REMOVAL SITE INSPECTION REPORT
ALMEDA MINE

Bureau of Land Management
Grants Pass Resource Area
Medford District Office, Oregon

Bureau of Land Management
National Science and Technology Center
Denver, Colorado

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1.0 INTRODUCTION AND OBJECTIVES

The Bureau of Land Management (BLM) National Science and Technology (NSTC) and the BLM Medford District Office performed a CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act) Removal Site Inspection for the Almeda Mine. According to Section 300.410 (b) of the National Contingency Plan (NCP), a removal site evaluation includes:

- identification of the source and nature of the release or threat of release,
- evaluation by agencies of the threat to public health,
- evaluation of the magnitude of threat,
- evaluation of factors necessary to determine whether a removal action is necessary,
- determination of whether a non-federal party is undertaking a response.

With these goals in mind, the overall purpose of the investigation was to determine the extent of heavy metal contamination at the site located near Galice, Oregon. Specific objectives were:

- sample the surface extent of selected heavy metals in soil and surface water,
- install and evaluate a pilot water treatment system for the adit flow,
- perform an underground assessment of Almeda Mine,
- prepare topographic and flood plain surveys of the site,
- determine whether potential health and environmental risks may be present,
- perform a screening of alternatives for the site.

2.0 SITE DESCRIPTION

2.1 Environmental Setting

The site is located in Josephine County, within the BLM Medford District, Grants Pass Resource Area, approximately 3 miles north of the town of Galice and 30 miles from Grants Pass in Township T34S, Range R7W, sections 7 and 18 and T34S, R8W sections 12 and 13 of the Willamette Meridian. Approximate coordinates are 42° 36' 15.3" north latitude and 123° 36' 12.6" west longitude. Figure 1 presents the location of the site as shown on the USGS Galice, Oregon 7.5' quadrangle map (1998). Access is via the Merlin-Galice Road to the north bank road turnoff at the east end of the ridge immediately below the mouth of Hellsgate Canyon. From this junction, at least ten miles via a series of logging roads leads to the site, the last portion of which is 4WD. During winter, this access is closed periodically due to landslides. The site is situated near the north bank of the Rogue River. Alternatively, near Galice, the site may be accessed via boat on the Rogue River and may be crossed from upstream of the site.

The annual average precipitation at Grants Pass is 33.5 inches, and the average annual temperature is 54 degrees F (Soil Conservation Service, 1984). Two-thirds of the precipitation occurs from November to March. Surface water in the area consists of the Rogue River, located within 200 feet of the site.

	Mean Temperature °F	Mean Precipitation in.
January	39.8	6.71
February	44.1	4.09
March	47.2	3.56
April	52.3	1.62
May	59.1	1.31
June	65.8	0.55
July	71.6	0.21
August	70.5	0.46
September	65.0	0.87
October	54.8	2.41
November	45.5	4.71
December	40.2	6.06

Vegetation in the area consists mainly of Douglas fir, Jeffrey pine, sugar pine, incense-cedar, tan oak, whiteleaf manzanita, California buckthorn, and poison oak. Although little vegetation will grow on the contaminated soil, there is algae growing in the acidic mine drainage in the flood plain.

The Site is located in the Recreation corridor of the National Rogue Wild and Scenic River and just upstream of the Wild Section. Both river segments are important for their rafting, scenic and fishing values. The Bureau of Land Management is undertaking this action to meet the objectives and requirements of the National Wild and Scenic Rivers Act (Public Law 90-542, October 2, 1968), and particularly the protection of the three outstandingly remarkable values (ORVs) that led to its congressional designation. The ORVs are: National Scenic Qualities, Fisheries Resource, and Recreation Opportunities Resource. The average daily discharge of the Rogue River at upstream Grants Pass ranges from 1409-5954 cubic feet per second (cfs), (mean 3,700 cfs) with lowest flow in September and the highest flow in January. The period of record is 1939-2000.

The collapsed River Level adit (also called the 520 adit and Seep-1) has an altitude of approximately 685 feet above sea level, and topography surrounding the site consists of steep canyon walls. Mine adit 620 (also referred to as "A" adit on mine maps) is the next higher opening that is situated near the access road and rock dumps and is at an elevation of 776 feet. The lower extent of the site is located at river channel at approximately 658 feet on February 4, 2002. The site has been surveyed and a topographic map developed, Figure 2.

The River Level adit is situated in the sulfides of the Rogue Formation and seeps at a rate of about 6-12 gpm from the Mine across the flood plain bedrock in a braided manner and into the Rogue River. Two smaller seasonal seeps emanate from below the rock dumps and join the flow from the River Level Adit, a collapsed adit that is stoped near the opening according to mine maps. The other seasonal seeps located nearby immediately east appear to be in the Galice Formation and have a estimated collective flow rate of about 5-10 gpm. BLM sampled the seeps quarterly on May 10, 2001, November 10, 2001, February 6, 2002 and June 18, 2002. The results showed high metals and sulfate loading at a very low/acidic pH, typical of acid mine drainage (AMD). Naturally occurring heavy metals in mine workings, waste ore, and waste rock are released from mining sites through several pathways. The primary mechanism is sulfide mineral oxidation from the action of oxygen and water contacting the mineral surfaces. The major chemical reactions are represented in general by the oxidation of iron sulfide (FeS_2), one of the most common sulfides (Cummings 2002, Ford, 2002). Other metals are also dissolved by the low pH caused by release of hydrogen ions.

$$FeS_2 + 7/2\ 0_2 + H_2O \text{-->} Fe^{2+} + 2SO_4^{2-} + 2H^+$$

The site is located within one mile of two developed Rogue River recreation sites, including Almeda County Park and the BLM Smullin Visitor Center at Rand. The adit and seep discharges spread out over the bedrock covering an area of 1-2 acres are highly accessible to boaters. The flood plain was evaluated by BLM for width and return frequency of 100 years. As shown in Figure 4, most of the site is within the 100 year flood plain. The location of the Aquafix unit during the pilot test (Section 3.3) was in an area of the 2-5 year flood plain.

