPECs to the selected ecological receptors. HQs are calculated by dividing an EPC by an ESV or TRV as follows:

$$HQ = \text{exposure} \div \text{toxicity}$$

Where:

| | |
|---|---|
| HQ | = hazard quotient (unit less) |
| Exposure | = the EPC (plants and invertebrates; in units of mg COPEC/kg soil) or EDD (for birds and mammals; in units of mg COPEC/kg BW [body weight]-day) |
| Toxicity | = the ESV (plants and invertebrates; in units of mg/kg) or TRV (for birds and mammals; in units of mg/kg BW-day) |

This section summarizes the no-effect and low-effect ESVs and TRVs selected for use in the terrestrial BERA. Exposure analysis information will be provided after this WP section (Section 7) followed by risk characterization methods (Section 8).

## 6.2 Selection of toxicity benchmarks

The terrestrial BERA will use ESVs and TRVs relevant to the BPMD assessment area exposure pathways, exposure media, COPECs, and ecological receptors. Exposure pathways will primarily consist of direct contact and dietary exposure to COPECs (Section 4.7). ESVs are direct contact soil values that represent COPEC concentrations which correspond to no- and low-effects levels (mg/kg). TRVs refer to doses of COPECs in wildlife diets which correspond to no- and low-effects levels (mg/kg BW-day).

### 6.2.1 Direct-contact soil ESVs

Direct-contact soil ESVs will be used to characterize metals toxicity in terrestrial plants and soil invertebrates. These two community-level receptor groups are assumed to be exposed to COPECs via direct contact with soil. **Tables 6.2** and **6.3** provide no- and low-effect ESVs for plants and soil invertebrates, respectively.

The no-effect plant and invertebrate soil ESVs primarily consist of EPA (2005c) EcoSSLs. These values were derived using an agency-accepted derivation approach that incorporates multiple studies, receptors, and endpoints. Note that the EcoSSLs were also used in the terrestrial SLERA to identify soil COPECs and calculate receptor-specific HQs. The LANL (2016) No Observable Adverse Effect Level (NOAEL) soil ESVs were used for no-effect ESVs when EcoSSLs were not available. When EcoSSL and LANL values were unavailable EPA Region 4 soil screening values for hazardous waste sites (EPA, 2015b) and ORNL preliminary remediation goals for soil were considered (Efroymson *et al*. 1997a,b,c).

Low-effect plant and invertebrate soil ESVs reported by LANL (2016) will be used in the terrestrial BERA. LANL (2016) developed Lowest Observable Adverse Effect Level (LOAEL) soil ESVs for most of the COPECs that will be considered in the terrestrial BERA. When LANL values were unavailable, ORNL preliminary remediation goals for soil were considered (Efroymson *et al*. 1997a,b,c).

### 6.2.2 Wildlife receptors

Wildlife toxicity evaluations will consider both no-effect and low-effect TRVs. Selected wildlife TRVs are dietary-based; specifically, milligrams of COPEC per kilograms of receptor BW consumed each day (i.e., mg/kg BW-day). This is a common dose metric for birds and mammals.

The terrestrial BERA will use the no-effect and low-effect TRVs for birds and mammals that were primarily obtained from the LANL (2016) ECORISK Database (**Table 6.4 and 6.5**). The LANL NOAEL TRVs are from the same toxicity studies used by EPA (2005c) to develop the EcoSSLs, except for barium for birds. LANL (2016) calculated the barium bird TRV by selecting the most-applicable toxicity study obtained from an independent review of primary toxicity literature using a procedure similar to the one used by EPA (2005c). LOAEL TRVs were derived by LANL (2016) by either applying an uncertainty factor or 10 to the selected NOAEL or using a LOAEL associated with the same study. Additional details on how LANL (2016) TRVs were develop can be found in LANL (2014; 2016). Note that LANL (2016) wildlife TRV were similar to those used in the TechLaw (2015) aquatic BERA. However, TechLaw (2015) TRVs were derived from EcoSSLs using different underlying exposure parameters and assumptions than those used by LANL (2016). TechLaw (2015) TRVs were not used herein because not all COPECs were represented. As such, the entire suite of LANL (2016) TRVs will be used in the terrestrial BERA for the sake of consistency.

A few additional NOAEL and LOAEL TRVs not reported in LANL (2016) were obtained from Sample *et al*. (1996). These TRVs were derived by selecting the most-applicable toxicity study for each COPEC obtained from an independent review of primary toxicity literature. Note that wildlife TRVs are not species-specific, but represent concentrations of compounds via the ingestion pathway that are protective of most bird and mammal species. As such, COPEC-specific bird and mammal TRVs will be used to derive HQs for respective target receptor bird and mammal species.

## 6.3 Site-specific wildlife toxicity studies

Site-specific toxicity studies characterize toxic responses in wildlife from site-specific and integrated COPEC exposures. Such studies are useful to consider during BERA planning stages when interpreting toxicological endpoints and developing exposure scenarios. A single BPMD wildlife study was identified and is summarized below.

Larison *et al*. (2000) provided a site-specific account of cadmium toxicity in white-tailed ptarmigan inhabiting the BPMD area. The authors conducted field-based cadmium exposure and effects assessments to follow up on a 1969 account of fragile-bone ptarmigan inhabiting the Animas River watershed. The authors collected soils and ptarmigan dietary items (vegetation) and found that only cadmium and zinc accumulated in plants to levels that would be expected to be toxic. The greatest cadmium concentrations were measured in willow (*Salix* spp.) leaf buds, new shoots and stems, which represent important dietary items for ptarmigan and other wildlife. Willow are often the only abundant source of vegetation during the winter. Paired histological and chemical analysis of ptarmigan kidney tissue samples showed that renal damage occurred in birds with high cadmium levels. Larison *et al*. (2000) also showed that ptarmigan with high kidney cadmium residuals had lower bone calcium concentrations, which potentially supported historical observations of fragile-boned ptarmigan. The authors reported that the Animas River watershed ptarmigan population had high adult mortality and lower than expected breeding densities, especially in areas with calcium-poor, acidic, metals-rich habitats.

The Larison *et al*. (2000) field study supports assessing ptarmigan exposure and risk in the terrestrial BERA. As such, white-tailed ptarmigan is considered a potentially sensitive wildlife receptor species and is retained for further evaluation. Additionally, willow buds, shoots and stems will be sampled for chemical analysis and metals concentrations will used to estimate exposure in wildlife receptors.

# SECTION 7: EXPOSURE ANALYSIS

## 7.1 Introduction

This section describes procedures that will be used in the terrestrial BERA to conduct exposure analyses for plants, soil invertebrates, and wildlife receptors at the BPMD. Exposure analyses are specific to each target receptor and will be based on BPMD assessment area habitat, wildlife home-ranges, and life-history traits. BPMD assessment area-specific field data will be used to quantify COPEC exposures in semi-aquatic and terrestrial wildlife receptors ingesting soils, drinking surface water, and feeding on contaminated dietary items. Field data will also be used to estimate direct exposure to soil contamination by plants and invertebrates.

The final BERA exposure analyses will use recent (2015 to 2016) analytical data collected by TechLaw (2016b; 2017a) and additional data to be collected in 2017 and 2018 to generate EPCs for each community-level receptor group (plants and soil invertebrates) and wildlife receptor. The 2017-18 data collection effort will reflect data needs described throughout the remainder of this WP section. Recent data collected by TechLaw (2016b; 2017a) include mine-site waste rock, river overbank soil, and campsite soil data; these analytical datasets were used in the terrestrial SLERA Although useful for selecting COPECs, mine waste rock provides little to no habitat for most ecological receptors. However, mine waste rock chemistry information is useful in understanding soil chemistry in habitats impacted by mine wastes. Overbank soil samples were collected in floodplain areas throughout the BPMD. They provide information on levels of floodplain soil contamination in different river reaches. Floodplain areas provide important habitat for semi-aquatic and terrestrial receptors. As such, overbank soil chemistry information will be used to assess the level of floodplain contamination and characterize floodplain soil exposure in select receptors. Campsite soils were collected from public campsites found in the vicinity of mine workings, off roads, and floodplains; all areas potentially impacted by mine wastes. Given that most of the sampled campsites were potentially within or near BPMD assessment area floodplains, campsite soil data will be used to assess floodplain contamination.

The terrestrial BERA will only use the most-recent environmental data when assessing level of contamination and characterizing COPEC exposure in semi-aquatic and terrestrial receptors since risk management decisions need to reflect current environmental conditions. These data include the 2015 and 2016 waste rock, river overbank soil, and campsite soil analytical datasets discussed above. The surface water chemistry dataset retained to quantify exposure from water ingestion by birds and mammals was collected during the 2016 and 2017 field seasons. The BERA will only use analytical chemistry data collected by EPA or its contractors. This approach ensures that all of the datasets are of known quality and reliability and collected using agency-approved SAP/QAPPs. Other environmental data, including plant (Lyon *et al*., 2003), animal (Larison *et al*., 2000) and geologic surveys (Church *et al*., 2007) may be used to support risk assessment activities, but not estimate exposure.

The terrestrial BERA will assess two different kinds of EPCs for each COPEC, namely more-conservative Reasonable Maximum Exposures (RMEs) and less-conservative Central Tendency Exposures (CTEs). Whenever possible (depending on the number of analytical data points within each dataset and/or associated variability), the ProUCL software will be used to calculate 95%

Upper Confidence Levels (UCLs) of the means for use as RMEs (EPA, 2013). Some RMEs may have to be represented by their maximum-detected concentrations if the available data sets are too small or variable to calculate reliable 95% UCL. RME 95% UCL calculations depend not only on the size of the dataset, but also on the variability of the values in the dataset. Highly-variable data result in large UCLs, especially with small datasets (EPA, 2013). Conversely, practical UCLs could be calculated using a small dataset if the data have low variability. The goal is to design future data collection efforts so that sample sizes should be large enough to calculate 95% UCLs. The CTEs will always be represented by arithmetic means when more than one value is available for a given EU.

The terrestrial BERA exposure analyses will consider all of the upland and riparian habitats within each of the main tributaries of the Animas River and the upper Animas River mainstem and associated gulches above the Arrastra Gulch confluence, which represents the BPMD assessment area. This includes the entire watersheds of Mineral Creek, Cement Creek, and the upper Animas River (**Figure 3.1**). The exposure analyses will also consider specific areas within the BPMD assessment area that are downgradient of contamination sources. Specifically, 25 floodplain EUs and 5 reference floodplain creek and river reaches that have similar boundaries as the aquatic EUs considered in BPMD aquatic BERA (TechLaw, 2016a; **Figure 7.1**). Lastly, the terrestrial BERA will evaluate plant, soil invertebrate and wildlife exposure in vegetated areas that are immediately adjacent to, downgradient, and up gradient from mine sites. Specific plant, soil invertebrate, and wildlife EUs will be defined later in this section. Before defining EUs, one must first understand the proposed exposure modeling approach and methodology to make sense of EU designations.

## 7.2 Exposure unit studies

This section of the terrestrial BERA WP describes an integrated habitat- and contamination-based approach that will be used to develop terrestrial EUs and respective exposure estimates. This approach focuses on wildlife exposure modeling but is also germane to plant and invertebrate exposures. Terrestrial EUs were developed using information on receptor-specific life-history, habitat, and feeding attributes. As described above, selected target receptors cover a range of life-history scenarios, habitat requirements, and feeding strategies (**Table 5.1**). Therefore, the terrestrial EUs and their specific respective RMEs and CTEs are specific to each wildlife receptor or small group of similar receptors. Specific EUs will be defined in subsequent subsections in this WP (Sections 7.3 and 7.5), after the exposure modeling approach and the related data collection studies are fully explained.

The proposed exposure modeling approach is based on categorizing and compartmentalizing many aspects of wildlife exposure modeling. This approach provides an efficient and ecologically-sound means to collect site-specific exposure information and apply it to a diverse set of wildlife species and their associated habitats. Given the large size of the BPMD, it is not feasible to sample all exposure media, in all areas, for all receptors. As such, much of the exposure data will be collected along, and applied to, a dose-response gradient. Specifically, the terrestrial BERA will apply site-specific media COPEC concentrations from high-level contamination, mid-level contamination, low-level contamination, upland vegetated, and reference sampling areas to similar areas classified as having high-level, mid-level, low-level, upland vegetated, and reference exposure conditions. This extrapolation approach requires categorizing exposure and field sampling areas into distinct

Dose-Response Categories (DRCs), after which field sampling will be conducted along a DRC gradient and applied to the same categorized EUs when conducting food chain modeling. DRCs are defined as high-level, mid-level, low-level, and reference exposure conditions. This DRC approach provides risk assessors and risk managers with information that can be used to investigate ecological risk at a diverse set of habitat types and mine-impacted sites without the need to sample the entire BPMD assessment area. DRC assignments have been conducted and are described in Sections 7.2.3 and 7.2.6. DRC-based field sampling methodology are provided in the BPMD *2017-2018 Combined Risk Assessment Sampling Events* SAP/QAPP (EPA, 2017b).

The four DRCs represent a possible range of ecological risk associated with the presence of the metals at the BPMD. DRCs should not be viewed in absolute terms because they only represent potential for ecological exposure in relative terms. For example, the low-level DRC does not mean low exposure but that exposure is expected to be lower than in the mid-level DRC. Upland vegetated areas and the floodplain reference DRC will be used to characterize natural environmental conditions and metals concentrations in areas not obviously impacted by past mining activities.

The four DRCs will be used as specific, hypothetical EUs for plants, soil invertebrates, and medium and small home-range wildlife receptors. This level of exposure analysis provides an efficient and useful means to characterize risks using sufficiently large datasets; as opposed to sample-by-sample analyses. DRC-based EUs will use exposure data collected within respective DRCs to calculate RMEs and CTEs. For terrestrial receptors, DRC-based EUs will be high-, mid- and low-level mine site areas. The upland vegetated area exposure will also be used to characterize risks to terrestrial receptors. Floodplain DRC-based EUs will also be assessed using exposure data collected within a subset of the sampled 25 high-level, mid-level, and low-level, and 5 reference floodplain EU reaches.

Larger home-range wildlife receptor EUs will be based on larger geographic areas, such as the entire BPMD assessment area or individual sub watersheds within the BPMD assessment area. These area-based EUs contain unique distributions of habitats within each DRC. All wildlife habitats within each area-based EU will be categorized into one of the four DRCs and vegetated upland areas. Exposure data will be collected at a subset of habitats within each of the DRCs and upland areas and extrapolated to similarly categorized habitats so that exposure throughout the entire area-based EU can be characterized. As evident, developing large home-range wildlife receptor EUs require extensive habitat identification and categorization.

Much of this section explains how to identify and categorize the large home-range receptor habitat. Habitat identification and use components are described in the next section. Subsequent sections describe how site-specific exposure sampling information will be collected and integrated into their respective DRCs. The final sections provide specific details on how habitat and DRC attributes will be applied in bird and mammal food chain models.

### 7.2.1 <u>Habitat identification and area use factors</u>

The BPMD watershed covers around 150 $mi^2$ and contains a diverse assemblage of habitats and mining-impacted areas. Mining-related contamination is not evenly distributed throughout the watershed or habitats. Additionally, ecological receptors do not use all habitats equally. Area Use Factors (AUFs) are used to tailor the exposure profiles of each wildlife receptor. AUFs will be used to develop food chain models for receptors with large home ranges. The terrestrial BERA will delineate the entire BPMD assessment area (**Figure 3.1**) according to the following habitat types to generate habitat-specific AUFs:

- **Mine site waste piles.** Waste rock and tailings are major sources of metals contamination in the BPMD. These areas often contain metals at levels that are toxic to vegetation. As a result, mine waste piles provide little to no habitat for most wildlife species. This AUF category will consist of acreages of mine wastes at mine sites that are covered with waste rock and are devoid of vegetation. Mine tailings deposits located in floodplains are excluded from this AUF category because the floodplain habitats and respective tailings deposits will be delineated using a floodplain-specific AUF (see further below for details). The terrestrial BERA will delineate mine site waste piles using Geographic Information System (GIS) remote sensing information and other available information. Mine-specific waste pile footprints reported by Church *et al*., (2007; Table 4 *Physical parameters that may contribute to the environmental effect of historical mines*) may be used to validate GIS delineations and/or directly estimate waste pile acreages. Note that only the NPL mine sites within the BPMD will be quantified and delineated using the approach outlined above. NPL mine sites represent the majority of larger mine waste sites in the BPMD that have been previously characterized.

- **Mine site halo areas.** The areas downwind and down gradient of mine waste piles are expected to contain materials that have blown or eroded from mine waste piles. Concentrations of metals in the halo areas are likely low enough to support some vegetation. As such, they will be defined as the total area outside of mine waste piles that have soil metal concentrations elevated above those in local upland soils that also support vegetation. These habitats will likely exemplify a mixture of native soils and mine wastes, contain high contaminant concentrations, and represent elevated exposure areas. Site-specific halo area footprint and contamination information currently does not exist. Therefore, site-specific halo area characterization studies will be implemented to estimate the halo-area footprints and measure respective metals contamination. These studies are described in Section 7.2.2.

- **Floodplain and valley floor areas**. The total acreage of all floodplain and valley floor areas will be estimated to calculate a floodplain AUF. BPMD floodplains and river valleys provide important habitat for both semi-aquatic and terrestrial wildlife. These habitats are also contaminated from eroding mine site waste piles, transportation routes, mill tailings, and mine wastes deposited during past flooding events. Floodplain areas will be delineated using GIS remote sensing information, based primarily on elevation data. Elevation profiles will be used to identify a contour-based relief threshold where upland areas "flatten out" into valley floors. For some BPMD locations this threshold will be in the regular, seasonal floodplain; in others it might be relic or periodic floodplain boundaries. As described in the Section 7.2.5, the terrestrial BERA will analyze soils and dietary items collected in these habitats.

- **Developed lands.** This AUF category will include all developed areas, including roads, driveways, and buildings, as well as all private and public land within the city limits of Silverton, CO. While these areas may provide marginal habitats for wildlife that are tolerant of human disturbance, much of developed land is private property and cannot be readily accessed. These areas will be delineated using GIS remote sensing with field validation, when needed. All areas in this AUF category will be removed from the exposure analyses, excluded from evaluation in the terrestrial BERA and not included in the total area of wildlife habitat. Note that some mine sites also contain developed areas such as roads, buildings, and support facilities. These areas will also be excluded.

- **Natural, non-vegetated areas**. This AUF category will include acreages of steep canyons, rocky peaks and outcrops, and talus fields that are not vegetated and not associated with mine sites. Many areas within the BPMD site are dominated by steep canyons. While these areas may provide refuge habitat for a few specialized wildlife species, they are not vegetated and any contamination would have a marginal impact on wildlife exposure. Additionally, most of these areas cannot be reliably or safely characterized. Natural, non-vegetated areas will be delineated using GIS remote sensing with field validation, when needed. Elevation information may also be used to validate remote-sensing results. All acreage in this AUF category will be removed from the exposure analyses and not included in the total area of wildlife habitat.

- **Natural, vegetated upland areas**. The total area of BPMD lands that are vegetated and up-gradient from or not clearly associated with any mine sites will be delineated. This category will cover grass- and forb-dominated alpine and sub-alpine meadows and sub-alpine forests. In practice, the vegetated reference areas will be what's left after all mine site waste piles, halo areas, developed areas, and non-vegetated steep canyons, rocky outcrops, and peaks are delineated. Natural, vegetated areas will be delineated using GIS remote sensing, with field validation when needed.

The total acreage of all mine site halo areas, floodplains/valley floors, and upland vegetated areas will constitute the total area used by large home-range receptors. The acres within each of these habitats will be divided by the total acreage to derive mine site halo, floodplains/valley floor, and natural vegetated AUFs. These AUFs estimate the fraction of exposure from each of these three habitat types for use in large home-range receptor exposure models. Note that AUFs will only apply to wildlife receptors with home-ranges large enough to span all three habitat types. This includes the entire BPMD assessment area for lynx, coyote, and eagle or whole sub-watersheds for moose and goshawk (Section 7.5).

### 7.2.2 <u>Mine site halo characterization studies</u>

The terrestrial BERA will use site-specific field studies to characterize mine site halo areas. As described in the previous section, mine halo areas have not previously been characterized. Therefore, site-specific studies are required to characterize metal concentrations in halo areas in order to develop conservative assumptions on the acreage of halo areas when deriving halo-area AUFs. This section describes such studies.

A total of 48 individual mine and tunnel sites, two study areas, three riparian tailings sites, and a series of waste repositories from a single mill are listed on the BPMD Superfund site NPL (EPA, 2016b). The two mine study areas are the Sunnyside Mine Pool and Prospect Gulch. The Sunnyside Mine Pool represents underground mine workings filled with contaminated water (Parker, 2016). While this pool of water is a source of hazardous contaminants within the BPMD, there is no chance of direct wildlife exposure to underground mine workings at this site. As such, this study area will not be assessed in the terrestrial BERA. The Prospect Gulch Study Area is located in Prospect Gulch within the Cement Creek drainage. Several mines are located in this gulch, of which Joe and Johns Mine, Lark Mine, and Henrietta Mine are included in the NPL and make up most of the mine workings in this study area. Therefore, risks associated with the Prospect Gulch will be evaluated based on data from these three individual mine sites. This study area will also be characterized and assessed using the floodplain EU methodology (Section 7.2.6). The three riparian tailings sites are in-river and streamside tailings deposits that will also be evaluated within respective floodplain EUs. The Mayflower Mill Repositories (#1 through #4) are on a parcel of developed land located next to the Animas River just above Silverton. Since this area is developed and on private property, the Mayflower Mill will not be assessed in the terrestrial BERA.

The group of 42 NPL mine and tunnel sites will be the total population of halo areas to be evaluated in the terrestrial BERA **(Table 7.1)**. These sites are distributed across the BPMD and different habitat types. Many of the sites contain barren waste rock piles located in, directly next to, or terminate into gulches and river floodplains. Others contain waste piles surrounded by alpine meadow or forest vegetation. Some waste piles and downgradient areas are quite complex with engineered pollution control structures, support buildings, and roads throughout. Nevertheless, many of the mine sites are flanked by vegetation or have vegetated areas downgradient or within mine waste impacted areas. The presence of vegetation indicates that these areas can provide habitat for plants, invertebrates, and wildlife. The proximity of these areas to known contamination sources also indicate that local receptors may be exposed to and at risk from metals contamination. The combination of available habitat and proximity to mine wastes warrants characterization and associated ecological risk analyses of mine site halo areas.

Mine site halo area characterization studies will be conducted to collect information to estimate the area of influence associated with mine waste rock piles. Such studies will be conducted at a subset of mine sites within each DRC; mine site DRC assignments and categorization rational are described in the next section. Information obtained from selected study sites will be used to make conservative estimates of halo area sizes for remaining mine sites halo areas that have not been studied so that the total area of all 42 mine sites halo areas can be estimated. The terrestrial BERA will use these estimates to derive mine halo area AUFs for large home-range wildlife receptors.

Field sampling will characterize metal concentrations in soils around selected mine waste piles to define mine site halo area footprints. Metals will be measured and results recorded along sampling transects using a handheld X-Ray Fluorescence (XRF) meter. XRF meters measure the fluorescence emitted from a sample irradiated with X-rays or gamma rays to quantitatively determine metals composition. As such, XRF analyses provide real-time concentration information on a large suite of metals for many samples very quickly. Although preliminary analysis of waste rock samples indicates that the composition of metals in waste rock are not substantially different between mine sites, halo area soils may contain different compositions of metals. Therefore, halo area delineation will be based on lead and zinc concentrations since these two metals are the primary wildlife risk drivers (TechLaw, 2017b). Each study site will be characterized so that the total area of the halo area footprint is demarcated with XRF results.

Halo area footprint results will then be used to derive conservative halo area footprint estimates for remaining mine sites where halo areas have not been determined. These estimates will be primarily based on the size or acreage of respective mine waste piles. For example, XRF surveys might show that studied halo areas range from 3 to 4 times the size of waste pile. In this case, a conservative halo area estimate of 5 to 6 times waste rock pile areas could be applied to remaining, non-surveyed NPL sites. This application assumes that a positive relationship exists between the footprint of the waste pile and total halo area acreage. As such, halo characterization study sites will include a wide range of waste pile sizes so that this relationship can be assessed. The conservativism of applied halo area estimates will be adjusted according to the strength of the waste pile to total halo area relationship and any other environmental conditions that may influence waste pile erosion.

In summary, mine site halo area field studies will be conducted to obtain information needed to conservatively estimate halo area footprints for the 42 NPL mine sites. These halo area footprints will be used to derive mine halo AUFs for large home-range wildlife receptors. Halo area characterization information will also be used to direct halo-area soil and dietary item sampling as described in the following sections.

### 7.2.3 Mine site halo area categorization

The terrestrial BERA will collect and analyze soil and dietary item samples obtained from mine site halo areas to estimate metals exposure to terrestrial receptors. Sampling of halo area soil and dietary items will be conducted in a subset of the mine site halo areas within each of the three non-reference DRCs; high-, mid-, and low-level. This approach requires categorizing each mine site halo area into one of the three non-reference DRCs.

Mine sites and their halo areas will be categorized into high-, mid-, and low-level DRCs using metal concentrations measured in mine site waste piles and their corresponding halo areas. Initial DRC assignments were conducted herein using available data on metals in mine waste piles because no information currently exists on mine halo area contamination. Such estimates are required so that sites with a range of contamination can be considered when selecting sites for halo area characterization and exposure media sampling. Mine waste-based initial DRC estimates may be changed when actual halo area field measurements become available and support reclassification.

DRC assignments were primarily based on the total risk results reported in the BPMD terrestrial SLERA (TechLaw, 2017b). These DRC assignments were screened against and, when deemed necessary, adjusted using Synthetic Precipitation Leaching Procedure (SPLP) results obtained during the same 2016 waste rock sampling effort (TechLaw, 2017a). The SPLP method quantifies the mobility of metals in waste rock from natural acidic precipitation (SERAS, 2005). As such, SPLP data can be used to understand potential for metals in rock to be mobilized and potentially expose ecological receptors. The remainder of this section provides details on how mine waste soil-based total risk and SPLP results were used to categorize mine sites into the three non-reference DRCs.

Risk ranking results from the BPMD terrestrial SLERA could not be used directly to assign DRCs because mine sites fell into only two of the three exposure categories, namely higher-risk and moderate-risk exposure areas. Therefore, a BERA-specific, stepwise categorization scheme was developed. The BPMD terrestrial SLERA provided total risk results for 33 of the 42 individual mine sites mine sites[3]. The first step in categorizing the 42 sites was to categorize each of the 33 mine sites into high-, mid- and low-level DRCs using a simple total risk percentile-based approach. Specifically, all sites with a total risk percentile score of 66.67% or greater were categorized into the high-level DRC. All sites with a percentile score lower than 66.67% but greater than 33.34% were categorized into the mid-level DRC. All sites equal to or lower than 33.34% categorized into the low-level DRC. Note that these three categories are only established to help with the DRC assignments and do not necessarily reflect actual risks to particular receptor groups. The next step in the process was to screen percentile-based results against respective mine-site SPLP results. SPLP results were available for 24 of the 33 mine sites. As such, only 24 sites could be evaluated using both total risk and SPLP results with the remainder only evaluated using total risk. Additionally, SPLP screening only considered the top three risk drivers identified in the SLERA, namely arsenic, lead, and zinc. The same percentile approach was used to categorize SPLP metals concentrations for each of the 24 sites. The final step in assigning initial DRCs was to compare SPLP categories to total risk categories for inconsistencies. The following logic was used when comparing total risk and SPLP exposure categories to derive initial DRCs for the entire set of 42 NPL mine sites:

1) Used the waste rock total risk DRC when:

- SPLP was unavailable (*9 mine sites*)
- Two or more of the three SPLP categories agreed with the waste rock category (*9 mine sites*)
- SPLP categories averaged out to the waste rock category (*3 mine sites*)

2) Changed waste rock total risk up one category when:

- SPLP categories averaged out higher than the waste rock category (*6 mine sites*)

3) Changed waste rock total risk down one category when:

- SPLP categories averaged out lower than the waste rock category (*6 mine sites*)

4) Assigned high-level DRC when waste rock sampling data were unavailable (*9 mine sites*)

**Table 7.1** summarizes all the waste rock total risk, the SPLP exposure category assignments, and the initial DRC assignments.

