EXECUTIVE SUMMARY OF DETERMINATIONS

The U.S. Department of the Interior (DOI), U.S. Department of Agriculture, and the Coeur d'Alene Tribe (collectively, the Trustees) have undertaken a natural resource damage assessment (NRDA) to assess injuries resulting from releases of hazardous substances from mining and mineral processing operations in the Coeur d'Alene River basin, Idaho. Section 107 of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) [42 U.S.C. § 9607], Section 311 of the Federal Water Pollution Control Act [33 U.S.C. § 1321], and the National Oil and Hazardous Substances Pollution Contingency Plan [40 CFR Part 300] provide authority to the Trustees to seek such damages.

This Report of Injury Assessment and Injury Determination presents a comprehensive evaluation of injuries to natural resources in the Coeur d'Alene River basin resulting from releases of mining-related hazardous substances. Natural resources of the Coeur d'Alene River basin that were assessed for injury include surface water; groundwater; bed, bank, and shoreline sediments; riparian and floodplain soils; aquatic biota, including both fish and aquatic invertebrates; wildlife, including birds, mammals, reptiles, amphibians; and vegetation. The area assessed for natural resource injuries includes the South Fork Coeur d'Alene River basin, tributary drainages to the South Fork Coeur d'Alene River in which mining and milling has occurred, the mainstem Coeur d'Alene River and lateral lakes and wetlands that border the lower river, and Coeur d'Alene Lake from the area near Conkling Point to the lake's outlet at the Spokane River.

The DOI has promulgated regulations for conducting NRDAs [43 CFR Part 11]. The Trustees relied on these regulations in assessing the natural resource damages. The application of these regulations is not mandatory, and the Trustees have the option of diverging from them as appropriate. However, assessments performed in compliance with these regulations have the force and effect of a rebuttable presumption in any administrative or judicial proceeding under CERCLA [42 U.S.C. § 9607 (f)(2)(C)].

S.1 RELEASE AND PATHWAY

Hazardous substances have been released from mining and mineral processing operations in the Coeur d'Alene River basin. Antimony, arsenic, cadmium, copper, lead, mercury, silver, and zinc. In particular, cadmium, lead, zinc, and compounds of these hazardous metals have been released from mining facilities. Sources of these releases of hazardous substances include smelter emissions, mill tailings, tailings piles and impoundments, waste rock piles, adit and seep drainage, and surface water, groundwater, sediments, and soils contaminated by releases.

Many of the releases went directly into the South Fork Coeur d'Alene River or its tributaries. The river's flow carried these hazardous substances downstream and deposited them in river, lake, and wetland sediments and on the banks and floodplains downstream. As a result of natural river flow and chemical processes, hazardous substances released from mining and mineral processing operations have been and continue to be remobilized and transported throughout the Coeur d'Alene River basin. These natural processes by which hazardous substances are transported in the basin are considered to be "pathways" [43 CFR § 11.14 (dd)].

Surface water serves as a critical transport and exposure pathway of these dissolved and particulate hazardous substances to soil, aquatic and terrestrial biological resources, and downstream surface water resources. Surface waters of the Coeur d'Alene River basin downstream of mining and mineral processing facilities have been and continue to be exposed to elevated concentrations of hazardous substances, and in particular, to elevated concentrations of cadmium, lead, and zinc. As a result of natural downstream transport mechanisms, surface waters throughout much of the Coeur d'Alene River basin, including the South Fork Coeur d'Alene River, the mainstem Coeur d'Alene River and associated lateral lakes, Coeur d'Alene Lake, and Canyon, Ninemile, Moon, Pine, Milo, Portal, Highland, Denver, and Nabob creeks and Grouse, Deadwood, Government, and Gorge gulches, are exposed to elevated concentrations of these same hazardous substances.

Sediments suspended in the water column and deposited on the beds and banks of Coeur d'Alene River basin drainages downstream of mining and mineral processing facilities also have been, and continue to be, a transport and exposure pathway of hazardous substances, and in particular, cadmium, lead, and zinc. Measurements of metals in suspended sediments have demonstrated transport of elevated concentrations of cadmium, lead, and zinc in both the South Fork Coeur d'Alene River and the mainstem Coeur d'Alene River as far downstream as Harrison. Bed and bank sediments throughout the basin, including Canyon and Ninemile creeks, the South Fork Coeur d'Alene River, the mainstem Coeur d'Alene River and associated lateral lakes, and Coeur d'Alene Lake, contain elevated concentrations of cadmium, lead, and zinc and other hazardous substances.

Contaminated streambed sediment results in exposure of fish, periphyton (algae attached to rocks in streams and rivers), and aquatic invertebrates to cadmium, lead, and zinc and other hazardous substances. Contaminated sediment re-deposited on floodplains and on vegetation surfaces is the predominant cause of exposure of wildlife and vegetation to cadmium, lead, and zinc and other hazardous substances.

Floodplain soils and sediments have been and continue to be a transport and exposure pathway.[1] Floodplain and wetland soils and sediments have become contaminated with hazardous substances through direct discharge of wastes to the floodplain, and through deposition of contaminated sediments through natural hydrological processes. Floodplain soils are contaminated with hazardous substances, in particular cadmium, lead, and zinc, in riparian and wetland areas downstream of mining and mineral processing facilities, including in riparian areas of the South Fork Coeur d'Alene River, the mainstem Coeur d'Alene River to its mouth near Harrison, the lateral lakes of the Coeur d'Alene River, and Canyon, Ninemile, Moon, and Pine creeks. Contaminated floodplain soils serve as an ongoing transport pathway to downstream resources through mobilization by surface waters and through leaching by groundwater. Contaminated floodplain soils also serve as a pathway by which vegetation and wildlife are exposed to cadmium, lead, and zinc.