In the following sentences, a distinction is made between groundwater and water in the mine pool (which is also groundwater). Groundwater at the lower terrace is from 0-12 feet below ground surface and is the source of the water emanating from the seeps. This range is due to the fact that emanation of groundwater from the mine workings raises the water table near the seeps, whereas groundwater near the potential repository location was found to be greater than 12 feet. The site is mostly covered by bedrock, and the limited soil in the area has a medium permeability. Despite the bedrock, communication of contaminants from the mine pool groundwater into the bedrock Rogue and Galice Formations groundwater is likely, however the bedrock appears to have limited vertical permeability. This is why the acidic groundwater pools or seeps onto the exposed bedrock in the flood plain. The Rogue River appears to be a gaining stream in the area because of the seeps.

Soil for the site is classified as Brockman Variant very gravelly loam by USDA Soil Conservation Service (Soil Conservation Service, 1984). The surface layer is about 12 inches thick of dark, reddish brown very gravelly loam. The next 23 inches of subsoil are yellowish red, dark reddish brown and strong brown gravelly clay loam and gravelly loam. The only soil profiles near the site likely to show this thickness are to the west above the 700' elevation. To the depth of 60 inches is a dark brown very gravelly loam. The soil is approximately 35% rock fragments. The soil has a moderate permeability with a slow water runoff and water erosion hazard is slight. The available water capacity is about 6.5 to 10.5 inches and water supplying capacity is 18 to 23 inches. The permeability of the soil is moderate at 0.6 - 2.0 in/hr.

The ore body of the Almeda Mine is located in volcanic massive sulfide materials of the Rogue Formation, itself a member of the Big Yank Lode. The rock mainly consists of basaltic to rhyoltic, fine-to medium-grained rocks. The rocks are closely related to calc-alkalic rocks. Sulfide lies over lava domes and formations and is in contact with the Galice Formation, deep-marine sediments which are also exposed on the flood plain. The contact bisects the center of the site and is visible (Wood, 1987). Past exploration constructed a vertical shaft 435 feet beneath the River level. The Almeda Mine consists of a series of adits and stopes, connected by crosscuts and raises, driven in the hillside from elevations over 300 feet above and, reportedly over 400 feet below the Rogue River level. Mine maps of uncertain accuracy are available (Libbey, 1967). The adits have various nomenclatures from various published sources, however, the lowest flowing adit is called the River Level adit or the 520 adit; a collapsed adit just above the 520 adit is called the 0 adit; the open adit at the access road level is called the 620 Adit and one upper adit is referred to as the 794 Adit (Cummings, 2002), for a total of four adits. These numbers are thought to refer to elevations, but are off by more than 100 feet and are not true elevations, based on BLM surveys. The River Level adit and many feet of mine works are submerged underwater (Wood, 1987). These have been drained of water and explored several times, however there are few published data.

Waste rock dumps and smelter slag are situated on the canyon wall down to the flood plain. They are yellowish/tan in color. Brownish-orange iron oxide covers much of the flood plain. The steep waste rock dumps cover an area of approximately 50,000 square feet and average about three feet in depth. The smelter slag pile covers about the 2,000 square feet and has about the same depth. This area is within 200 feet of a favorite lunch and fishing spot along the bank below the Almeda riffle for many rafters and kayakers. There are a few remnants of old mining structures, but most are hidden in the vegetation. This site is also cluttered with pieces of old metal scraps and some smelter slag in a few areas.

2.2 Flood Frequency and Inundation

This section summarizes efforts to quantify Rogue River flood frequencies at the Almeda Mine and to estimate elevation of the water surface for floods of various recurrence intervals. Since no nearby gage data is available for estimating flood frequencies or water-surface elevations, a considerable amount of professional judgment was required to extrapolate flow information from distant gages. Anecdotal information was then used to calibrate a water-surface-profile model of the site to high-water marks associated with the 1964 flood of record. Results are summarized below.

Several stream gages are operated by the U.S. Geological Survey on the Rogue River; however, none are near the Almeda Mine location. The nearest upstream gage is located in Grants Pass, where the contributing watershed drainage area is 2459 square miles, while the nearest downstream gage is near Agness, Oregon, where the contributing drainage area is 3939 square miles. Total watershed area at the mine site is approximately 3500 square miles. Flow levels in the Rogue River at the mine are regulated somewhat by upstream reservoirs on both the Rogue and the Applegate River, a major tributary to the Rogue.

Flood estimates for the site can be calculated with regional regression equations developed by the U.S. Geological Survey for magnitude and frequency of floods at ungaged sites in western Oregon (Harris et al. 1979). These equations are developed by regressing statistically derived flood frequencies at gaged sites against various characteristics of the contributing watershed. In the Rogue-Umpqua Region of western Oregon, the three predictor variables found most useful for estimating flood frequency are drainage area, 2-year, 24-hour rainfall, and percent of the watershed in lakes and ponds. The equations can be in error by as much as 50 percent; thus, it may be necessary to adjust flood estimates from the regression equations to better match information derived from the closest gages on the river.