[3] Nine mine sites were not sampled because they were on private property or were too dangerous to access.

### 7.2.4 Mine site halo area exposure media sampling

Soil, plant tissue, and invertebrate tissue samples will be collected from a subset of mine halo areas and analyzed for the full suite of total recoverable metals. The subset of sampled halo areas will include sites from each of the three non-reference DRCs (**Table 7.1**). The metals concentrations measured in the soil and dietary samples collected at each DRC will then be extrapolated to the same high-, mid- and low-level categorized mine site halo areas when conducting terrestrial receptor food chain modeling.

Information obtained from halo area characterization studies (Section 7.7.2) will be used to define the boundaries of the soil and dietary item sampling areas. Soil samples will be multi-point composites made from subsamples collected throughout the XRF-identified halo area footprint so that composite samples will be representative of the respective halo area. Soil samples will be sieved prior to chemical analysis.

Plant tissues samples will also consist of multi-point composites made in each halo area. Subsamples will consist of the edible above-ground portions of plants (stems, shoots, and leaves, but not the roots and seeds, fruits, and flowers when present). Chemical analysis of vegetation samples will be used to estimate COPEC exposure in the terrestrial wildlife receptors that eat leafy plants. Plants will be not washed prior to analysis; however, they may be brushed off so that soil particles and insects are not sampled. Plant tissue samples will be analyzed for total recoverable metals with concentrations reported on a dry and wet weight basis.

Flying insect tissue samples will be primarily collected using composite vegetation sweeps made throughout the halo area until enough invertebrate tissue mass is collected for metals analysis. Pitfall traps will also be deployed to sample ground-dwelling insects. Soil-dwelling invertebrates, such as earthworms and grubs will also be collect using digging tools. Samples will be specific to each of the collection methods. Each flying insect, ground-dwelling insect, and soil invertebrate composite sample is expected to contain multiple species. An attempt will be made to identify major insect taxa within each sample in the field. All invertebrate tissues will be analyzed for total recoverable metals with concentrations reported on a dry and wet weight basis.

### 7.2.5 Vegetated upland area exposure media sampling

The terrestrial BERA will analyze soil, plant tissue, and invertebrate tissue samples obtained from upland vegetated areas to estimate exposure in terrestrial wildlife receptors. These samples will be collected from vegetated areas up-gradient and not obviously impacted by any mining-related activities. Field sampling will be conducted among a diverse selection of sampling locations spanning the BPMD assessment area and available upland, vegetated habitats. Upland habitats will include alpine and sub-alpine meadows and spruce-fir forests. XRF soil data obtained from the characterization studies of the mine site halo areas may be used to screen vegetated upland area soil sampling locations that are within levels found outside of mine-halo impacted areas. This screening step is needed to verify that the sampled soils are not impacted by mining-related contamination.

Similar to soil and dietary sampling described in the previous section, all samples will be multi-point composites. Soil samples will be sieved prior to analyses. All samples will be analyzed for total recoverable metals. Additional details on vegetated upland area data collection efforts are provided in terrestrial sampling and analysis plan (EPA, 2017b).

#### 7.2.6 Floodplain EU categorization

The terrestrial BERA will assess floodplain EUs with respect to high-, mid-, and low-level DRCs. Reference area floodplain EUs will also be assessed. Floodplain EU DRC categorization is required to guide the sampling of soil and dietary items for chemical analyses and to quantify large home-range receptor exposures based on the sampling results.

The floodplain EU boundaries will mirror the aquatic EUs and reference reaches used in the BPMD aquatic BERA (TechLaw, 2016a; **Figure 7.1)**. Reference aquatic EUs were determined and agreed upon by the BTAG during development of the aquatic BERA WP. Note that overbank soil analytical chemistry data have become available for four of the five reference reaches since the aquatic BERA was drafted. These existing data, combined with future data collections, will provide additional information about contaminant levels in the reference areas. The terrestrial BERA may change the designation of the reference areas if such data indicate that they need to be re-categorized.

Floodplain EUs were categorized into the four DRCs using metals data from overbank soils, campsite soils, and sediments collected and/or compiled in EPA (2017a). Overbank soil samples were collected from riparian areas throughout the BPMD and used in the BPMD terrestrial SLERA. Campsite soils were collected from public campsite areas that were within or near river floodplains. These data were also used in the terrestrial SLERA. EPA (2017a) BPMD assessment area sediment samples were also considered because they were collected throughout the BPMD and should be similar geologic materials as floodplain soils before being deposited into local floodplains during high flow runoff events. Analyses of overbank soil, campsite soil, and in-stream sediment samples where conducted by similar laboratories and contained a similar suite of metals. Therefore, maximum and average metals concentrations of all available overbank soil, floodplain campsite, and sediment samples were considered.

A total-risk approach was used to categorize floodplain EUs into DRCs. First, the maximum and average metals concentrations in soils and sediment collated within each EU were divided by the lowest ESVs to derive HQs and total risk values. The DRC selection generally followed risk ranking and respective risk exposure area methodology used in the BPMD terrestrial SLERA; however, all average and maximum overbank soils and sediments total risk estimates for each floodplain EU were considered herein. **Table 7.2** summarizes the total risk results and DRCs for each floodplain EU. With a few exceptions, reference floodplain EUs with little mining impacts had comparably lower total risk estimates than those observed in low-level DRC floodplain EU reaches. Floodplain EUs with the greatest total risk estimates were located downgradient from significant contamination sources, which is consistent with the fate and transport processes described in Sections 4.1 through 4.3 of this WP.

### 7.2.7 Floodplain exposure media sampling

The terrestrial BERA will use analytical data from site-specific floodplain soil and dietary item samples to estimate COPEC exposures to target receptors. Sampling of floodplain soil and dietary items will be conducted in a subset of floodplain EUs within each of the four DRCs. Sampling area selection will consider the range of DRC exposure conditions, diversity of riparian habitats and vegetation communities, and distribution throughout the BPMD assessment area watersheds. Metals concentrations from dietary items collected in sampled DRCs will then be applied to the same high-level, mid-level, low-level, and reference floodplain EUs when conducting food chain modeling. The four DRCs will also be the basis for estimating DRC-based exposure for select small home-range receptors (Section 7.5.6).

Exposure media will consist of composite samples of soil, above-ground biomass plant tissues, and terrestrial invertebrate tissues. Final sampling locations will be determined in the field using soil-based XRF measurements and will mirror the expected DRC concentration ranges. Sampling locations will be within a large-enough area of similar DRC-specific metals concentrations so that each composite sampling point will be representative of the respective DRC. In theory, each sampling location should encompass an area larger than the home-range of terrestrial invertebrates being sampled. A preliminary review of overbank soils data indicated that areas with similarly high, mid, low, and reference metals concentrations are located throughout the BPMD.

Soil samples will be collected at a subset of high-level, mid-level, low-level, and reference DRC floodplain EUs. Soil samples will be taken in specific areas where plants and invertebrates are collected. These samples will be multi-point composites made in each sampling area. They will be sieved and analyzed for the full suite of total recoverable metals.

Plant tissues samples will also consist of multi-point composites collected from each sampling area. Subsamples will consist of the edible above-ground portions of plants (stems, shoots, and leaves and seeds, fruits, and flowers when present). Specific plant tissue samples will also be collected, as appropriate. For example, willow shoots and buds preferentially accumulate metals and serve as preferred dietary items for certain wildlife receptors and will be collected (Larison *et al*., 2000). Sampled plants will be not washed prior to analysis. Plant tissue samples will be analyzed for total recoverable metals with concentrations reported on a dry and wet weight basis.

Invertebrate tissue samples will consist of composite vegetation sweeps made throughout the sampling area until enough invertebrate tissue mass is collected for analysis. Pitfall traps will also be deployed to collect ground-dwelling insects. Soil-dwelling invertebrates, such as earthworms and grubs will also be collected. Although samples will be specific to each collection method, terrestrial invertebrate composite samples are expected to contain multiple species. An attempt will be made to identify the major insect taxa in the field. All invertebrate tissue samples will be analyzed for total recoverable metals with concentrations reported on a dry and wet weight basis.

## 7.3 Exposure to plants and soil invertebrates

The terrestrial BERA will evaluate direct exposures to plants and soil invertebrates using soil-based RMEs and CTEs calculated for different EUs. Exposure will be assessed at each mine site halo DRC (high-, mid- and low-level), vegetated upland, each of the floodplain EUs and each of the floodplain sampling areas (high-level, mid-level, low-level, and reference floodplain DRCs). **Table 7.3** summarizes the plant and invertebrate EUs that will be evaluated.

The mine site halo EPCs will consist of RMEs and CTEs that correspond to the high-, mid-, and low-level halo areas. Halo area RMEs and CTEs will be calculated using measured soil COPEC concentrations from the subset of sampled mine-halo areas within each DRC; the XRF results will not be used to estimate soil exposure. RMEs and CTEs will also be calculated using all the soil data from the vegetated upland areas.

The EPCs for the Floodplain EUs will consist of all 25 assessment and 5 reference floodplain EUs (n=30). The RMEs and CTEs will be calculated using the COPEC concentrations measured in the overbank and campsite samples (TechLaw, 2017a). Sediment samples will not be used to assess plant and soil invertebrate exposures, nor will any XRF analysis results. All the overbank and campsite soil samples collected from respective floodplain EUs will be used to generate the EPCs.

The EPCs for the floodplain sampling areas will consist of high-level, mid-level, low-level, and reference DRCs (n=4). The RMEs and CTEs for these four DRC-based EUs will be calculated using measured COPEC concentrations in soil samples obtained from each of the floodplain sampling areas.

## 7.4 Wildlife exposure modeling

Exposure models will be used to derive EDDs for each wildlife target receptor and COPEC. An EDD represents a dose of a COPEC that a wildlife receptor may obtain while foraging in the BPMD. Receptor-specific EDDs will be calculated using analytical data for soil, surface water, and dietary items collected and/or applied to habitats throughout the BPMD assessment area. EDDs also incorporate receptor-specific exposure parameters and food chain model assumptions. Soil, water, and food ingestion rates for each wildlife receptor species are provided in **Table 7.4**. Note that the terrestrial BERA will assume that the COPECs in soil, water, and dietary items are 100% bioavailable when ingested by the wildlife receptors. This assumption is likely to be conservative. As described in Section 8.3, the terrestrial BERA will include an uncertainty section that will discuss the 100% bioavailability assumption and associated biases. If wildlife risks are identified, this discussion may include a sensitivity analysis using different bioavailability assumptions.

The total EDD ($EDD_{total}$) experienced by the wildlife receptors foraging in the BPMD is the sum of the doses obtained from the three major routes of exposure, as follows.

$$EDD_{total} = EDD_{soil} + EDD_{water} + EDD_{diet}$$

The dose associated with each exposure route will be calculated using the following equations:

**Dose from ingesting soil:**

$$EDD_{soil} = SIR \cdot C_{soil}$$

Where:

$EDD_{soil}$ = Dose of COPEC obtained from ingesting soil (mg COPEC/kg BW-day)

SIR = Soil ingestion rate (kg/kg BW-day, dry weight [DW])

$C_{soil}$ = RME or CTE COPEC level in soil (mg COPEC/kg soil, DW); this parameter will be tailored to each receptor or group of receptors as described in the next section

**<u>Dose from ingesting surface water</u>:**

$$EDD_{water} = WIR \cdot C_{water}$$

Where:

$EDD_{water}$ = Dose of COPEC obtained from drinking surface water (mg COPEC/kg BW-day)

WIR = Water ingestion rate (L/kg BW-day)

$C_{water}$ = RME or CTE COPEC level in drinking water (mg COPEC/L water); this parameter will be tailored to each receptor or group of receptors as described in the next section

**<u>Dose from ingesting dietary items</u>:**

$$EDD_{diet} = FIR \cdot C_{biota}$$

Where:

$EDD_{diet}$ = Dose of COPEC from feeding on plants, invertebrates, and/or small mammals (mg COPC/kg BW-day)

FIR = Food ingestion rate (kg food/kg BW-day, DW)

$C_{biota}$ = RME or CTE COPEC level in diet (mg/kg, DW); this parameter will be tailored to each receptor or group of receptors as described in the next section

## 7.5 <u>Target receptor-specific exposure estimates</u>

This section provides receptor-specific exposure equations that will be used to estimate EDDs in the terrestrial BERA. As stated above, target receptor habitat preferences, home-ranges, and dietary information will be used to tailor respective EDD calculations. **Table 7.5** summarizes home-range categories and respective EUs for each target receptor. This information provides the basis for selecting RMEs or CTEs and calculating the $C_{soil}$, $C_{water}$, and $C_{biota}$ values described above. The remainder of this section provides receptor-specific $C_{soil}$, $C_{water}$, and $C_{biota}$ models. These models rely on habitat and exposure characterization information described in Section 7.2.

As stated earlier, small mammal tissue concentrations will be estimated using soil-to-biota uptake factors or regression equations and measured soil concentrations. The small mammal metals concentrations will be incorporated into the food chain models for the Canada lynx, coyote, golden eagle, and northern goshawk. **Table 7.6** summarizes soil-to-small mammal equations for the 15 wildlife COPECs identified in **Table 3.1**. Most of these equations were obtained from EPA (2007a) EcoSSL guidance document. Sample *et al*. (1998) and Ainsworth *et al*. (1990a,b) were used to obtain factors and equations for COPECs not included in EPA (2007a). A moisture content of 68% will be used to convert small mammal concentrations to and from DW and wet weights when calculating the EDDs (EPA, 2007a).

Note that Ainsworth *et al*. (1990a,b) did not report a soil-to-small mammal factor for antimony, but provided enough information to independently derive one based on small mammal liver and co-located soil analytical data. These data were used to independently derive an antimony soil-to-small mammal uptake factor as done in other risk assessments where antimony was a COPEC (McCormick, 1999). First, the concentration of antimony measured in the livers from three small mammal species were divided by co-located soil concentrations to derive a series of species-specific antimony soil-to-liver uptake factors. The average of the three uptake factors will be used in the terrestrial BERA and is reported in **Table 7.6**. It is assumed that using a soil-to-liver uptake factor will provide a conservative estimate of small mammal whole body concentrations since the liver preferentially accumulates metals. The uncertainty associated with this approach will be discussed in the uncertainty analysis of the BERA.

### 7.5.1 Canada lynx

Canada lynx have very large home-ranges that are assumed to span the entire BPMD assessment area (see **Table 7.5**). However, lynx are expected to occur only in spruce-fir forests that provide dense cover and the habitat for its main prey base, the snowshoe hare (Interagency Lynx Biology Team, 2013). Therefore, the BERA will assume that lynx exposure only occurs in upland spruce-fir forests. The total area of spruce-fir forests within the BPMD assessment area will be delineated using GIS remote sensing technology. This habitat includes Mineral and Cement Creek watershed forests and forested areas along the west side of the Animas River from Silverton up to about Eureka, all below tree line. Habitat-specific AUFs will be adjusted to only include upland habitats within the spruce-fir forested area ($AUF_{FOREST}$). The food chain model will use soil chemistry data from high-, mid-, and low-level mine halo and forested upland areas located within and next to these forested areas. The $C_{water}$ model will use length-weighted average (LWA) RME and CTE COPEC concentrations in surface water for Mineral Creek, Cement Creek, the Animas River between the Arrastra Gulch confluence and Eureka, and Cunningham Creek (details provided below). The $C_{biota}$ model assumes that small mammals represent 100% of lynx' diet. Published soil-to-small mammal uptake factors and equations will be used to estimate the COPEC levels in small mammals based on soil concentration data.

**Soil:**

$$C_{soil} = (HH_{soil} * \text{High-level halo } AUF_{FOREST}) + (HM_{soil} \cdot \text{Mid-level halo } AUF_{FOREST}) + (HL_{soil} \cdot \text{Low-level halo } AUF_{FOREST}) + (VG_{soil} \cdot \text{Vegetated upland } AUF_{FOREST})$$

Where:

$HH_{soil}$ = RME and CTE COPEC concentration in high-level waste rock halo area soils

$HM_{soil}$ = RME and CTE COPEC concentration in mid-level waste rock halo area soils

$HL_{soil}$ = RME and CTE COPEC concentration in low-level waste rock halo area soils

$VG_{soil}$ = RME and CTE COPEC concentration in forested upland area soils

**Water:**

$$C_{water} = SW_{LWA}$$

Where:

$SW_{LWA}$ = RME and CTE COPEC concentration in surface water*

* = The surface water COPEC concentrations for $SW_{LWA}$ will be based on LWA from unfiltered surface water samples collected during 2016 pre-runoff, high-flow snowmelt runoff, and summer/fall low-flow sampling events (TechLaw, 2017a). The RME and CTE COPEC concentrations in surface water will be calculated for each floodplain EU within Mineral Creek, Cement Creek, the Animas River between the Arrastra Gulch confluence and Eureka, and Cunningham Creek (*i.e.* selected watersheds) over the course of the 2016 water-year, i.e., the eight months when not under ice. EU-specific water-year RME and CTE concentrations will be based on a monthly value for each sampling event according to **Table 7.7**. For example, the average zinc concentration in a hypothetical EU would be 72.5 µg/L if pre-runoff, high-flow, and low-flow average zinc concentrations in that EU equaled 60, 150, and 40 µg/L. Once water-year averages for each floodplain EU are calculated, a single set of LWAs will be obtained using all water-year RME and CTE concentrations. First, water-year values will be multiplied by respective EU reach lengths (river miles). Then, all EU multiplication products will be summed across the selected watersheds and divided by the total length of all floodplain EUs in selected watersheds.

**Diet:**

$$C_{biota} = (HH_{sm} * \text{high-level halo } AUF_{FOREST}) + (HM_{sm} * \text{mid-level halo } AUF_{FOREST}) + (HL_{sm} * \text{low-level halo } AUF_{FOREST}) + (VG_{sm} * \text{vegetated upland } AUF_{FOREST})$$

Where:

$HH_{sm}$ = Estimated RME and CTE COPEC concentrations in high-level halo sampling area small mammals; calculated using **Table 7.6** equations where $C_s = HH_{soil}$ RME and CTE

$HM_{sm}$ = Estimated RME and CTE COPEC concentrations in mid-level halo sampling area small mammals; calculated using **Table 7.6** equations where $C_s = HM_{soil}$ RME and CTE

$HL_{sm}$ = Estimated RME and CTE COPEC concentrations in low-level halo sampling area small mammals; calculated using **Table 7.6** equations where $C_s = HL_{soil}$ RME and CTE

$VG_{sm}$ = Estimated RME and CTE COPEC concentrations in forested upland sampling area small mammal tissues; calculated using **Table 7.6** equations where $C_s$ = $VG_{soil}$ RME and CTE

### 7.5.2 Coyote and golden eagle

Coyote and golden eagle have very large home-ranges that are assumed to span the entire BPMD assessment area (see **Table 7.5**). Therefore, AUFs calculated for each habitat type within the entire BPMD assessment area will be used to calculate assessment area-wide RME and CTE COPEC concentrations in soil and diet ($AUF_{BPMD}$). The $C_{water}$ model will use LWA RME and CTE COPEC concentrations in surface water that will also encompass the entire BPMD assessment area; more details below. For coyote, the $C_{biota}$ model assumes the following distribution of dietary items; 87% small mammals, 10% ground-dwelling insects, and 3% vegetation. These values were obtained from % volume of stomach contents cited in the California Wildlife Biology Exposure Factor and Toxicity Database (Cal/Ecotox, 2017; Ferrel *et al.*, 1953). For golden eagle, the $C_{biota}$ model assumes that small mammals represent 100% of the diet. While golden eagle may also prey upon birds (Kochert *et al.*, 2002), bird tissue chemistry data are not available. Instead, this receptor is assumed to obtain its daily intake of vertebrate prey entirely in the form of small mammals.

**Soil:**

$C_{soil}$ = ($HH_{soil}$ * High-level halo $AUF_{BPMD}$) + ($HM_{soil}$ · Mid-level halo $AUF_{BPMD}$) + ($HL_{soil}$ · Low-level halo $AUF_{BPMD}$) + ($FP_{soil}$ · Floodplain $AUF_{BPMD}$) + ($VG_{soil}$ · Vegetated upland $AUF_{BPMD}$)

Where:

$HH_{soil}$ = RME and CTE COPEC concentration in high-level waste rock halo area soils

$HM_{soil}$ = RME and CTE COPEC concentration in mid-level waste rock halo area soils

$HL_{soil}$ = RME and CTE COPEC concentration in low-level waste rock halo area soils

$FP_{soil}$ = RME and CTE COPEC concentration in floodplain soils among all floodplain EUs*

$VG_{soil}$ = RME and CTE COPEC concentration in vegetated upland area soils

* = The COPEC concentrations for $FP_{soil}$ will be based on LWAs among all established floodplain EUs in the BPMD using overbank soil samples. LWAs will be calculated using the 95% UCLs and average overbank soil concentrations measured in each floodplain EU to calculate RMEs and CTEs, respectively. To calculate LWA soil concentrations the floodplain EU COPEC concentrations will first be multiplied by respective EU lengths. Then, all EU COPEC multiplication products will be summed across the entire BPMD. Next, summed multiplication products will be divided by the total length of all floodplain EUs in the BPMD. Resulting COPEC concentration dividends are the watershed LWAs.

**Water:**

$$C_{water} = SW_{LWA}$$

Where:

$SW_{LWA}$ = RME and CTE COPEC concentration in surface water*

* = The surface water COPEC concentrations for $SW_{LWA}$ will be based on an entire BPMD LWA from unfiltered surface water samples collected during 2016 pre-runoff, high-flow snowmelt runoff, and summer/fall low-flow sampling events (TechLaw, 2017a). The RME and CTE surface water COPEC concentrations will be calculated for each floodplain EU over the course of the 2016 water-year. EU-specific water-year RME and CTE concentrations will be based on a monthly value for each sampling event according to **Table 7.7**.

**Diet:**

$$C_{biota} = (HH_{diet} * \text{high-level halo } AUF_{BPMD}) + (HM_{diet} * \text{mid-level halo } AUF_{BPMD}) + (HL_{diet} * \text{low-level halo } AUF_{BPMD}) + (FP_{diet} * \text{floodplain } AUF_{BPMD}) + (VG_{diet} * \text{veg. upland } AUF_{BPMD})$$

Where:

$HH_{diet}$ = Estimated RME and CTE COPEC concentrations in high-level halo sampling area dietary items; small mammal tissue concentrations will be calculated using **Table 7.6** equations where $C_s = HH_{soil}$ RME and CTE

$HM_{diet}$ = Estimated RME and CTE COPEC concentrations in mid-level halo sampling area dietary items; small mammal tissue concentrations will be calculated using **Table 7.6** equations where $C_s = HM_{soil}$ RME and CTE

$HL_{diet}$ = Estimated RME and CTE COPEC concentrations in low-level halo sampling area dietary items; small mammal tissue concentrations will be calculated using **Table 7.6** equations where $C_s = HL_{soil}$ RME and CTE

$FP_{diet}$ = Estimated RME and CTE COPEC concentrations in small mammal tissues among all floodplain EUs*

$VG_{diet}$ = Estimated RME and CTE COPEC concentrations in vegetated upland sampling area dietary items; small mammal tissue concentrations will be calculated using **Table 7.6** equations where $C_s = VG_{soil}$ RME and CTE

* = The floodplain dietary items COPEC concentrations for $FP_{sm}$ will be LWAs of all established floodplain EUs in the BPMD. Coyote dietary items LWAs will be calculated using the RME and CTE floodplain dietary item tissue concentrations assigned to each floodplain EU. COPEC tissue concentrations will be specific to each of the three floodplain EU DRCs; high-level, mid-level, low-level, and reference. One RME and one CTEs floodplain total tissue concentration will be assigned to each DRC to calculate DRC-specific RMEs and CTEs. These two sets of values will then be applied to all floodplain EUs within the entire BPMD assessment area. RMEs and CTEs tissue concentrations will be multiplied by respective floodplain reach lengths (river miles). Then, all EU multiplication products will be summed across all EUs within the entire BPMD

assessment area and divided by the total length of all floodplain EUs within the entire BPMD assessment area. For golden eagle, small mammal LWAs will be calculated from the same RME and CTE $FP_{soil}$ LWAs used in the coyote and eagle $C_{soil}$ equation describe above. These RME and CTE $FP_{soil}$ LWAs values will be the $C_s$ parameter in soil to small mammal equations provided in **Table 7.6**.

### 7.5.3 Moose

Moose represent a large home-range receptor that would be primarily associated with floodplain and other riparian, valley-floor habitats. The terrestrial BERA will estimate moose exposure within each of the three major BPMD sub watersheds, namely Mineral Creek, Cement Creek, and upper Animas River (i.e. three EUs). The terrestrial BERA will also assume that moose would be exposed to COPECs found along the floodplain within each of these major sub watersheds. As such, RME and CTE COPEC concentrations will represent watershed-based LWAs for soil, surface water, and diet. The $C_{biota}$ model assumes that 100% of the moose diet will be provided from ingesting floodplain plants.

**Soil:**

$$C_{soil} = FP_{SOIL\text{-}LWA}$$

Where:

$FP_{SOIL\text{-}LWA}$ = RME and CTE COPEC concentrations in floodplain soils among watershed-specific floodplain EUs*

* = LWAs will be based on RME and CTE concentrations of COPECs in floodplain soils from all established floodplain EUs for each of the three BPMD sub watersheds, namely Mineral Creek, Cement Creek, and the upper Animas River. For each floodplain EU, RME and CTE concentrations will be determined as described for $FP_{soil}$ values above, except that $FP_{LWA}$ length-weighted RMEs and CTEs will be specific to each of the three sub watersheds instead of the entire BPMD.

**Water:**

$$C_{water} = SW_{LWA}$$

Where:

$SW_{LWA}$ = RME and CTE COPEC concentrations in surface water*

* = The LWAs for $SW_{LWA}$ will be based on the RME and CTE concentrations of COPECs in surface water as described above for lynx and golden eagle. However, moose $SW_{LWA}$ values described here will be specific to each of the three sub watersheds instead of the entire BPMD.

**Diet:**

$$C_{biota} = FP_{VEG\text{-}LWA}$$

Where:

$FP_{VEG\text{-}LWA}$ = RME and CTE COPEC concentrations in floodplain vegetation among watershed-specific floodplain EUs*

* = LWAs will be based on the sub-watershed RME and CTE COPEC concentrations in plant tissues collected from floodplain sampling areas. LWAs will be calculated using the RME and CTE floodplain plant tissue concentrations assigned to each floodplain EU. COPEC tissue concentrations will be specific to each of the three floodplain EU DRCs; high-level, mid-level, low-level, and reference. One 95% UCL and one average floodplain plant tissue concentration will be assigned to each DRC to calculate DRC-specific RMEs and CTEs. DRC-specific RMEs and CTEs will then be applied to all floodplain EUs within each of the three sub watersheds. RMEs and CTEs plant tissue concentrations will be multiplied by respective floodplain reach lengths (river miles). Then, all EU multiplication products will be summed across all EUs within each of the sub watersheds and divided by the total length of all floodplain EUs in each sub watershed.

