4.0 Preliminary Identification of Resources Potentially at Risk

Section 11.25 of the CERCLA regulations, 43 C.F.R. Part 11, requires a preliminary identification of potential exposure pathways to allow identification of resources at risk. In addition, the section requires a trustee following the regulations to identify areas where exposure or effects may have occurred or are likely to occur. It also encourages the trustee to consider concentrations of hazardous substances to which natural receptors might be exposed. Finally, it requires that the trustee following the regulations preliminarily identify potentially affected resources.

In Section 3.0 above, the Forest Service has addressed concentrations of hazardous substances released into the environment, including to Joe Creek and beyond, to which natural resources have been and could be exposed. The section will address other considerations outlined in Section 11.25 of the regulations.

4.1 Preliminary Identification of Exposure Pathways and Exposed Areas

There are a variety of pathways by which hazardous substances can enter the environment from the Blue Ledge Mine Site. Preliminarily, the Forest Service has identified surface water, movement of contaminated particulates, groundwater, and food chain as important exposure pathways for natural resources.

4.1.1 Surface Water and Particulate Movement

Surface Water Transport of Dissolved Metals

An average annual precipitation in the vicinity of the mine of 138 inches of snow and 33 inches of rain (Hundhausen 1947) results in substantial runoff from the mine as well as percolation through the waste piles below the mine. At 4,800 feet above sea level, the Blue Ledge Mine is located in a transient snow zone where periods of rain-on-snow events can occur, which creates a high risk of mass wasting and surface erosion (USFS 1995).

One-third of the Joe Creek watershed is located within the transient snow zone (above 4,000 feet) and can receive moisture either as rain or snow. Given that most of the precipitation occurs during winter months, rain-on-snow events are not uncommon and are the primary cause of flooding in the Upper Applegate watershed. Pulses of runoff occurring at these times create a high risk for mass wasting and surface erosion (USFS 1995).

At the Blue Ledge Mine, waste rock and exposed minerals in abandoned underground workings, excavations, etc. are oxidized during all times of the year, except in cases when rock surfaces are submerged. However, such processes are greatest during the dry period from July to November. Thus, it follows that high flow periods of the spring offer the greatest opportunity to flush the metals that have accumulated from the oxidation of the summer months and transport them downstream.

Consistent with this conceptual site model for transport and exposure, as noted in Section 3.2.2 above, surface water shows highly elevated concentrations of metals, as compared to background and upstream locations unaffected by AMD, during the spring high flow period. Data show that dissolved metals released from the mine can be traced to effects in Elliott Creek as a clear gradient exists from Elliott Creek upstream to the mine (see Charts 2-4, pp. 19-20).

Spring months are not the only months of the year in which surface water can be a pathway of exposure to resources of the national forest. In fact, the same water quality data discussed above show very high metal concentrations in summer in a sample downstream of waste disposal areas and collapsed mine portals not visible from FS Road 1060 (JC6) as well as from a spring near Joe Creek (JCS2). Historical accounts of waste disposal suggest that this seep may well be in an area in which waste rock was disposed at the bottom of the mountain (see Charts 2-4, pp. 19-20).

Sediment Transport -- Transport of Fines from the Waste Disposal Areas

Site visits and photos of the site indicate that a majority of the waste material below the mine is in the form of fines the size of coarse sand, intermixed with small rocks 6 cm or smaller.

As a result, particles from Blue Ledge Mine waste rock piles or precipitates from mine drainage are likely to be entrained during runoff and carried into Joe Creek and downstream. Particle transport by streams depends on stream velocity. Moderate currents (20-50 cm/s) move sand and smaller particles; these currents are common in most rivers. The suspended load of a stream can carry fines even at relatively low flows, lower than those of mountain streams like Joe Creek and Elliott Creek. At higher flow velocities and volumes, fine particles may be carried for miles before the carrying capacity of the water is reduced sufficiently so that the sediment load is deposited.

The Joe Creek watershed is long and narrow and ranges in elevation from 6,200 feet at the headwaters to 2,100 feet at its mouth. Two reaches of Joe Creek were surveyed and identified based largely on changes in stream gradient (Siskiyou Research Group 2002). Reach 1, extending from the mouth for 1.69 miles upstream to Manzanita Gulch, exhibited a stream gradient that averaged 7%. Reach 2, extending from the gulch to the mine site (1.71 miles), exhibited an average gradient of 18%. It is therefore likely that during individual high flow events, or as a result of successive high flow events, fine particles can be carried through Joe Creek to Elliott Creek, the Applegate River, and possibly well into the Applegate Reservoir.

Transport of metals and hazardous particles is widely known. In one study of a stream downstream of a mine, 98% of excess copper, 91% of excess arsenic, and 70% of excess cadmium measured in the riparian zone was deposited by a river transporting contaminated sediments originating from upstream mining and smelting activities. This study showed that metal concentrations in contaminated sediments did not decrease with distance downstream from the source areas (Rice et al. 1985).

There is a strong likelihood that particles originating from the Blue Ledge Mine have been transported from their origin, by weathering, mass wasting, and runoff, downslope and downstream as far as the Applegate Reservoir.

4.1.2 Groundwater

Another way for polluted discharges from the mine and the waste piles to potentially reach natural resources of the National Forest is via groundwater flow. According to the infiltration theory of runoff (Chorley 1978), precipitation on a hillslope will be absorbed if the intensity is less than the infiltration capacity. As infiltration capacity is exceeded during high precipitation periods, overland flow is produced. Both subsurface and overland flow occur at the Blue Ledge Mine Site.