For the Rogue River, flood magnitudes were estimated for three sites (at Grants Pass, at Almeda Mine, and near Agness) with the regional regression equations. Equation-based flood estimates for the gaged sites were then compared to statistical estimates derived from gage records to determine if the equations systematically under- or over-predict flood magnitudes in the Rogue River. Table 1 clearly shows that the regional regression equations over-predict Rogue River floods when compared to statistical estimates from gage records. For the Grants Pass gage, equation-based estimates are 50 to 75 percent higher than estimates based on gage records. For the gage near Agness, regression estimates are 3 to 20 percent higher. Based on the consistent over-prediction of Rogue River floods by the regression equations, regression estimates for the Rogue River at Almeda Mine are reduced by about 10 percent to obtain a final frequency estimate for the site. The results are contained below:

Flood estimates for Rogue River at Almeda Mine (cfs).					
2-Year	5-Year	10-Year	20-Year	50-Year	100-Year
75000	130000	160000	198000	268000	304000

Water-surface elevations for the flood estimates in shown above were calculated with the U.S. Army Corps of Engineers' HEC-RAS hydraulic analysis software. Field surveys of valley cross sections downstream of the mine area were combined with cross sections constructed from the one-foot contour map of the site to perform hydraulic routing of flood profiles from a major downstream, hydraulic control up through the site. Since the stream could not be waded and boat-mounted sounding equipment was not available at the time of field work, elevation of ground points within the low-water channel were estimated on the basis of channel characteristics observed during the field visit.

No stream stage records are available for the Rogue River in the vicinity of Almeda Mine; thus, it was not possible to calibrate the model to known water-surface elevations. However, weathered flood debris was observed at or slightly above the 700-foot elevation in the trees on the north side of the river between cross sections two and three at the time of the field visit. Anecdotal information attributed this debris to the 1964 flood, which was within three percent of the 100-year flood at the "near-Agness" stream gage downstream. Thus, model results were reviewed for reasonableness by comparing simulated water-surface elevations for the 100-year flood at sections two and three with the estimated elevation of the weathered debris in the field.

Cross sections were surveyed at several locations by BLM (Figure 3). Cross sections three, four, and five are depicted in upstream order (i.e., left to right, west to east, downstream to upstream) on the map created from the photogrammetric survey (Figure 4). Cross-section one is not included in

Figure 3, since it is well downstream of the project area and was included in the hydraulic analysis only because it likely is the controlling channel feature at very high discharges. Cross section two also is downstream of the site close to the western boundary of the map, particularly where the northeast end of the cross section is just off the northwest corner of the map.

Water-surface elevations associated with the estimated 2, 5, 10, 20, 50, and 100-year floods are depicted on Figure 4. It is interesting to note that the bedrock bench on the right (north) side of section four provides enough obstruction/constriction during high flow that a backwater condition develops upstream, with a depressed water-surface elevation through/over the constriction and a rise in elevation as the water moves downstream to section three. This likely explains the scour to bedrock in the vicinity of the mine.

Because of uncertainty associated with calculated flood magnitudes, unmeasured bed elevations within the low-flow channel, and lack of water-surface elevations to calibrate Manning's roughness coefficient, estimated flood levels are probably accurate to only plus-or-minus one to three feet for the 100-year flood. Estimated water surface could be off by as much as 5 feet for more frequent flood events (e.g., 10-year flood). Additional measurements of streambed elevation within the low-flow channel would reduce the error associated with the modeling, especially for more frequent flow events where the low-flow channel carries a greater percentage of the total discharge; however, it's likely that simulated 100-year flood elevations still would carry an error of plus-or-minus one to two feet.

2.3 Site History

The mine was discovered as part of the Big Yank Lode in 1874 by prospectors who formed the Almeda Mining Company (AMC). Major commodities were gold, silver and copper. The main production occurred in 1905-1917 by the same AMC. Approximately 23,000 tons of ore worth $123,000 were shipped to the Tacoma or Choanocyte Smelters. In 1908 AMC built a 100 ton smelter and matting furnace. After much inactivity, a small amount of production of 287 tons of ore were shipped in 1942, but the site has been largely inactive (except some exploration and other activities) since that time (Wood, 1987).

The site was explored several times since being shut down in 1942, but mainly for the purpose of studying the geology or engineering aspects of the Almeda Mine. Libbey wrote much on the structural analysis by Kay in 1967 and the Homestake Mining Company and the Texasgulf Western, Inc. looked at the sites' volcanic and strata-bound characteristics in the 1970's. They also conducted underground drilling and geochemical sampling.

2.4 National Register Eligibility

The Almeda Mine is an example of the large-capitalization mining enterprises that were active in southwestern Oregon during the late nineteenth and early twentieth centuries.

During the main period of this mine's operation (1903 - 1917), the physical features included a low water log bridge across the Rogue River, a number of wooden buildings and structures (mill, smelter, water tank, residences), adits, and waste piles.

Currently, all the wooden buildings and structures have been removed. In fact, the wooden bridge was washed away by the flood of 1927. The remaining features include adits, waste piles, a few large pieces of smelting equipment, cement foundations, and scattered pieces of machinery. The essential physical features, i.e. wooden mill, smelter, water tank, and bridge, that made up its characteristics during its period of operation are no longer retained. The Almeda Mine site lacks this type of integrity, and is therefore not eligible for the National Register under Criteria A.

The Almeda Mine site is eligible for the National Register under Criteria D. The mine site, in particular Features 1 and 2 (the habitation flat and the smelter area), have the potential to yield archeological information concerning potential Native American use of the area, domestic residence pattern, and a more complete understanding of the technology employed at the on-site smelter.

3.0 SAMPLING ACTIVITIES AND RESULTS

3.1 Objectives:

The objectives of the sampling and analysis were to: characterize quarterly the surface water chemistry and flow at the adit, characterize upstream and downstream water quality, identify and quantify all sources of contaminants from the site, perform a topographic survey and a 100 year flood plain survey, and collect information necessary for an evaluation of treatment and removal alternatives for the site.

3.2 Sample Collection:

BLM performed quarterly seep sampling during May and November 2001, February and June, 2002. Seep samples were also collected from several other locations throughout the site, Figure 2. Samples were analyzed for acidity, pH, lead, zinc, aluminum, manganese and other metals concentrations (Ford 2002). Metals analysis were performed using EPA 200 series methods with lowest detection limits.