### 7.5.4 Northern goshawk

Northern goshawk represents a large home-range receptor with a home range that would potentially cover upland and riparian foraging habitats at the BPMD. The terrestrial BERA will assume that northern goshawk would be exposed to contamination within each of the three major BPMD sub watersheds, consisting of Mineral Creek, Cement Creek, and the upper Animas River. As such, watershed-based AUFs will be used to calculate watershed-normalized RME and CTE COPEC concentrations in soil and diet. The $C_{water}$ model will use a similar watershed-based calculation as described above for moose to derive $LWA_{WS}$ RME and CTE COPEC concentrations in surface water for each of the three watersheds. The $C_{biota}$ model assumes that small mammals represent 100% of the northern goshawk diet. While goshawk may also prey upon birds, bird tissue chemistry data will not be collected.

**Soil:**

$$C_{soil} = (HH_{soil} * \text{high-level halo } AUF_{WS}) + (HM_{soil} * \text{mid-level halo } AUF_{WS}) + (HL_{soil} * \text{low-level halo } AUF_{WS}) + (FP_{soil} * \text{floodplain } AUF_{WS}) + (VG_{soil} * \text{vegetated upland } AUF_{WS})$$

Where:

$HH_{soil}$ = RME and CTE COPEC concentrations in high-level waste rock halo area soils

$HM_{soil}$ = RME and CTE COPEC concentrations in mid-level waste rock halo area soils

$HL_{soil}$ = RME and CTE COPEC concentrations in low-level waste rock halo area soils

$FP_{soil}$ = RME and CTE COPEC concentration in floodplain soil among watershed-specific floodplain EUs*

$VG_{soil}$ = RME and CTE COPEC concentration in vegetated upland reference area soils

* = The floodplain soil RME and CTE COPEC concentration for $FP_{soil}$ will be based on LWAs of established floodplain EUs within each of the three BPMD sub watersheds. The procedures will be similar to that described for lynx and golden eagle above, except that northern goshawk soil exposure will be calculated on a sub watershed-basis.

**Water:**

$$C_{water} = SW_{LWA}$$

Where:

$SW_{LWA}$ = RME and CTE COPEC concentration in surface water*

* = The surface water RME and CTE COPEC concentrations for $SW_{LWA}$ will be based on the LWAs of measured COPEC concentrations in surface water in each of the three sub watersheds as described for moose.

**Diet:**

$$C_{biota} = (HH_{sm} * \text{high-level halo } AUF_{WS}) + (HM_{soil} * \text{mid-level halo } AUF_{WS}) + (HL_{soil} * \text{low-level halo } AUF_{WS}) + (FP_{sm} * \text{floodplain } AUF_{WS}) + (VG_{sm} * \text{vegetated upland } AUF_{WS})$$

Where:

$HH_{sm}$ = Estimated RME and CTE COPEC small mammal tissue concentrations in high-level waste rock halo area; small mammal tissue concentrations will be calculated using **Table 7.6** equations where Cs = $HH_{soil}$ RME and CTE

$HM_{sm}$ = Estimated RME and CTE COPEC small mammal tissue concentrations in mid-level waste rock halo area; small mammal tissue concentrations will be calculated using **Table 7.6** equations where $C_s$ = $HM_{soil}$ RME or CTE

$HL_{sm}$ = Estimated RME and CTE COPEC small mammal tissue concentrations in low-level waste rock halo area; small mammal tissue concentrations will be calculated using **Table 7.6** equations where $C_s$ = $HL_{soil}$ RME or CTE

$FP_{sm}$ = Estimated sub watershed LWA RME and CTE COPEC floodplain small mammal tissue concentrations; small mammal tissue concentrations will be calculated using **Table 7.6** equations where $C_s$ = LWA $FP_{soil}$ RME or CTE

$VG_{sm}$ = Estimated RME and CTE COPEC small mammal tissue concentrations in vegetated upland area; small mammal tissue concentrations will be calculated using **Table 7.6** equations where $C_s$ = $VG_{soil}$ RME or CTE

### 7.5.5 Medium home-range receptors: American robin, cliff swallow, fringed myotis bat, and American beaver

The terrestrial BERA will assume that the American robin, cliff swallow, fringed myotis bat, and American beaver primarily forage within floodplain and associated riparian habitats. Hence, RME and CTE COPEC concentrations in soil, water, and diet will be calculated for each individual floodplain EU, including reference reaches (**Table 7.5**).

**<u>Soil:</u>**

$$C_{soil} = EU_{soil}$$

Where:

$EU_{soil}$ = RME and CTE COPEC concentrations in overbank soils for each floodplain EU

**<u>Water:</u>**

$$C_{water} = EU_{water}$$

Where:

$EU_{water}$ = RME and CTE COPEC concentrations in surface water for each floodplain EU*

* Surface water RME and CTE COPEC concentrations will be calculated for each floodplain EU according to the water-year procedure described above using the field sampling event application information presented in **Table 7.7**.

The analytical data for mine adit and mine drainage water will be used instead of surface water to calculate $C_{water}$ for fringed myotis bats. The RME and CTE values will be calculated for all mines associated with each floodplain EU. However, mine adit water chemistry may not be available for all floodplain EUs. If these data are missing, the RME and CTE COPEC concentrations for all available mine adit water data in the entire respective sub watershed will be used in the exposure calculations.

**<u>Diet:</u>**

$$C_{biota} = EU_{diet}$$

Where:

$EU_{diet}$ = RME and CTE COPEC concentrations in each dietary item for each floodplain EU*

* = Note that dietary items will only be sampled at a subset of high-level, mid-level, low-level, and reference floodplain EUs. As such, dietary item sampling results from each DRC floodplain sampling area will be applied to all other similarly categorized floodplain EUs. Section 7.2.6 provides more information on how floodplain EUs were categorized.

Each medium home-range receptor food chain model will incorporate a unique set of dietary items as described in **Table 7.8**.

### 7.5.6 Medium home-range receptors: Mountain bluebird, white-tailed ptarmigan, American pika, yellow-bellied marmot, and northern pocket gopher

The terrestrial BERA will assume that the mountain bluebird, white-tailed ptarmigan, American pika, yellow-bellied marmot, and northern pocket gopher forage within upland habitats at the BPMD. Four terrestrial DRCs will be used as hypothetical EUs for these wildlife receptors. DRC-based EUs will be vegetated upland and high-, mid- and low-level mine site halo areas. Food chain models will use soil and dietary item chemistry data from samples collected within respective DRCs to calculate RMEs and CTEs. Surface water RME and CTE COPEC concentrations will be calculated using surface water metal concentrations obtained from each of the four similarly categorized floodplain EU DRCs.

**Soil:**

$$C_{soil} = HH_{soil} \text{ or } HM_{soil} \text{ or } HL_{soil} \text{ or } VG_{soil}$$

Where:

$HH_{soil}$ = RME and CTE COPEC concentrations in high-level waste rock halo area soils

$HM_{soil}$ = RME and CTE COPEC concentrations in mid-level waste rock halo area soils

$HL_{soil}$ = RME and CTE COPEC concentrations in low-level waste rock halo area soils

$VG_{soil}$ = RME and CTE COPEC concentrations in vegetated upland area soils

American pika and yellow-bellied marmot are often observed inhabiting BPMD mine waste piles. Waste piles and respective features likely offer easily accessible refuge. Therefore, these two species may be preferentially exposed to mine site soils in waste rock piles. As such, the terrestrial BERA will include three additional EUs for these two species that will substitute halo area soil with respective mine waste rock soil COPEC concentrations. The three additional EUs will consist of high-, mid- and low-level EUs that utilize TechLaw (2017a) mine site soil RME and CTE COPEC concentrations from respective high-, mid- and low-level categorized mine sites. Since waste piles do not support plants, remaining dietary exposure for the three additional EUs will be from halo area sources. This exposure modeling scenario will result in a total of seven unique EUs for American pika and yellow-bellied marmot.

**Water:**

$$C_{water} = SW_{HI} \text{ or } SW_{MED} \text{ or } SW_{LOW} \text{ or } SW_{REF}$$

Where:

$SW_{HI}$ = RME and CTE COPEC concentrations in surface water from all high-level floodplain EUs

$SW_{MED}$ = RME and CTE COPEC concentrations in surface water from all mid-level floodplain EUs

$SW_{LOW}$ = RME and CTE COPEC concentrations in surface water from all low-level floodplain EUs

$SW_{REF}$ = RME and CTE COPEC concentrations in surface water from all reference floodplain EUs

Surface water RME and CTE COPEC concentrations will be calculated for each floodplain EU according to the water-year procedure described above using the field sampling event application information presented in **Table 7.7**.

Note that $C_{water}$ for the American pika and yellow-bellied marmot will be based on the RME and CTE COPEC concentrations calculated using all available mine adit water data in the entire BPMD. This approach will characterize high levels of metal exposure in two species that have smaller home-ranges and are associated with mine sites.

**Diet:**

$$C_{biota} = HH_{diet} \text{ or } HM_{diet} \text{ or } HL_{diet} \text{ or } VG_{diet}$$

Where:

$HH_{diet}$ = RME and CTE COPEC concentrations in high-level waste rock halo area dietary items

$HH_{diet}$ = RME and CTE COPEC concentrations in mid-level waste rock halo area dietary items

$HH_{diet}$ = RME and CTE COPEC concentrations in low-level waste rock halo area dietary items

$VG_{diet}$ = RME and CTE COPEC concentrations in vegetated upland area dietary items

Each terrestrial medium home-range receptor food chain model will incorporate a unique set of dietary items as described in **Table 7.8**.

### 7.5.7 Small home-range receptors

The two small home-range receptor species (montane shrew and deer mouse) forage in a diverse set of habitats. The terrestrial BERA will assume that these species primarily forage within floodplain areas. Four floodplain DRCs will be used as hypothetical EUs for these two wildlife receptors. DRC-based EUs will be high-level, mid-level, low-level, and reference floodplain DRC sampling areas. Food chain models will use soil, surface water, and dietary item chemistry data from samples collected within respective floodplain DRC sampling areas to calculate four sets of RMEs and CTEs.

**Soil:**

$$C_{soil} = FH_{soil} \text{ or } FM_{soil} \text{ or } FL_{soil} \text{ or } FR_{soil}$$

Where:

$FH_{soil}$ = RME and CTE COPEC concentrations in high-level floodplain sampling area soils

$FM_{soil}$ = RME and CTE COPEC concentrations in mid-level floodplain sampling area soils

$FL_{soil}$ = RME and CTE COPEC concentrations in low-level floodplain sampling area soils

$FR_{soil}$ = RME and CTE COPEC concentrations in reference floodplain soil sampling area soils

**Water:**

$$C_{water} = SW_{HI} \text{ or } SW_{MED} \text{ or } SW_{LOW} \text{ or } SW_{REF}$$

Where:

$SW_{HI}$ = RME and CTE COPEC concentrations in surface water from all high-level floodplain EUs

$SW_{MED}$ = RME and CTE COPEC concentrations in surface water from all mid-level floodplain EUs

$SW_{LOW}$ = RME and CTE COPEC concentrations in surface water from all low-level floodplain EUs

$SW_{REF}$ = RME and CTE COPEC concentrations in surface water from all reference floodplain EUs

Surface water RME and CTE COPEC concentrations will be calculated for each floodplain EU according to the water-year procedure described above using the field sampling event application information presented in **Table 7.7**.

**Diet:**

$$C_{biota} = FH_{diet} \text{ or } FM_{diet} \text{ or } FL_{diet} \text{ or } FR_{diet}$$

Where:

$FH_{diet}$ = RME and CTE COPEC concentrations in high-level floodplain dietary item sampling areas

$FH_{diet}$ = RME and CTE COPEC concentrations in mid-level floodplain dietary item sampling areas

$FL_{diet}$ = RME and CTE COPEC concentrations in low-level floodplain dietary item sampling areas

$FR_{diet}$ = RME and CTE COPEC concentrations in reference floodplain dietary item sampling areas

Each terrestrial small home-range receptor food chain model will incorporate a unique set of dietary items as described in **Table 7.9**.

# SECTION 8: RISK CHARACTERIZATION

## 8.1 Introduction

The potential for ecological risk will be quantified during risk characterization. This phase, which represents the last stage of the risk assessment, is built around three sequential steps: 1) risk estimation; 2) risk description and 3) uncertainty analysis.

The characterization of effects and the exposure analysis presented in the previous two sections of this terrestrial BERA WP are integrated during risk estimation to determine the potential for adverse effects to each of the assessment endpoints, given the assumptions inherent in the analysis phase. Each risk endpoint is tied to specific or similar groups of target receptors. As such, the risk characterization depends on the home-range or EU for each receptor. The receptor-specific EUs are very diverse (**Table 7.3** and **Table 7.5**) and provide a wide range of exposure scenarios for use in estimating risk on different geographical scales or hypothetical DRCs. This approach provides risk managers with different options to evaluate and address terrestrial ecological risk.

Risk findings are summarized, interpreted, and discussed in the risk description section using various lines of evidence which address the risk estimates.

The terrestrial BERA will include a thorough uncertainty analysis to provides context regarding the influences of the multiple assumptions made during the risk estimation process. This section provides details on how risk estimation analyses will be conducted and uncertainties addressed in the final terrestrial BERA.

## 8.2 Risk estimation and description methods

The BPMD terrestrial BERA will focus on providing an "integrated" risk characterization for plants, invertebrates, and target wildlife receptors which will be evaluated using a HQ approach. Such an approach can provide an understanding of the potential for ecological risk for each assessment endpoint using stated measurement endpoints. Each of the risk assessment endpoints identified in Section 5 will be evaluated using the HQ approach.

The HQ method compares measured exposures (i.e., direct contact with soil) or estimated exposures (i.e., wildlife EDDs) to corresponding toxicity values (i.e., no- and low-effect soil ESVs for the community level receptor groups and no- and low-effect TRVs for the wildlife receptors).

For the evaluation of the direct contact with soil and the wildlife food chain modeling results, the risk calculation approach will generate four complementary HQs for each combination of target receptor and COPEC and EU, as follows:

- HQ = RME exposure ÷ no-effect toxicity value (more conservative)
- HQ = CTE exposure ÷ no-effect toxicity value
- HQ = RME exposure ÷ low-effect toxicity value
- HQ = CTE exposure ÷ low-effect toxicity value (less conservative)

The approach outlined above generates a set of four HQs for a given receptor and COPEC in order to provide a broader context in support of future risk management decision making. The terrestrial BERA will assume that the potential for risk increases from the most conservative HQ to the least conservative HQ.

The terrestrial BERA will quantify "total risk" and not "incremental risk" for each receptor. Total risk characterization does not attempt to subtract contribution of non-NPL site impacted or reference area exposure from NPL site exposure when deriving HQs. Note that this methodology only relates to a few larger home-range receptors with EUs that span impacted and non-impacted habitats. For smaller home-range receptors, EUs are specific to either one of the three four DRCs that includes reference floodplain EUs. Any risks identified at reference floodplain EUs will be fully discussed in the terrestrial BERA uncertainty section. The BERA uncertainty analysis may also discuss any reference EU risks in the context of uncertainty and identify biases stemming from related exposure and effects modeling, site selection, or other pertinent attributes of reference conditions. Such discussion may be important for risk managers to consider when selecting remediation actions and cleanup levels.

## 8.3 Uncertainty analysis

Uncertainty is inherent in a BERA because numerous assumptions need to be made in order to proceed with the assessment. These assumptions can affect all aspects of the BERA, including the CSM, the characterization of effects, the exposure analysis, and the risk characterization.

The uncertainty analysis will identify and discuss the major assumptions made in the terrestrial BERA. It will also provide a short description to determine if each assumption is likely to have overestimated or underestimated the potential for ecological risk. If the risk interpretation at a particular EU is inconclusive, then EPA may be open to collecting more site-specific data from that EU at a later date to narrow down the uncertainties and strengthen the conclusions. The end result will be a balanced overview of uncertainty to help risk managers understand the full extent of potential ecological risk to terrestrial receptors in the BPMD. The following uncertainty analysis topics may include, but may not be limited to the following examples:

- Derivation of ESVs and TRVs
- Missing ESVs or TRVs for certain metals
- Applicability of soil ESVs derived from soluble metals to metal-enriched mine soils
- Selection of exposure media sampling areas
- Selection of representative receptor groups
- Selection of food chain model intake parameters
- Assumption of 100% bioavailability associated with COPEC ingestion
- Habitat use by wildlife receptors
- Extrapolating analytical data collected from targeted areas to a wider set of areas with similar exposure conditions
- The inherent quality of the habitat represented by the mine waste piles and their halo zones
- Lack of evaluation of dermal uptake and inhalation of COPECs

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**Tables**

| Table 3.1 Summary of contaminants of potential ecological concern (COPEC) that will be evaluated in the terrestrial baseline ecological risk assessment. | | | | |
|---|---|---|---|---|
| **COPEC[1]** | **Plants** | **Invertebrates** | **Birds** | **Mammals** |
| Aluminum | X[a] | | | |
| Antimony | X | X | | X |
| Arsenic | X | X | X | X |
| Barium | X | X | X | |
| Beryllium | X | | | |
| Cadmium | X | X | X | X |
| Chromium | | X | X | X[b] |
| Cobalt | X | | | |
| Copper | X | X | X | X |
| Iron | X[a] | | | |
| Lead | X | X | X | X |
| Manganese | X | X | X | X |
| Mercury | | X | X | X |
| Molybdenum | X | | X | X |
| Nickel | X | | X[b] | X[b] |
| Selenium | X | X | X | X |
| Silver | | | X | X |
| Thallium | X | | | X |
| Vanadium | X | | X | |
| Zinc | X | X | X | X |

a = COPEC did not have an ecological screening value but was retained due to known sensitivity to plants in certain soil types
b = Not identified as a COPEC using the hazard quotient screening process but retained for wildlife receptors due to bioaccumulation potential
1 = “X” indicates that a chemical was selected as a COPEC for respective receptor groups

| Table 5.1. Target wildlife receptors retained for evaluation in the terrestrial baseline ecological risk assessment. | | |
|---|---|---|
| **Feeding guild** | **Birds** | **Mammals** |
| **Herbivores** | White-tailed ptarmigan | American pika<br>Yellow-bellied marmot<br>Northern pocket gopher<br>American beaver<br>Moose |
| **Terrestrial insectivores** | Mountain bluebird | Montane shrew |
| **Aerial insectivores** | Cliff swallow | Fringed myotis bat |
| **Omnivores** | American robin | Coyote<br>Deer mouse |
| **Carnivores** | Golden eagle<br>Northern goshawk | Canada lynx |

| Table 5.2. Summary of exposure pathways and respective target receptors associated with each assessment endpoint | | |
|---|---|---|
| **Assessment endpoints** | ***Exposure pathways*** | **Receptors** |
| 1) Maintain stable and healthy plant communities | *Direct contact with terrestrial and floodplain soils* | Plants (receptor group) |
| 2) Maintain stable and healthy soil terrestrial invertebrate communities | *Direct contact with terrestrial and floodplain soils* | Soil invertebrates (receptor group) |
| 3) Maintain stable and healthy herbivorous bird populations | *Ingestion of soils, plants, and surface water* | White-tailed ptarmigan |
| 4) Maintain stable and healthy herbivorous mammal populations | *Ingestion of soils, plants, and surface water* | American pika; Yellow-bellied marmot; Northern pocket gopher; American beaver; Moose |
| 5) Maintain stable and healthy insectivorous bird populations | *Ingestion of soils, surface water, and invertebrates* | Mountain bluebird<br>Cliff swallow |
| 6) Maintain stable and healthy insectivorous mammal populations | *Ingestion of soils, surface water, and invertebrates* | Montane shrew<br>Fringed myotis bat |
| 7) Maintain stable and healthy omnivorous bird populations | *Ingestion of soils, plants, surface water, and invertebrates* | American robin |
| 8) Maintain stable and healthy omnivorous mammal populations | *Ingestion of soils, plants, surface water, invertebrates, and small mammals*[1] | Coyote<br>Deer mouse |
| 9) Maintain stable and healthy carnivorous bird populations | *Ingestion of soil, surface water, and small mammals* | Golden eagle<br>Northern goshawk |
| 10) Maintain stable and healthy carnivorous mammal populations | *Ingestion of soil, surface water and small mammals* | Canada lynx |

1 = Small mammal exposure only for coyote

| Table 6.1. Adverse sublethal effects for select contaminants of potential ecological concern (COPECs) reported in the literature for birds and mammals | | | |
|---|---|---|---|
| **COPEC** | **Birds** | **Mammals** | **References** |
| Arsenic | Oxidative stress-related tissue damage; Decreased growth, food intake, and weight; changes in organ weights; blood enzyme changes | Peripheral nervous system dysfunction; Decreased growth; Anemia; Cardiac abnormalities; Liver damage | Eisler, 1988; Sanchez-Virosta *et al*., 2015 |
| Cadmium | Damage to kidney and liver tissues; Anemia; Reduced growth, egg production, and bone calcium; Low population densities | Damage to kidney, liver, and gonad tissues; Anemia | Eslier, 1985; Irwin *et al*., 1997a; Larison *et al*., 2000; EPA, 2005a |
| Copper | Reduced growth; Gizzard erosion; Hepatocyte damage; Kidney cell necrosis | Liver, kidney, brain, and muscle damage; Reduced growth; Altered liver and serum enzyme activities; Hemolytic anemia | Eisler, 1998; Iqbal *et al*., 2012; Irwin *et al*., 1997b |
| Lead | Decreased eggshell thickness, egg production, egg survival, fledgling success, growth, and fertility | Peripheral nervous system dysfunction (ataxia); Increased organ weights; Anemia; Enzyme inhibition; Increased risk of abortion and miscarriage | Beyer *et al*., 2013; Irwin *et al*., 1997c; EPA, 2005b |
| Manganese | Oxidative damage to immune system organs; Hepatocyte damage | Hypo activity, tremors, ataxia; Myocardial contraction inhibition, blood vessel dilation, hypotension; Liver damage; Decreased growth | EPA, 2007c; O'Neal and Zheng 2015; Roy *et al*., 2015; WHO, 2005 |
| Zinc | Skeletal anomalies; Ataxia; Reduced growth and reproductive success; Delayed hatching: Gizzard and pancreatic lesions; Changes in organ weights | Dermatitis; Emaciation/anorexia; Reduced fecundity and growth | ATSDR, 2005; 2006; Irwin *et al*., 1997d; USDOI, 1998; EPA, 2007d |

ATSDR = Agency for Toxic Substances and Disease Registry; EPA = U.S. Environmental Protection Agency; USDOI = U.S. Department of the Interior; WHO = World Health Organization

**Table 6.2. Ecological screening values (ESVs) for terrestrial plants.** All values are in mg of contaminant of potential ecological concern (COPEC; dry weight) per kg soil (mg/kg).

| COPEC | No-effect ESV | Source | Low-effect ESV | Source |
|---|---|---|---|---|
| Aluminum | narrative* | a | narrative* | a |
| Antimony | 11 | b | 58 | d |
| Arsenic | 18 | a | 91 | d |
| Barium | 110 | b | 260 | d |
| Beryllium | 2.5 | b | 10 | e |
| Cadmium | 32 | a | 160 | d |
| Cobalt | 13 | a | 20 | e |
| Copper | 70 | a | 490 | d |
| Iron | narrative* | a | narrative* | a |
| Lead | 120 | a | 570 | d |
| Manganese | 220 | a | 1,100 | d |
| Molybdenum | 2 | c | 2[#] | e |
| Nickel | 38 | a | 270 | d |
| Selenium | 0.52 | a | 3 | d |
| Thallium | 0.05 | b | 0.5 | d |
| Vanadium | 60 | b | 80 | d |
| Zinc | 160 | a | 810 | d |

Sources for the ESVs:
a = EPA (2005c) ecological soil screening levels
b = Los Alamos National Laboratory (2016) no observable adverse effect level ecological screening level
c = EPA (2015b) Region 4 soil screening values for hazardous waste sites
d = Los Alamos National Laboratory (2016) lowest observable adverse effect ecological screening level
e = Oak Ridge National Laboratory preliminary remediation goals (Efroymson *et al*., 1997a,b,c)
* = Aluminum and iron ESVs are based on chemical and physical soil conditions not concentrations of metals in soil. As such, plant ESVs for aluminum and iron will be based on narrative guidance provided in EPA (2003a,b).
# = If exposure estimates are greater than the no-effect ESV for molybdenum, this low-effect ESV may be revised to that reported in McGrath *et al*. (2010).