In the area surrounding the mine, precipitation that infiltrates to groundwater is very likely impacted by AMD through its contact with mine waste materials as described above. Depending on the local geology, this water may continue to generate AMD as it percolates downward through sulfide-bearing rocks below the surface or through fractures and voids where sulfide minerals are also present. This impacted groundwater emerges downslope at seeps and enters streams, carrying with it elevated metals concentrations.

Precipitation also enters abandoned adits and mine shafts. The same processes that generate AMD within the waste rock outside the mine also occur on the vast surfaces within the mine as they are exposed to moisture and oxygen. This impacted water likely flows from the mine's workings through preferential subsurface pathways along the rock's bedding surfaces and associated voids and fractures. The predominant strike of the schist below the mine averages North 10^{o} East (Hundhausen 1947), indicating groundwater likely flows from the mine to the north and south, working its way along these pathways until it surfaces downslope of the mine. This is another pathway by which impacted groundwater emerges at seeps and enters streams, creating effects on surface water resources and a pathway of exposure for biologic resources.

At the Blue Ledge Mine, most of the AMD-generating oxidation of waste rock and exposed minerals in abandoned excavations occurs during the dry period from July to November. Most metals mobilized by infiltrating precipitation enter the groundwater system as leachate during the wet period from December to June.

4.1.3 Food Chain Pathways

In polluted aquatic ecosystems the transfer of metals through the food chain can cause high concentrations in invertebrates and toxicity in fish (Dallinger 1985). When invertebrate species sensitive to the metal contamination are eliminated, metal-tolerant food organisms can become dominant. Their tolerance may be based on their ability to accumulate excessive amounts of metals, which would lead to increased dietary exposure among fish predators (Timmermans 1989, Woodward 1995).

Studies show that heavy metals, such as cadmium, copper, and zinc released from the Blue Ledge Mine, may be stored in various tissues of organisms including the liver, muscle, skin, or gills (see Besser et al. 1995). The amount of metal storage varies with the metal and pathways of uptake (e.g., via water, sediments, food). For the foregoing reasons, the food chain has been identified as an exposure pathway at the Blue Ledge Mine Site.

4.2 Exposed Areas

The Forest Service has preliminarily identified the areas in and around 1) Joe Creek, 2) Elliott Creek downstream of Joe Creek, 3) the Applegate River downstream of Elliott Creek, and 4) the Applegate Reservoir as areas where exposures to hazardous substances released from the Blue Ledge Mine can occur. The Forest Service reached this conclusion for the following reasons.

First, as noted above, it is likely that fines from the Blue Ledge Mine waste are transported via Joe Creek to Elliott Creek and to the Applegate Reservoir. It is well documented that such fines from mining operations can offer a continuing source of releases of hazardous substances locations far downstream of the mine (Rice et al. 1985).

Second, analyses of water samples taken in April 2001 in Elliott Creek upstream and downstream of the confluence with Joe Creek document that dissolved metals from the mine have been transported to Elliott Creek (See discussion in Section 3.2.2 above). There are no samples taken downstream of EC1 (see Map 2); however, transport of dissolved metals beyond this sample location is likely.

Third, to the extent bioaccumulation of hazardous substances has occurred, natural resources in areas other than these water-bodies could be affected.

4.3 Affected and Potentially Affected Resources

This subsection presents a list of resources that the Forest Service has preliminarily identified as potentially affected natural resources under its trusteeship. Given the limited nature of the investigation allowed by a PAS, this list is preliminary. With further assessment the list will be refined to reflect a more complete understanding of natural resource injury that follows a natural resource damage assessment.

4.3.1 Surface Water Resources

Recent data presented in this PAS demonstrate that releases from the Blue Ledge Mine have increased the concentrations of metals, which are listed hazardous substances, to such levels that the water of Joe Creek is potentially injurious to human health and is toxic to aquatic organisms.

As noted above, elevated dissolved metals were observed downstream of Joe Creek in the April 2001 sample round above background and upstream locations unaffected by AMD. For example, copper was not detected at JC5, but was detected downstream at JC4 at 790 ppb. As noted in Section 3.2.2 above, the data document violations of primary and secondary drinking water standards. Moreover, a comparison of the data with aquatic life criteria (ALCs) for surface waters demonstrates that the AMD has caused concentrations well in excess of ALCs in Joe Creek and Elliott Creek. ALCs include contaminant maximum concentrations (CMCs) and contaminant continual concentrations (CCCs). CMCs are the highest concentration of a pollutant to which aquatic life can be exposed for a short time (one hour) without deleterious effects. Thus, CMCs are acute ALCs. CCCs are chronic ALCs and equal the highest concentration of a pollutant to which aquatic life can be exposed for an extended time (four days) without deleterious effects. EPA regulations promulgated for the state of California define both acute and chronic ALCs. Toxicity of metals to aquatic organisms is often dependent upon hardness of the water. As a result, in the EPA regulations ALCs for metals including cadmium, copper, and zinc are expressed as a function of hardness, as shown in Table 2 below.

Table 2. Aquatic Life Criteria as a Function of Hardness		
Metal	**Acute ALC**	**Chronic ALC**
Cadmium	ALC= e^(1.128*ln(hd)-3.6867)	ALC= e^(.7852*ln(hd)-2.715)
Copper	ALC= e^(.9422*ln(hd)-1.7)	ALC= e^(.8545*ln(hd)-1.702)
Zinc	ALC= e^(.8473*ln(hd)+.884)	ALC= e^(.8473*ln(hd)+.884)

Using the above equations and hardness data, ALCs were calculated for cadmium, copper and zinc for each sampling site in the September 2000, April 2001, and August 2001 sampling rounds. These ALCs were compared with the concentrations of the applicable metal at the site. The results are summarized in Tables 3 through 5.