Most of the rest of the field work was performed in June 2002. Upstream and downstream Rogue River surface water samples were collected using an equal-width-increment (EWI) sampling method. The upstream location was collected about 100' upstream of the eastern border of the site and the downstream location was collected about 0.25 miles downstream.

An automatic flow recorder will be installed at the main seep area since it is believed that seepage is occurring elsewhere below the rock dumps. Flow rates were measured by a bucket and stopwatch or v-notch weir during quarterly sampling.

The rock dump was divided into 50' by 50' grid intervals to sample metal concentrations in the soil. The Niton 702 X-ray Fluorescence spectrometer (XRF) was used with EPA Method 6200 to determine the concentration of metals in the soil. Due to the steepness of the pile, portions of the interior where not accessed because it was too dangerous to sample this area. A composite soil sample was taken from the grid nodes of the waste rock dumps for EPA Method 1312 synthetic precipitation leaching procedure (SPLP) and for acid base accounting (ABA). Soil measurements were also taken in the area of the smelter slag and sites where water samples were taken in June 2002 around the seep.

One soil sample for particle size analysis was collected from a test pit excavated near a potential repository location near the "V" in the access road. This soil texture is classified as a poorly graded sand with gravel (SP) This soil profile showed 12 feet of SP with few small gravels and no groundwater.

3.3 Water Treatment Pilot Test

In order to increase the pH and reduce the leaching of metals from the Seep-1, a pilot test using an Aquafix treatment unit was installed in June 2002. The Aquafix was installed to add calcium oxide lime at a constant rate to raise pH so that metals in the water precipitate into a settling pond near the unit. The settling pond was sized for a minimum 1 day retention time or 1,150 cubic feet. The actual constructed pond size was about 2,600 cubic feet, most of which filled with sludge during the three month test. This is a new technology and was monitored for overall effectiveness. The target pH of the treated water was raised to a minimum 9.5 after lime had been added to the water and the Aquafix was allowed to run for a week. The pilot test was scheduled to run for two months, but the test was extended by one month. Attachment 1 shows photographs of the Aquafix unit at the site.

4.0 DISCUSSION OF RESULTS

4.1 Water

All water samples were analyzed by Neilson Laboratory of Medford, Oregon. Table 2 shows the laboratory analytical results for the 520 or River Adit (Seep-1) water sampling. Review of Table 2 shows that over the course of the year May 2001 to June 2002, concentrations of metals increased, pH decreased and flows decreased. The precipitation pattern for the area suggests that flow rates would increase in winter and spring and decline in summer and fall. The area has been in a drought for several years and 2001 was extremely dry, so these quarterly results may not be entirely representative.

Seep-1 is characterized by high iron and zinc concentrations and acid pH. Similar chemistry is shown by samples SP-2, SP-3, SP-4 and SP-5, all collected in the sheet flow downgradient of Seep-1. Cadmium, copper, lead, mercury, silver and zinc were detected in the samples. The Galice seep concentrations (SP-6, SP-7) show a yellow color and differing chemistry from the River Level (Seep-1) seep water. The Galice seeps show higher hardness (calcium and magnesium), and much lower iron concentrations than one might expect from the volcanic massive sulfides of the Rogue Formation. This is consistent with the seeps' location in the Galice shale formation and not from the iron pyrite-rich Rogue Formation massive sulfide ore body (Wood, 1987).

Table 2 shows complete analytical results for all the seep and flow locations, including those in the Galice Formation (SP-6 and SP-7) sampled over 2001-2002. These seeps had a yellow-green appearance. These data show a slightly different pattern of metals, with higher hardness, copper, but much lower iron results, but otherwise similar results and pH.

Table 3 shows the results of upstream and downstream Rogue River sampling. The results are very similar, however the upstream location has slightly higher metals concentrations than downstream of the Site. Neither sample exceeds Rogue River water quality standards.

4.2 Mining Waste

Detailed XRF analytical results are shown in Table 4. The table below presents the average XRF analytical results for the waste rock grid points within the site compared to risk management criteria (RMC) for campers (Section 4.7). The metals principally elevated are iron, lead, arsenic, and zinc.

ppm	Mean	RMC-Camper
Iron	127,396	not available
Lead	537	1000
Arsenic	410	20
Zinc	462	40000

The average thickness of the waste material ranges typically from several inches to three feet in depth. The waste rock covers an area of approximately 50,000 square feet and the smelter slag is about 2,000 square feet. The estimated volumes of waste rock and slag are 5,600 cubic yards and 250 cubic yards, respectively. Tables 5 and 6 show results from the composite waste rock sample for SPLP and ABA as analyzed by ACZ Laboratory of Steamboat Springs, Colorado. These samples were collected to assess the importance of the waste rock dumps in contributing acid rock drainage to the Galice Formation seeps below.

SPLP results derived from the composite waste rock of the Almeda massive sulfides show that leachable concentrations of cadmium, copper and zinc in excess of Rogue River water quality standards are potentially produced by the waste rock (Table 5). However, waste rock leachate concentrations are about an order of magnitude less than the seep concentrations in Table 2. This suggests that the waste rock dumps are not an important source of the acid rock drainage seeps below the rock dumps. SPLP results are also less than Oregon cleanup levels for metal leachate in soil.

As expected from a volcanic massive sulfide material, ABA results show the waste rock is moderately acid generating, with a value of 69 tons of limestone/kiloton of waste, and a lime requirement of 32 mtons/hectare (Table 6). No net neutralization capacity is present as one would expect with higher calcium and magnesium in the Galice seeps. Due to the steepness of the waste rock dumps and their minor importance in acid rock generation, application of a liquid stabilization reagent such as lime in water ($Ca(OH)_2$ at pH 12) or similar product would neutralize the rock dumps if trickle sprayed so as to maximize infiltration and minimize runoff. This treatment will also reduce leaching and bioavailability. The smelter slag is glassified and essentially inert and does not require treatment.