**Table 6.3. Ecological screening values (ESVs) for soil invertebrates.** All values are in mg of contaminant of potential ecological concern (COPEC; dry weight) per kg soil (mg/kg).

| COPEC | No-effect ESV | Source | Low-effect ESV | Source |
|---|---|---|---|---|
| Antimony | 78 | a | 780 | d |
| Arsenic | 6.8 | b | 68 | d |
| Barium | 330 | a | 3,200 | d |
| Cadmium | 140 | a | 760 | d |
| Chromium | 0.4 | e | 28 | c |
| Copper | 80 | a | 530 | d |
| Lead | 1,700 | a | 8,400 | d |
| Manganese | 450 | a | 4,500 | d |
| Mercury[#] | 0.05 | b | 0.5 | d |
| Selenium | 4.1 | a | 41 | d |
| Zinc | 120 | a | 930 | d |

Sources for the ESVs:
a = EPA (2005c) ecological soil screening levels
b = Los Alamos National Laboratory (2016) no observable adverse effect level ecological screening level
c = EPA (2015b) Region 4 soil screening values for hazardous waste sites
d = Los Alamos National Laboratory (2016) lowest observable adverse effect ecological screening level
e = Oak Ridge National Laboratory preliminary remediation goals (Efroymson *et al*., 1997a,b,c)
# = ESVs are for inorganic mercury

**Table 6.4. Toxicity reference values (TRVs) for birds.** All values are in mg of contaminant of potential ecological concern (COPEC; dry weight) per kg body weight per day.

| COPEC | No-effect TRV | Source | Low-effect TRV | Source |
|---|---|---|---|---|
| Arsenic | 2.24 | a | 22.4 | c |
| Barium | 73.5 | a | 131 | c |
| Cadmium | 1.47 | a | 14.7 | c |
| Chromium | 2.66 | a | 26.6 | c |
| Copper | 4.05 | a | 12.1 | c |
| Lead | 1.63 | a | 3.26 | c |
| Manganese | 179 | a | 1,790 | c |
| Mercury[#] | 0.45 | b | 0.9 | d |
| Molybdenum | 3.5 | a | 35 | c |
| Nickel | 6.71 | a | 67.1 | c |
| Selenium | 0.29 | a | 0.579 | c |
| Silver | 2.02 | a | 20.2 | c |
| Vanadium | 0.344 | a | 0.688 | c |
| Zinc | 66.1 | a | 661 | c |

Sources for the TRVs:
a = Los Alamos National Laboratory (2016) no observable adverse effect level ecological screening level
b = Sample *et al*. (1996) no observable adverse effect level toxicological benchmark
c = Los Alamos National Laboratory (2016) lowest observable adverse effect level ecological screening level
d = Sample *et al*. (1996) lowest observable adverse effect level toxicological benchmark
# = TRVs are for inorganic mercury from a Japanese quail chronic toxicity study

**Table 6.5. Toxicity reference values (TRVs) for mammals.** All values are in mg of contaminant of potential ecological concern (COPEC; dry weight) per kg body weight per day.

| COPEC | No-effect TRV | Source | Low-effect TRV | Source |
|---|---|---|---|---|
| Antimony | 0.059 | a | 0.59 | c |
| Arsenic | 1.04 | a | 1.66 | c |
| Cadmium | 0.77 | a | 7.7 | c |
| Chromium | 2.4 | a | 24 | c |
| Copper | 5.6 | a | 9.34 | c |
| Lead | 4.7 | a | 8.9 | c |
| Manganese | 51.5 | a | 515 | c |
| Mercury[#] | 1.0 | b | 14.1 | c |
| Molybdenum | 0.26 | b | 2.6 | d |
| Nickel | 1.7 | a | 3.4 | c |
| Selenium | 0.143 | a | 0.215 | c |
| Silver | 6.02 | a | 60.2 | c |
| Thallium | 0.0071 | a | 0.071 | c |
| Zinc | 75.4 | a | 754 | c |

Sources for the TRVs:
a = Los Alamos National Laboratory (2016) no and lowest observed effect levels
b = Sample *et al*. (1996) no observable adverse effect level toxicological benchmark
c = Los Alamos National Laboratory (2016) no and lowest observed effect levels
d = Sample *et al*. (1996) lowest observable adverse effect level toxicological benchmark
# = TRVs are for inorganic mercury in from chronic mink toxicity studies

| Table 7.1. National Priorities List (NPL) mine and tunnel site halo areas to be considered in the Bonita Peak Mining District (BPMD) terrestrial baseline ecological risk assessment. | | | | | | |
|---|---|---|---|---|---|---|
| **Site name** | **Site type** | **Waste rock total risk** | **SPLP arsenic** | **SPLP lead** | **SPLP zinc** | **Initial DRC** |
| Anglo Saxon Mine | Mine | Mid | Low | Mid | Mid | Mid-level |
| Aspen Mine | Mine | NA | NA | NA | NA | High-level[a] |
| Bandora Mine | Mine | High | Low | High | High | High-level |
| Ben Butler Mine | Mine | High | Low | High | High | High-level |
| Ben Franklin Mine | Mine | Low | NA | NA | NA | Low-level |
| Boston Mine | Mine | Mid | Low | Low | Mid | Low-level |
| Brooklyn Mine | Mine | Low | Low | High | High | Mid-level |
| Clipper Mine | Mine | High | NA | NA | NA | High-level |
| Columbus Mine | Mine | Low | NA | NA | NA | Low-level |
| Dewitt Mine | Mine | Low | Low | High | High | Mid-level |
| Forest Queen Mine | Mine | Mid | NA | NA | NA | Mid-level |
| Gold King Mine | Mine | Low | Low | Mid | Mid | Mid-level |
| Grand Mogul Mine | Mine | High | Low | High | High | High-level |
| Henrietta Mine | Mine | Mid | Low | Low | Low | Low-level |
| Joe and Johns Mine | Mine | Low | Low | Mid | Low | Low-level |
| Junction Mine | Mine | High | High | Mid | Mid | Mid-level |
| Lark Mine | Mine | Low | Low | Low | Low | Low-level |
| Little Nation Mine | Mine | NA | NA | NA | NA | High-level[a] |
| London Mine | Mine | Mid | Low | Low | Mid | Low-level |
| Longfellow Mine | Mine | Mid | High | Low | Low | Mid-level |
| Mogul Mine | Mine | High | High | High | High | High-level |
| Mountain Queen Mine | Mine | High | NA | NA | NA | High-level |
| Natalie/Occidental Mine | Mine | Low | High | Low | Low | Low-level |
| Paradise Mine | Mine | Mid | Mid | High | Low | Mid-level |
| Pride of the West Mine | Mine | High | Low | Low | Mid | Mid-level |
| Red and Bonita Mine | Mine | Low | Mid | Mid | High | Mid-level |
| Red Cloud Mine | Mine | High | High | High | High | High-level |
| Senator Mine | Mine | NA | NA | NA | NA | High-level[a] |
| Silver Ledge Mine | Mine | NA | NA | NA | NA | High-level[a] |
| Silver Wing Mine | Mine | Mid | NA | NA | NA | Mid-level |
| Sunbank Group Mine | Mine | Low | NA | NA | NA | Low-level |
| Sunnyside Mine | Mine | High | NA | NA | NA | High-level |
| Tom Moore Mine | Mine | Mid | High | Mid | High | High-level |
| Vermillion Mine | Mine | Mid | High | Mid | Low | Mid-level |
| Wynona Mine | Mine | NA | NA | NA | NA | High-level[a] |

| Site name | Site type | Waste rock total risk | SPLP arsenic | SPLP lead | SPLP zinc | Initial DRC |
|---|---|---|---|---|---|---|
| American Tunnel | Tunnel/mine | NA | NA | NA | NA | High-level[a] |
| Amy Tunnel | Tunnel/mine | NA | NA | NA | NA | High-level[a] |
| Frisco/Bagley Tunnel | Tunnel/mine | Mid | NA | NA | NA | Mid-level |
| Koehler Tunnel | Tunnel/mine | High | High | Low | Low | Mid-level |
| Mammoth Tunnel | Tunnel/mine | NA | NA | NA | NA | High-level[a] |
| Terry Tunnel | Tunnel/mine | NA | NA | NA | NA | High-level[a] |
| Yukon Tunnel (Gold Hub) | Tunnel/mine | Low | Mid | Mid | Mid | Mid-level |

Note: this table does not provide the full list of BPMD NPL sites. Missing NPL sites include Eureka, Howardsville, and Kittimack tailings, Prospect Gulch Study Area, Sunnyside Mine Pool Study Area, and Mayflower Mill repositories.

SPLP = Synthetic Precipitation Leaching Procedure

NA = Mine waste chemistry data were unavailable

DRC = dose-response category

a = Mine waste chemistry data were unavailable to categorize this site in to a DRC. Therefore, the terrestrial BERA will assume that this site is in the high-level DRC until data becomes available. See text for more details.

| Table 7.2. Total risk results for maximum and average overbank soils and sediments for floodplain exposure units that were considered when assigning dose-response categories. | | | | | | | |
|---|---|---|---|---|---|---|---|
| **EU** | **Watershed** | **Waterbody** | **Max. OB** | **Max. sed** | **Avg. OB** | **Avg. sed** | **DRC** |
| EU-15 | Animas River | West Fork | 4,175 | 1,273 | 1,180 | 630 | High-level |
| EU-10 | Animas River | Mainstem | 2,024 | 1,158 | 1,033 | 606 | High-level |
| EU-24 | Cement Creek | Mainstem | 1,259 | 1,352 | 322 | 336 | High-level |
| EU-13 | Animas River | South Fork | 1,222 | 406 | 816 | 311 | High-level |
| EU-16 | Animas River | Placer Gulch | 898 | 3,991 | 534 | 1,741 | High-level |
| EU-12 | Animas River | Eureka Gulch | 757 | 2,686 | 302 | 401 | High-level |
| EU-04 | Mineral Creek | Mainstem | 755 | 1,493 | 170 | 323 | High-level |
| EU-3.5 | Mineral Creek | Browns Gulch | 670 | 682 | 160 | 188 | High-level |
| EU-22 | Cement Creek | Mainstem | 664 | 373 | 205 | 140 | High-level |
| EU-19 | Animas River | Burrows Gulch | 650 | 845 | 236 | 341 | High-level |
| EU-09 | Animas River | Mainstem | 590[a] | 1,776 | 226[a] | 458 | High-level |
| EU-14 | Animas River | Mainstem | 2,107[a] | 832 | 659[a] | 287 | High-level |
| EU-07 | Animas River | Mainstem | 7,640[a] | 829 | 1,441[a] | 412 | High-level |
| EU-05 | Mineral Creek | South Fork | 516[a] | 227 | 114[a] | 100 | Mid-level |
| EU-20 | Cement Creek | Mainstem | 411[a] | 944 | 172[a] | 221 | Mid-level |
| EU-08 | Animas River | Cunningham Cr. | 330 | 1,938 | 188 | 412 | Mid-level |
| EU-01 | Mineral Creek | Mainstem | 320 | 268 | 168 | 137 | Mid-level |
| EU-03 | Mineral Creek | Mainstem | 314 | 416 | 109 | 196 | Mid-level |
| EU-21 | Cement Creek | Prospect Gulch | 257 | 577 | 115 | 162 | Mid-level |
| EU-18 | Animas River | North Fork | 147 | 1,189 | 106 | 319 | Mid-level |
| EU-06 | Mineral Creek | Middle Fork | 185 | 192 | 85 | 72 | Low-level |
| EU-17 | Animas River | West Fork | 182 | 397 | 155 | 139 | Low-level |
| EU-23 | Cement Creek | South Fork | 139 | 117 | 82 | 72 | Low-level |
| EU-02 | Mineral Creek | Mainstem | 168[a] | NA | 98[a] | NA | Low-level |
| EU-11 | Animas River | South Fork | 100 | 151 | 100 | 110 | Low-level |
| NA | Mineral Creek | Mill Creek | 369 | 136 | 169 | 91 | Reference |
| NA | Animas River | Upper North Fork | 167 | 336 | 167 | 176 | Reference |
| NA | Animas River | Picayune Gulch | 135 | 144 | 135 | 115 | Reference |
| NA | Animas River | Maggie Gulch | 60 | 87 | 60 | 57 | Reference |
| NA | Mineral Creek | Bear Creek | NA | NA | NA | NA | Reference |

EU = exposure unit; OB = overbank; sed = sediment; DRC = dose-response category NA = soil/sed chemistry data were unavailable

a = Campsite soil data added to the overbank dataset for this EU.

**Table 7.3. Summary of plant and soil invertebrate direct contact soil exposure units (EUs)**

| Soil sampling areas | Number of EUs |
|---|---|
| Samples collected from high-, mid-, and low-level DRC sites | 3 |
| Vegetated upland area samples | 1 |
| Overbank samples from floodplain EUs; including reference reaches | 30 |
| Samples collected from high-level, mid-level, low-level, and reference DRC floodplain sampling areas | 4 |

DRC = Dose-response category

| Target receptor | Body weight (kg) | Soil ingestion rate (kg DW/kg BW/day) | Water ingestion rate (L/kg BW/day) | Food ingestion rate (kg WW/kg BW/day) |
|---|---|---|---|---|
| American beaver | 20.3[a] | 0.00085[d] | 0.073[o] | 0.153[s] |
| American pika | 0.100[a] | 0.00940[e] | 0.125[o] | 0.470[t] |
| American robin | 0.081[b] | 0.02500[f] | 0.136[p] | 0.434[v] |
| Canada lynx | 11.4[b] | 0.00053[f] | 0.078[p] | 0.070[u] |
| Coyote | 13.25[a] | 0.00073[ƨ] | 0.076[ǂ] | 0.091[ə] |
| Cliff swallow | 0.023[a] | 0.01510[g] | 0.204[o] | 0.708[v] |
| Deer mouse | 0.021[b] | 0.00180[f] | 0.150[p] | 0.268[u] |
| Fringed myotis bat | 0.009[a] | --[h] | 0.159[q] | 0.573[w] |
| Golden eagle | 4.80[a] | 0.00078[i] | 0.035[o] | 0.178[x] |
| Montane shrew | 0.015[c] | 0.04060[j] | 0.223[r] | 0.406[y] |
| Moose | 386[a] | 0.00036[k] | 0.055[o] | 0.022t |
| Mountain bluebird | 0.030[a] | 0.02239[l] | 0.189[o] | 0.644[v] |
| Northern goshawk | 1.04[a] | 0.00078[i] | 0.058[o] | 0.297[x] |
| Northern pocket gopher | 0.104[c] | 0.00895[m] | 0.124[o] | 0.313[s] |
| White-tailed ptarmigan | 0.326[a] | 0.00070[n] | 0.085[o] | 0.047[z] |
| Yellow-bellied marmot | 3.50[a] | 0.00388[e] | 0.087[o] | 0.194[s] |

**Table 7.4. Food chain model parameter values for target wildlife receptors.**

BW = body weight; DW = dry weight; WW = wet weight
a = Species-specific adult BW reported by Tacutu *et al*. (2013)
b = Species-specific BW reported by EPA (2016a)
c = Species-specific BW reported by LANL (2015)
d = Used EPA (1994a) reported soil ingestion rate 2.4% of diet to estimate soil ingestion
e = Assumed soil ingestion would be same as woodchuck 2.0% soil in diet (on a DW basis) reported by Beyer *et al*. (1994)
f = Soil ingestion rate reported for this species by EPA (2016a) for use in Carpenter Snow Creek Mining District Site risk assessment
g = Soil ingestion rate reported for this species by EPA (2007b) for use in Standard Mine Site risk assessment
h = Assumed the same zero soil ingestion rate reported for big brown bat by EPA (2007b) for use in Standard Mine Site risk assessment
i = BW normalized soil ingestion rate for bald eagle reported by Pascoe *et al*. (1996)

j = Soil ingestion rate estimated using 10% fraction of diet used for montane shew in LANL (2015)
k = Soil ingestion rate estimated using 2.0% soil in diet (on a DW basis) reported by Beyer *et al*. (1994)
l = Estimated using American woodcock 10.4% soil in diet (on a DW basis) reported by Beyer *et al*. (1994)
m = Estimated using black-tailed prairie dog 7.7% soil in diet (on a DW basis) reported by Beyer *et al*. (1994)
n = Assumed the same soil ingestion rate reported for sage grouse by EPA (2007b) for use in Standard Mine Site risk assessment
o = Estimated using BW normalized water ingestion rate equations provided in EPA (1993)
p = Water ingestion rate reported for this species by EPA (2016a) for use in Carpenter Snow Creek Mining District Site risk assessment
q = Water ingestion rate reported for little brown myotis bat in LANL (2015)
r = Water ingestion rate reported for this species in LANL (2015)
s = Estimated using Nagy (2001) fresh matter intake equation for Rodentia, and Tacutu *et al*. (2013) BW
t = Estimated using Nagy (2001) fresh matter intake equation for mammalian herbivores, and Tacutu *et al*. (2013) BW
u = Food ingestion rate reported for this species by USEPA (2016a) for use in Carpenter Snow Creek Mining District Site risk assessment
v = Estimated using Nagy (2001) fresh matter intake equation for Passerines, and Tacutu *et al*. (2013) BW
w = Estimated using Nagy (2001) fresh matter intake equation for bats, and Tacutu *et al*. (2013) BW
x = Estimated using Nagy (2001) fresh matter intake equation for carnivorous birds, and Tacutu *et al*. (2013) BW
y = Estimated using Nagy (2001) fresh matter intake equation for Insectivora, and Tacutu *et al*. (2013) BW
z = Estimated using Nagy (2001) fresh matter intake equation for Galliformes, and Tacutu *et al*. (2013) BW
ƨ = Soil ingestion rate estimated using 2.8% soil in diet (on a DW basis) for red fox reported by Beyer *et al*. (1994)
ɨ = Water ingestion rate estimated using EPA (1993) allometric scaling formula for mammals and Tacutu *et al*. (2013) BW
ə = Estimated using Nagy (2001) fresh matter intake equation for Carnivora, and Tacutu *et al*. (2013) BW

| Table 7.5. Target wildlife receptor home-range categories and associated exposure unit (EU) descriptions | | |
|---|---|---|
| **Target receptor species** | **Home-range category** | **EU descriptions (number of EUs)** |
| Canada lynx<br>Coyote<br>Golden eagle | Very large | Entire BPMD, including upland and floodplain habitats (n=1)[a] |
| Moose<br>Northern goshawk | Large | Major sub watersheds located in the BPMD; Mineral Creek, Cement Creek, and Animas River above Silverton (n=3) |
| American robin<br>Cliff swallow<br>Fringed myotis bat<br>American beaver | Medium | Each floodplain EU located along Mineral Cr., Cement Cr., and Animas R. above Silverton; Including reference reaches (n=30) |
| Mountain bluebird<br>White-tailed ptarmigan<br>American pika<br>Yellow-bellied marmot<br>Northern pocket gopher | Medium | Mine site halo high-, mid-, and low-level DRCs, and vegetated upland area (n=4)[b] |
| Montane shrew<br>Deer mouse | Small | Each of the four floodplain sampling area DRCs; High-level, mid-level, low-level, and reference sampling areas (n=4) |

BPMD = Bonita Peak Mining District; DRC = Dose-response category

a = Canada lynx EU will only include spruce-fir forest habitats within the BPMD assessment area; see Section 7.5.1 for more details. Coyote and golden eagle EU will include the entire BPMD assessment area; see Section 7.5.2 for more details.

b = An additional three EUs will be used to assess American pika and yellow-bellied marmot risk (n=7). Additional EUs will substitute halo area soil exposure with respective mine waste pile soil exposures. All other dietary exposures for these two species will be from halo area sources. See Section 7.5.6 for more details.

**Table 7.6. Soil to small mammal tissue uptake equations for each bird and mammal contaminant of potential ecological concern (COPEC).**

| COPEC | Equation | Source |
|---|---|---|
| Antimony | $C_m = 0.002 * C_s^*$ | Ainsworth *et al*., 1990a,b |
| Arsenic | $\ln(C_m) = 0.8188 * \ln(C_s) - 4.8471$ | EPA, 2007 |
| Cadmium | $\ln(C_m) = 0.4723 * \ln(C_s) - 1.2571$ | EPA, 2007 |
| Chromium | $\ln(C_m) = 0.7338 * \ln(C_s) - 1.4599$ | EPA, 2007 |
| Copper | $\ln(C_m) = 0.1444 * \ln(C_s) + 2.042$ | EPA, 2007 |
| Lead | $\ln(C_m) = 0.4422 * \ln(C_s) + 0.0761$ | EPA, 2007 |
| Manganese | $C_m = 0.0205 * C_s$ | EPA, 2007 |
| Mercury | $C_m = 0.0543 * C_s$ | Sample *et al*., 1998 |
| Molybdenum | Not applicable# | -- |
| Nickel | $\ln(C_m) = 0.4658 * \ln(C_s) - 0.2462$ | EPA, 2007 |
| Selenium | $\ln(C_m) = 0.3764 * \ln(C_s) - 0.4158$ | EPA, 2007 |
| Silver | $C_m = 0.004 * C_s$ | EPA, 2007 |
| Thallium | $C_m = 0.1124 * C_s$ | Sample *et al*., 1998 |
| Vanadium | $C_m = 0.0123 * C_s$ | EPA, 2007 |
| Zinc | $\ln(C_m) = 0.0706 * \ln(C_s) + 4.3632$ | EPA, 2007 |

$C_m$ = COPEC concentration in small mammal tissue (mg/kg dry weight)
$C_s$ = COPEC concentration in soil (mg/kg dry weight)
* = Approximate value derived from antimony concentrations in surfical soil and small mammal liver reported by Ainsworth *et al*. (1990a,b); see text for more details
# = No apparent bioaccumulation of molybdenum in animal tissues; therefore, no soil to small mammal tissue uptake equations are available
A percent water content of 68% will be used when converting dry weight small mammal concentrations to wet weight (EPA, 2007a)

| Table 7.7. Monthly application key for each surface water chemistry sampling event | |
|---|---|
| **Month** | **Sampling event** |
| March | Pre-runoff |
| April | Pre-runoff |
| May | High-flow |
| June | High-flow |
| July | Low-flow |
| August | Low-flow |
| September | Low-flow |
| October | Low-flow |

| Table 7.8. Dietary items for use in food chain modeling for medium home-range target wildlife receptors. | |
|---|---|
| **Target wildlife receptor** | **Dietary item (proportion of total diet)** |
| American robin | Plants (58%) and soil invertebrates (42%)[a] |
| Cliff swallow | Flying insects (100%) |
| Fringed myotis bat | Flying insects (100%) |
| American beaver | Floodplain plants (100%) |
| Mountain bluebird | Flying insects (35%), ground-dwelling insects (35%), soil invertebrates (22%) and plants (8%)[b] |
| White-tailed ptarmigan | Plants (100%) |
| American pika | Plants (100%) |
| Yellow-bellied marmot | Plants (95%), ground-dwelling insects (2.5%) soil invertebrates (2.5%)[c] |
| Northern pocket gopher | Plants (100%) |

a = The proportion of American robin dietary items was obtained from Vanerhoff *et al*. (2016). If soil dwelling invertebrates (worms) are sampled, the proportion of invertebrates may be adjusted to account for a mixed worm, soil invertebrate, and plant diet.
b = The proportion of mountain bluebird dietary items was obtained from Power and Lombardo (1996).
c = Yellow-bellied marmots are reported to occasionally consume insects (Gellhorn, 2002); therefore, it was assumed that 5% of diet corresponded to an occasional invertebrate diet.

| Table 7.9. Dietary items for use in food chain modeling for small home-range target wildlife receptors. | |
|---|---|
| **Target wildlife receptor** | **Dietary item (proportion of total diet)** |
| Montane shrew | Ground-dwelling (45%), soil invertebrates (45%), and plants (10%)[a] |
| Deer mouse | Plants (75%), ground-dwelling (12%), and soil invertebrates (13%)[b] |

a = The proportion of montane shrew dietary items was obtained from Williams (1955).
b = The proportion of deer mouse dietary items was obtained from Sullivan (1995a).

**Figures**

**Figure 2.1. National Priorities List sites**

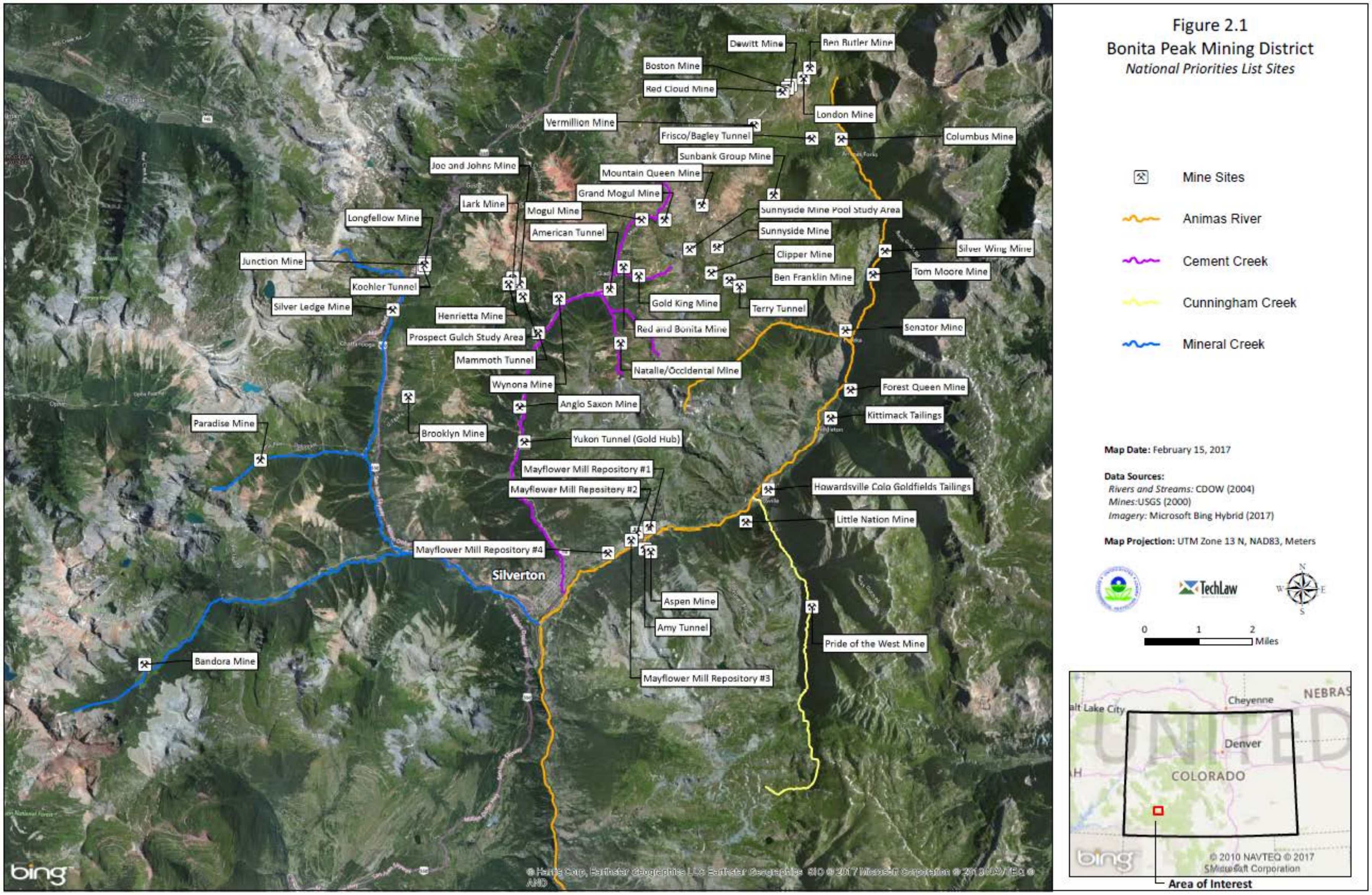


**Figure 2.2. Pair of Canada lynx (*Lynx canadensis*) photographed near Molas Pass outside of Silverton, Colorado on December 15, 2016.** Photograph taken by Dontje Hildebrand (2016).