Table 3. Exceedances of Aquatic Life Criteria for Cadmium									
	September-00			**April-01**			**August-01**		
Location	Conc.	Acute ALC	Chronic ALC	Conc.	Acute ALC	Chronic ALC	Conc.	Acute ALC	Chronic ALC
PG1	ND	2.9	1.8	ND	1.5	1.1	ND	2.7	1.7
EC1	ND	3.3	2.0	ND	1.4	1.1	ND	2.5	1.6
EC2	ND	3.3	2.0	ND	1.6	1.2	ND	2.3	1.5
JC1	ND	3.3	2.0	1.3	1.4	1.1	ND	3.3	2.0
JC2	ND	3.2	1.9	1.7	1.4	1.1	ND	3.3	2.0
JC3	0.5	1.6	1.2	2.5	0.80	0.74	1.7	1.6	1.2
JC4	ND	1.4	1.1	4.1	0.91	0.81	ND	1.4	1.1
JC5	ND	1.5	1.2	ND	0.70	0.67	ND	1.5	1.2
JC6				ND	0.34	0.40	13.4	1.9	1.4
JCS1	ND	2.0	1.4	ND	1.2	0.95	ND		
JCS2	3.7	1.6	1.2	15.6	2.1	1.5			
BL1				40.3	1.2	1.6			

Table 4. Exceedances of Aquatic Life Criteria for Copper									
	September-00			April-01			August-01		
Location	Conc.	Acute ALC	Chronic ALC	Conc.	Acute ALC	Chronic ALC	Conc.	Acute ALC	Chronic ALC
PG1	ND	9.6	6.6	ND	5.5	4.0	ND	9.2	6.4
EC1	ND	11	7.3	73.5	5.2	3.8	ND	8.5	6.0
EC2	ND	11	7.3	ND	5.8	4.2	ND	7.9	5.5
JC1	ND	11	7.3	280	5.3	3.9	ND	11	7.4
JC2	11.4	10	7.1	309	5.3	3.9	ND	11	7.4
JC3	30.8	5.9	4.2	436	3.3	2.5	101	6.0	4.3
JC4	53.7	5.2	3.8	790	3.7	2.8	83.9	5.3	3.9
JC5	ND	5.7	4.1	ND	2.9	2.3	ND	5.7	4.1
JC6				ND	1.6	1.3	1830	6.9	4.9
JCS1		7.1	5.1	ND	4.5	3.3	ND		
JCS2	407	5.9	4.3	2990	7.5	5.3			
BL1				6990	8.3				

Table 5. Exceedances of Aquatic Life Criteria for Zinc*						
	September-00		April-01		August-01	
Location	Conc.	Criteria	Conc.	Criteria	Conc.	Criteria
PG1	8.7	85	ND	52	ND	82
EC1	2.6	94	78.3	49	ND	77
EC2	ND	94	ND	54	ND	71
JC1	21.9	94	287	50	54.2	95
JC2	29.1	92	360	50	71.3	95
JC3	50.7	55	481	33	278	56
JC4	70.4	49	774	36	144	50
JC5	ND	53	ND	29	ND	53
JC6	ND		ND	17	2750	64
JCS1	3.6	65	ND	43		
JCS2	727	55	2880	68		
BL1			6800	75		

* - Equations for Acute and Chronic ALCs are the same for zinc

Exceedances of the calculated ALCs are highlighted in green. *At least* one exceedance of the ALCs for each metal was detected during each sampling round. Particularly telling are the data taken in the Spring 2001 sampling round during the wet season when AMD releases are expected to be the highest. In the mine discharge, acute ALCs for cadmium, copper, and zinc were exceeded 34-, 844-, and 91-fold, respectively. Cadmium exceedances of acute and chronic ALCs were noted as far downstream as JC1. Exceedances for copper and zinc (both acute and chronic ALCs) were detected in Elliott Creek. The data clearly show metal concentrations above those protective of aquatic communities.

Elevated dissolved metals are not the only injuries to aquatic resources from the AMD. Injuries to aquatic resources also are likely to have resulted from the transport of contaminated particles downstream. Although sediments samples have not yet been taken, as described below the site characteristics are favorable for such contaminant transport. Such transport could have occurred as far as downstream as the Applegate Reservoir. Given the years of release of such contaminated fines, contaminated sediments are likely to be found in depositional areas in Joe Creek, Elliott Creek, and the Applegate River and Reservoir, offering a source of continuing releases of hazardous substances. Such contamination is considered an injury to surface water resources under the regulations. The fact that surface water resources well beyond Joe Creek could be compromised is born out by recent studies on the toxic effects of metals.

The conditions at the Blue Ledge Mine can be compared to those of the Methow Valley on the eastern slopes of the north Cascade Mountains in Okanogan County, Washington. The Methow basin is similar to the Blue Ledge Mine site in that the mined ore deposits are rich in sulfides and AMD has been the cause of elevated metals concentrations in runoff to streams. A recent study conducted in the Methow Valley found reduced growth and increased mortality among trout maintained in pens downstream from the mines despite the fact that water was meeting water quality standards *and* concentrations of metals were *at detection limits* (Peplow 2002). Such toxic affects were seen 10 km from the mine site. Sediments contaminated by releases from upstream abandoned mines were identified as the cause.

In summary, the aquatic resources of the National Forest have been injured by the AMD from the Blue Ledge Mine. Such injuries extend to Elliott Creek and likely to the Applegate Reservoir.