The repository soil sample was analyzed for particle size using ASTM D422 by Hammond Engineering of Medford and for metals by on-site XRF. The particle size analysis showed a unified soil texture classification of SP, poorly graded sand with gravel. The metals analyses were nondetect for toxic metals except for small amounts of zinc, Table 4.

4.3 Aquafix Treatment Unit

This section reports on the results of the Aquafix pilot treatment system. The Aquafix was placed about 50 feet downhill from the adit such that an inlet hose from the adit would feed the water wheel by gravity. See Attachment 1 photographs. A granular calcium oxide lime was supplied to the bin and a mixing ditch was directed to the settling pond located about 25 feet south of the unit. It took several days to calibrate the Aquafix lime dispenser to the flow and chemistry of the adit, with a final feed rate of 25 rpms.

During the first week (June 20), overdosing of the lime occurred and treated water pHs were above the target pH of 9.5. Treated water samples were collected at this time, see Table 7.

Problems were encountered over the next two months with accumulation of the granular lime below the dispenser. Bridging of the lime up into the dispenser occurred, thus halting dispensing of the lime. This problem is due to the low flow of the adit water and the granular form of the lime. It was decided to continue with the granular lime as it reacts faster with the low water flow. Various cones, wind screens, and flumes were tried and eventually an eddy flow was created that averted the bridging problem.

Table 7 shows the mean concentration of metals in the Aquafix-treated water and a comparison with the mean Seep water quality. The percent reductions in metal concentrations and a comparison with Oregon water quality standards is also shown. Metal concentration reductions are in the 94-99% range for the principal acid mine drainage metals of aluminum, cadmium, copper, iron, lead, manganese, and zinc.

Table 7 shows the Aquafix-treated water concentrations are less than chronic aquatic life water quality standards for the Rogue River except for mercury. Mercury has an extremely low water quality standard, 12 parts per trillion (ppt). During the course of the sampling, BLM requested lower detection limits for several metals (lead, mercury and silver) to enable comparison with water quality standards. A number of the measurements were still below detection, (e.g. mercury was only detected 2/5 times for the treated water in the Pond at pH >9.0). The mercury detections were only about twice the detection limit and are therefore uncertain. One half the detection limit was used in computing the mean concentration when analytes were undetected.

The water quality standards for lead and silver are hardness dependent, that is the water quality standard is adjusted upwards based on hardness. Since the Aquafix contributes hardness, the water quality standards were recalculated and shown in the table for lead and silver using 954 mg/L mean hardness from the treated water. The resulting criteria are 0.026 mg/L lead and 0.167 mg/L silver (1 hour acute). Neither standard is exceeded by the Aquafix treated water.

A sample of the sludge from the Aquafix settling pond was analyzed via the Toxicity Characteristic Leaching Procedure to determine whether the sludge qualifies as a hazardous waste (Table 5). Comparison with TCLP regulatory limits indicated that it does not qualify as a hazardous waste, but that copper and zinc were re-solubilized in this acidic extraction. It is important to note that this test is not intended to determine the amount of leaching with normal precipitation.

Results from the Aquafix pilot project demonstrate that the Aquafix unit is capable of effectively reducing the major loading metals and other trace metals in acid mine drainage by 95% and achieving water quality standards if the pH is greater than 9.5. However, modification of the unit is needed to handle the low flows encountered at this site.

4.4 Open Limestone Channels Test

An alternative limestone technology is open limestone channels (OLC), where the AMD is directed through a channel filled with limestone. OLC can remove metals depending on the contact time and degree of mixing caused by vertical gradients. A disadvantage of OLC is that the limestone will become armored or covered with iron hydroxides and the neutralization effect becomes diminished over 1-2 years and eventually has to be replaced. A jar test was performed to evaluate the ability of OLC to neutralize acidity and precipitate the metals from the AMD at the site.

A sample of AMD water from Seep-1 was collected and transported to Neilson Laboratories for a treatment test with three limestone products. Equal volumes of AMD water and limestone gravel were mixed for one hour to simulate the flow of AMD down a constructed OLC to the River. The results are contained in Table 8. The test shows that most metals, except zinc, are reduced to less than water quality standards. The pH of each mixture did not exceed 7.0. Had the pH exceeded 9.0, zinc precipitation would probably have been accomplished, based on results from the Aquafix unit. A mixture of limestone and lime (calcium oxide) is likely to better accomplish the zinc removal.

4.5 Underground Assessment

Saguaro GeoServices, Inc.(SGSI) was tasked by BLM to conduct a surface and underground assessment of the abandoned Almeda Mine, for the purpose of determining the feasibility of installing bulkheads to plug the acid mine drainage (AMD) flow and the feasibility of segregating neutral water flows from AMD. The assessment included a site inspection of mine openings and seep areas outside the mine as well as a review of supplied drawings and reports. The underground assessment included specific water quality tests, identification of sources of flow and estimation of flow volumes. The work was performed on July 15 and 16, 2002. The text in the section is excerpted from that report (Cummings, 2002). The full report is Attachment 2.

According to SGSI, the available hydrologic and underground mine data do not support specific designs or rankings of remediation approaches. Therefore, a phased program of continuing investigation, measurement of underground conditions is recommended. The program should have as its immediate goals the partial sealing of the 520 and No. 0 levels.