**Figure 3.1. Overview map.**

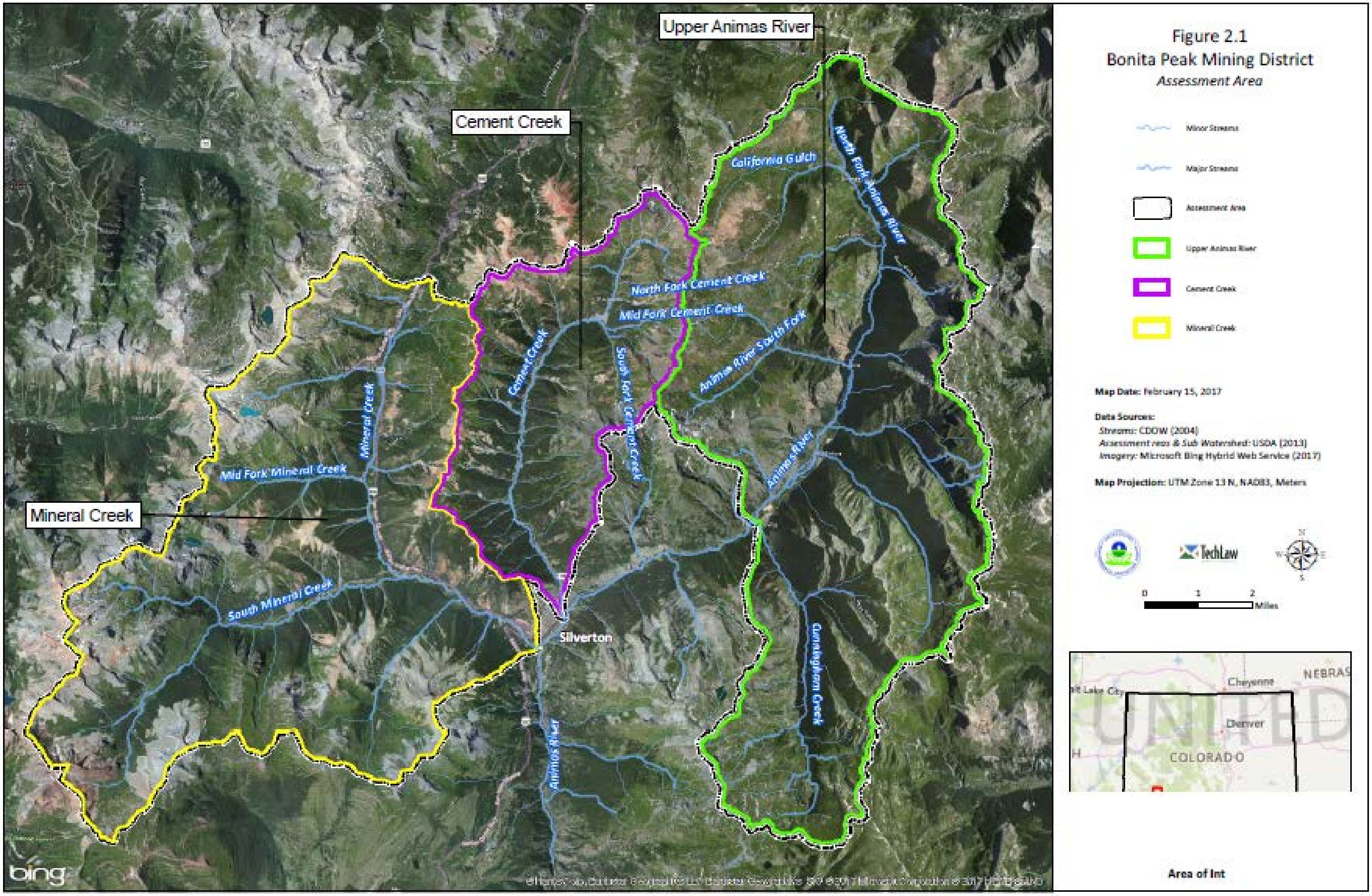
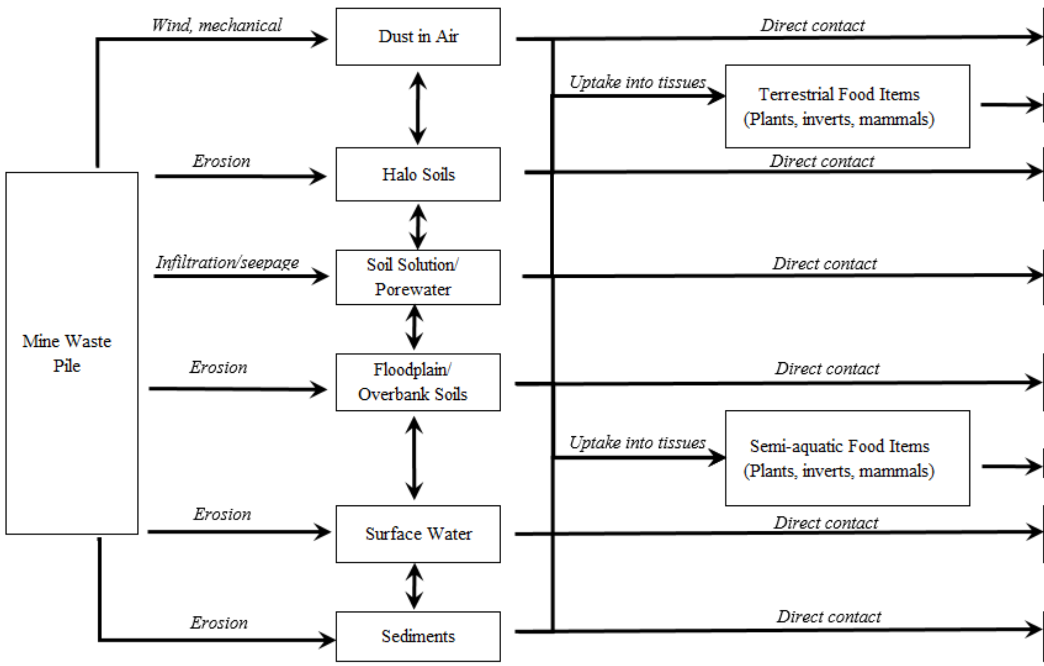


**Figure 4.1. Bonita Peak Mining District terrestrial baseline ecological risk assessment (BERA) work plan conceptual site model.**



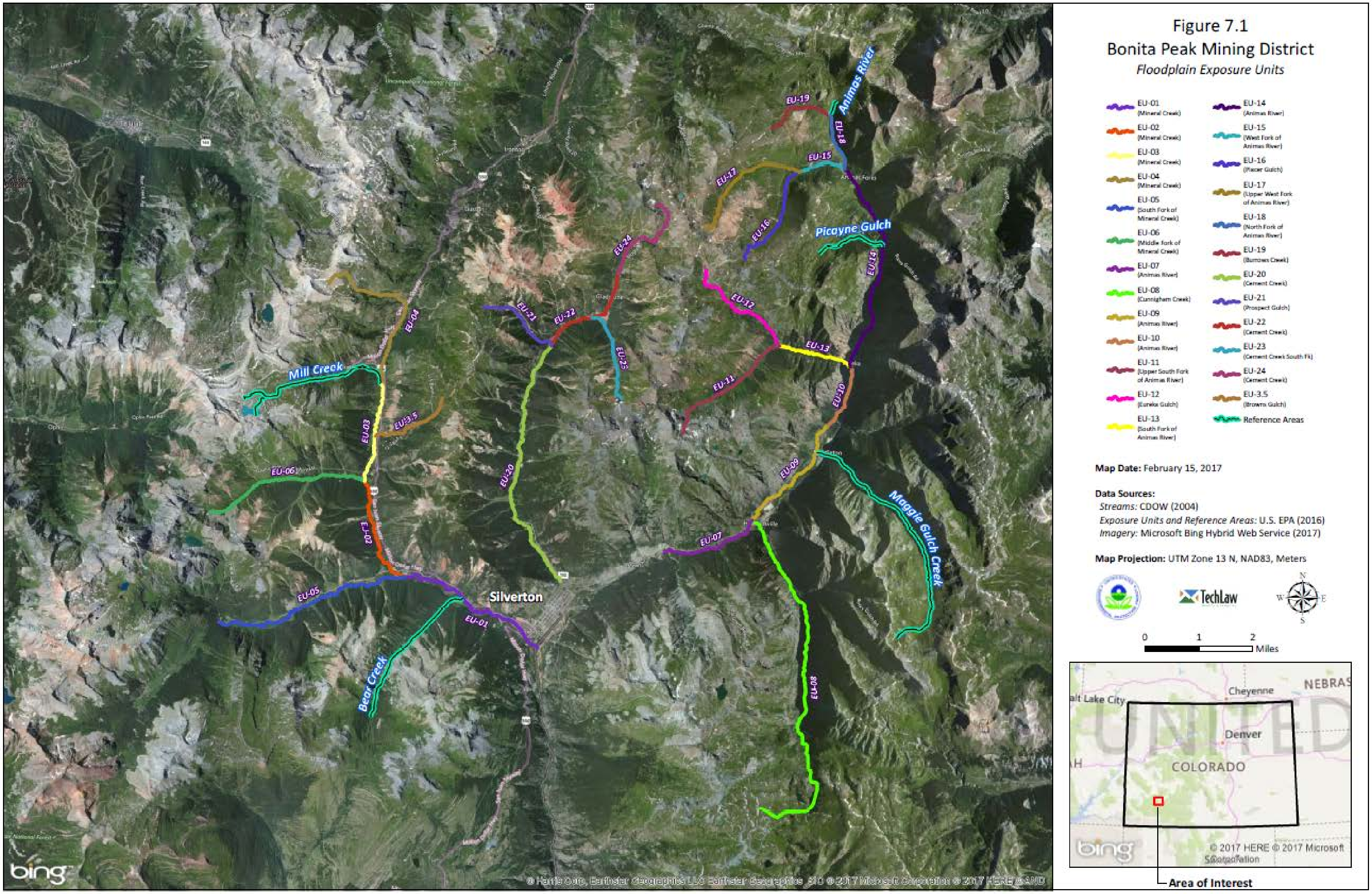

| | Plants | | Invertebrates | | Wildlife | |
|---|---|---|---|---|---|---|
| | Semi-aquatic | Terrestrial | Semi-aquatic | Terrestrial | Birds | Mammals |
| Inhalation | | | | | X | X |
| Direct contact | | X | | X | X | X |
| Ingestion | | | | O | O | O |
| Ingestion | | | X | O | O | O |
| Direct contact | | O | X | O | X | X |
| Ingestion | | | | | | |
| Direct contact | O | O | X | X | | |
| Ingestion | | | O | X | O | O |
| Direct contact | O | | O | X | X | X |
| Ingestion | | | O | | O | O |
| Ingestion | | | O | | O | O |
| Direct contact | O | | O | | X | X |
| Ingestion | | | O | | O | O |
| Direct contact | O | | O | | X | X |

**Symbol key**

| | |
|---|---|
| O | Complete pathway that will be evaluated |
| O | Complete pathway that could be significant |
| X | Complete pathway but potentially minor |
| Blank | Incomplete pathway |

Note that shaded cells identify which exposure pathways will be evaluated in the terrestrial BERA

**Figure 7.1. Floodplain exposure units**



**Appendix A.**
**List of vertebrate wildlife species for San Juan County**

# San Juan county
## Known or Likely Species Occurrence

| Group | Common Name | Scientific Name | Occurence | Abundance |
|---|---|---|---|---|
| Amphibians | Boreal Toad | Bufo boreas | Likely to occur | Unknown |
| Amphibians | Bullfrog | Rana catesbeiana | Likely to occur | Unknown |
| Amphibians | Northern Leopard Frog | Rana pipiens | Known to occur | Unknown |
| Amphibians | Tiger Salamander | Ambystoma tigrinum | Known to occur | Locally Common |
| Amphibians | Western Chorus Frog | Pseudacris triseriata | Known to occur | Common |
| Amphibians | Woodhouse's Toad | Bufo woodhousii | Likely to occur | Unknown |
| Birds | American Coot | Fulica americana | Known to occur | Uncommon |
| Birds | American Crow | Corvus brachyrhynchos | Known to occur | Uncommon |
| Birds | American Dipper | Cinclus mexicanus | Known to occur | Uncommon |
| Birds | American Goldfinch | Carduelis tristis | Known to occur | Unknown |
| Birds | American Kestrel | Falco sparverius | Known to occur | Rare |
| Birds | American Peregrine Falcon | Falco peregrinus anatum | Known to occur | Unknown |
| Birds | American Pipit | Anthus rubescens | Known to occur | Fairly Common |
| Birds | American Robin | Turdus migratorius | Known to occur | Common |
| Birds | American Tree Sparrow | Spizella arborea | Known to occur | Unknown |
| Birds | Baird's Sandpiper | Calidris bairdii | Likely to occur | No Occurrence |
| Birds | Band-tailed Pigeon | Columba fasciata | Known to occur | Unknown |
| Birds | Belted Kingfisher | Ceryle alcyon | Known to occur | Uncommon |
| Birds | Black Rosy Finch | Leucosticte atrata | Known to occur | Unknown |
| Birds | Black Swift | Cypseloides niger | Known to occur | Uncommon |
| Birds | Black-billed Magpie | Pica pica | Known to occur | Fairly Common |
| Birds | Black-capped Chickadee | Poecile atricapillus | Known to occur | Fairly Common |
| Birds | Black-crowned Night-Heron | Nycticorax nycticorax | Known to occur | Unknown |
| Birds | Black-headed Grosbeak | Pheucticus melanocephalus | Known to occur | Fairly Common |
| Birds | Blue Grouse | Dendragapus obscurus | Known to occur | Uncommon |
| Birds | Bonaparte's Gull | Larus philadelphia | Known to occur | Unknown |
| Birds | Boreal Owl | Aegolius funereus | Known to occur | Rare |
| Birds | Brewer's Blackbird | Euphagus cyanocephalus | Known to occur | Fairly Common |
| Birds | Brewer's Sparrow | Spizella breweri | Known to occur | Uncommon |
| Birds | Broad-tailed Hummingbird | Selasphorus platycercus | Known to occur | Common |
| Birds | Brown Creeper | Certhia americana | Known to occur | Uncommon |
| Birds | Brown-capped Rosy Finch | Leucosticte australis | Known to occur | Fairly Common |
| Birds | Brown-headed Cowbird | Molothrus ater | Known to occur | Common |

| | | | | |
|---|---|---|---|---|
| Birds | Bullock's Oriole | Icterus bullockii | Known to occur | Unknown |
| Birds | Calliope Hummingbird | Stellula calliope | Likely to occur | No Occurrence |
| Birds | Canada Goose | Branta canadensis | Known to occur | Unknown |
| Birds | Cassin's Finch | Carpodacus cassinii | Known to occur | Fairly Common |
| Birds | Cedar Waxwing | Bombycilla cedrorum | Known to occur | Unknown |
| Birds | Chipping Sparrow | Spizella passerina | Known to occur | Common |
| Birds | Clark's Nutcracker | Nucifraga columbiana | Known to occur | Fairly Common |
| Birds | Clay-colored Sparrow | Spizella pallida | Likely to occur | No Occurrence |
| Birds | Cliff Swallow | Petrochelidon pyrrhonota | Known to occur | Abundant |
| Birds | Common Goldeneye | Bucephala clangula | Known to occur | Unknown |
| Birds | Common Loon | Gavia immer | Known to occur | Unknown |
| Birds | Common Merganser | Mergus merganser | Known to occur | Unknown |
| Birds | Common Nighthawk | Chordeiles minor | Known to occur | Unknown |
| Birds | Common Raven | Corvus corax | Known to occur | Fairly Common |
| Birds | Common Redpoll | Carduelis flammea | Likely to occur | No Occurrence |
| Birds | Common Snipe | Gallinago gallinago | Known to occur | Unknown |
| Birds | Cooper's Hawk | Accipiter cooperii | Known to occur | Rare |
| Birds | Cordilleran Flycatcher | Empidonax occidentalis | Known to occur | Fairly Common |
| Birds | Dark-eyed Junco | Junco hyemalis | Known to occur | Common |
| Birds | Downy Woodpecker | Picoides pubescens | Known to occur | Uncommon |
| Birds | Dusky Flycatcher | Empidonax oberholseri | Known to occur | Fairly Common |
| Birds | Eared Grebe | Podiceps nigricollis | Known to occur | Unknown |
| Birds | European Starling | Sturnus vulgaris | Known to occur | Uncommon |
| Birds | Evening Grosbeak | Coccothraustes vespertinus | Known to occur | Fairly Common |
| Birds | Flammulated Owl | Otus flammeolus | Known to occur | Unknown |
| Birds | Fox Sparrow | Passerella iliaca | Known to occur | Uncommon |
| Birds | Franklin's Gull | Larus pipixcan | Likely to occur | No Occurrence |
| Birds | Golden Eagle | Aquila chrysaetos | Known to occur | Rare |
| Birds | Golden-crowned Kinglet | Regulus satrapa | Known to occur | Uncommon |
| Birds | Gray Catbird | Dumetella carolinensis | Known to occur | Unknown |
| Birds | Gray Jay | Perisoreus canadensis | Known to occur | Uncommon |
| Birds | Gray-crowned Rosy Finch | Leucosticte tephrocotis | Likely to occur | No Occurrence |
| Birds | Great Blue Heron | Ardea herodias | Known to occur | Unknown |
| Birds | Great Horned Owl | Bubo virginianus | Known to occur | Uncommon |
| Birds | Greater Scaup | Aythya marila | Known to occur | Unknown |
| Birds | Green-winged Teal | Anas crecca | Known to occur | Uncommon |
| Birds | Hairy Woodpecker | Picoides villosus | Known to occur | Uncommon |

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|---|---|---|---|---|
| Birds | Hammond's Flycatcher | Empidonax hammondii | Known to occur | Uncommon |
| Birds | Harris' Sparrow | Zonotrichia querula | Likely to occur | No Occurrence |
| Birds | Hermit Thrush | Catharus guttatus | Known to occur | Common |
| Birds | Horned Grebe | Podiceps auritus | Likely to occur | No Occurrence |
| Birds | Horned Lark | Eremophila alpestris | Known to occur | Uncommon |
| Birds | House Finch | Carpodacus mexicanus | Known to occur | Uncommon |
| Birds | House Sparrow | Passer domesticus | Known to occur | Uncommon |
| Birds | House Wren | Troglodytes aedon | Known to occur | Common |
| Birds | Juniper Titmouse | Baeolophus griseus | Known to occur | Unknown |
| Birds | Killdeer | Charadrius vociferus | Known to occur | Fairly Common |
| Birds | Lazuli Bunting | Passerina amoena | Known to occur | Rare |
| Birds | Least Sandpiper | Calidris minutilla | Likely to occur | No Occurrence |
| Birds | Lesser Goldfinch | Carduelis psaltria | Known to occur | Unknown |
| Birds | Lincoln's Sparrow | Melospiza lincolnii | Known to occur | Common |
| Birds | Loggerhead Shrike | Lanius ludovicianus | Known to occur | Unknown |
| Birds | Long-eared Owl | Asio otus | Known to occur | Unknown |
| Birds | MacGillivray's Warbler | Oporornis tolmiei | Known to occur | Uncommon |
| Birds | Mallard | Anas platyrhynchos | Known to occur | Common |
| Birds | Marsh Wren | Cistothorus palustris | Known to occur | Unknown |
| Birds | Mountain Bluebird | Sialia currucoides | Known to occur | Fairly Common |
| Birds | Mountain Chickadee | Poecile gambeli | Known to occur | Common |
| Birds | Mourning Dove | Zenaida macroura | Known to occur | Uncommon |
| Birds | Northern Flicker | Colaptes auratus | Known to occur | Fairly Common |
| Birds | Northern Goshawk | Accipiter gentilis | Known to occur | Rare |
| Birds | Northern Harrier | Circus cyaneus | Known to occur | Unknown |
| Birds | Northern Pintail | Anas acuta | Known to occur | Unknown |
| Birds | Northern Rough-winged Swallow | Stelgidopteryx serripennis | Known to occur | Rare |
| Birds | Northern Saw-whet Owl | Aegolius acadicus | Known to occur | Unknown |
| Birds | Olive-sided Flycatcher | Contopus cooperi | Known to occur | Uncommon |
| Birds | Orange-crowned Warbler | Vermivora celata | Known to occur | Fairly Common |
| Birds | Pacific Loon | Gavia pacifica | Likely to occur | No Occurrence |
| Birds | Peregrine Falcon | Falco peregrinus | Known to occur | Unknown |
| Birds | Pied-billed Grebe | Podilymbus podiceps | Known to occur | Unknown |
| Birds | Pine Grosbeak | Pinicola enucleator | Known to occur | Fairly Common |
| Birds | Pine Siskin | Carduelis pinus | Known to occur | Common |
| Birds | Pinyon Jay | Gymnorhinus cyanocephalus | Known to occur | Unknown |
| Birds | Plumbeous Vireo | Vireo plumbeus | Known to occur | Rare |

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|---|---|---|---|---|
| Birds | Prairie Falcon | Falco mexicanus | Known to occur | Uncommon |
| Birds | Pygmy Nuthatch | Sitta pygmaea | Known to occur | Uncommon |
| Birds | Red Crossbill | Loxia curvirostra | Known to occur | Uncommon |
| Birds | Red-breasted Nuthatch | Sitta canadensis | Known to occur | Uncommon |
| Birds | Red-naped Sapsucker | Sphyrapicus nuchalis | Known to occur | Uncommon |
| Birds | Red-necked Phalarope | Phalaropus lobatus | Likely to occur | No Occurrence |
| Birds | Red-tailed Hawk | Buteo jamaicensis | Known to occur | Uncommon |
| Birds | Red-winged Blackbird | Agelaius phoeniceus | Known to occur | Common |
| Birds | Ring-billed Gull | Larus delawarensis | Known to occur | Unknown |
| Birds | Ring-necked Duck | Aythya collaris | Known to occur | Rare |
| Birds | Rock Dove | Columba livia | Known to occur | Unknown |
| Birds | Rock Wren | Salpinctes obsoletus | Known to occur | Rare |
| Birds | Rough-legged Hawk | Buteo lagopus | Known to occur | Unknown |
| Birds | Ruby-crowned Kinglet | Regulus calendula | Known to occur | Common |
| Birds | Ruddy Duck | Oxyura jamaicensis | Known to occur | Unknown |
| Birds | Rufous Hummingbird | Selasphorus rufus | Known to occur | Unknown |
| Birds | Sabine's Gull | Xema sabini | Likely to occur | No Occurrence |
| Birds | Sage Thrasher | Oreoscoptes montanus | Known to occur | Unknown |
| Birds | Semipalmated Sandpiper | Calidris pusilla | Likely to occur | No Occurrence |
| Birds | Sharp-shinned Hawk | Accipiter striatus | Known to occur | Uncommon |
| Birds | Solitary Sandpiper | Tringa solitaria | Likely to occur | No Occurrence |
| Birds | Song Sparrow | Melospiza melodia | Known to occur | Fairly Common |
| Birds | Sora | Porzana carolina | Known to occur | Unknown |
| Birds | Southwestern Willow Flycatcher | Empidonax traillii extimus | Known to occur | Uncommon |
| Birds | Spotted Sandpiper | Actitis macularia | Known to occur | Uncommon |
| Birds | Steller's Jay | Cyanocitta stelleri | Known to occur | Fairly Common |
| Birds | Swainson's Thrush | Catharus ustulatus | Known to occur | Rare |
| Birds | Three-toed Woodpecker | Picoides tridactylus | Known to occur | Uncommon |
| Birds | Townsend's Solitaire | Myadestes townsendi | Known to occur | Uncommon |
| Birds | Tree Swallow | Tachycineta bicolor | Known to occur | Common |
| Birds | Tundra Swan | Cygnus columbianus | Likely to occur | No Occurrence |
| Birds | Turkey Vulture | Cathartes aura | Known to occur | Rare |
| Birds | Varied Thrush | Ixoreus naevius | Likely to occur | No Occurrence |
| Birds | Vesper Sparrow | Pooecetes gramineus | Known to occur | Unknown |
| Birds | Violet-green Swallow | Tachycineta thalassina | Known to occur | Common |
| Birds | Virginia's Warbler | Vermivora virginiae | Known to occur | Uncommon |
| Birds | Warbling Vireo | Vireo gilvus | Known to occur | Common |
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|---|---|---|---|---|
| Birds | Western Bluebird | Sialia mexicana | Known to occur | Rare |
| Birds | Western Meadowlark | Sturnella neglecta | Known to occur | Unknown |
| Birds | Western Sandpiper | Calidris mauri | Likely to occur | No Occurrence |
| Birds | Western Tanager | Piranga ludoviciana | Known to occur | Uncommon |
| Birds | Western Wood-Pewee | Contopus sordidulus | Known to occur | Fairly Common |
| Birds | White-breasted Nuthatch | Sitta carolinensis | Known to occur | Uncommon |
| Birds | White-crowned Sparrow | Zonotrichia leucophrys | Known to occur | Common |
| Birds | White-faced Ibis | Plegadis chihi | Known to occur | Unknown |
| Birds | White-tailed Ptarmigan | Lagopus leucurus | Known to occur | Uncommon |
| Birds | White-throated Sparrow | Zonotrichia albicollis | Likely to occur | No Occurrence |
| Birds | White-throated Swift | Aeronautes saxatalis | Known to occur | Common |
| Birds | White-winged Crossbill | Loxia leucoptera | Known to occur | Unknown |
| Birds | Williamson's Sapsucker | Sphyrapicus thyroideus | Known to occur | Uncommon |
| Birds | Willow Flycatcher | Empidonax traillii | Known to occur | Uncommon |
| Birds | Wilson's Warbler | Wilsonia pusilla | Known to occur | Common |
| Birds | Wood Thrush | Hylocichla mustelina | Likely to occur | No Occurrence |
| Birds | Yellow Warbler | Dendroica petechia | Known to occur | Unknown |
| Birds | Yellow-rumped Warbler | Dendroica coronata | Known to occur | Common |
| Mammals | American Badger | Taxidea taxus | Known to occur | Uncommon |
| Mammals | American Beaver | Castor canadensis | Known to occur | Fairly Common |
| Mammals | American Elk | Cervus elaphus | Known to occur | Abundant |
| Mammals | American Marten | Martes americana | Known to occur | Uncommon |
| Mammals | American Pika | Ochotona princeps | Known to occur | Common |
| Mammals | Big Brown Bat | Eptesicus fuscus | Likely to occur | Unknown |
| Mammals | Bighorn Sheep | Ovis canadensis | Known to occur | Fairly Common |
| Mammals | Black Bear | Ursus americanus | Known to occur | Common |
| Mammals | Bobcat | Lynx rufus | Known to occur | Uncommon |
| Mammals | Bushy-tailed Woodrat | Neotoma cinerea | Known to occur | Fairly Common |
| Mammals | Colorado Chipmunk | Tamias quadrivittatus | Known to occur | Fairly Common |
| Mammals | Common Muskrat | Ondatra zibethicus | Known to occur | Common |
| Mammals | Common Porcupine | Erethizon dorsatum | Known to occur | Uncommon |
| Mammals | Coyote | Canis latrans | Known to occur | Fairly Common |
| Mammals | Deer Mouse | Peromyscus maniculatus | Known to occur | Abundant |
| Mammals | Ermine | Mustela erminea | Known to occur | Uncommon |
| Mammals | Golden-mantled Ground Squirrel | Spermophilus lateralis | Known to occur | Fairly Common |
| Mammals | Hoary Bat | Lasiurus cinereus | Likely to occur | Unknown |
| Mammals | House Mouse | Mus musculus | Known to occur | Abundant |

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|---|---|---|---|---|
| Mammals | Little Brown Myotis | Myotis lucifugus | Likely to occur | Unknown |
| Mammals | Long-eared Myotis | Myotis evotis | Known to occur | Fairly Common |
| Mammals | Long-legged Myotis | Myotis volans | Known to occur | Common |
| Mammals | Long-tailed Vole | Microtus longicaudus | Known to occur | Fairly Common |
| Mammals | Long-tailed Weasel | Mustela frenata | Known to occur | Uncommon |
| Mammals | Lynx | Lynx canadensis | Known to occur | Very Rare |
| Mammals | Masked Shrew | Sorex cinereus | Known to occur | Fairly Common |
| Mammals | Mink | Mustela vison | Known to occur | Uncommon |
| Mammals | Montane Shrew | Sorex monticolus | Known to occur | Common |
| Mammals | Montane Vole | Microtus montanus | Known to occur | Common |
| Mammals | Moose | Alces alces | Known to occur | Uncommon |
| Mammals | Mountain Cottontail | Sylvilagus nuttallii | Known to occur | Fairly Common |
| Mammals | Mountain Goat | Oreamnos americanus | Known to occur | Fairly Common |
| Mammals | Mountain Lion | Felis concolor | Known to occur | Uncommon |
| Mammals | Mule Deer | Odocoileus hemionus | Known to occur | Abundant |
| Mammals | Northern Pocket Gopher | Thomomys talpoides | Known to occur | Common |
| Mammals | Pine Squirrel | Tamiasciurus hudsonicus | Known to occur | Fairly Common |
| Mammals | Raccoon | Procyon lotor | Likely to occur | Unknown |
| Mammals | Red Fox | Vulpes vulpes | Known to occur | Uncommon |
| Mammals | Silver-haired Bat | Lasionycteris noctivagans | Likely to occur | Unknown |
| Mammals | Snowshoe Hare | Lepus americanus | Known to occur | Fairly Common |
| Mammals | Southern Red-backed Vole | Clethrionomys gapperi | Known to occur | Fairly Common |
| Mammals | Striped Skunk | Mephitis mephitis | Known to occur | Fairly Common |
| Mammals | Water Shrew | Sorex palustris | Likely to occur | Unknown |
| Mammals | Western Jumping Mouse | Zapus princeps | Known to occur | Fairly Common |
| Mammals | Western Small-footed Myotis | Myotis ciliolabrum | Known to occur | Fairly Common |
| Mammals | White-tailed Jackrabbit | Lepus townsendii | Known to occur | Fairly Common |
| Mammals | Wolverine | Gulo gulo | Known to occur | Extirpated |
| Mammals | Yellow-bellied Marmot | Marmota flaviventris | Known to occur | Common |
| Reptiles | Fence Lizard | Sceloporus undulatus | Likely to occur | Unknown |
| Reptiles | Gopher Snake | Pituophis catenifer | Likely to occur | Unknown |
| Reptiles | Milk Snake | Lampropeltis triangulum | Likely to occur | Unknown |
| Reptiles | Painted Turtle | Chrysemys picta | Likely to occur | Unknown |
| Reptiles | Short-horned Lizard | Phrynosoma hernandesi | Likely to occur | Unknown |
| Reptiles | Smooth Green Snake | Liochlorophis vernalis | Likely to occur | Unknown |
| Reptiles | Western Terrestrial Garter Snake | Thamnophis elegans | Known to occur | Locally Common |