Although comprehensive data are not available throughout the Coeur d'Alene River basin, available information illustrates that groundwater in certain locations (including lower Canyon Creek and the South Fork Coeur d'Alene River) acts as a pathway by which hazardous substances are transported through leaching of hazardous substances in contaminated floodplain deposits. Groundwater transports these hazardous substances to downgradient surface waters.

Biological resources serve as contaminant exposure pathways through dietary, food-chain relationships. Contaminated periphyton, aquatic and terrestrial invertebrates, and fish act as exposure routes of cadmium, lead, and zinc to higher trophic level consumers. Aquatic vegetation containing or coated with elevated concentrations of lead exposes waterfowl to lead through their diets.

S.2 EXPOSURE OF NATURAL RESOURCES TO HAZARDOUS SUBSTANCES

As a result of the above pathways, natural resources in the Coeur d'Alene Basin have been and continue to be exposed to elevated concentrations of the cadmium, lead, and zinc and other hazardous substances at and downgradient of releases from mining and mineral processing facilities.

1. The description of materials in a floodplain as soils or sediments is largely related to scientific discipline. Sediment is the term most frequently used by geologists, and soil by ecologists and biologists. Regardless of the nomenclature, soils and sediments are closely related spatially and functionally in riverine and riparian ecosystems. Both include substrates developed in place from weathering of parent materials and transported substrates, plus incorporated organic materials. Both are influenced by parent material in the uplands, weathering and erosion, fluvial mixing and sorting, deposition and burial, remobilization and redeposition, incorporation of organic materials, and geochemical transformations related to saturation and redox state. In this report, the terms "soils" and "sediments" are both used to describe substrate in the floodplains, banks, and wetlands of the basin.

Elevated concentrations of hazardous substances have been measured in surface waters, bed, bank, wetland, and shoreline sediments, and in riparian (streamside) soils downgradient of mining facilities in the South Fork Coeur d'Alene River, the mainstem Coeur d'Alene River, lateral lakes and wetlands of the Coeur d'Alene River, Canyon Creek, Ninemile Creek, Pine Creek, Moon Creek, Milo Creek, Portal Creek, Highland Creek, Denver Creek, and Nabob Creek, Grouse Gulch, Deadwood Gulch, Government Gulch, and Gorge Gulch. In addition, elevated concentrations of cadmium, lead, and zinc and other hazardous substances have been measured in surface waters and bed sediments of Coeur d'Alene Lake.

"Baseline"[2] concentrations of cadmium, lead, and zinc in surface water and sediments of the Coeur d'Alene River basin are low relative to concentrations in surface water and sediments near and downstream of sources of mining related waters. The elevated concentrations of hazardous substances measured downstream of mining sources are not naturally occurring. The metals that contaminate the basin are derived from mining and mineral processing operations.

Biological resources (such as fish, vegetation, wildlife) that rely on media such as surface water, soil, and sediments as part of their critical habitat are exposed to cadmium, lead, and zinc and other hazardous substances when these media are contaminated with hazardous metals. This exposure of biological resources to hazardous substances downstream of mining sources also has been confirmed through measurement of cadmium, lead, and zinc in biological tissues.

S.3 NATURAL RESOURCE INJURIES

As a result of this exposure to elevated concentrations of hazardous substances, and particularly cadmium, lead, and zinc, natural resources in the Coeur d'Alene River basin have been and continue to be injured.

Surface Water Injury

Surface water in the Coeur d'Alene River basin has been and continues to be injured as a result of releases of the hazardous substances cadmium, lead, and zinc. Surface waters of the Coeur d'Alene River basin are injured when concentrations and duration of hazardous substances exceed water quality criteria established by section 304(a)(1) of the Clean Water Act in surface waters that before the release met the criteria and are a committed use for aquatic life [43 CFR § 11.62 (b)(1)(iii)]. A committed use in this context means a current public use, including use as habitat for aquatic life [43 CFR § 11.14 (h)]. Based on State of Idaho use designations, U.S. Environmental Protection Agency water quality standards, and Coeur d'Alene Tribe water quality standards, the surface waters of the Coeur d'Alene River basin are currently designated for the protection and support of aquatic biota and therefore have a committed use.

2. Baseline concentrations are the concentrations of metals that would have existed absent the releases from mining and mineral processing operations.

Applicable water quality criteria are referred to as "Aquatic Life Criteria," or ALC. ALC include both "acute" and "chronic" criteria. The acute and chronic criteria specify concentrations of substances in water that cannot be exceeded for a specified average duration. The duration of exposure to water containing substances in concentrations exceeding the acute ALC is a 1-hour average. The exposure duration for chronic criteria is defined as a 4-day average concentration. Both values may not be exceeded more than once in a 3-year period. ALC for the hazardous substances cadmium, lead, and zinc are dependent on the "hardness"[3] of the water body. In general, the toxicity of cadmium, lead, and zinc to aquatic organisms decreases as water hardness increases. Therefore, exceedences of ALC are evaluated using the measured hardnesses of the surface water in question.