For this reason, BLM requested an assessment of the feasibility of installing a partial bulkhead seal in the 520 level so that the point of acid drainage discharge could be raised higher, allowing the lime dosage operation to take place out of the river flood plain. Raising the mine pool so that the point of discharge is away from the active river channel would be desirable if feasible. However, the rock conditions and the proximity of open stopes close to the 520 level portal, coupled with the presence of the No. 0 portal, indicate that installation of a bulkhead seal in the 520 level adit probably will not be successful by itself in backing up the drainage to the 620 level where it could most effectively be handled. In addition, the installation of such a bulkhead would be complicated by any need to remove material from the 520 portal area to directly access a bulkhead site. Finally, installation of any bulkhead seal must be between the presumed 520 portal area and the first stope 120 ft inside the portal and therefore would be in rock with low ground pressures and likely elevated permeability, and would therefore need to be supported by a fairly comprehensive pressure grouting program.

Among SGSI's more important recommendations are:

1. Install piezometers into the mine openings at the 520 level. The hydrostatic pressures at the 520 level should be determined before any ground disturbance is done in that area. At least one drill hole should be advanced into the 520 adit, or the stope leading from the 520 level, or both, so that the mine pool elevation and hydrostatic pressures can be measured. Another drill hole should be performed to recover core from the wall rock some distance (say 20 ft) away from the drift to determine the degree of fracturing and water pressure within the wall rock. The road in front of the 620 portal is a convenient place from which to stage this drilling. If the drill hole is advanced through waste dump material, the waste dump material should be sampled and tested for metals, and any wet zones should be noted and sampled. Both the drill hole into the opening and the one into the wall rock should be fitted with piezometers connected to data loggers, to record the fluctuations in hydrostatic pressure and their relationships to portal discharges being measured elsewhere. The drill holes should be reviewed with a borehole televiewer or (preferably) video camera, after the water within the drill holes has been given a chance to clarify, to assist with selection of plug location(s) and assess condition of adit back, ribs and floor. Siting of the drill holes should be done carefully, to avoid intercepting the stope at the No. 0 level. The drill holes should be vertical if at all possible. If necessary, the drill hole into the 520 adit could be used as a well point at some time in the future should dewatering be required.

Piezometer(s) in borehole(s) should be used to monitor water pressures in existing underground openings before and after plug placement. Vibrating wire piezometers are recommended to facilitate continuous data logging. Borehole(s) should be provided with steel collar casing and locking caps to prevent tampering.

2. Tests in the wall rock hole should be performed to indicate rock mass permeability and the general range of likely grout takes. Staged packer permeability and/or air-lift tests should be performed to provide hydrologic design parameters for bulkhead (plug) design and pressure grouting and to confirm the suitability of potential plug location(s).

3. Due to the shallow depth of cover at the location of the stopes, the occurrence of many intermediate portals, and the poor ground conditions, a total seal approach does not seem feasible at this mine according to present information. SGSI recommended that BLM evaluate the concept for remote placement of plug seals to raise the mine pool to the 620 or No. 0 level. Conventional placement involves driving or re-opening an access adit to the plug location and constructing a bulkhead underground. Remote placement involves drilling boreholes from the surface and injecting concrete and grout through the boreholes to construct the plug. Remote placement is preferable in this case because of technical issues and safety concerns associated with mining through poor ground. The remote placement approach eliminates the health and safety and ground support concerns associated with underground mining, and greatly alleviates the environmental issues associated with containing the release of the AMD and mine waste at the river flood plain. Remote placement may need to be supplemented with pressure grouting of the wall rock and with consolidation grouting of mine waste and debris. In addition, it may be necessary to develop a plan for what to do with displaced AMD because the volumes of material emplaced with remote plugs generally are larger than with direct placed bulkheads. A program of monitoring potential alternative release pathways should be a part of any plan to raise the mine pool.

4. A systematic surface reconnaissance is recommended to check for the potential occurrence of subsidence features or fissures. Thermal imaging may be worthwhile to try if the equipment is readily available. Often, mine exhalation through fissures can be detected with hand-held thermal scanners on cool, moist days. If surface fissures are detected they should be sealed. The mine outflow hydrograph should be inspected for indications of direct surface connections.

5 . Additional investigation of the 620 level is warranted to determine whether there are relatively uncontaminated waters that could be divided from the outflow at the 520 level.

4.6 Summary of the Source and Nature of the Release:

As described in Sections 4.1 and 4.2, the source of the release is AMD emanating from the 520 adit and the Galice seeps. The flow rate is relatively small, about 6-12 gallons per minute, but the AMD pools on the flood plain bedrock before draining into the Rogue River. A description of the areal extent and analytical results, are provided in Section 3. Iron is by far, the largest metal loading to surface water. While iron is not a hazardous substance, it does contribute to the acidity problem which leads to releases of cadmium, copper, lead, manganese, and zinc. These releases are occurring from the site, but they do not exceed reportable quantities.

4.7 Threat to Public Health and Environment:

Threats to human health are not as significant as threat to the environment because human use of the site is limited to casual visitors. Visitors are not likely to drink the AMD at the site because of its discolored appearance nor to camp at the site because of the AMD. However, the AMD runs directly into the Rogue River where it could present a potential ecological problem to receptors in the immediate mixing zone in the River.

Based on concentration, zinc is the principal contaminant of concern at the site to aquatic life. Zinc is of low toxicity to humans, but toxic to fish. In general, zinc toxicity is greater under the following conditions: to embryos and juveniles more so than adults, to starved animals, at elevated temperatures, in the presence of cadmium, in the absence of chelating agent, at reduced salinities, under conditions of marked oscillations in ambient zinc concentrations, at decreased water hardness and alkalinity, and at low dissolved oxygen concentrations. Zinc toxicosis affects freshwater fish by destruction of gill epithelium and consequent tissue hypoxia.

The site is also visited frequented by recreational users. Arsenic is a human carcinogen and lead has a variety of toxic effects to humans. Recreational users may come into contact with the tailings by several exposure pathways. Adults may inhale dust during dry periods; they may accidently ingest soil by hand-to-mouth activities including eating, drinking and smoking; and small children may ingest larger amounts of soil than adults.