4.3.2 Groundwater Resources

No groundwater samples have been collected. However, samples have been collected in seeps that have daylighted near the mine. The samples show that groundwater has been affected. Such samples show elevated concentrations of metals. As a result, principles of geochemistry, an understanding of AMD, and such data from seeps, groundwater resources, under the trusteeship of the Forest Service, are likely to have been affected at the Blue Ledge Mine Site. Daylighted groundwater at the sample location JCS2 shows metal concentrations in exceedance of both drinking water standards and acute and chronic ALCs. A sample taken at JCS2 in April 2001 exceeded the MCL for copper and the state secondary standard for iron. Samples taken at JCS2 in September 2000 and April 2001 exceeded acute *and* chronic ALCs for cadmium, copper, and zinc. In April 2001, the acute and chronic ALCs for copper were exceeded 400-fold and 566-fold, respectively; the same sample showed an exceedance of the zinc ALCs of 42-fold. These data indicate that AMD at the mine has had a negative impact on groundwater.

4.3.3 Biologic Resources

Survey data and water sampling indicate that AMD from the Blue Ledge Mine is resulting in widespread impacts to aquatic life in Joe and Elliott Creeks. As discussed in Section 4.3.1, concentrations of cadmium, copper, and zinc exceed acute and chronic ALCs intended to protect of aquatic communities in California. Literature, some of which was used to derive the ALCs, show that the metals concentrations found in Joe Creek downstream of the mine, have adverse effects, including mortality, on macroinvertebrates, fish, and amphibians. Surveys confirm that such adverse effects have occurred due to AMD releases from the Blue Ledge Mine.

Macroinvertebrates

Surveys of macroinvertebrates indicate injuries have occurred due to AMD releases from the Blue Ledge Mine. Freshwater invertebrates are ubiquitous; even the most polluted or environmentally extreme lotic environments (those with swift flowing waters) usually contain some representatives of this diverse and ecologically important group of organisms (Hauer and Resh 1996). Healthy aquatic systems of western United States montane rivers typically support complex and diverse macroinvertebrate communities that include mayflies, stoneflies, caddisflies, and Diptera (midges, black flies, crane flies, etc.). However, survey data taken indicate that Joe Creek cannot support even a marginal macroinvertebrate community.

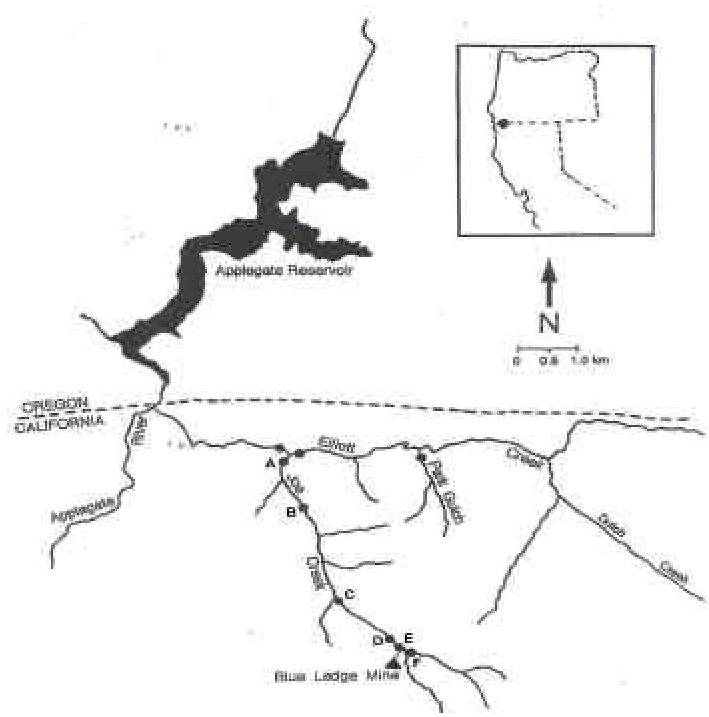
In September 2000 and May 2001, the Forest Service commissioned macroinvertebrate surveys to investigate the effect of the Blue Ledge Mine on the macroinvertebrate community within the National Forest up- and downstream of the Blue Ledge Mine (Parker 2000, 2001). The Rapid Bioassessment Procedure was used for the two Joe Creek surveys as a method to identify community structure while minimizing time spent sorting and identifying organisms from large samples (Resh and Jackson 1993). This method provides a comparison between reference sites and sites that may be affected by hazardous substances.

As shown in Map 3, the sampling sites are in the same locations as those of the 2000 and 2001 sample sites, unless there was no water present. The primary reference sites are located upstream of the mine area (Site F) and on Park Gulch (see Map 3). Park Gulch was selected as an appropriate reference site because it is the northerly extension of the Blue Ledge mineralization. It is also the only location within the watershed with similar mineral influences as that found in Joe Creek and is not influenced by AMD from the Blue Ledge Mine. Two sites are located on Elliott Creek approximately 50 to 100 m upstream and downstream of the confluence with Joe Creek. The surveys documented a diverse invertebrate community above the mine site; whereas sample locations downstream of the mine discharge area in Joe Creek were heavily impacted compared to reference sites (Parker 2000, 2001). (See Charts 5 and 6)

In the fall 2000 survey, macroinvertebrate density and diversity were dramatically reduced from the mine site to 3 km below the mine, compared to the community sampled upstream of mine discharges (Parker 2000). Macroinvertebrate densities and diversity at the farthest downstream sites did not approach those observed within Elliott Creek and at Park Gulch.