Concentrations of hazardous substances in surface water resources of the Coeur d'Alene River basin now exceed ALC, and have in the past have exceeded ALC, and the duration of exceedences also is sufficient to trigger exceedences of ALC. Given the substantial magnitude of the exceedences, as well as the very high percentage of samples collected during the past 30 years that exceed the ALC, the measured concentrations clearly meet both the 1-hour and 4-day average concentration standards. Moreover, exceedences are sufficiently frequent (approaching 100% of samples collected between 1967 and 1998) to indicate that the 3-year recovery period clearly is exceeded. Based on the concentration and duration of cadmium, lead, and zinc in surface water, these three hazardous substances exceed ALC and therefore cause injury.

Baseline water quality values for cadmium, lead, and zinc in the Coeur d'Alene River basin are low, as shown by the low concentrations of metals in stream segments upstream of mining operations in the basin and in streams draining unmined but mineralized tributary basins. Moreover, absent mining and mineral processing operations, even drainages with mineralized outcrops or near-surface mineral veins had low concentrations of cadmium, lead, and zinc in surface water. The ALC exceedences, and thus the surface water injuries, are caused by mining and mineral processing operations rather than by naturally occurring releases of metals.

Exceedences of ALC, and therefore surface water injuries, have been documented from the upper reaches of the South Fork Coeur d'Alene River (downstream of Daisy Gulch) to at least the lake outlet to the Spokane River (the downstream boundary of the assessment area). Exceedences also have been documented at the U.S. Geological Survey gauge station at Post Falls Dam on the Spokane River. Surface waters of the mainstem Coeur d'Alene River from the North Fork Coeur d'Alene River confluence to Coeur d'Alene Lake are injured, and surface waters of Coeur d'Alene Lake are injured. Exceedences of ALC have also been documented in tributaries of the South Fork Coeur d'Alene River, including Canyon Creek from approximately Burke to the mouth and Gorge Gulch downstream of the Hercules No. 3 adit; the East Fork and mainstem Ninemile Creek from the Interstate-Callahan Mine to the mouth; Grouse Gulch from the Star Mine waste rock dumps to the mouth; Moon Creek from the Charles Dickens Mine/Mill to the

3. Hardness is a measure of the concentration in water of two naturally occurring ions (calcium and magnesium), and is expressed in terms of concentrations of calcium carbonate.

mouth; Milo Creek from the Sullivan Adits to the mouth; Portal Gulch from the North Bunker Hill West Mine to the mouth; Deadwood Gulch/Bunker Creek from the Ontario Mill to the mouth; Government Gulch from the Senator Stewart Mine to the mouth; East Fork and mainstem Pine Creek from the Constitution Upper Mill to the mouth; Highland Creek from the Highland Surprise Mine/Mill and the Sidney (Red Cloud) Mine/Mill to the mouth; Denver Creek from the Denver Mine to the mouth; and Nabob Creek from the Nabob Mill to the mouth.

These exceedences of ALC confirm that surface waters have been injured as a result of releases of cadmium, lead, and zinc from mining and mineral processing operations. In addition, concentrations of hazardous substances in surface water are sufficient to cause injury to aquatic biological resources of the South Fork Coeur d'Alene River, the mainstem Coeur d'Alene River, and Coeur d'Alene Lake.

Sediment Injury

Sediment resources of the Coeur d'Alene Basin also are injured. Sediments include suspended sediments in the water column, and bed, bank, and floodplain sediments. Sediments carried in the water column are suspended sediments. Sediment resources are defined by DOI NRDA regulations both as geologic resources [43 CFR §11.14 (s)] and as a component of surface water resources [43 CFR § 11.14 (pp)]. However, because sediments represent a distinct component of the ecosystem, data on sediments are discussed separately from surface water. Injuries to sediments occur when concentrations and duration of hazardous substances are sufficient to have caused injury to other natural resources when exposed to sediments [43 CFR §11.62 (b)(1)(iv) and 43 CFR § 11.62 (e)(11)].

Coeur d'Alene River basin sediments containing elevated concentrations of lead and other hazardous substances are ingested by migratory birds. Ingestion of lead-contaminated sediments injures migratory birds in the Coeur d'Alene River basin, causing death and other adverse biological effects. Ingestion of prey contaminated by ingestion of lead-contaminated sediments also causes injury to predators. Therefore, sufficient concentrations of lead are present in sediments to cause injury to biological resources. In addition, concentrations of cadmium, lead, and zinc in sediments are sufficient such that sediments serve as a pathway of injury to surface water resources. As a result, sediments are injured.

Sediment injuries occur throughout the lateral lakes area and other wetland habitats in the basin where concentrations of lead in sediments exceed concentrations determined to cause both sublethal injuries and death to migratory birds. In addition, sediments throughout the floodplains of the South Fork Coeur d'Alene River and several of its tributaries, the mainstem Coeur d'Alene River, and Coeur d'Alene Lake contain hazardous substances in concentrations sufficient to serve as a pathway of injury to surface water.