BLM uses a reference document, "Risk Management Criteria for Metals at BLM Mining Sites." Using a risk assessment approach, the document cites concern levels for various metals and for various human and ecological receptors (Ford, 1999). These criteria are listed in Table 4. Of the metals detected in waste rock, only arsenic is a concern for human health with a risk management criteria of 20 ppm for a 14 day camper. However, the areas of exceedance are situated on a steep rock dump wall and at a small area near Seep-1 and are not likely to attract visitors, nor is the arsenic likely to be very bioavailable based on SPLP results. Concentrations of lead, arsenic, and zinc are found on the rock dump and are mostly of low risk. Lead and zinc are toxic to plants and terrestrial animals at concentrations greater than 125 ppm and 307 ppm, respectively (Ford, 1999) and site concentrations are of low risk to these receptors . The BLM reference indicates that if the criteria is exceeded by 1-10 times the criteria, the site is moderate risk and if >100 times the criteria, the site is extremely high risk.

EPA ambient water quality criteria are also cited in Ford (1999) as RMCs for surface water. Exceedances are noted for the six metals listed above, see Table 2.

4.8 Factors Relating to the Need for a Removal Action

Section 40 CFR 300.415 (b) (2) of the NCP cites other factors to be considered in determining the need for a removal action:

1. *Actual or potential exposure to nearby human populations, animals or the food chain from hazardous substances, pollutants or contaminants*: The site is located within 200 feet of the Rogue River and is within 1 mile downstream from two developed recreation sites and the National Rogue Wild and Scenic River. The Rogue River is an important salmon and steelhead fishery. There is a release of hazardous substances within the meaning of CERCLA into the soil and water.

2. *Actual or potential contamination of drinking water supplies or sensitive ecosystems*: The Rogue River has Wild and Scenic designation and is an important salmon and steelhead fishery. While water quality standards are not exceeded in the Rogue River, hazardous substances are being released that may possibly affect aquatic life on a localized basis.

3. *Hazardous substances or pollutants, or contaminants in drums, barrels, tanks or other bulk storage containers that may pose a threat of release*: No storage containers on site.

4. *High levels of hazardous substances, pollutants or contaminants in soils largely at or near the surface that may migrate*: The site contains mine waste in the form of rock dumps and slag the former of which may leach or erode contaminants into surface water drainage. The site contains mine waste with moderate concentrations of arsenic, lead and zinc that have migrated slightly over the years into site drainages.

5. *Weather conditions that may cause hazardous substances, pollutants or contaminants to migrate or be released*: Rain and flood erosion only. Much of the site below Seep-1 is located in the 100 year flood plain and contaminants are periodically washed away. The site is subject to periodic inundation from flooding which entrains contaminants into the Rogue River.

6. *Threat of fire or explosion*. Not applicable.

7. *Availability of other appropriate federal or state response mechanisms to respond to the release*. The Oregon Department of Environmental Quality has been notified, however they will not be available to respond.

8. *Other situations or factors that may pose threats to public health or welfare or the environment.* The source area receives recreational visitors with access via boating the Rogue River. The site is surrounded by rough terrain.

5.0 APPLICABLE, OR RELEVANT AND APPROPRIATE REQUIREMENTS

The lead agency is responsible for the identification of applicable or relevant and appropriate requirements (ARARs) at the site under CERCLA that pertain to any CERCLA removal actions. As defined in the Guidance on Consideration of ARARs During Removal Actions (EPA 1991), ARARs are:

> "Applicable requirements are cleanup standards, standards of control, and other substantive requirements, criteria or limitations promulgated under Federal environmental or State environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location or other circumstances found at a CERCLA site.
>
> Relevant and appropriate requirements are cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location or other circumstances at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site and are well-suited to the particular site.
>
> Other information To Be Considered (TBC) generally falls within three categories: health effects information with a high degree of credibility; technical information on how to perform or evaluate site investigations or response actions; and policy."

The tables presented in Attachment 3 identify the major ARARs as follows:

- Chemical specific standards established for specific chemicals found on the site,
- Location specific restrictions based on the location of the site, and
- Action specific limitations on "actions" associated with a CERCLA removal action.

The process of identifying additional ARARs or modifying this initial determination will continue in consultation with the State as removal action alternatives are selected and further developed. The designations suggested should be used as guidance when working with Federal and State regulators involved in the final removal action.

The principal state ARARs are:

- Water quality standards as shown in tables in this document and stream classifications are found in Oregon Administrative Rules (OAR) 340-041-0365.
- State standards for metals concentration in soil are provided in OAR Division 122, Hazardous Substance Remedial Action Rules at 340-122-0045.

6.0 POTENTIAL ALTERNATIVES

The various types of removal actions listed in 40 CFR 300.415 (e) range from fencing and signs to physical removal of the hazardous substances. The following discussion describes and screens a range of potential time-critical removal action alternatives evaluating each alternative's ability to attain ARARs for the site.

1. No Action. The least expensive alternative is to not take any action. However, this alternative does not meet ARARs and does nothing to reduce onsite exposure or release of hazardous substances to the soil, and to surface water.

2. Fence and Sign. Fencing and signing the site are used to prevent or minimize exposure. This alternative is not very effective because of the proximity to the Rogue River, theft and vandalism. Nor does the fence stop water migration into drainages which is necessary to attain ARARs. Posting signs may reduce the amount of trespassers, but past experience suggests that many people would not be stopped by signs nor fences, and signs are frequently stolen. Posting a sign warning people not to drink the AMD water is prudent.

3. Water Treatment Options.
A. Option A - Aquafix. Migration of metals from the Almeda seep into the River could be significantly reduced by using the Aquafix to raise the pH of the seepage water and precipitate the metals into a settling pond. The Galice acidic seeps would be conveyed to the Aquafix unit for treatment. A lined trench would be used to intercept and collect runoff of the east seeps. Water would be routed via gravity to the Aquafix, or a solar-powered pump could be used to pump the water to the Aquafix. In this alternative, an estimated 100 cubic yards of non-hazardous, but potentially leachable sludge would be produced per year from the Aquafix settling pond. This material would be removed to a landfill or placed into a lined, on-site repository.