The spring 2001 survey, conducted in May when there was considerable surface flow from the mine tributary entering Joe Creek, indicated even greater impacts on the benthic invertebrate community than did the fall survey (Parker 2001). From the tributary that runs through the main waste pile on the mountainside to a distance of over 2 km downstream, macroinvertebrates were virtually eliminated. As noted, invertebrate densities were extremely low for the *entire* length of Joe Creek downstream of the mine. The decrease in invertebrate densities observed downstream of the mine is correlated with the direct *and* indirect effects of the elevated metal concentrations. Direct effects result from the exposure of invertebrates to elevated dissolved metals associated with the leachate from the Blue Ledge Mine – copper, cadmium, zinc, and iron. Indirect effects caused by the releases of hazardous substances (dissolved metals) also contributed to the injury observed. A comparison of the fall and spring survey suggests that the adverse effects to macroinvertebrate communities and stream health are most severe during the spring high flows (Parker 2001). During spring, as supported by water quality data collected in 2000 and 2001, high volumes of metals are pulsing through the system after a summer of oxidation of the sulfide deposits still found in the mine and its waste.

Metals data taken in Joe Creek indicate that the lack of macroinvertebrates in Joe Creek is due to AMD releases from Blue Ledge Mine. Streams experiencing environmental stresses often have reductions in benthic macroinvertebrate density and diversity (Barbour et al. 1995). Norris et al. (1990) showed significant reductions in density and diversity of mayflies, stoneflies, and caddisflies in response to copper mine effluent. Concentrations of copper as low as 25 ppb (790 ppb in Joe Creek; 73.5 ppb in Elliott Creek) have been correlated with 67-100% reduction in ephemeroptera populations and 16-30% reduction in plecoptera populations (Clements, et al., 1992). Clearly, concentrations in Joe Creek are much higher than these levels and result in the low numbers of macroinvertebrates seen in Joe Creek. High levels of zinc (up to 774 ppb in Joe Creek; 78.3 ppb in Elliott Creek) are also a potential source of injury to aquatic invertebrates. Studies have shown that concentrations of 37 ppb result in 50% mortality rates in embryos of some diptera species (EPA 1980; EPA 1987). Concentrations of 30 ppb have been shown to reduce growth rates as well as cause mortality in ephemeroptera larvae, and concentrations of 100-300 ppb resulted in 100% mortality (Hatekeyama, 1989).