Riparian Resources Injury

Surface water and sediments containing elevated concentrations of cadmium, lead, and zinc and other hazardous substances serve as transport and exposure pathways to floodplain soils of the Coeur d'Alene River basin. Floodplain soils and sediments in Canyon Creek, Ninemile Creek, Moon Creek, Pine Creek, the South Fork Coeur d'Alene River, and the lower Coeur d'Alene basin, including the Coeur d'Alene River and lateral lakes, contain elevated concentrations of cadmium, lead, and zinc. As a result, riparian vegetation is exposed to those hazardous substances.

Injury to riparian soils and vegetation is confirmed when hazardous substances are sufficient to cause a phytotoxic response (i.e., toxicity to plants), specifically, retardation of plant growth [43 CFR § 11.62 (e)(10)]. Injury also occurs when riparian vegetation suffers adverse changes in viability, specifically, reductions in vegetation cover, and simplification of community structure and composition [43 CFR § 11.62 (f)(1)(i)].

Floodplain soils of Canyon Creek, Ninemile Creek, and the South Fork Coeur d'Alene River were found to be phytotoxic (i.e., cause toxicity to plants) relative to control soils. Plant growth performance in field-collected assessment soils was measured under controlled laboratory conditions. Plant growth in contaminated soils was reduced relative to control soils, and plant growth was significantly negatively correlated with concentrations of hazardous substances in the soils. Concentrations of cadmium, lead, and zinc in floodplain soils of Canyon Creek, Ninemile Creek, the South Fork Coeur d'Alene River, Moon Creek, and Pine Creek exceed phytotoxic threshold concentrations identified in the scientific literature, and the observed reductions in plant growth are consistent with the phytotoxic effects of cadmium, lead, and zinc as reported in the scientific literature.

In the riparian zones of Canyon Creek, Ninemile Creek, and the South Fork Coeur d'Alene River, field studies show that extent of vegetation cover, species richness, and vegetation structural complexity are significantly negatively correlated with concentrations of cadmium, lead, and zinc in soils; percent cover of bare ground is significantly positively correlated with concentrations of these hazardous substances. In other words, increased concentrations of cadmium, lead, and zinc were related to increased bare ground and reduced vegetation.

Phytotoxic concentrations of cadmium, lead, and zinc in floodplain soils have resulted in significant and substantial reductions in riparian vegetative cover and an increase in the amount of bare ground in the riparian zones of Canyon Creek, Ninemile Creek, Moon Creek, Pine Creek, and the South Fork Coeur d'Alene River. The soil phytotoxicity and reductions in vegetation cover have resulted in significant reductions of habitat complexity and availability for wildlife species that inhabit riparian areas, and in deterioration of ecological functions.

Factors other than hazardous substances can cause impacts to vegetation. These factors include effects of fire, road construction, logging, grazing, road building and industrialization in the urban corridor, and other land uses. These other factors were considered as potential causes of the injuries observed in the Coeur d'Alene River basin. Riparian injury assessment studies were designed to sample vegetation cover, structure, and composition in reference stream reaches as well as in contaminated stream reaches. These reference areas were selected based on similarity of natural physical environmental controls on vegetation and on similarity of major nonmining environmental factors that affect plant growth and vegetation development. Reference areas incorporated historical effects of logging, splash dams and related erosion, road building, and channelization. Reference areas did not incorporate effects of urbanization, but sampling was not conducted in, and the riparian injury claim for vegetation, soils, and habitat does not include, urban riparian zones. Therefore, these other factors were considered in the design of the injury studies and are not the cause of the observed loss of vegetation in contaminated areas. The only factor that consistently explains the toxicity of the soils to plants and the continued preclusion of plant growth is the elevated concentrations of hazardous substances such as cadmium, lead, and zinc in the soils. Soil chemistry data, vegetation community measurements, phytotoxicity test results, and negative correlations between cadmium, lead, and zinc concentrations and plant growth in the laboratory, vegetative cover, species richness, and structural complexity in the field indicate that it is the elevated concentrations of these hazardous substances in floodplain soils of the upper Coeur d'Alene River basin that cause injury to riparian vegetation communities.

Injuries to riparian soils and vegetation caused by releases of the hazardous substances cadmium, lead, and zinc have occurred at and downstream of mining operations in the South Fork Coeur d'Alene River, Canyon Creek, Ninemile Creek, Pine Creek, and Moon Creek. The injuries to riparian soils and vegetation have substantially reduced the quality of riparian habitat. This, in turn, injures critical habitat that supports wildlife, aquatic biota, and other ecosystem functions.

Fish Injury

Fish resources of the Coeur d'Alene River basin are injured as a result of exposure to hazardous metals (particularly cadmium and zinc, which are highly toxic to fish). Fish are exposed to hazardous substances through direct contact with surface water containing elevated concentrations of cadmium and zinc, and through food chain exposure. Fish resources have been injured in the South Fork Coeur d'Alene River, Canyon Creek, Ninemile Creek, and the mainstem Coeur d'Alene River, as well as other stream/river reaches affected by releases of hazardous substances from mining and mineral processing operations. Injured fish resources include resident, fluvial, and adfluvial species of the South Fork Coeur d'Alene River, the lower Coeur d'Alene River, and Coeur d'Alene Lake.

Injuries to fish include death [43 CFR § 11.62 (f)(4)(i)], as confirmed by *in situ* bioassays [43 CFR § 11.62 (f)(4)(i)(D)] and laboratory toxicity testing [43 CFR § 11.62 (f)(4)(i)(E)]; behavioral avoidance [43 CFR § 11.62 (f)(4)(iii)(B)], as confirmed by laboratory tests using fish placed in testing chambers in controlled laboratory conditions, and by field tests; and physiological malfunctions, including effects on growth [43 CFR § 11.62 (f)(4)(v)], and other physical deformations, such as histopathological lesions [43 CFR § 11.62 (f)(4)(vi)(D)], as confirmed by laboratory testing.