**Appendix B.**
**List of wildlife species that potentially occur in the Bonita Peak Mining District and considered for selection of target species**

| Appendix B. List of wildlife species that potentially occur in the Bonita Peak Mining District (BPMD) and considered for selection of target species | | |
|---|---|---|
| **Species** | **Attributes** | **Reference(s)** |
| White-tailed ptarmigan (*Lagopus leucurus*) | Year-round resident; not migratory<br>Nests exclusively on the alpine tundra<br>Mixed herbivore that feeds on willow buds in winter<br>Ingest grit to help pulverize food in gizzard<br>Game species | Braun *et al*., 1993 |
| Dusky grouse (*Dendragapus obscurus*) | Year-round resident<br>Builds nests on the ground in a shallow depression<br>Eats leaves, flowers and conifer needles<br>Game species | Hanophy and Teitelbaum, 2003; Zwickel, 1992 |
| Brown-capped rosy-finch (*Leucosticte australis*) | Seasonal resident<br>Nests exclusively on the alpine tundra<br>Ground forager for insects and seeds<br>Builds nests above tree line in caves, cliff ledges, and buildings, including abandoned mines | Hanophy and Teitelbaum, 2003; Johnson *et al*., 2000 |
| American pipit (*Anthus rubescens*) | Seasonal migrant or resident (during summer breeding season)<br>Nest in dried grasses and sedges exclusively in alpine grasslands<br>Eats insects and seeds | Hanophy and Teitelbaum, 2003; Verbeek and Hendricks, 1994 |
| Mountain bluebird (*Sialia currucoides*) | Potential year-round resident; may move to lower elevations in winter<br>Cavity nester<br>Mainly insectivorous, but will consume seeds and berries | Power and Lombardo, 1996 |
| Chipping sparrow (*Spizella passerina*) | Summer resident<br>Nest in evergreen forests<br>Young molt in alpine tundra<br>Ground forage for seeds, but focuses on insects during breeding season | Middleton, 1998 |
| Cliff swallow (*Petrochelidon pyrrhonota*) | Summer resident<br>Build nests on cliff faces with mud that's collected and shaped with their bills<br>Forms colonies ranging from hundreds to thousands of nests<br>Forage for flying insects from the air | Brown and Brown, 1995 |

| Species | Attributes | Reference(s) |
|---|---|---|
| Dark-eyed junco (*Junco hyemalis*) | Doesn't migrate but winter habitat more diverse and wider range than summer<br>Builds nests on the ground or wood piles in sub-alpine forests<br>Ground forager for seeds, but will eat insects<br>Tolerant of human disturbance | Nolan *et al*., 2002 |
| Grey jay (*Perisoreus canadensis*) | Year-round resident<br>Nests during late winter<br>Omnivorous, eating invertebrates, berries, carrion, nestling birds, and fungi | Hanophy and Teitelbaum, 2003; Strickland and Ouellet, 2011 |
| Steller's jay (*Cyanocitta stelleri*) | Year-round resident<br>Nests in evergreen trees<br>Omnivore that will eat insects, seeds, berries, small animals, eggs, and nestlings<br>Habitat generalist that may be common in developed habitats near towns and houses | Greene *et al*., 1998 |
| American robin (*Turdus migratorius*) | Year-round resident<br>Nests in trees or manmade structures<br>Ground forager, eating large numbers of soil invertebrates and fruit<br>Generalist, common in developed habitats near towns and houses<br>Often used bioindicator species for chemical exposure sites | Sallabanks and James, 1999 |
| Clark's nutcracker (*Nucifraga columbiana*) | Year-round resident<br>Nests in forked branches of conifer trees<br>Feeds on pine cone seeds<br>Buries summer seed catches for winter forage | Hanophy and Teitelbaum, 2003; Tomback, 1998 |
| Three-toed woodpecker (*Picoides dorsalis*) | Year-round resident<br>Nests in tree cavities<br>Feeds on bark and wood-boring beetle larvae<br>Prefers mature boreal and montane coniferous forests | Hanophy and Teitelbaum, 2003; Leonard, 2001 |
| Broad-tailed hummingbird (*Selasphorus platycercus*) | Summer resident<br>Nest in tree branches<br>Diet consists of nectar from flowers, columbine, Indian paintbrush, sage, and scarlet mint<br>Has several adaptations to survive freezing conditions | Camfield *et al*., 2013 |

| Species | Attributes | Reference(s) |
|---|---|---|
| Northern goshawk (*Accipiter gentilis*) | Year-round resident<br>Prefers to nest in mature and old-growth forests near a water source<br>Preys on birds and small mammals<br>Hunts along riparian corridors and open areas | Squires and Reynolds, 1997 |
| Prairie falcon (*Falco mexicanus*) | Summer or year-round resident, likely migrate to lower elevations for winter<br>Nests on cliff faces or other structures that provide protection from mammalian predators<br>Feeds on ground squirrel or pika in alpine habitats | Steenhof, 2013 |
| Red tailed hawk (*Buteo jamaicensis*) | Potential year-round resident<br>Large home range<br>Forages for small mammals and birds in many types of open habits<br>Known predator of pika and marmot in the BPMD<br>May nest on cliff edges or on artificial structures | Preston and Beane, 1993 |
| Golden eagle (*Aquila chrysaetos*) | Potential year-round resident<br>Large home range<br>Forages for small mammals along canyons, cliffs and steep terrain<br>Known predator of pika and marmot in the BPMD<br>May nest on cliff edges or on artificial structures<br>Avoid developed areas and thick forests | Kochert *et al*., 2002 |
| Boreal owl (*Aegolius funereus*) | Year-round resident<br>Cavity nester<br>Hunts for small mammals at night; will consume other birds and insects<br>Uses nest boxes | Hanophy and Teitelbaum, 2003; Hayward and Hayward, 1993 |
| American elk (*Cervus elaphus*) | Social and occur in various sized in herds; Older bulls can be solitary<br>Large home range and migrate with seasonal food availability<br>Diet can be seasonal, summer/fall grasses and forbs; winter grasses, shrubs, tree bark and twigs<br>Require and are attached to salt licks (high mineral content soils)<br>High value game species; populations are closely managed; culturally important | National Park Service, 2016; Rocky Mountain Elk Foundation, 2016 |

| Species | Attributes | Reference(s) |
|---|---|---|
| Mule deer (*Odocoileus hemionus*) | Herds composed of small family groups; males (bucks) often solitary; can form large, mixed gender herds in winter range<br>Subalpine forest are important summer habitat types<br>Often migrate between local summer and winter ranges; elevation dependent<br>Browsers with an extremely varied plant-based diet; forbs and grasses are most important<br>High value game species | Innes, 2013 |
| Moose (*Alces americanus*) | Less gregarious than elk and mule deer, but will aggregate in small groups during mating season<br>Occur in many habitats, but stream valleys and floodplain riparian communities dominated by willows are important in Rocky Mountains<br>Either use same range year round or migrate to separate summer and winter ranges<br>Seasonal diet consisting of leaves and shoots of deciduous plants in summer and stems and twigs of woody plants in winter<br>Require and are attached to salt licks (high mineral content soils)<br>High value game species; populations are closely managed; culturally important | De Bord, 2009; Innes, 2010 |
| Mountian goat (*Oreamnos americanus*) | Prefer steep slopes and talas cover<br>Routinely winter just above tree line<br>Summer forage in alpine meadows<br>Mixed herbivorous feeder; often eating above and below ground biomass<br>Require and are attached to salt licks (high mineral content soils)<br>Highly sensitive to human disturbance, especially in winter<br>Game species | Innes, 2011 |

| Species | Attributes | Reference(s) |
|---|---|---|
| Bighorn sheep (O*vis canadensis*) | Form small herds and often defend their established territory<br>Use a wide variety of open to semi open habitats and avoid dense forests<br>Often occur in areas with steep and rocky slopes, ridges, and canyons (escape terrain)<br>Migrate between seasonal ranges<br>Opportunistic feeders; forbs and grasses most important<br>Very susceptible to human disturbance<br>High value game species | Beecham *et al*., 2007; Tesky, 1993b |
| Black bear (*Ursus americanus*) | Generally solitary, but do aggregate during breeding season, when young, and in areas with abundant food<br>Often hibernate (denning) during the coldest winter months<br>Require a diverse assemblage of habitat types over a large range<br>Omnivorous and opportunistic feeders, with a diet consisting of grasses, forbs, berries, insects, carrion, birds/eggs, and small mammals<br>Game species | Ulev, 2007b |
| Coyote (*Canis latrans*) | Mostly solitary, but dependent on foraging activities; will form groups to hunt large prey<br>Occupy a wide range of habitats, but prefer to hunt in open and semi-open areas<br>Active year-round, day or night<br>Excavate dens from 5 to 25 feet long<br>Opportunistic feeders, but majority of diet comes consists of small mammals, birds, and carrion | Tesky, 1995 |
| Canada lynx (*Lynx canadensis*) | Generally solitary, but do aggregate when young and during breeding season<br>Require early- and mid-successional forests for hunting prey (hare) and late-successional forests for denning and raising kittens<br>Highly mobile and occupy a large and mutually exclusive home ranges<br>Specialist carnivore, preferring foraging habitats that support snowshoe hare<br>Also preys on squirrel and grouse<br>State listed endangered species<br>Federally listed threatened species; since March 2000 | Colorado Parks and Wildlife, 2016; Interagency Lynx Biology Team, 2013; Ulev, 2007a; United States Fish and Wildlife Service, 2016a |

| Species | Attributes | Reference(s) |
|---|---|---|
| American beaver (*Castor canadensis*) | Do not hibernate<br>Semi-aquatic<br>Prefer low gradient creek and rivers in which they build lodges and dams<br>Create calm pools used for feeding and resting<br>Diet consists of herbaceous vegetation; however, when not available will consume woody vegetation<br>Will occupy mined areas and acid waters when suitable foods are present<br>Have few predators; however, coyote, lynx, and bears will prey on beaver in some areas | Tesky, 1993a |
| Common muskrat (*Ondatra zibethicus*) | Do not hibernate<br>Semi-aquatic<br>Build lodges out of vegetation or burrows in or near water<br>Diet consists of roots, rhizomes, and leaves of aquatic emergent vegetation; occasionally fish and crustaceans<br>Prey item of avian and mammalian predators | Snyder, 1993; United States Fish and Wildlife Service, 2015 |
| Pine marten (*Martes americana*) | Active year-round, but less active in winter<br>Adults are solitary<br>Particularly associated with Engelmann spruce sub alpine fir forests in Colorado<br>Have high fidelity to established home ranges<br>Avoid open areas<br>Are preyed upon by raptors and large carnivores | Stone, 2010 |
| American pika (*Ochotona princeps*) | Active year-round; forage within snow tunnels in winter<br>Require talus or rock piles bordered by suitable vegetation<br>Consume a wide variety of plants, but have reported to avoid plants with toxic chemicals<br>Cache vegetation in hay piles for winter forage; forbs and grasses most often hayed<br>Will consume lichens during winter<br>Prey species for coyote and pine marten | Smith and Weston, 1990 |

| Species | Attributes | Reference(s) |
|---|---|---|
| Yellow-bellied marmot (*Marmota flaviventris*) | Hibernates all winter; may spend between 60% to 80% of their life in burrows<br>Occupy vegetated, talus slopes and meadow rock outcrops<br>Rocks and boulders are important burrow, sunning, and observation posts<br>Diet consists of a wide variety of forbs, grasses, seeds, flowers, and occasional insects<br>Has few natural predators; however, coyote may prey upon young | Frase and Hoffmann, 1980 |
| Snowshoe hare (*Lepus americanus*) | Active year-round<br>Primarily occur in sub alpine forests with a dense shrub layer<br>Require dense, brushy, coniferous cover<br>Diet changes with season/availability; green leafy vegetation in summer/spring and twigs and small stems in winter<br>Very important prey species for a wide variety of predators; including Canada lynx | Sullivan, 1995a |
| Golden-mantled ground squirrel (*Spermophilus lateralis*) | Hibernates and goes into torpor for long periods at high elevations<br>Occurs over a variety of high altitude habitats; including rocky slopes, meadow margins and forest floors<br>Omnivorous; diet consists of fungi, seeds, forbs, insects, bird eggs and hatchlings, carrion, and people handouts<br>Tolerant of human disturbance and may be attracted to campgrounds | Bartels and Thompson, 1993 |
| Red squirrel (*Tamiasciurus hudsonicus*) | Active year-round, throughout the day<br>Territorial and defends up to 100% of their home range<br>Nests in tree cavities or builds nest in trees with leaf litter<br>Require mature coniferous trees for a source of pine cones and seed<br>Other food sources include nuts, buds, sap, tender leaves, fruits, flowers, fungi, bird eggs, and small vertebrates<br>Important prey species for a wide variety of predators | Sullivan, 1995c |

| **Species** | **Attributes** | **Reference(s)** |
|---|---|---|
| Northern pocket gopher (*Thomomys talpoides*) | Active year-round; forage within snow tunnels in winter<br>Key species in turning over and cycling alpine soils<br>Local distribution governed by soil type (deep, light soils) and interspecific competition<br>Burrow mounds are easily observed from the ground surface<br>Preferred diet is forbs, but will consume a wide variety of vegetation; often consume roots encountered underground<br>State species of special concern | Colorado Parks and Wildlife. 2016; Hanophy and Teitelbaum, 2003; Verts and Carraway, 1999 |
| Deer mouse (*Peromyscus maniculatus*) | Active year-round, but reduced activity in cold or wet conditions<br>Nearly ubiquitous in sub alpine forests<br>May prefer disturbed habitats (logging and livestock grazing)<br>Omnivorous; important dietary items include arthropods, seeds, berries, and fungi<br>Cache food in protected locations or winter forage<br>Important prey species for a wide variety of avian and mammalian predators | Sullivan, 1995b |
| Montane shrew (*Sorex monticolus*) | Active year-round<br>Most common shrew spp. and occurs over a wide range of montane and alpine habitat types<br>Requires a dense understory ground cover and abundant litter<br>Diet consists of insects, earthworms, seeds, fungi, and lichens<br>Important prey for avian predators | Natural History Museum of Utah, 1999; Smith and Belk, 1996 |
| Fringed myotis bat (*Myotis thysanodes*) | Some populations hibernate<br>May be migratory and descend to lower, warmer elevations<br>Roost in caves; may be attracted to mine adits<br>Nocturnal<br>Insectivore, with beetles and moths reported as the most abundant dietary items<br>May be sensitive from human disturbance | Hanophy and Teitelbaum, 2003; Keinath, 2003; McFarrel and Studier, 1980 |

**Appendix C.**
**Screening-level risk assessment tables**

| Appendix C.1. Soil COPECs for the mine waste sites. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Analyte** | **Min. detected value (mg/kg)** | **Max. detected value (mg/kg)** | **Station ID of max detect. value** | **Mine name** | **Soil ESV (mg/kg)** | **HQ** | **Soil COPEC?** | **Reason code** |
| aluminum | 800 | 16,100 | WR1-M16 | Paradise Mine | NA | -- | Y | c |
| antimony | 0.57 | 332 | AE-1 | Mountain Queen Mine | 0.27 | **1,230** | Y | a |
| arsenic | 3.7 | 13,700 | WR-M02C | Koehler Tunnel | 6.8 | **2,015** | Y | a |
| barium | 8.6 | 1,110 | WR2-M24 | Bandora Mine | 110 | **10** | Y | a |
| beryllium | 0.034 | 4.0 | WR4-M24 | Bandora Mine | 2.5 | **2** | Y | a |
| cadmium | 0.15 | 160 | WR4-M24 | Bandora Mine | 0.36 | **444** | Y | a |
| chromium | 0.65 | 16.5 | WR-M02D | Junction Mine | 0.4 | **41** | Y | a |
| cobalt | 0.26 | 117 | WR4-M24 | Bandora Mine | 13.0 | **9** | Y | a |
| copper | 38 | 3,830 | AE32a | Silver Wing Mine | 28.0 | **137** | Y | a |
| iron | 5,690 | 262,000 | WR2-M16 | Paradise Mine | NA | **--** | Y | c |
| lead | 36.3 | 35,700 | AE-1 | Mountain Queen Mine | 11 | **3,245** | Y | a |
| manganese | 43 | 72,100 | WR4-M24 | Bandora Mine | 220 | **328** | Y | a |
| mercury | 0.015 | 7.6 | WR-M02D | Junction Mine | 0.013 | **585** | Y | a |
| molybdenum | 0.91 | 159 | WR-TM | Tom Moore Mine | 2.0 | **80** | Y | a |
| nickel | 0.15 | 34.6 | WR4-M24 | Bandora Mine | 38.0 | 0.9 | N | b |
| selenium | 0.57 | 32.3 | AE-1 | Mountain Queen Mine | 0.52 | **62** | Y | a |
| silver | 0.247 | 93.7 | WR-BB | Ben Butler Mine | 4.2 | **22** | Y | a |
| thallium | 0.097 | 4.6 | AE45 | Sunbank Group Mine | 0.05 | **92** | Y | a |
| vanadium | 1.3 | 70.3 | WR-M02C | Koehler Tunnel | 7.8 | **9** | Y | a |
| zinc | 23.6 | 66,800 | WR3-M24 | Bandora Mine | 46.0 | **1,452** | Y | a |

COPEC = contaminant of potential ecological concern; ESV = ecological screening value; HQ = hazard quotient
Reason code:
a = HQ > 1
b = HQ < 1
c = analyte was detected but has no ESV

| Appendix C.2. Soil COPECs for the overbank soils. | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Analyte** | **Min. detected value (mg/kg)** | **Max. detected value (mg/kg)** | **EU with max detected value** | **Soil ESV (mg/kg)** | **HQ** | **Soil COPEC?** | **Reason code** |
| aluminum | 3,920 | 48,300 | EU-19 | NA | -- | Y | c |
| antimony | 0.016 | 26.5 | EU-10 | 0.27 | **98** | Y | a |
| arsenic | 0.095 | 831 | EU-04 | 6.8 | **122** | Y | a |
| barium | 10.7 | 357 | EU-15 | 110 | **3.2** | Y | a |
| beryllium | 0.11 | 9.0 | EU-15 | 2.5 | **3.6** | Y | a |
| cadmium | 0.11 | 216 | EU-15 | 0.36 | **600** | Y | a |
| chromium | 0.12 | 27 | EU-13 | 0.4 | **68** | Y | a |
| cobalt | 0.65 | 81.5 | EU-24 | 13.0 | **6.3** | Y | a |
| copper | 4.5 | 2,890 | EU-15 | 28.0 | **103** | Y | a |
| iron | 13,000 | 317,000 | EU-03 | NA | **--** | Y | c |
| lead | 0.92 | 10,500 | EU-10 | 11 | **955** | Y | a |
| manganese | 73.3 | 55,900 | EU-15 | 220 | **254** | Y | a |
| mercury | 0.0044 | 2.6 | EU-15 | 0.013 | **200** | Y | a |
| molybdenum | 0.11 | 81.8 | EU-15 | 2.0 | **41** | Y | a |
| nickel | 0.59 | 63.7 | EU-13 | 38.0 | **1.7** | Y | a |
| selenium | 0.5 | 7 | EU-06 | 0.52 | **13** | Y | a |
| silver | 0.0145 | 47.9 | EU-10 | 4.2 | **11** | Y | a |
| thallium | 0.02 | 3.3 | EU-19 | 0.05 | **66** | Y | a |
| vanadium | 0.52 | 76.1 | EU-01 | 7.8 | **10** | Y | a |
| zinc | 18.7 | 30,200 | EU-15 | 46.0 | **657** | Y | a |

COPEC = contaminant of potential ecological concern; ESV = ecological screening value; EU = exposure unit; HQ = hazard quotient

Reason code:
a = HQ > 1
b = HQ < 1
c = analyte was detected but has no ESV

**Appendix C.3. Soil COPECs for the public campsites.**

| Analyte | Min. detected value (mg/kg) | Max. detected value (mg/kg) | Location of max detected value | Soil ESV (mg/kg) | HQ | Soil COPEC? | Reason code |
|---|---|---|---|---|---|---|---|
| aluminum | 7,050 | 14,100 | CMP5 | NA | **--** | Y | c |
| antimony | 0.57 | 46.8 | CMP4 | 0.27 | **173** | Y | a |
| arsenic | 7.7 J- | 86.9 J- | CMP7 | 6.8 | **13** | Y | a |
| barium | 75.7 | 193 | CMP10 | 110 | **1.8** | Y | a |
| beryllium | 0.19 | 1.4 | CMP15a | 2.5 | <1 | N | b |
| cadmium | 0.18 | 94.3 | CMP4 | 0.36 | **262** | Y | a |
| chromium | 4.1 | 10.5 | CMP9 | 0.4 | **26** | Y | a |
| cobalt | 2.6 | 29.7 | CMP15a | 13.0 | **2** | Y | a |
| copper | 20.4 | 2,510 | CMP4 | 28.0 | **90** | Y | a |
| iron | 19,000 J | 48,100 J | CMP11 | NA | **--** | Y | c |
| lead | 73.6 | 44,200 | CMP4 | 11 | **4,018** | Y | a |
| manganese | 202 | 9,030 | CMP15a | 220 | **41** | Y | a |
| mercury | 0.016 J | 6.0 | CMP4 | 0.013 | **462** | Y | a |
| molybdenum | 1.1 | 118 J | CMP4 | 2.0 | **59** | Y | a |
| nickel | 2.2 | 18.6 | CMP15a | 38.0 | <1 | N | b |
| selenium | 0.69 | 7.1 | CMP4 | 0.52 | **14** | Y | a |
| silver | 0.58 | 96.9 | CMP4 | 4.2 | **23** | Y | a |
| thallium | 0.14 | 0.43 | CMP7 | 0.05 | **9** | Y | a |
| vanadium | 15.4 | 45 | CMP15a | 7.8 | **6** | Y | a |
| zinc | 74.3 | 17,300 | CMP4 | 46.0 | **376** | Y | a |

COPEC = contaminant of potential ecological concern; ESV = ecological screening value; HQ = hazard quotient
Reason code:
a = HQ > 1
b = HQ < 1
c = analyte was detected but has no ESV

| Appendix C.4. Maximum HQs for the four terrestrial receptor groups at the three exposure areas. | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Mine sites maximum HQs** | | | | **Overbank soils maximum HQs** | | | | **Campsites maximum HQs** | | | |
| **COPEC** | **Plants** | **Inverts** | **Birds** | **Mammals** | **Plants** | **Inverts** | **Birds** | **Mammals** | **Plants** | **Inverts** | **Birds** | **Mammals** |
| antimony | 30 | 4 | -- | 1,230 | 2 | <1 | -- | 98 | 4 | <1 | -- | 173 |
| arsenic | 761 | 2,015 | 319 | 298 | 46 | 122 | 19 | 18 | 5 | 13 | 2 | 2 |
| barium | 10 | 3 | 1.4 | <1 | 3 | 1.1 | <1 | <1 | 2 | <1 | <1 | <1 |
| beryllium | 2 | <1 | -- | <1 | 4 | <1 | -- | <1 | <1 | <1 | -- | <1 |
| cadmium | 5 | 1.1 | 208 | 444 | 7 | 2 | 281 | 600 | 3 | <1 | 122 | 262 |
| chromium | -- | 41 | <1 | <1 | -- | 68 | 1.0 | <1 | -- | 28 | <1 | <1 |
| cobalt | 9 | -- | <1 | <1 | 6 | -- | 0.7 | <1 | 2 | -- | <1 | <1 |
| copper | 55 | 48 | 137 | 78 | 41 | 36 | 103 | 59 | 36 | 31 | 90 | 51 |
| lead | 298 | 21 | 3,245 | 638 | 88 | 6 | 955 | 188 | 368 | 26 | 4,018 | 789 |
| manganese | 328 | 160 | 17 | 18 | 254 | 124 | 13 | 14 | 41 | 20 | 2 | 2 |
| mercury | <1 | 152 | 585 | 4 | <1 | 52 | 200 | 2 | <1 | 120 | 462 | 4 |
| molybdenum | 80 | -- | 9 | 33 | 41 | -- | 5 | 17 | 59 | -- | 7 | 25 |
| nickel | <1 | <1 | <1 | <1 | 2 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| selenium | 62 | 8 | 27 | 51 | 13 | 2 | 6 | 11 | 14 | 2 | 6 | 11 |
| silver | <1 | -- | 22 | 7 | <1 | -- | 11 | 3 | <1 | -- | 23 | 7 |
| thallium | 92 | -- | <1 | 21 | 66 | -- | <1 | 15 | 9 | -- | <1 | 2 |
| vanadium | 1.1 | -- | 9 | <1 | 1.3 | -- | 10 | <1 | <1 | -- | 6 | <1 |
| zinc | 418 | 557 | 1,452 | 846 | 189 | 252 | 657 | 382 | 108 | 144 | 376 | 219 |

COPEC = contaminant of potential ecological concern; HQ = hazard quotient
-- = a soil benchmark is not available to calculate an HQ