Map 3

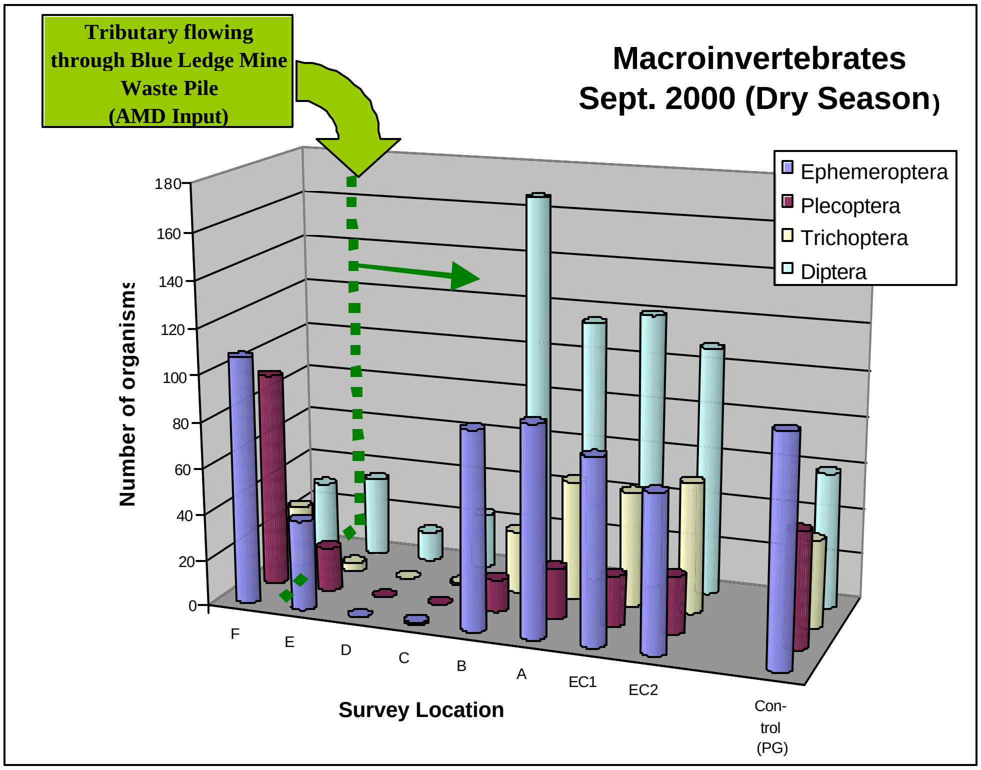


Chart 5

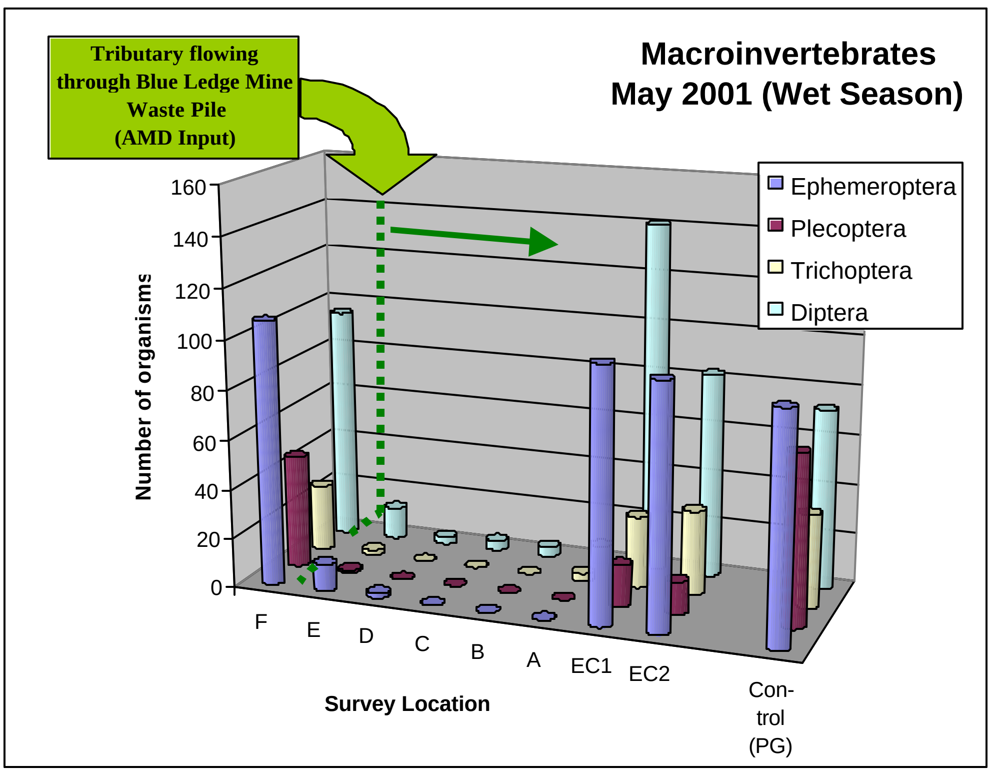


Chart 6

Amphibians

Stream-dwelling amphibians were studied during the fall and spring invertebrate surveys (Parker 2000, 2001). Various life stages of tailed frog (*Ascaphus truei*) and Pacific giant salamander (*Dicamptodon tenebrosus*) were found upstream of the mine in both surveys; however, very few, if any, were found along Joe Creek from the mine to the confluence with Elliott Creek. These data provide evidence of injury to amphibians from AMD downstream of the mine.

Amphibian survey data are highly indicative of AMD effects on amphibian populations downstream of the Blue Ledge Mine. Various life stages of tailed frog (*Ascaphus truei*) and Pacific giant salamander (*Dicamptodon tenebrosus*) were found upstream of the mine in both surveys; however, no amphibians were counted at the JC4 site directly downstream of the mine and a maximum of only three was found at any site further downstream (See Chart 7). This pattern is consistent with metal concentration data taken in Joe Creek, particularly that of copper. The concentrations of copper found in Joe Creek are associated with adverse effects and mortality in amphibians. In previous experiments with frog species, copper concentrations of 10 ppb resulted in 34-39% mortality rate in embryos within four days of hatching (Birge and Black, 1979). Copper was detected at 79 times this level at the JC4 site and from 28 to 43.6 times this level at the other Joe Creek sites downstream of the mine where amphibian impacts were detected.