Sufficient concentrations of hazardous substances, particularly cadmium and zinc, exist in pathway resources now, and have existed in the past, to expose and injure fish of the Coeur d'Alene River basin. Concentrations of hazardous substances in surface water (including suspended and bed sediments), biofilm (attached algae and associated detritus), and aquatic invertebrates are elevated and are pathways of metals exposure and injury to fish. As noted previously, concentrations of cadmium, lead, and zinc in surface water exceed chronic and acute water quality criteria (ALC) for the protection of aquatic life.

Concentrations of cadmium and zinc in surface water of the South Fork Coeur d'Alene River, Canyon Creek, and Ninemile Creek are sufficient to cause acute mortality to trout. In *in situ* bioassays in the South Fork Coeur d'Alene River, laboratory bioassays using field collected waters, and laboratory bioassays using waters formulated to simulate conditions in the basin, concentrations of hazardous substances that occur in the South Fork Coeur d'Alene River caused acute mortality of rainbow trout and cutthroat trout.

Salmonids avoid water containing zinc at concentrations that occur in the South Fork Coeur d'Alene River, the lower Coeur d'Alene River as far downstream as Harrison, and in Coeur d'Alene Lake. *In situ* trials using chinook salmon and laboratory exposures using cutthroat trout have demonstrated behavioral avoidance of Coeur d'Alene River basin waters, and preference for water containing lower concentrations of zinc. The combination of laboratory and field studies demonstrated that salmonids would avoid zinc-contaminated water of the South Fork Coeur d'Alene River, the lower Coeur d'Alene River as far downstream as Harrison, Coeur d'Alene Lake, Canyon Creek, and Ninemile Creek. Therefore, avoidance injuries occur throughout these areas.

In controlled laboratory studies, ingestion by juvenile cutthroat trout of aquatic invertebrates from the South Fork and lower Coeur d'Alene rivers that were contaminated with cadmium, lead, and zinc was found to cause increased mortality, reduced feeding activity, and histopathological lesions.

Populations of trout species and other fish species have been reduced or eliminated by elevated concentrations of hazardous substances in the South Fork Coeur d'Alene River and its tributaries. Canyon Creek and Ninemile Creek are nearly devoid of all fish life downstream of mining releases of hazardous substances. Canyon Creek upstream of mining influences at Burke supports a population of native cutthroat trout. Similarly, other tributaries in the Coeur d'Alene system unaffected by mine wastes typically support populations of trout and sculpin, a native fish that

resides on stream bottoms. Fish populations in the South Fork Coeur d'Alene River are depressed downstream of the Canyon Creek confluence with the South Fork Coeur d'Alene River. A clear upstream-downstream pattern in fish population density is apparent in the river. Fish density is much greater in the South Fork Coeur d'Alene River upstream of the Canyon Creek confluence than downstream of it. Populations of sculpin and mountain whitefish are depressed in stream reaches affected by mining, whereas in reaches not affected by releases of hazardous substances from mining, these species are abundant. These fish population data are consistent with the conclusion that hazardous substances released from mining operations are causing injuries to fish. Thus, the population data are confirmatory of the toxicological information.

Other possible causes of fish injuries (such as channelization, logging, fires, introduction of exotic species, etc.) were evaluated. Field studies were designed to include sampling of reference locations to enable explicit consideration of many of these possible factors. Further, the nature, extent, and pattern of fish injuries and population responses, coupled with data showing that surface water causes acute lethality and other injuries to fish, demonstrate that releases of metals (particularly zinc and cadmium) injure fish.

Bird Injury

Migratory birds that rely on riparian, wetland, and open water habitats in the Coeur d'Alene River basin have been injured by hazardous substances. In the upper Coeur d'Alene River basin, birds such as migratory songbirds that rely on riparian habitats for food and cover have been injured as a result of the loss of vegetation in riparian zones of Canyon Creek, Ninemile Creek, Pine Creek, and Moon Creek, and the South Fork Coeur d'Alene River downstream of Canyon Creek. Migratory bird species (such as tundra swans, Canada geese, and various other species) have been injured as a result of direct ingestion of lead-contaminated sediments. In addition, migratory songbirds, which feed on insects, worms, and other invertebrates, exhibit physiological malfunctions from lead exposure, and are injured by ingestion of hazardous substances through dietary pathways.

Injuries to migratory birds include death [43 CFR § 11.62(f)(4)(v)], as demonstrated through wildlife kill investigations [43 CFR § 11.62(f)(4)(i)(C)] and controlled laboratory experiments [43 CFR § 11.62 (f)(4)(i)(E)]; physiological malfunctions [43 CFR § 11.62(f)(4)(v)], including inhibition of the blood-enzyme ALAD [43 CFR § 11.62(f)(4)(v)(D)], decreases in hemoglobin and hematocrit, increases in protoporphyrin (another chemical element of blood formation), and loss of body weight; and physical deformations [43 CFR § 11.62(f)(4)(vi)] such as lesions caused by exposure to lead at toxic concentrations.