Advantages: The obvious advantage of this system is that pilot testing has shown this technology can meet ARARs. The treated water would continue to flow into the River, and would meet water quality standards except for a possible very slight exceedance of mercury. *Disadvantages*: A shed or fence would need to be constructed around the Aquafix to protect it from curious visitors, and a larger pond would need to be constructed to hold the sludge that would be formed. An important disadvantage is that due to topography, the unit may have to be located in 2-5 year flood plain. However the unit can be placed and secured to bedrock to resist flood loss. Based on flood plain modeling, the unit would be inundated every five years or so. If such a flood causes loss of the unit, replacement cost is about $17,000, so replacement costs every five years may be a reasonable expense compared to other alternatives. Replacement of the unit, flood plain considerations, and effluent quality are not significant issues if the unit can be placed at the 620 adit by raising the elevation of mine pool discharge (see #4 below).

B. Option B - Constructed wetland. A constructed anaerobic wetland may be able to treat the seep water, reduce acidity and precipitate most metals. *Advantages:* Such a system would require low operation and maintenance (if not flooded) and would have low visual impact. *Disadvantages:* It is doubtful that this technology could meet all water quality ARARs (Ford, 2002), but could reduce loadings substantially. Using design criteria for acidity and flow loading, it would require approximately 1.5 acres (Ford, 2002) based on acidity loading. There are three significant disadvantages to this option. First, the system would have to be built in shallow groundwater at the site and it would be nearly impossible to exclude groundwater. Bedrock would also have to be blasted and removed. Second, the location of a wetland is severely restricted due to topography. A system requiring 1 acre near the seeps would be located in the 1-2 year flood plain. It would be impossible to protect the system against regular flood events. Finally, the capital cost of such a system (estimated to be more than $100,000) would preclude the reconstruction of the system every two years. Other construction-related ARARs such as Flood Plain Management and the Clean Water Act Section 404 would have to be met.

C. Option C - Open Limestone Channels. In this option, a ditch would be constructed from the River Adit to the Galice seeps and thence to the River. If hydraulic controls (see #4 below) can raise the discharge to the 620 adit, this would more than double the potential ditch length and gradient. Crushed limestone rock and lime would be spread into the ditch. As water travels over the ditch, acidity is neutralized by the limestone and metals precipitated in an insoluble form. This option relies on length of channel and gradient to promote mixing and neutralization and to reduce armoring of the rock. *Advantages:* The advantages include initial low cost, low routine maintenance and minimal aesthetic impact. These are very compelling advantages considering disadvantages of other options. *Disadvantages:* The limestone will need replacement every few years based on loss of limestone due to flooding every few years, or armoring or sludge accumulation. Jar tests indicate that limestone may not meet zinc water quality standards (although this can be corrected by a mix of lime and limestone). The State will be consulted concerning the ability of this alternative to fully meet water quality requirements.

4. Hydraulic Controls. This alternative would involve: (1) run-on controls to divert precipitation and runoff water away from the mine workings to avoid contamination and to reduce seep flow, and (2) closure of the River Level (520) adit. This would involve sealing the lower seep. *Advantages:* If successful, it would cause the water in the mine pool to rise to the upper 620 adit where the Aquafix could be more safely located, directing the treated water through a recommended longer channel to a settling pond. *Disadvantages:* Adit closure can be a difficult and risky procedure due to danger of a blowout. Raising the mine pool may increase the flow at other seeps, which would not be productive. Further underground studies are required to determine the feasibility of closing the River Level (520) adit.

5. Treat Rock Dumps with Stabilization Reagent. The rock dumps are not a major source of acid rock drainage and do not exceed Oregon cleanup levels except for total (but not leachable) metals. Because of the steep angle of repose and slope stability concerns, it is not necessary nor recommended to remove this material. Instead, the rock dumps could be sprayed with a lime or stabilizing reagent to neutralize acidity, reduce acid rock drainage and to reduce bioavailability. The amount of lime required can be calculated from the ABA tests. This alternative would be used in conjunction with a water treatment option.

7.0 SELECTED ALTERNATIVE

Because of the release and potential threat of release of hazardous substances into soil and water and potential onsite health and ecological risks, it is recommended that a time-critical removal action be implemented involving a combination of several of the alternatives listed above. It is recommended that the following activities be conducted in sequence:

1. Install an open limestone channel with a mixture of limestone and lime to intercept and treat the seep water. Monitor quarterly for effectiveness. Post a warning sign not to drink the water from the site. Estimated 2003 costs: <$15,000.
2. Conduct soil borings at the 620 adit into the lower mine workings to investigate the feasibility of closing the 520 adit. Estimated 2003 costs: <$20,000.
3. Chemically stabilize waste rock dumps using an aqueous lime reagent. Estimated 2003 costs: <$5,000.
4. If it is found to be feasible to close the 520 adit, conduct closure activities of the adit. Estimated costs are unknown at this time.
5. If closure is successful, install an Aquafix or open limestone channels at the new discharge location at the 620 adit. Estimated 2004 costs: <$25,000.
6. If closure is found not to be feasible, investigate other means to reduce the flow of AMD.

According to BLM archeologists, as currently proposed, the installation of the open limestone channels, soil borings, and chemical stabilization of waste rock dumps would not compromise the National Register eligibility of the Almeda mine site. Although not currently proposed, activity within the habitation flat or within the smelter area would impact the National Register eligibility of this site. Before any activity is authorized in either of these two areas, more testing and evaluation will be required.

8.0 REFERENCES

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