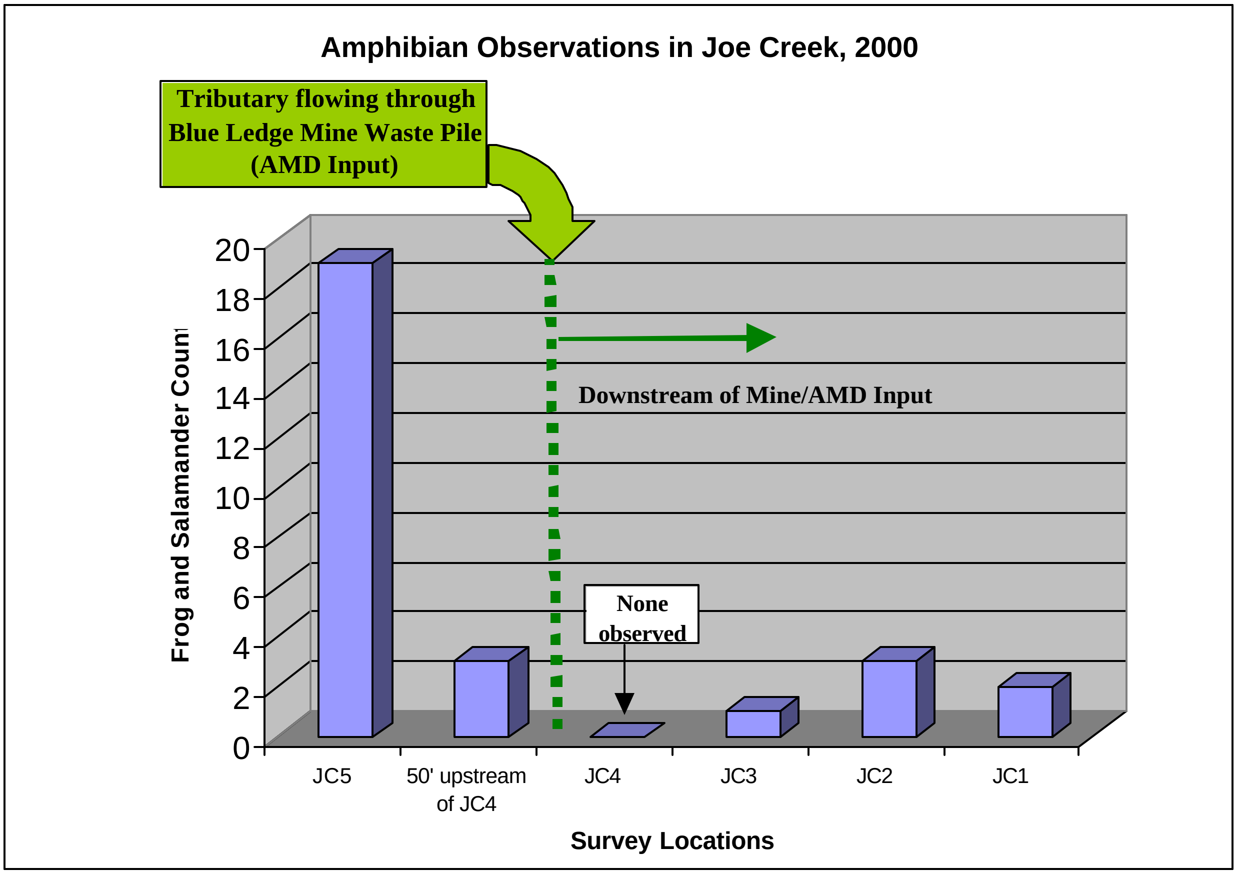


Chart 7

Fish

Data from fish surveys taken on Joe Creek, examined in combination with the water quality data, demonstrate that hazardous substances from the Blue Ledge Mine have caused injury to fish resources under the trusteeship of the Forest Service. Fish surveys were conducted by the Forest Service in September 2000 (Reid 2000). Data from these fish surveys are displayed on Chart 8. Rainbow trout (*Oncorhynchus mykiss*) and unidentified sculpins were found in Elliott Creek and in Joe Creek immediately upstream of the confluence with Elliott Creek. No fish were found upstream of this sampling location. Reid noted that trout captured within the mouth of Joe Creek were all young-of-the-year. He postulated that these fish probably entered Joe Creek from Elliott Creek rather than being the result of spawning in Joe Creek because no adult trout were found in Joe Creek.

The absence of fish in Joe Creek is particularly striking when displayed on a map of the watershed showing the presence and absence of fish. Joe Creek is the only stream where fish are absent in the watershed except for small reaches of certain streams where there are likely to be physical barriers to fish (see Map 4, p. 32).

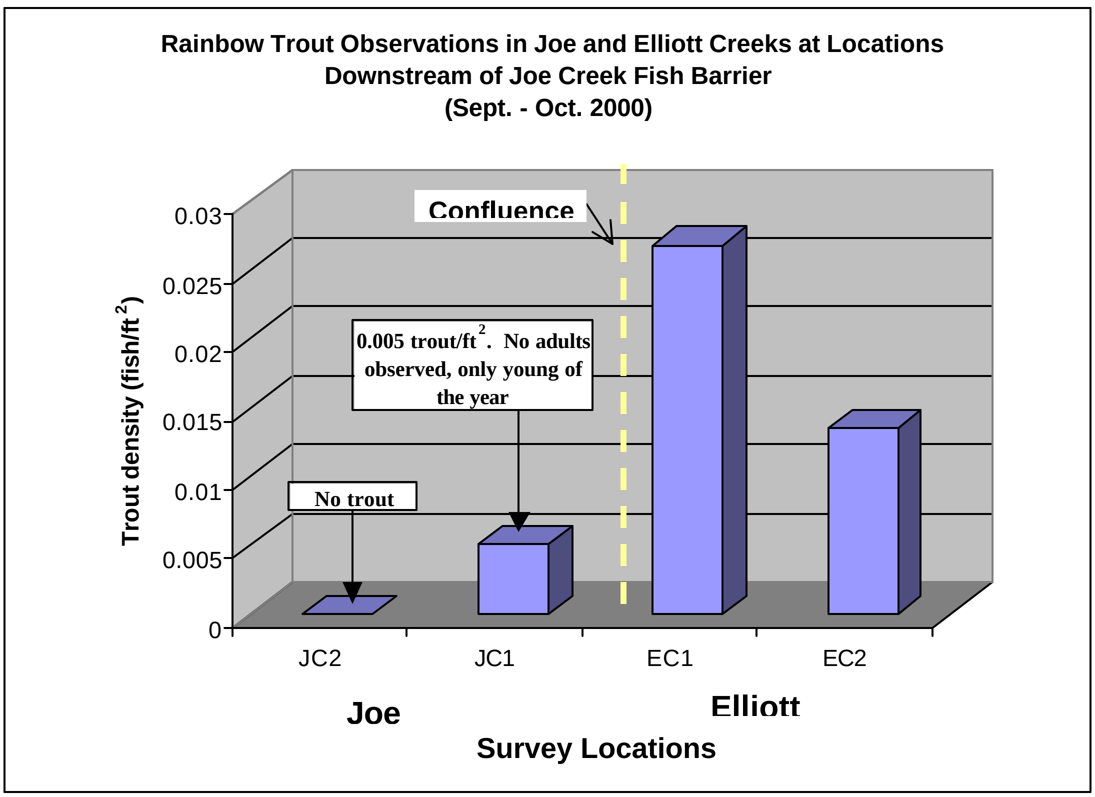
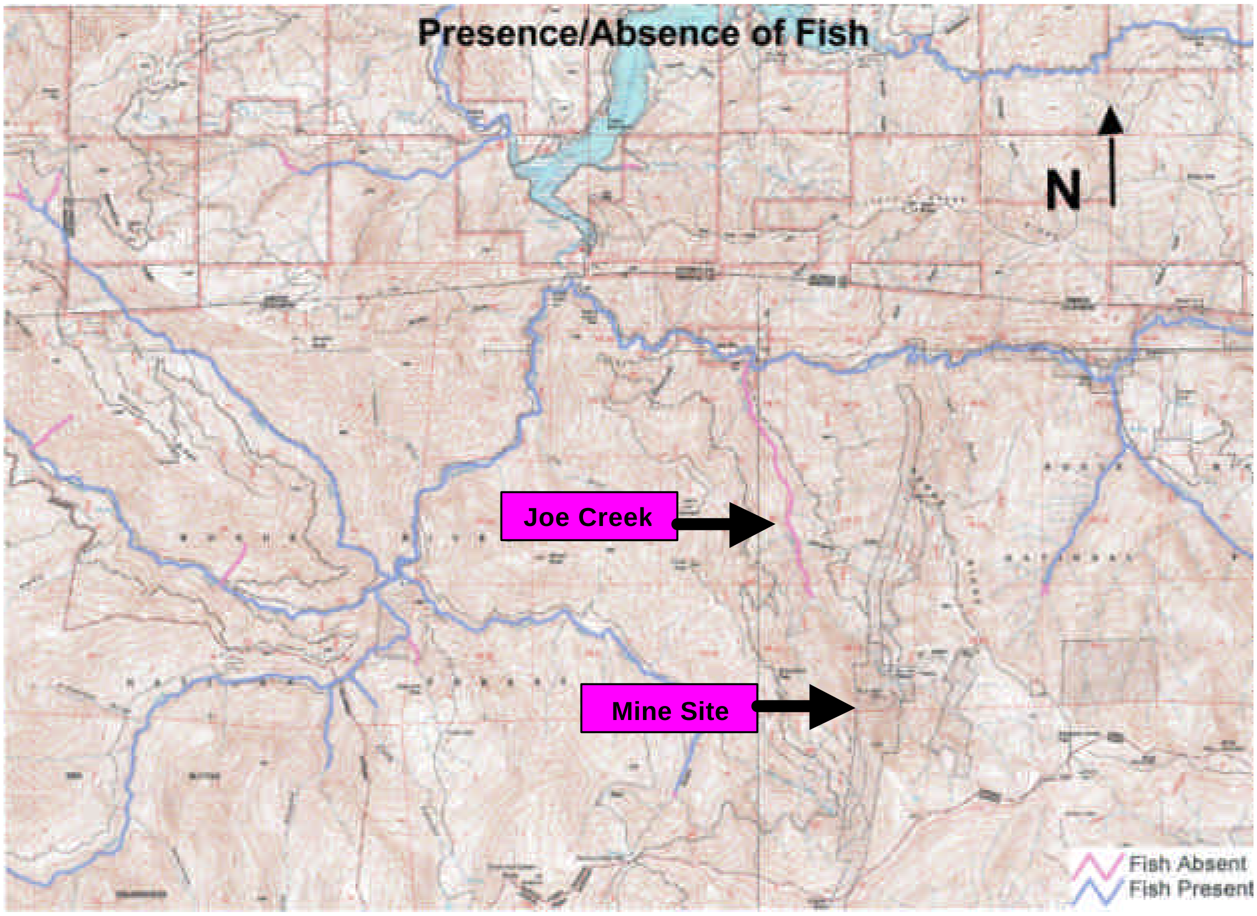