The results of field investigations and controlled laboratory experiments demonstrate that death, physiological malfunctions, and physical deformation injuries to wildlife of the Coeur d'Alene River basin have occurred and continue to occur as a result of exposure to lead in Coeur d'Alene River basin sediments. Adverse effects that have been caused by lead exposure and have been observed in migratory birds in the field include death; physiological malfunctions, including

changes in parameters related to impaired blood formation and impaired growth; and physical deformations, including gross and histopathological lesions in multiple tissues.

Laboratory studies have demonstrated a dose-response relationship between the magnitude of exposure to Coeur d'Alene River basin sediment and physiological malfunctions such as biochemical changes in waterfowl. The injury assessment studies demonstrated a causal relationship between increasing sediment ingestion and adverse changes in parameters related to blood formation in multiple species of waterfowl.

Ingestion of lead-contaminated soil and sediment is the pathway and cause of the injuries to migratory birds in the basin. Injury studies were designed to explicitly assess whether the observed deaths and sublethal injuries were caused by other agents, including lead artifacts (e.g., shot/sinkers), disease (e.g., aspergillosis, avian cholera), or other factors (e.g., trauma). Detailed evaluation of field observations and diagnostic histological studies demonstrated that the cause of the injuries was exposure to lead-contaminated sediments. Therefore, injuries to migratory birds are caused by hazardous substances, particularly lead, released from mining and mineral processing facilities.

Benthic Invertebrate Injury

Benthic invertebrates (invertebrates that live in and on the bottoms of streams, lakes, and wetlands) are an important source of food for juvenile and small fish. Benthic macroinvertebrates in the assessment area are exposed to elevated cadmium, lead, and zinc concentrations in surface water, sediment, and biofilm. Concentrations of cadmium and zinc to which assessment area benthic macroinvertebrates are exposed exceed concentrations shown to cause toxicity. Toxicity tests using water and sediment collected from the assessment area demonstrate that assessment area surface water and sediment are toxic to invertebrates under controlled laboratory conditions.

Benthic macroinvertebrate communities in the South Fork Coeur d'Alene, Canyon Creek, Ninemile Creek, and other stream/river reaches are injured by metals. Specifically, metal-sensitive species are largely absent from the invertebrate communities of these waterways downstream of mining activity. Community composition was found to be inversely related to zinc concentrations in surface water. Historical data also demonstrate that the invertebrate communities in the mainstem Coeur d'Alene River and Coeur d'Alene Lake were adversely affected in the past, but more recent data on the communities in these areas are not available to confirm that the effects are continuing. However, physical deformation injuries, specifically, chironomid mouthpart deformities resulting from metals exposure, may be ongoing in the South Fork and mainstem Coeur d'Alene rivers.

Natural Resource Injury Conclusions

The above-referenced information demonstrates that hazardous substances (particularly cadmium, lead, and zinc) have been released from mining and mineral processing facilities; that the released hazardous substances are mobile in the environment and have been transported downgradient via natural processes such as water and sediment flow; that the transported hazardous substances have, in turn, caused substantial contamination in surface water, groundwater, sediments, soils, vegetation, and biota; that this contamination has resulted from releases from mine facilities and is not naturally occurring; that exposure to the hazardous substances released has resulted in, and continues to result in, substantial injuries to surface water, sediments, riparian soils, riparian vegetation, riparian wildlife habitat, fish, aquatic invertebrates, and wildlife; that exposure to hazardous substances has caused substantial losses of habitat and habitat services for various species of fish, aquatic invertebrates, vegetation, and wildlife; and that the injuries observed to natural resources have been caused by exposure to metals as opposed to some other factor.

S.4 INJURY QUANTIFICATION

Injury quantification includes determination of the baseline condition and baseline services of the injured resources, determination of the extent of the injuries and the reduction in services resulting from the injuries, and determination of the recoverability of the injured resources [43 CFR 11.70 (c)].

The purpose of injury quantification is "for use in determining the appropriate amount of compensation" in an NRDA [43 CFR § 11.70 (b)]. Because the Trustees' claim for compensation (i.e., damages) will be based on calculation of restoration costs and must include consideration and estimation of losses residual to any remedial or response actions undertaken in the Coeur d'Alene River basin by the U.S. Environmental Protection Agency or other response agencies, final injury quantification cannot be performed until remedial and response actions are determined and the Trustees prepare a restoration plan. Thus, the initial quantification of injury presented in this report is subject to change.

Baseline Conditions

Baseline refers to the conditions that would have existed had the releases of hazardous substances not occurred [43 CFR § 11.14 (e)]. Baseline services normally provided by the injured resources [43 CFR 11.72 (a)] include:

- ***Surface water services,*** such as habitat for migratory birds and their supporting ecosystem; habitat for fish and their supporting ecosystem; habitat for benthic macroinvertebrates and aquatic, semiaquatic, and amphibious animals; water, nutrients, sediments for riparian vegetation and its supporting ecosystem; nutrient cycling; geochemical exchange processes; primary and secondary productivity and transport of

energy (food) to downstream/downgradient organisms; growth media for aquatic and wetland plants; a migration corridor; and cultural services.

- ***Sediment services,*** such as providing habitat services for all biological resources that are dependent upon the aquatic habitats in the basin. In addition, bed sediment services contribute to services provided by surface water, including suspended sediment transport processes, security cover for fish and their supporting ecosystems, primary and secondary productivity, geochemical exchange processes, nutrient cycling and transport, and cultural services.