**Appendix D.**
**Target receptor species selection table**

| Appendix D. Wildlife receptor species selection table. | | |
|---|---|---|
| **Wildlife species** | **Retained** | **Selection reasoning** |
| White-tailed ptarmigan (*Lagopus leucurus*) | Yes | Ptarmigan health affects previously documented (Larison *et al*., 2000)<br>Known high exposure route; willow bud consumption |
| Dusky grouse (*Dendragapus obscurus*) | No | Very similar to ptarmigan |
| Brown-capped rosy-finch (*Leucosticte australis*) | No | Migratory<br>Not common to the assessment area<br>Similar to mountain bluebird but lower exposure potential |
| American pipit (*Anthus rubescens*) | No | Migratory<br>Not common to the assessment area<br>Similar to mountain bluebird but lower exposure potential |
| Mountain bluebird (*Sialia currucoides*) | Yes | Potential year-round resident that may be susceptible to cumulative metals exposure<br>Utilizes diverse forage habitats<br>Majority of their diet consists of insects that are known to accumulate metals |
| Chipping sparrow (*Spizella passerina*) | No | This species is a seasonal resident and nests in forest habitats<br>Although this species does consume insects, majority of their diet consists of seeds that do not typically accumulate metals<br>Not retained due to low exposure potential |
| Cliff swallow (*Petrochelidon pyrrhonota*) | Yes | This species builds nests on cliff faces with mud; floodplain soil and sediments<br>Diet consists of emergent insects that are known to accumulate metals from contaminated areas<br>Retained due to high exposure potential |
| Dark-eyed junco (*Junco hyemalis*) | No | Primarily a ground forager with a seed diet<br>Not retained due to low exposure potential |

| Wildlife species | Retained | Selection reasoning |
|---|---|---|
| Grey jay (*Perisoreus canadensis*) | No | This species nests in forest habitats<br>Omnivorous<br>Not retained due to being too similar to mountain bluebird, but with lower exposure potential |
| Steller's jay (*Cyanocitta stelleri*) | No | This species nests in forest habitats<br>Omnivorous<br>Not retained due to being too similar to mountain bluebird, but with lower exposure potential |
| American robin (*Turdus migratorius*) | Yes | Year-round residents that may be susceptible to cumulative metals exposure<br>Dietary preference for soil invertebrates increases exposure to soil and sediment potentially contaminated with metals<br>Also known to utilize disturbed habitats<br>Heavily studied receptor, chemical bioindicator species, and shown to be highly exposed to environmental contaminants at other sites |
| Clark’s nutcracker (*Nucifraga columbiana*) | No | This species feeds primarily on pine cone seeds; reported metal accumulation in seeds is likely lower than any other plant tissues<br>This species also inhabits forests; BPMD habitats with the least amount of mining impacts<br>Would not have significant exposure to soil |
| Three-toed woodpecker (*Picoides dorsalis*) | No | Species prefers mature forests; habitat that is likely least impacted by mining<br>Diet consist of bark and pine beetle larvae that have little potential to accumulate metals<br>Nests in cavities and forages in forest canopy; therefore, would have little to no direct exposure to contaminated soils |
| Broad-tailed hummingbird (*Selasphorus platycercus*) | No | Seasonal resident species would occur in BPMD for a short portion of the year<br>Nests in trees and primarily feeds on nectar; therefore, would have little to no direct exposure to contaminated soils |

| Wildlife species | Retained | Selection reasoning |
|---|---|---|
| Northern goshawk (*Accipiter gentilis*) | Yes | Potential year-round resident species<br>Diet consists of small mammals and other prey items that are exposed and could accumulate metals; including pika, shrew, and mice.<br>Forage and refuge areas are associated with contaminated floodplain habitats |
| Prairie falcon (*Falco mexicanus*) | No | Very similar to northern goshawk, but not as common in assessment area |
| Red tailed hawk (*Buteo jamaicensis*) | No | Very similar to golden eagle, but not as common in assessment area |
| Golden eagle (*Aquila chrysaetos*) | Yes | Known to occur in the assessment area<br>Diet consists of small mammals and other prey items that are exposed and could accumulate metals; including pika, shrew, and mice. |
| Boreal owl (*Aegolius funereus*) | No | Potential year-round resident species<br>Inhabits forests habitats with the least amount of mining impacts<br>Not retained due to low exposure potential |
| American elk (*Cervus elaphus*) | No | Seasonal and migratory species<br>Very large home range<br>Easily disturbed by human recreational activities<br>Not retained due to low exposure potential |
| Mule deer (*Odocoileus hemionu*s) | No | Seasonal and migratory species<br>Very large home range<br>Easily disturbed by human recreational activities<br>Not retained due to low exposure potential |

| Wildlife species | Retained | Selection reasoning |
|---|---|---|
| Moose (*Alces americanus*) | Yes | Potential year-round BPMD resident<br>Although this species has potentially large home range, it would utilize habitats that are most contaminated with metals; riparian corridors<br>Known to feed on aquatic vegetation, such as willow that are known to accumulate metals<br>Mammals are not as sensitive to most metals as other receptors, but retained due to potential for elevated exposure |
| Mountian goat (*Oreamnos americanus*) | No | Sensitive to human disturbance<br>Not a common assessment area species<br>Not retained due to low exposure potential |
| Bighorn sheep (*Ovis canadensis*) | No | Sensitive to human disturbance<br>Not a common assessment area species<br>Not retained due to low exposure potential |
| Black bear (*Ursus americanus*) | No | Species has a very large home range with a diverse assemblage of habitat types<br>Diet largely consists of vegetation<br>Hibernates over winter<br>Not retained due to low exposure potential |
| Coyote (*Canis latrans*) | Yes | Species has a very large home range<br>Omnivorous diet largely consists of small mammals<br>Retained due to large home-range, non-specific habitat requirements, and varied diet |
| Canada lynx (*Lynx canadensis*) | Yes | Very rare species with a large home range and specialized habitat requirements<br>Diet almost exclusively consists of snowshoe hare<br>Retained because it has been observed near the study and is a federally threatened listed species; also a Colorado state endangered species |

| Wildlife species | Retained | Selection reasoning |
| --- | --- | --- |
| American beaver (*Castor canadensis*) | Yes | Semi-aquatic habitat and diet of aquatic emergent vegetation support a very high exposure potential |
| Common muskrat (*Ondatra zibethicus*) | No | Not retained due to similarity with beaver target receptor |
| Pine marten (*Martes americana*) | No | Primarily occurs in mature forest habitats; areas not particularly associated with mine wastes<br>Diet consists of small mammals and birds<br>Not retained due to low exposure potential |
| American pika (*Ochotona princeps*) | Yes | May occur in rock piles and talus slopes associated with mine sites<br>Burrow within rock piles<br>Consumes vegetation adjacent to rock piles<br>Retained due to high exposure potential and common in assessment area |
| Yellow-bellied marmot (*Marmota flaviventris*) | Yes | May occurs in rock piles and talus slopes associated with mine sites<br>Burrow within rock piles<br>Consumes vegetation adjacent to rock piles<br>Retained due to high exposure potential and known to occur in assessment area |
| Snowshoe hare (*Lepus americanus*) | No | Active year-round and feeds on vegetation close to the ground surface<br>Important prey item for predatory wildlife, including lynx<br>Not retained as a target receptor, but may be sampled for predatory wildlife dietary exposure |

| Wildlife species | Retained | Selection reasoning |
|---|---|---|
| Golden-mantled ground squirrel (*Spermophilus lateralis*) | No | Hibernates for a large proportion of the year<br>Occurs in coniferous forests<br>Not retained due to low exposure potential<br>Not retained as a target receptor, but may be sampled for predatory wildlife dietary exposure |
| Red squirrel (*Tamiasciurus hudsonicus*) | No | Spends most of its time in trees and eats pine cone seeds<br>Not retained because of low potential of exposure to mine wastes<br>Not retained as a target receptor, but may be sampled for predatory wildlife dietary exposure |
| Northern pocket gopher (*Thomomys talpoides*) | Yes | This species burrows in alpine soils<br>Diet consists of vegetation and often consumes entire plants; including roots<br>Retained due to high direct and dietary exposure |
| Deer mouse (*Peromyscus maniculatus*) | Yes | Prefers riparian habitats and often occurs in disturbed habitats<br>Is in close contact with soils and feeds on soil invertebrates<br>Retained due to high direct and dietary exposure<br>Also an important prey item for predatory wildlife |
| Montane shrew (*Sorex monticolus*) | Yes | Is in close contact with soils and feeds on soil invertebrates<br>Retained due to high direct and dietary exposure<br>Also an important prey item for predatory wildlife |
| Fringed myotis bat (*Myotis thysanodes*) | Yes | Potentially roosts in mine adits<br>Diet consists of insects that can accumulate metals<br>Recent studies show that bats have potential to accumulate high levels of metals in certain tissues<br>This species was retained due to high potential for metals exposure |

BPMD = Bonita Peak Mining District

**Attachment 1**
**Biological Technical Assistance Group Draft Baseline Ecological Risk Assessment Work Plan Comments and Agency Responses and Actions**

## United States Forest Service (USFS) Comments

**USFS #1** <u>§2.3 Habitats and wildlife, 2nd to last paragraph</u>: An important aspect of fen systems and other high alpine wetland systems is their role in storing and cycling carbon, and regulating hydrological processes that provide more stable base flows in streams. Connectivity of terrestrial-hydrologic systems might be cross referenced in the [Baseline Ecological Risk Assessment] BERA for terrestrial and aquatic systems.

> *<u>EPA Response #1</u>: Addressed comment by adding carbon cycling and hydrology attributes information to the iron fen description.*

**USFS #2** <u>§2.5 Special status species, 1st paragraph</u>: Federal [Threatened and Endangered] T&E lists are obtained from [United States Fish and Wildlife Service] USFWS, not [Colorado Parks and Wildlife] CPW, for consultation purposes. Should be clarified. A recent list from the USFWS from 2017 should be cited here as well as the state list.

> *<u>EPA Response #2</u>: Addressed comment by reorganizing and rewriting most of Section 2.5 to focus on the USFWS iPAC environmental conservation online system list of T&E species for the upper Animas River watershed. This list was cited as USFWS (2017).*

**USFS #3** <u>§2.5 Special status species, 1st paragraph</u>: Wolverine also has status as a proposed species under the ESA [Endangered Species Act], should be mentioned here. I recommend going to USFWS website and pulling the most current T&E list for the project area.

> *<u>EPA Response #3</u>: North American wolverine federal ESA status was described as being currently under review which was supported by USFWS (2016) citation reference.*

**USFS #4** <u>§2.5 Special status species, 1st paragraph</u>: This species [boreal toad] has been petitioned for federal listing.

> *<u>EPA Response #4</u>: Boreal toad federal ESA status was described as being currently under review which was supported by USFWS (2011) citation reference.*

**USFS #5** <u>§2.5: Special status species, 2nd paragraph:</u> Recommend stating which counties [for boreal toad]

> *<u>EPA Response #5</u>: Boreal toad counties reported by Keinath and McGee (2005) were added. Note that only counties that were near San Juan County were listed so the added text does not list all Colorado counties were boreal toads have been documented. Note that San Juan County was not included since Keinath and McGee (2005) did not report that boreal toad were found in San Juan County.*

**USFS #6** <u>§2.5: Special status species, 2nd paragraph:</u> Not sure I concur with regard to boreal toad without more rationale for its potential absence. It is within the range of the species.

*<u>EPA Response #6</u>: Keinath and McGee (2005) was cited as the source for supporting that boreal toad did not occur in San Juan County. However, portions of San Juan County and the Bonita Peak Mining District (BPMD) terrestrial BERA assessment area were reported as falling within the historic range of boreal toad distribution; see* Figure 1 Boreal toad distribution in [United States Department of Agriculture] USDA Forest Service Region 2 *in Keinath and McGee (2005). This description of historical boreal toad distribution was added to address this comment. We also noted that BLM (2006) have also reported that boreal toad do not occur in the BPMD despite the presence of boreal toad habitat.*

**USFS #7** <u>§3.0 Summary of the terrestrial BPMD SLERA, Introduction, 2nd paragraph</u>: Suggest explaining how the [ecological screening value] ESVs is derived

*<u>EPA Response #7</u>: Comment was addressed by adding the sources of all the ESVs that were used in the BPMD terrestrial Screening-Level Ecological Risk Assessment (SLERA). Note that the majority of the ESVs were EPA Ecological Soil Screening Levels (EcoSSLs).*

**USFS #8** <u>§3.0 Summary of the terrestrial BPMD SLERA, Introduction, 2nd paragraph</u>: Eco-SSLs (= ESVs) [Exposure Screening Values] are concentrations of contaminants in soils (specifically; there are ESVs for other matrices) that are protective of ecological receptors that commonly come into contact with soil or ingest biota that live in or on soil. There are four steps that are generally involved: (1) literature searches of toxicity and susceptibility, (2) select literature using exclusion and acceptability criteria, (3) determine applicability in deriving an Eco-SSL, and (4) derive the value.

*<u>EPA Response #8</u>: This comment was made in response to USFS #7. The revised ESV description does not go into as much detail as provided in this comment when responding to USFS#7, but full citations to respective ESV source references were provided and can be reviewed for more information on ESV derivation.*

**USFS #9** <u>§3.4 Risk ranking and COPEC summary, 3rd bullet</u>: Why do birds have low ESVs?

*<u>EPA Response #9</u>: This comment was addressed by adding a sentence that states birds are sensitive to lead and zinc because they are susceptible to exposure and suffer from biochemical dysfunctions at low doses.*

**USFS #10** <u>§3.4 Risk ranking and COPEC summary, 3rd bullet</u>: [U.S. Forest Service response to comment USFS #9] This reflects their susceptibility to both the pathway of exposure and the bioaccumulation of certain contaminants.

*<u>EPA Response #10</u>: This comment was made in response to USFS #9. No action items are associated with this comment.*

**USFS #11** <u>§4.2 Sources of contamination, 2nd paragraph</u>: Suggest changing waste rock to mined rock globally. Miners may still consider residual from mining or milling as personal property and want to process again.

*<u>EPA Response #11</u>: EPA agrees that "waste rock" may be still valuable to mine claim owners and that the term may contrary to this fact. However, the term is widely used throughout the industry and by definition is waste until deemed economically viable to process. Replacing this term would require substantial changes to the terrestrial SLERA and BERA Work Plan (WP) text, tables, and figures and will therefore not be considered. However, new text was added in Section 3.1 to clarify that waste rock may still have value to, and is the property of, claim owners. The same description will be added to the terrestrial SLERA.*

**USFS #12** <u>§4.2 Sources of contamination, 4th paragraph</u>: RMRS can provide source-risk assessment for sediment delivery to aquatic resources. Our Geomorphic Road Analysis and Inventory Program (GRAIP) can be used for empirical analysis and the GIS-based platform (GRAIPLite) used for empirical analysis and the GIS-based platform (GRAIPLite) which was funded by EPA can be used to highlight at-risk areas for further analysis. Sidebar: This is one element of the exposure pathway for fens and alpine wetland systems where the road cuts have hydraulically altered them. Roads that disrupt groundwater connections to fens AND contribute contaminated sediment can disrupt these systems and the ecological values they provide.

*<u>EPA Response #12</u>: This comment offers help with determining potential impacts from roads. EPA may request such information in the future, but it is not needed to help develop a Conceptual Site Model (CSM). As such, there are no action item associated with this comment.*

**USFS #13** <u>§4.5 Routes of entry, 2nd paragraph</u>: Why is this difficult to characterize? It would seem as though the effects from contact with water could be substantial to semi-aquatic wildlife.

*<u>EPA Response #13</u>: This comment was addressed by explicitly stating why reported exposure routes were difficult to characterize. This reasoning was also supported by citing EPA (2007b) which provides guidance on conducting metals-based risk assessments.*

**USFS #14** <u>§4.5 Routes of entry, 2nd paragraph</u>: Selecting representative semiaquatic species (American Dipper; Beaver; Boreal Toad) allows insight into exposure pathways via both diet and contact. Dipper have transient contact with surface water while feeding but consume aquatic invertebrates that have been continuously exposed (dietary > contact). Beaver have a moderately greater terrestrial diet source but higher contact. This is conceptualized in the exposure pathways described in the next section.

*<u>EPA Response #14</u>: EPA agrees that some wildlife receptors have higher affinity for exposure to contaminants via direct contact. However, this exposure pathway is considered minor for metals-based risk assessments; see USFS #13 comment and*

*terrestrial BERA WP changes. Also note that direct contact exposure models for wildlife receptors are not readily available.*

**USFS #15** <u>§4.7 Exposure pathways, 2nd bullet</u>: What about ingestion of plants/other inverts?

*<u>EPA Response #15</u>: Section 4.7 provides a list of the exposure pathways which will be evaluated in the terrestrial BERA. Ingestion of plants and invertebrates by invertebrates cannot be reliably characterized. As such, it will not be added to the list of pathways that will be considered. However, this exposure pathway was added to the minor and/or difficult list of exposure routes listed in Section 4.5.*

**USFS #16** <u>§4.7 Exposure pathways, 2nd bullet</u>: Agree [with comment USFS #15].

*<u>EPA Response #16</u>: See EPA's response to comment USFS #15.*

**USFS #17** <u>§5.3 Endpoint selection, 1st paragraph</u>: How will the difference in contribution of the mine site to "appropriate" reference site within BPMD be statistically measured? The BPMD geology and hydrogeology varies significantly within a drainage and across the whole BPMD site….so that would imply many reference sites that may or may not vary statistically vary from mined material. "To ensure the long-term sustainability of ecosystems, humans must manage within the physical and biological capabilities of the land, maintain all of the ecological components and processes, and not irreversibly alter ecosystem integrity and resilience. The concept of sustainability is a fundamental component of the LRMP and is guided by the Multiple-Use Sustained-Yield Act (MUSY) and the FLPMA. The MUSY directs that federal lands are managed in a manner that provide a framework of social, economic, and ecological conditions that sustain native ecosystems, support a diversity of native plant and animal species, and provide a continuous flow of goods and services to the nation." Vol II San Juan NF LRMP

*<u>EPA Response #17</u>: This comment pertain to how risk from reference vs. impacted areas will be assessed. The current approach is to use a "total risk" characterization approach that does not attempt to characterize "incremental risk" which is subtracting out risk from reference areas or by comparing reference-area risks to impacted-area risks. This approach is explained at the end of Section 8.2, <u>Risk estimation and description methods</u>. Section 8.2 was rewritten to make this point more clear. No changes were made to Section 5.3 regarding this comment; please refer to Section 8.2. Also, note that more details on the selection, location, and number of reference and impacted sampling areas will be provided in Sampling and Analysis Plans (SAPs) that will be provided to the Biological Technical Assistance Team (BTAG) for review and comment.*

**USFS #18** <u>§5.3 Endpoint selection, Assessment Endpoint #1</u>: Thinking out loud: Tree cores? Dendrochronology would age the woody vegetation, associate it with climate (& seasonal) cycles, and could (?) be analyzed for trace metals. Perhaps the tree cores could relate time sequences from mining activity and unmined (or areas not directly affected by waste rock) areas.

*<u>EPA Response #18</u>: Risk assessment endpoints are designed to characterize risk associated with current conditions. Although the commenters idea is fascinating, historical records of vegetation stress would have little value in characterizing current conditions.*

**USFS #19** <u>§7.2.1 Area use factors, 3rd bullet</u>: We are at the leading edge of geomorphology and stream morphology so being able to distinguish between mine material and other mass (stream bed) loading will be interesting. Granted there are "some" sites where there is definable evidence of mine material from "natural processes".

*<u>EPA Response #19</u>: This comment suggests that differentiating mine waste materials from other non-mine waste materials will be challenging. EPA agrees with the observation; however, the BERA will not attempt to distinguish between mine material and native floodplain soils. The current approach is based solely on elevation data to delineate and sample in floodplain depositional areas. No changes were made to Section 7.2.1 with respect to this comment.*

**USFS #20** <u>§7.2.1 Area use factors, 3rd bullet</u>: The siting proposals for the sludge waste repository has some analyses of geologic hazard. What was the source of that info (other than the Colorado Landslide Inventory)? Have other assessments been done (e.g., of alluvial fan deposits from natural mass wasting)?

*<u>EPA Response #20</u>: This comment was made in response to USFS #19 comment and suggests that there might be data that is available to distinguish mine waste material from native floodplain soils. Since floodplain areas will be delineated using elevation information, data sources that support distinguishing between mine waste and native soils will not be useful. No changes were made to Section 7.2.1 with respect to this comment.*

**USFS #21** <u>§7.2.2 Mine site halo categorization studies, 5th paragraph</u>: Never heard of this [X-Ray Fluorescence - XRF - meter], but I want one. Does this use a "global standard" for calibration or does it need to be calibrated relative to samples from the particular study area? See comment above about relating tree ring data to ambient soil conditions. Could the savings from doing soil chemistry along the transects by applied to the question of woody vegetation as receptors/sentinels.

*<u>EPA Response #21</u>: This comment was addressed by adding a general description of XRF technology.*

**USFS #22** <u>§7.2.4 Floodplain EU categorization, 1st paragraph</u>: How will the reference areas be determined? Many floodplain terraces are relicts of prior debris flows. Where these eroded mineral deposits they might represent a false positive. Does [San Juan National Forest] SJNF have aerial photography that could help determine stability of floodplains and alluvial deposits?

*<u>EPA Response #22</u>: The aquatic BERA reference reaches were determined and agreed upon by the BTAG. The terrestrial BERA uses the same floodplain EU designation used in the aquatic BERA. Note that overbank soil analytical chemistry data have become available for four of the five reference reaches since the aquatic BERA was drafted; see the terrestrial SLERA and Table 7.2 in the terrestrial BERA WP. This information, combined with future sampling, will provide additional reference area analytical data. The terrestrial BERA may change their designation if such data indicate that reference areas need to be re-categorized.*

**USFS #23** <u>§7.2.5 Floodplain exposure media sampling, last paragraph</u>: If lynx is used in food chain modeling, then tissue samples must be collected from snowshoe hares since lynx prey almost exclusively on hares.

*<u>EPA Response #23</u>: Small mammal sampling has since been replaced by modeling small mammal tissue concentration using published soil-to-small mammal uptake factors and equations for all the target metals; see revised Section 7.5 and new Table 7.6. Many of the soil-to-small mammal equations incorporate accumulation data for Leporid (rabbit and hare family) species. Therefore, the revised approach indirectly responds to this comment.*

**USFS #24** <u>§7.2.5 Floodplain exposure media sampling, last paragraph</u>: Generally, it is a safe assumption that most carnivores will consume the entire organism. Unless relative accumulation rates are of interest, whole organism samples should be taken. As an alternative, there's an abundant literature on the use of hair samples for determining metal contaminants. Use snag traps for hair, DNA to determine species, and analyze the hair for metals. Might make the public a little more agreeable than trapping and euthanizing mammals?

*<u>EPA Response #24</u>: As noted in EPA's response to comment USFS #23, small mammal sampling has been replaced by published soil-to-small mammal uptake factors and equations.*

**USFS #25** <u>§7.5.1 Canada lynx and golden eagle, 1st paragraph</u>: Lynx prey almost exclusively on snowshoe hares and occasionally red squirrels. Therefore, if the model is using other small mammals as primary prey, the model is going to substantially overestimate lynx exposure. I recommend collecting snowshoe hare tissue samples to run the model for lynx. Or perhaps using coyote as a receptor instead.

*<u>EPA Response #25</u>: See comment USFS #23 response.*

**USFS #26** §<u>§7.5.1 Canada lynx and golden eagle, 1st paragraph</u>: Lynx do not prey on birds. Golden eagles do.

*<u>EPA Response #26</u>: While EPA agrees that birds may not be a major dietary item for lynx, the Interagency Lynx Biology Team (2013) reports that this predator feeds on grouse across its range. This reference was added to support the original statement. Also, Kochert et al. (2002) was added to support that golden eagle prey on birds.*

**USFS #27** Appendix D, Target receptor species selection table: See below [USFS #28]

*EPA Response #27: See response to USFS #28.*

**USFS #28** Appendix D, Target receptor species selection table: Suggest replacing lynx with coyote. Lynx spends majority of its time in spruce-fir and preys primarily on snowshoe hare. Coyotes would likely have a higher exposure risk because they utilize more diverse habitat types than lynx. The risk associated with coyotes could then be extrapolated to lynx if necessary. If lynx is retained, suggest sampling snowshoe hares to get a more accurate assessment of risk.

*EPA Response #28: This comment was addressed by retaining lynx but adjusting the lynx Exposure Unit (EU) to only include lower elevation spruce-fir forest habitats in Mineral Creek, Cement Creek, Cunningham Creek, and the east side of the Animas River from Arrastra Gulch confluence to Eureka. This change required adding new text about Canada lynx exposure modeling in Section 7.5. Note that the coyote was added to the list target wildlife receptors to assess large home-range receptor exposure and risk over the entire BPMD assessment area. As such, the terrestrial BERA exposure characterization will assume that this omnivorous species forages over the entire BPMD assessment area. Coyote exposure modeling is described in Section 7.5.2.*

## United States Bureau of Land Management (BLM) Comments

**BLM #1** General Comment: Campsite areas were identified as one of three primary exposure units in the SLERA. However, campsite areas are mentioned in the BERA WP only in the context of sampling previously conducted for the SLERA (Section 3). Has the concept of campsite areas as an important ecological exposure unit been dropped? Recommend that the BERA WP provide some explanation as to the status of campfire areas so that there is continuity between the two documents.

> *EPA Response #29: Most of the campsites are located in floodplain areas that may have been impacted by past mining activities. While campsites do not provide optimal habitat for terrestrial receptors, species that are tolerant to human disturbances may use campsite as habitat. This concept was described in Section 3.3 when describing datasets used in the BPMD terrestrial SLERA. Campsite soil chemistry data are also now summarized and described with respect to ecological importance in the introduction of Section 7 Exposure Analysis. Additionally, campsite soil data were added to the overbank soils dataset and used when categorizing floodplain EUs into Dose-response Categories (DRCs); see Section 7.2.6 for more details.*

**BLM #2** General Comment: Are there any plans to evaluate bioavailability? The toxicity criteria may have been developed using material that is more or less bioavailable than the soil/sediment/water at BPMD. Recommend including some discussion of this important parameter and the possibility of collecting field data to evaluate bioavailability if needed.

> *EPA Response #30: EPA agrees that the current assumption of 100% bioavailability is conservative and that actual bioavailability of contaminants from exposure media is lower than 100%. This conservative assumption is commonly used in ecological risk assessments and will be used unless site-specific data dictate otherwise. That said, this issue will be discussed in the uncertainty section of the terrestrial BERA. The discussion may use decreasing assumed bioavailability (e.g., 100%, 50%, 25%, 10%) to evaluate the resulting Hazard Quotients (HQs). Also note that the current terrestrial BERA WP has incorporated available Synthetic Precipitation Leaching Procedure (SPLP) chemistry data when categorizing mine sites into DRCs; see Section 7.2.3. SPLP analyses are designed to simulate mobility of metals in waste rock from natural acidic precipitation (SERAS, 2005). Such data may provide some insight on the potential bioavailability of metals in waste rock to plants, which form the base of terrestrial food webs.*

**BLM #3** General Comment: Will the BERA incorporate any historical information or data available for the BPMD? If so, please provide a summary of the approach.

> *EPA Response #31: The terrestrial BERA will focus on recently-collected (within the last couple of years) and yet-to-be-collected environmental sampling. Environmental data from historical studies will not be used to estimate exposure, since the purpose of the terrestrial BERA is to evaluate the potential for ecological risk under "current" conditions. However, information from historical studies were used to develop the BERA WP. Examples of which include; BPMD-specific plant, animal and geologic surveys*

*conducted by Lyon et al. (2003), Larison et al. (2000), and Church et al. (2007), respectively. A new paragraph was added to the introduction in Section 7 Exposure Analysis that clearly states which data will be used in the terrestrial BERA.*

**BLM #4** General Comment: In Section 1 and elsewhere the distinction between "current" and "future" needs to be clarified. Section 1.1 has a specific goal of describing current conditions in the BPMD are, while Section 7 repeatedly refers to the "future terrestrial BERA". Recommend defining how the concepts of current and future are being used in the context of this WP and the BERA.

*EPA Response #32: EPA agrees that the "current" and "future" terminology associated with descriptions of the terrestrial BERA is unclear and confusing. This terminology was originally added to clarify that the planned terrestrial BERA will be separate from aquatic BERAs that have been conducted at the site. EPA has removed this terminology with respect to terrestrial BERA descriptions and will assume that readers will understand that the "terrestrial BERA" refers to the final BPMD terrestrial risk assessment.*

**BLM #5** §3.5 BERA COPEC selection, 3rd paragraph: Recommend adding more discussion as to how COPECs were selected. The connection between the list of [Contaminants of Potential Ecological Concern] COPECs in Table 3.1 and the tables in Appendix C needs clarification. Were COPECs for each receptor class based on an HQ >1 for a chemical in any of the three exposure areas?