Chart 8



Map 4

Although impacts to fish from AMD have long been suspected, until the Forest Service undertook a stream survey in 2001 it had not ruled out the possibility that physical features of the stream were responsible for limiting or excluding fish distribution. Thus, the express purpose of this study was to eliminate from consideration such explanation for the apparent lack of fish in Joe Creek (Siskiyou Research Group 2001). This study concluded that "the results of this survey show no physical reason Joe Creek could not support a resident trout population in the lower 2.04 miles" (Siskiyou Research Group 2001). The study did find barriers to fish distribution, however, within the 1.36 miles closest to the Blue Ledge Mine Site.

Metal concentrations detected in Joe and Elliott Creeks are much higher than those shown to have adverse effects and high mortality rates in rainbow trout and other fish. Studies have shown a 50% mortality rate in adult trout after 96 hours of exposure to water with just 13.8 ppb copper (Buhl and Hamilton, 1990). Concentrations of copper in Joe Creek in areas downstream of the Joe Creek fish barrier have been found up to 22.4 times this level in Joe Creek and 5.3 times this level in Elliott Creek downstream of its confluence with Joe Creek. Concentrations of zinc found in Joe Creek (up to 360 ppb in Joe Creek downstream of the fish barrier) have also been found at levels resulting in harmful effects to fish. The LC-50 for zinc in rainbow trout alevins and larvae is reported as 10 ppb; the LC-50 for rainbow trout fry ranges from 90 to 93 ppb (EPA 1980; EPA 1987; Spear 1981). Avoidance in cutthroat trout was found downstream of a mining waste site in which metal concentrations were similar to or below those found at the Blue Ledge Mine (12 ppb copper; 1.1 ppb cadmium; 50 ppb zinc) (Hansen, et al. 1999). Reduced growth and delayed sexual maturation has also been associated with exposure to elevated concentrations of As, Cd, Cu, Pb, Mn, and Zn (Kemble 1994). Cell death occurs in Cu-exposed fish (Kamunde et al., 2001) and increased mortality occurs when trout consume contaminated sediments (Mount et al., 1994).

Mammals and Avian Resources

No data have been collected that would help shed light on metal exposures to birds and mammals. However, because such species frequent the area in which there is surface water contaminated by metals released from the Blue Ledge Mine and also because there is a possible food chain pathway of exposure to such species, mammals and birds are considered by the Forest Service to be resources potentially affected by the releases from the Blue Ledge Mine.