- ***Services provided by floodplain soils and sediments,*** such as habitat for all biological resources that are dependent upon riparian or floodplain wetland habitats in the basin. Floodplain soils and sediments provide habitat for migratory birds and mammals; habitat for soil biota; growth media for plants and invertebrates; primary productivity, carbon storage, nitrogen fixing, decomposition, and nutrient cycling; soil organic matter and energy (food) to streams; hydrograph moderation; geochemical exchange processes; and cultural services.

- ***Migratory bird services***, including providing prey for carnivorous and omnivorous wildlife, as well as existence values, food, recreational opportunities for humans, and cultural services.

- ***Fish services***, including providing food for other biota, existence values and recreational opportunities for humans, and cultural services.

- ***Riparian vegetation*** provides primary productivity; food and cover (thermal cover, security cover) for fish and migratory birds and mammals; feeding and resting areas for fish, and migratory birds and mammals; the migration corridor provided by the riparian zone; habitat for macroinvertebrates; nutrient cycling; soil/bank stabilization and erosion control; hydrograph moderation; and cultural services.

The services listed above are interdependent [43 CFR 11.71 (b)(4)] and interact to create a functional ecosystem. The injuries to natural resources have reduced individual resource services and services provided at the ecosystem level. The high degree of overlap in services affected by the injuries results from the fact that contaminated surface water and soil/sediment resources are now ubiquitous in parts of the basin downgradient of mining and milling operations, and the services provided by these resources are integral parts of an ecologically interdependent ecosystem. For this reason, injuries were quantified at the habitat level [43 CFR 11.71 (l)(1)]. The area where hazardous metal concentrations in surface water and soils/sediment resources exceed baseline concentrations and have reduced ability to sustain aquatic biota, vegetation, and habitat for wildlife was quantified relative to baseline [43 CFR 11.71 (h)(4)(i) and (k)(1,2)]. Baseline conditions for riparian vegetation cover, structure, and composition were also determined, since restoration of riparian vegetation in the upper basin is crucial to restoration of the Coeur d'Alene River basin ecosystem.

For baseline determination, floodplain soils and sediments and bed, bank, and suspended sediments from the Coeur d'Alene River basin were assessed collectively. Mean baseline concentrations for soil and sediment are 30 mg lead/kg dry weight of sediment (dw), 0.61 mg cadmium/kg dw, and 63 mg zinc/kg dw.

For surface water baseline determination, the Coeur d'Alene River basin was divided into three areas of ore deposit type. Median values for dissolved cadmium, lead, and zinc in the upper South Fork Coeur d'Alene River basin were 0.06, 0.15, and 5.35 μg/L, respectively. Median values for dissolved cadmium, lead, and zinc in the Page-Galena mineral belt area were 0.1, 0.44, and 9.04 μg/L, respectively. Median values for dissolved cadmium, lead, and zinc in the Pine Creek drainage were 0.03, 0.11, and 3.68 μg/L, respectively. For the South Fork Coeur d'Alene River basin as a whole, median baseline concentrations for the three metals were 0.06, 0.18, and 6.75 μg/L, respectively.

The riparian vegetation baseline data represent a range of site types reflecting elevational gradients, hydrologic gradients, valley shape, width, and orientation, and successional stages of patches of vegetation within the areas sampled. The characterization of riparian vegetation baseline condition focuses on parameters directly related to the injuries quantified: mean percent cover of bare ground (3.0%), mean percent cover of vegetation (139%),[4] mean species richness (17 total species), and mean structural complexity (4 layers present).

Surface Water Injury Quantification

The area of injured surface water resources was quantified as the area over which dissolved concentrations of cadmium, lead, or zinc exceed water quality criteria for the protection of aquatic biota (ALC). Within the assessment area, injured surface waters include a total of 181 km (113 miles):

- 107 km (67 miles) of the South Fork and mainstem Coeur d'Alene rivers from downstream of Daisy Gulch to the mouth at Coeur d'Alene Lake
- 11.3 km (7.0 miles) of Canyon Creek from approximately Burke to the mouth
- 11.6 km (7.2 miles) of East Fork and mainstem Ninemile Creek from the Interstate-Callahan Mine to the mouth
- 2.7 km (1.7 miles) of Milo Gulch from the Sullivan Adits to the mouth
- 4.0 km (2.3 miles) of Grouse Gulch from the Star Mine waste rock dumps to the mouth
- 5.0 km (3.1 miles) of Moon Creek from the Charles Dickens Mine/Mill to the mouth

4. The cover of vegetation can exceed 100% where multiple layers of vegetation overlap vertically.

- 0.9 km (0.5 miles) of Portal Gulch from the North Bunker Hill West Mine to the mouth
- 4.7 km (2.9 miles) of Deadwood Gulch/Bunker Creek from the Ontario Mill to the mouth
- 4.1 km (2.5 miles) of Government Gulch from the Senator Stewart Mine to the mouth
- 16.8 km (10.4 miles) of the East Fork and mainstem Pine Creek from the Constitution Upper Mill to the mouth
- 5.2 km (3.2 miles) Highland Creek from the Highland Surprise Mine/Mill and the Sidney (Red Cloud) Mine/Mill to the mouth
- 5.3 km (3.3 miles) Denver Creek from the Denver Mine to the mouth
- 0.5 km (0.3 miles) Nabob Creek from the Nabob Mill to the mouth.