*EPA Response #33: Section 3.5 was revised to include a more detailed description of the COPEC-selection process. This revised text now includes a reference to Appendix C.4 table that summarizes HQs for each of the four receptor groups. Additional revisions were made to the description of bioaccumulative metals so that metals added due to bioaccumulation potential did not include those that were added due to HQs > 1.0. These revisions should provide clarification on the COPEC-selection process and address this comment.*

**BLM #6** §3.5 BERA COPEC selection, Table 3.1: Please add a footnote stating "X" indicates that a chemical has been selected as a COPEC for that receptor group.

*EPA Response #34: This comment was addressed by defining "X" with a footnote in Table 3.1.*

**BLM #7** §5.3 Endpoint section, 1st paragraph: Should any of the endpoints or risk questions consider the possibility of future contaminant migration? Do the "future risk management decisions" mentioned in Section 5.1 consider future contaminant movement? The halo area model mentioned in Section 7.2.2 may be useful to estimate future contaminant migration.

*EPA Response #35: Future risk management decisions will be based on risk assessment endpoints and measurement results that will rely on current data and data that has yet to be collected. Assessment and measurement endpoints were designed to characterize* *current conditions so that future management decisions are based on current ecological risks. As the commenter brought up, the proposed exposure analysis approach may provide information on future contaminant migration. For example, mine site halo area studies will help characterize the extent of contaminant migration from mine waste piles to surrounding soils and biota. However, contaminant migration is not something that can be quantified for risk by identifying assessment and measurement endpoints. Therefore, risks associated with contaminant migration will not be characterized using assessment and measurement endpoints.*

**BLM #8** <u>§8.2 Risk estimation and description methods, 4th paragraph</u>: This section defines low, medium and high risk as a tight range of HQs between <2 and >5. Given that screening level risks in the SLERA were in the thousands, is this range realistic or should it be expanded?

<u>*EPA Response #36*</u>*: The binning of HQs into risk categories was proposed as a way to efficiently describe risk characterization results in the terrestrial BERA. After further internal deliberations, EPA decided not to place the terrestrial HQs into risk categories because it limits the interpretation of the results associated with specific risk drivers and potential biases associated with uncertainties. The future terrestrial BERA will simply assume that HQs > 1.0 identify the presence of potential risk. Such risk will be evaluated with respect to the range of HQs generated for each endpoint; from the most conservative reasonable maximum exposure/no-effect toxicity value based HQs to least conservative central tendency exposure /low-effect toxicity value based HQs.*

**BLM #9** <u>§8.2 Risk estimation and description methods, 5th paragraph</u>: It is stated that "EPA believes that the best way forward is to present and discuss total risk in the risk characterization and then determine in post-BERA risk management discussions with the BTAG how best to account for local reference conditions." BLM is of the opinion that risk estimates should be explicitly discussed in the larger context of site, background, and incremental risks. Although risk managers will eventually make the site decisions, the risk assessors must ensure that the risk values they review are kept in the appropriate context. Recommend that this section be revised to include greater detail regarding the importance of background to understanding total site risks.

<u>*EPA Response #37*</u>*: The terrestrial BERA will quantify total risk for large home-range receptors with EUs that span NPL site impacted and non-NPL site impacted habitats. This approach provides the most ecologically sound exposure scenarios associated with large home-range receptors. Smaller home-range receptors, EUs are specific to either one of the three four DRCs that includes reference floodplain EUs. Therefore, the terrestrial BERA should provide enough information to semi quantitatively evaluate incremental risk to smaller home-range receptors from reference floodplain area exposures. Reference floodplain EUs are the same reaches used in the aquatic BERA and were selected by the BTAG. Any risks identified at reference floodplain EUs will fully discussed in the terrestrial BERA uncertainty section. Section 8.2 was rewritten to make these points clearer.*

## New Mexico Environment Department (NMED) Comments

**NMED #1** General Comment: Overall, both drafts are well written and the proposed methodologies explained effectively. The methods described are consistent with EPA guidance and the ongoing upstream work is consistent with approaches for ecological risk assessments described in the NMED Risk Assessment Guidance for Site Investigations and Remediation, Volume II Soil Screening Guidance for Ecological Risk Assessments March 2017.

> *EPA Response #38: No action items are associated with this comment.*

**NMED #2** General Comment: In general, NMED urges that future work consider BTAG recommendations to evaluate reaches located further downstream. For example, the previous BERA WP 2016 proposes a future addendum BERA for "Durango Reach EUs" described as EU-DR1: Animas River – James Ranch to 32nd Street, and EUDR2: Animas River – 32nd Street to Purple Cliffs (see BTAG WP 2016, p. 2 and p. 6). During the BTAG meeting it was suggested that additional sediment testing may be warranted for this reach, and we agree that the BERA work should be expanded accordingly.

> *EPA Response #39: This comment is out of place for the current terrestrial BERA WP and more appropriately applied to future BPMD aquatic risk assessments. EPA acknowledges this comment and will consider NMED's suggestion in the context of future aquatic risk assessment activities.*

**NMED #3** §3.4 Risk ranking and COPEC summary, 3rd bullet: Considering the SLERA risk ranking discussion in this summary, the information for Pb-related bird [Toxicity Reference Values] TRVs in Table 6-4 does not relate well with the soil ESVs for Pb in EUs described in Appendices C.1-3. This could also affect the HQ for Pb.

> *EPA Response #40: The SLERA used no-effect ESVs (EcoSSLs) that were based on concentrations of COPECs in soil (mg of COPEC/kg soil) as reported in EPA (2005a). As noted in this comment, these ESVs are provided in Appendix C tables. However, Table 6.4 provides TRVs for birds. These toxicity values represent concentration of COPECs in diet (mg of COPEC/kg body weight [BW]/day) and therefore represent a very different measurement unit than the lead EcoSSL. EPA (2005a) derived the soil-based ESV for lead in birds (11 mg/kg) from the dietary-based TRV for lead in birds (1.63 mg lead/kg BW/day) using factors to estimate the transfer of chemical from soil, sediment, or water to dietary media and receptor-specific exposure parameters. Therefore, the lead ESV and TRV for birds are from the same toxicity study, but are presented in different units. Please refer to EPA (2005b; 2007a) for more information on ESV/EcoSSL derivation methods.*

**NMED #4** §4.4 Contact point and exposure media, 1st paragraph: Suggested edit for missing information.

*<u>EPA Response #41</u>: The EPC [Exposure Point Concentration] acronym is first defined in Section 3.1 and also defined in the acronyms list. Therefore, no changes were made to Section 4.4 with respect to this comment.*

**NMED #5** <u>§4.6 Key receptor groups, 1st paragraph</u>: Are migratory terrestrial wildlife included/considered here? If so, could this be mentioned?

*<u>EPA Response #42</u>: Yes, migratory wildlife species are considered and some were selected as target receptors for evaluation in the terrestrial BERA. This comment was addressed by adding a sentence to Section 4.6 stating that year-round residents, seasonal residents and migratory wildlife species were considered.*

**NMED #6** <u>§4.7 Exposure pathways, 1st paragraph</u>: While these represent a refinement (i.e., subcategories of receptors), to be consistent, and to avoid confusion, the receptors could be aligned or least cross-walked (i.e., in a table) with their respective endpoints in Section 5.2.

*<u>EPA Response #43</u>: EPA agrees that a cross-walk table would be useful in explicitly aligning assessment and exposure endpoints to receptors. This comment was addressed by drafting <u>Table 5.2 Summary of exposure pathways and respective target receptors associated with each assessment endpoint</u>.*

**NMED #7** <u>§4.7 Exposure pathways, 2nd paragraph</u>: We note the approach is consistent with NMED guidance.

*<u>EPA Response #44</u>: No action items are associated with this comment.*

**NMED #8** <u>§5.2 Selecting representative assessment endpoint communities or species, 1st paragraph</u>: Suggest tying this information to proposed groups in the key exposure pathways described in Section 4.

*<u>EPA Response #45</u>: See comment NMED #6 response.*

**NMED #9** <u>§5.2.1 Plants and invertebrates, 2nd paragraph</u>: More discussion could be included here on why terrestrial aquatic invertebrates are included vs. semi-aquatic invertebrates (which are not covered in the BERA WP). Alternatively, it could be mentioned in this report where semi-aquatic invertebrates are considered (i.e., in a previous or planned BERA or study).

*<u>EPA Response #46</u>: This comment was addressed by revising the invertebrate receptor selection text to include information on why soil invertebrates were considered as target receptors that will be evaluated in the terrestrial BERA. This description also included information on semi-aquatic invertebrates and why they will be evaluated in aquatic risk assessments.*

**NMED #10** §5.2.2 Wildlife species, 1st paragraph: suggested edit.

> *EPA Response #47: This comment was addressed by adding the suggested edit to Section 5.2.2.*

**NMED #11** §5.3 Endpoint selection, last paragraph on page 20: How will such qualitative assessment be documented, i.e., habitat assessment forms, etc.? This kind of detail will be covered in a future SAP/QAPP [Sampling Analysis Plan/Quality Assurance Project Plan], but it would be helpful to describe or reference how physical habitat suitability will be assessed for this endpoint.

> *EPA Response #48: The aforementioned assessment of plant habitat was not intended to be based on field survey data. This statement was made because certain locations within the BPMD assessment area are not expected to support plants. As such, these areas will not be considered when estimating exposure and risks to plants. The section was rewritten to make this point clear. Note that the similar section for invertebrate Assessment Endpoint #2 was also edited to make this same point.*

**NMED #12** §5.3 Endpoint selection, 1st bullet: Semi aquatic inverts already covered (i.e., in previous BERA)?

> *EPA Response #49: This section and the entire terrestrial BERA WP was edited to specify that soil invertebrates and not terrestrial invertebrates will be considered under this assessment endpoint. This change and edits associated with comment NMED #9 should address this comment here and throughout the current terrestrial BERA WP.*

**NMED #13** §6.1 Introduction, second paragraph: Methods seem consistent with NMED ecological risk assessment guidance 2015/see pp. 19-20.

> *EPA Response #50: No action items are associated with this comment.*

**NMED #14** Table 6.4 and Appendices C1-C3: For Pb, the lowest ESV [1.63 mg/kg body weight/day] among the Tables 6.2 – 6.5. So, following the SLERA methodology which this BERA WP 2017 expands upon, what is the basis for using the ESV of 11 in Appendix C.2? Why not use no-effect for birds from Table 6-4? This could also affect the HQ calculations.

> *EPA Response #51: See response to comment NMED #3*

**NMED #15** §7.5.1 Canada lynx and golden eagle, 1st paragraph: Minor typo, suggested delete “a” in front of LWAs.

> *EPA Response #52: This comment was addressed by deleing “a” in the aforementioned paragraph. Note that this typo was also fixed in other similar sections.*

## Sunnyside Gold Corporation (SGC) Comments

**SGC #1** §2.4 Non-mining impacts, $2^{nd}$ paragraph, last sentence: Suggest rewording as follows: "Mountain goats, in particular, can be disturbed…"

> *EPA Response #53: This comment was addressed by making suggested edit.*

**SGC #2** §3.1 Mine wastes, $1^{st}$ paragraph: When discussing COPEC selection, please add a reference to the draft SLERA. Include mention that the SLERA is intended to be used only to rank sites in terms of potential risk and not to assess risk at the sites.

> *EPA Response #54: This comment was addressed by making suggested edit.*

**SGC #3** §4.7 Exposure pathways, last paragraph: The last three sentences seem to indicate that wildlife exposure factors have not yet been selected, but values for the exposure factors are provided in Section 7. If the factors in Section 7 are to be used, please rephrase this paragraph to clarify.

> *EPA Response #55: The last paragraph in this section was amended to clarify that species-specific intake rates and dietary items are provided in Section 7.*

**SGC #4** §5.3 Endpoint selection, Assessment Endpoints #3 through #10: 1) In the second bullet of each assessment endpoint, a statement is made regarding the availability of the specific tissue data required for the measurement endpoints. In all cases, the phrase, 'or deemed unreliable' is included. Please provide more clarity with respect to the factors that would cause data to be deemed unreliable. 2) In the same bullets, a discussion of using published uptake factors or regression equations in the absence of data is provided. Please provide the source of the estimation methods to be used and a hierarchy for selection of such methods."

> *EPA Response #56: The phrase 'or deemed unreliable' was included in the statements on the availability of tissue data to call out cases were analytical data obtained from tissue samples are outside quality assurance, quality control (QA/QC) limits. In this context, data can be deemed unreliable for many different reasons, such as improper sample handling, storage and chain of custody, matrix interferences during analysis, and not meeting project-specified analytical QA/QC limits. These examples were added to the first occurrence of the 'or deemed unreliable' phrase. The second part of this comment pertains to using published uptake factors or equations to estimate dietary item tissue residuals from soil. EPA plans on using agency-approved uptake factors summarized in EPA (2007b) Table 4a or from studies cited in the same table. This information was added to the terrestrial BERA WP when first mentioned (Assessment Endpoint #3), but not repeated thereafter.*

**SGC #5** §5.3 Endpoint selection, Assessment Endpoint #5. 1) Please specify the type of invertebrate tissues to be used in the measurement endpoint. For example, Assessment Endpoint #6 indicates that terrestrial invertebrates will be used in the measurement endpoint while Assessment Endpoint #7 indicates that soil invertebrates will be used in the measurement endpoint. 2) Please clarify if terrestrial and soil invertebrates are intended to be two separate sample types."

> *<u>EPA Response #57</u>: The terminology associated with describing invertebrate types was revised throughout the entire terrestrial BERA WP to clarify what is being assessed. Revisions specify whether invertebrates are soil invertebrates (earthworms), flying insects, or ground-dwelling insects. Soil invertebrates are considered in Assessment Endpoint #2; via direct exposure to soil. All three invertebrate types will be sampled and analytical results used to estimate wildlife receptor exposure. The three invertebrate types will be specific to one of three invertebrate sampling methods first described in Section 7.2.4.*

**SGC #6** <u>Table 6.2 and 6.3</u>: Footnote 'b' in both tables indicates that the values designated with a 'b' are no effect screening levels, but the same footnote appears for both no effect ESVs and low-effect ESVs. Please clarify.

> *<u>EPA Response #58</u>: This comment was addressed by re-defining and adding new footnotes to identify sources of ESVs in each of the two tables.*

**SGC #7** <u>Table 6.4 and 6.5</u>: These tables contain inconsistent lists of chemicals that do not match the COPEC list for wildlife provided in Section 3.5. Please revise for consistency.

> *<u>EPA Response #59</u>: Section 3.5 was substantially revised to better match COPECs listed in Table 6.4 and 6.5. Note that the COPECs identified in Table 3.1 match respective receptor tables Table 6.2 through 6.5 and Appendix 3 C.4 SLERA maximum HQ table.*

**SGC #8** <u>§6.2.2 Wildlife receptors, 2nd paragraph</u>: Additional explanation, especially for the low-effect TRVs, would be helpful. Information should be provided regarding the derivation process for the TRVs. For TRVs derived from a single study at a minimum, test species, effect observed, and other information pertinent to review of the TRVs should be provided. In addition, the low-effect TRVs presented in this table are different than were used in the 2015 aquatic assessment for wildlife. Please indicate why different TRVs were selected.

> *<u>EPA Response #60</u>: Section 6.2.2 of the terrestrial BERA WP was extensively edited to provide more detail on the process for selecting and deriving TRVs. The revised text also explains why the low-effect TRVs used in the aquatic BERA were not used in the terrestrial BERA.*

**SGC #9** <u>§6.3 Site-specific wildlife toxicity studies, 1st paragraph</u>: No information is provided as to if or how information from the cadmium toxicity study for the ptarmigan will be utilized in the BERA. Please provide some indication of how these data will be used.

> *<u>EPA Response #61</u>: This comment was addressed by adding a summary paragraph to this section that explicitly states how the Larison et al. (2000) ptarmigan field study information was considered to help develop the terrestrial BERA WP.*

**SGC #10** <u>§7 Exposure analysis, general comment</u>: It would be helpful to the reader to move Section 7.4, Wildlife Exposure Modeling closer to the beginning of this section. The use of EUs, DRCs, and AUFs is somewhat non-standard for a BERA and Section 7.2 is difficult to follow without prior knowledge of how the exposure terms are applied in the exposure calculation. By putting the exposure modeling section in front of the exposure term explanations, references to later sections could be put into the modeling section making the use of each term more transparent to the reader.

> *<u>EPA Response #62</u>: EPA agrees that the wildlife exposure modeling approach is complicated with many interrelated pieces. Section 7.2 was largely rewritten and should be easier to follow. However, the wildlife modeling section was not moved to the beginning of the Section 7. Section 7.4 and 7.5 provide detailed descriptions of wildlife exposure modeling that reference and rely on all of the information described in previous sections. Therefore, moving the exposure modeling section to the beginning of Section 7 would be difficult and likely also lead to some confusion. EPA expects that revised Section 7 is now clearer and easier to follow.*

**SGC #11** <u>§7.1 introduction, 3rd paragraph</u>: 1) The first sentence in this paragraph indicates that additional data will be collected in 2017. Please provide a reference to the pertinent section discussing the data collection. 2) The next to the last sentence indicates that the [Reasonable Maximum Exposures] RME exposure will be calculated using 95th [Upper Confidence Levels] UCLs unless the datasets are too small. How small is too small? Can the data collection planned in 2017 be used to ensure adequate data are available to avoid having data sets that are too small?"

> *<u>EPA Response #63</u>: The first part of this comment was addressed by describing that the 2017 sampling effort will reflect the data needs described in subsequent exposure analysis subsections. Additional information on data that will be considered in the terrestrial BERA was also provided. The second part of this comment was addressed by expanding on RME/95% UCL description to include reference to data variability. 95% UCL calculations depend not only on the size of the corresponding dataset, but also on the variability between values in the dataset. Highly-variable data yield impractically-large UCLs, especially with small datasets (EPA, 2013). Conversely, practical UCLs could be calculated using a small dataset when data have low variability. There is no set sample size that guarantees that a UCL can be calculated using ProUCL given the interrelatedness of sample size and data variability. However, EPA (2013) recommends that the minimum dataset size should be 10 observations with 6 or more detections. A sentence was also added to this paragraph stating that field studies will be designed so that samples sizes should be large enough to calculate 95% UCLs.*

**SGC #12** <u>§7.2 Exposure unit studies, general comment:</u> This section is unclear regarding what constitutes an Exposure Unit (EU) and what EUs will be assessed in the BERA. The previous section indicates that 25 floodplain and 5 reference floodplain EUs will be evaluated, but provides no information regarding upland EUs. The section discusses the Dose Response Categories (DRCs) to be sampled and the targeted receptors, but does not define what the EUs will be. Will each exposure unit be assumed to be representative of sufficient habitat to support a population of each wildlife receptor evaluated for that EU? Section 4.4 explains what an EU is, but defers the additional information on EUs to Section 7. Some additional discussion would be helpful.

> *EPA Response #64: This comment was addressed by adding a new paragraph to the end of Section 7.2 that introduces the types of EUs and how EUs relate to DRCs. This new text provides a clear introduction to the AUFs and subsequent exposure modeling sections.*

**SGC #13** §7.2 Exposure unit studies, 1st paragraph: Please provide additional information or reference to pertinent sections in the document where the methodology for selection and categorization of Dose Response Categories (DRCs) is defined.

> *EPA Response #65: This comment was addressed by adding references to the mine site halo area and floodplain EU DRC categorization sections.*

**SGC #14** §7.2 Exposure unit studies, 2nd paragraph: The draft SLERA described in this Work Plan categorizes risk potential into 3 categories (higher-, moderate, and lower-risk) but the DRCs are only defined for high-level and low-level categories in addition to reference. This could be important for the mined areas that had no sites in the lower-risk category. Does that indicate that all mined areas will be assessed risk in the same high-level DRC?

> *EPA Response #66: A fourth DRC was added so that the terrestrial BERA WP better matches the terrestrial SLERA. The revised set of DRCs now include high-level, mid-level, low-level, and reference exposure categories. Note that the terrestrial SLERA also uses similar higher, moderate, and lower risk categories when describing risk at mine sites, floodplain reaches, and campsite EUs. While these categories and subsequent EU classifications are useful in determining floodplain DRCs they were not useful for categorizing mine sites/halo areas. The reason is partly because no mine sites fell into the lower-risk category. Given this disparity, the terrestrial BERA WP uses a different categorization approach than the one employed in the terrestrial SLERA. This approach is described and categorization results are provided in the new Section 7.2.3.*

**SGC #15** §7.2.1 Area use factors, 1st paragraph: It is unclear in this section how the AUFs will be calculated. Will the AUF represent the proportion of a total EU that is made up of the specific habitat types? The habitat types are well described, but the reader is not informed of how the described measurements will be applied to the exposure assessment.

> *EPA Response #67: This comment was addressed by rewriting the last paragraph in Section 7.2.1 to include specific description of how AUFs are derived to represent the proportion of specific habitat types in large home-range receptor EUs and applied in food chain models.*

**SGC #16** §7.2.2 Mine-site halo categorization studies, 2nd paragraph: The discussion of the Halo Area Model (HAM) is limited and provides only general details regarding what the planned model will entail. It also provides an assumption of a measureable and significant relationship between the footprint of waste rock piles and the total halo acreages. A contingent plan should be provided for how the data will be evaluated if a measureable and significant relationship is not identified.

> *EPA Response #68: The terrestrial BERA WP no longer considers HAM derivation and application. After considering BTAG input, EPA realized that such a model may be more complex than needed and might not reliably estimate halo area acreages. The terrestrial BERA WP describes the new process of estimating halo area acreages. This approach is similar to the previous one, except that halo acreages will be estimated using a conservative assumption of the proportion of the waste rock pile size. Halo area field survey data will be collected and assessed to identify conservative estimates. This approach, and related data collection activities, are described in the revised Section 7.2.2.*

**SGC #17** §7.2.2 Mine-site halo categorization studies, 3rd paragraph: The use of X-ray fluorescence (XRF) to delineate the extent of the halo is described, but little information is provided regarding the chemical sampling plan and planned statistical calculation of exposure concentrations within the halo. Please provide information regarding the minimum and maximum number of samples to be collected in each halo, the number of halos to be sampled, how exposure concentrations will be calculated in the halos (one EPC or EPCs for each halo), information on weighting of each chemical sample in the halo based on potential concentration gradients, etc.

> *EPA Response #69: This comment was partially addressed by adding more information on XRF survey methods. EPA believes that the requested level of detail about the number of samples and mine sites to be surveyed are better left to the corresponding SAP/QAPP. This way survey details can be dictated using the data quality objectives process. Note that the BTAG will have an opportunity to review and provide comments on the SAP/QAPP before its finalized.*

**SGC #18** §7.2.5 Floodplain exposure media sampling, 2nd paragraph: 1) This paragraph indicates that exposure will be estimated based on leafy plant parts and/or entire plant portions. Please specify that the entire plant portion either does or does not contain the root of the plant. If the root is to be sampled, please indicate which receptors are assumed to eat the root of the plant and indicate if the root of the plant will be washed to avoid double counting of the soil ingestion pathway. 2) A subset of samples should be collected as both washed and unwashed collocated samples. A statistical comparison should be conducted to determine if washing significantly changes the concentration in the plant samples. If it does, since soil ingestion is being treated separately, the soil ingestion pathway would be over-estimated by using unwashed samples."

> *EPA Response #70: The first part of this comment was addressed by removing plant root sampling. The herbivore and omnivore receptor exposure estimates will only consider leafy plant/aboveground live biomass sample results. The second part of this comment pertains to how plant samples will be prepared for chemical analysis. The current terrestrial BERA WP states that plants will not be washed but brushed off prior to*

*analysis. Therefore, any larger soil, dust, and foreign residues will not be included in sample. It is likely that unwashed plant tissue samples would contain more soil and dust than washed samples. Therefore, analysis of unwashed plant tissues could result in higher COPEC concentrations if soil and dust contain higher levels of metals than the plant tissues. Also note that published wildlife soil ingestion rates may account for incidental soil ingestion when foraging on plants. Therefore, not washing plants and using published soil ingestion rates would yield fairly conservative exposure estimates. EPA feels that using conservative exposure estimates outweighs potential refinement and use of resources needed to conduct a washed vs. unwashed comparison study.*

**SGC #19** §7.2.5 Floodplain exposure media sampling, 4th paragraph: Please expand the description of the small mammal samples to be collected. How many animals in a composite sample? Will composite samples be single species or mixed species? If multiple samples are planned for each location, single animal samples should be considered and a minimum number of samples needed should be identified.

*EPA Response #71: The terrestrial BERA WP no longer discusses collecting small mammals for chemical analysis and exposure modeling. Published soil-to-small mammal tissue uptake factors and equations will be used instead. These uptake factors and equations are COPEC-specific, and will be applied to the RME and CTE soil concentrations for respective receptor EUs. Section 7.5 provides more information on this subject.*

**SGC #20** §7.3 Exposure to plants and invertebrates, 1st paragraph: The EUs presented in Table 7.3 are potentially confusing. EUs should be described in Section 7.1 and a table showing each EU and the receptors to be evaluated in each EU should be provided there.

*EPA Response #72: See EPA responses to comments SGC #10, #12, and #13.*

**SGC #21** §7.4 Wildlife exposure modeling, Dose from ingesting soil equation: Bioavailability of each COPEC should be acknowledged in this section and considered as part of the soil ingestion pathway. The calculations should be conducted assuming 100% bioavailability and then adjusted accordingly by COPEC.

*EPA Response #73: This comment was partly addressed by stating that the terrestrial BERA will assume 100% bioavailability. The EPA understands that assuming 100% bioavailability will result in conservative exposure and risk estimates but also believes that this approach is more defensible than what would be achieved by using published soil bioavailability data. However, those data may be used in the uncertainty section to further evaluate the HQs.*

**SGC #22** §7.4 Wildlife exposure modeling, Dose from dietary items equation: As presented, the equation does not provide calculation of dietary exposure for receptors ingestion multiple prey tissues. Please provide an equation that shows how multi-tissue ingestion will be calculated.

*EPA Response #74: Food chain models are further refined for each wildlife receptor in the next Section 7.5, Target receptor-specific exposure estimates. This section provides receptor-specific $C_{soil}$, $C_{water}$, and $C_{biota}$ models to calculate multi-tissue ingestion estimates. Also, note that tables 7.8 and 7.9 provide fractions of dietary items that will be used to estimate omnivorous wildlife receptor exposures.*

**SGC #23** §7.5 Target receptor-specific estimates, multiple subsections: Please provide additional details of how the length-weighted average [LWA] calculations for exposure media will be calculated. In the water section on Page 37, the LWA calculation discusses calculations related to time under each runoff scenario but it is not clear whether length indicates length of time in each runoff scenario or length of the floodplain in each EU. Since the soil EPC discusses the length of each floodplain EU, it appears that both factors are important for water.

*EPA Response #75: This comment was addressed by providing the requested level of detail for each of the LWAs presented in Section 7.5.*

**SGC #24** §7.5.2 Moose, Diet equation: Please provide a definition for FVLBA.

*EPA Response #76: $FV_{LBA}$ represented a floodplain vegetation length-weighted average and is no longer included in the terrestrial BERA WP as an exposure equation parameter. It was replaced with $FP_{VEG-LWA}$, which is defined when first presented in the WP. The acronym, FP is defined as "Floodplain sampling area (combined) exposure equation parameter" in the acronyms and abbreviations list.*

**SGC #25** §8.3 Uncertainty analysis, 1st paragraph: Please provide a list of major uncertainty topics that will be included in the BERA.

*EPA Response #76: This comment was addressed by adding a list of potential uncertainty topics to Section 8.3.*

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