In addition, injured surface waters include:

- the lateral lakes
- Coeur d'Alene Lake from near Conkling Point to the lake's outlet at the Spokane River.

Floodplain Soil and Sediment Injury Quantification

The extent of injury to floodplain soil and sediment in the upper basin was quantified as the area over which hazardous substance concentrations exceed baseline and have reduced the soil's ability to sustain vegetation and habitat for wildlife relative to baseline [43 CFR § 11.71 (h)(4)(i) and (k)(1-2)]. Vegetation cover mapping was used as a conservative indicator of soils with reduced ability to sustain vegetation and habitat for biota relative to baseline. The total area of barren or substantially devegetated floodplains along the South Fork Coeur d'Alene River downstream of the Canyon Creek confluence, Canyon Creek, Ninemile Creek, Moon Creek, and Pine Creek is 1,522 acres. This barren or sparsely vegetated area comprised greater than 80% of the available nonurban floodplain. Floodplains of the upper basin underlying urban development, which were not included in the riparian resources injury claim, also contain contaminated soils and sediments that may serve as a pathway of injury to surface water, via leaching by groundwater.

The extent of injury to soils and sediments of the lower basin was quantified as the area in the floodplain in which hazardous substance concentrations exceed baseline concentrations and have reduced ability to provide suitable (nontoxic) habitat for wildlife relative to baseline [43 CFR 11.71 (h)(4)(i) and (k)(1-2)]. Modeled predictions of lead concentration in surficial sediments were used to estimate the area of contaminated sediments that exceeded four threshold concentrations: 30 ppm lead, the geometric mean baseline concentration; 175 ppm lead, the

upper 90th percentile of baseline concentration; 530 ppm lead, a lowest observed effect level for waterfowl; and 1,800 ppm lead, a lethal effect level for waterfowl. The area in which sediment lead concentrations exceed the lethal threshold is 15,368 acres, the area in which sediment lead concentrations exceed the lowest observed effect level for waterfowl is 18,298 acres, and the area in which sediment lead concentrations exceed the 90th percentile of baseline concentration is 18,558 acres. The area in which sediment lead concentrations exceed the geometric mean baseline concentration is 18,608 acres.

Resource Recoverability

Existing surface water data do not indicate declining hazardous substance concentrations with time during the past two decades. There is no clear evidence that maximum, minimum, or mean zinc concentrations have declined during that period. The data do not indicate that water quality is improving, nor do they allow projection of a date when conditions will return to baseline without cleanup or restoration actions.

Similarly, sediment data do not indicate that concentrations of cadmium, lead, and zinc in sediments are decreasing with time, nor do they allow projection of a date when conditions will return to baseline. Concentrations of cadmium, lead, and zinc in lower Coeur d'Alene River basin sediment samples collected recently (1990s) from the lower basin are similar to concentrations in samples collected previously, during the 1970s and 1980s.

Recovery of fish, benthic invertebrate, wildlife, and riparian resources is dependent on suitable habitat quality, which requires recovery of surface water, sediment, and floodplain soil resources. Once surface water, sediment, and floodplain soil resources have recovered to a condition that will support biological resources, recovery of the Coeur d'Alene River basin ecosystem will be constrained by the rate of natural physical and biological recovery (vegetation reestablishment and physical habitat rebuilding by natural hydrologic, geologic, and biological processes).

For wildlife resources of the lower basin, recovery will occur rapidly once sediments are nontoxic, since physical modifications resulting from sediment injuries are not negatively affecting habitat use. For fish and benthic macroinvertebrates, when surface water and sediment conditions improve, both can move from upstream clean reaches and clean tributaries to recolonize the recovered areas. Recovery time for fish also will include time required for reestablishment of physical features of habitats that were degraded as a result of the injuries, such as overhanging banks, vegetative overhang, and pools created by woody debris and roots. Natural recovery of the aquatic physical habitat of the upper basin will depend strongly on recovery of riparian resources.

Natural recovery time for riparian resources will depend on time required for floodplain soils to become diluted to nonphytotoxic levels, followed by primary vegetation succession, organic soil development, and development of vertically and horizontally diverse vegetation communities. Natural recovery of riparian resources includes development of vegetation that will overhang the stream, modulate stream temperatures, and provide security cover for fish. It includes recovery of

riparian vegetation to the point where the vegetation provides habitat structure (e.g., large woody debris; bank stabilization) and a source of energy (i.e., detritus) to the aquatic ecosystem. It also includes reestablishment of diverse early and late successional vegetation and the expected range of terrestrial habitat features (e.g., mature tree boles for tree-cavity nesting birds).

Throughout the Coeur d'Alene River basin, the hazardous substances cadmium, lead, and zinc are the cause of the injuries described in this report. Existing concentrations of cadmium, lead, and zinc in the basin, ongoing releases of these hazardous substances from sources, and ongoing transport and exposure pathways limit natural recovery of the injured resources. There will be little recovery unless releases from sources are eliminated and transport and exposure pathways are eliminated. Existing surface water and sediment data show no evidence of either elimination of sources or pathways over the last 20 to 30 years. Therefore, it is reasonable to expect that natural recovery of the Coeur d'Alene River basin ecosystem will take hundreds of years.

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