Action Memorandum

for

ZORTMAN AND LANDUSKY MINES
TIME-CRITICAL REMOVAL

OPERABLE UNIT 1 & OPERABLE UNIT 2

Malta Field Office, Bureau of Land Management
Phillips County, Montana

June 2004

ACTION MEMORANDUM

To: Martin C. Ott, State Director

Through: Mark K. Albers, Field Manager, Malta Field Office MKA 6/22

From: Scott Haight, On-Scene Coordinator SH 6/21

Subject: Request to Commence a Time Critical Removal Action at the Zortman and Landusky Mines, Phillips County, Malta Field Office

I. PURPOSE

The Bureau of Land Management (BLM) will continue to conduct response actions at the Zortman and Landusky Mines located in Phillips County, Montana, through the agency's delegated authority (Executive Order 12580) under the Comprehensive, Environmental, Response, Compensation, and Liability Act (CERCLA). All response actions will be consistent with the National Contingency Plan (40 CFR Part 300). Due to the intermingled private land at the mines, and the previous integration of BLM's mining regulation program (particularly reclamation bonding) with the State of Montana's mining regulation program, the removal actions will be conducted in conjunction with the Montana Department of Environmental Quality (DEQ) reclamation and water treatment activities at the Site.

The purpose of this specific Action Memorandum is to document and request continued approval of the Time-Critical Removal, as authorized by section 104 (42 U.S.C. 9604) of CERCLA, at the Zortman and Landusky Mine sites (the mines, or the Site) [1]. Copies of the Administrative Record for this project are available for viewing at the Lewistown Field Office, Lewistown, Montana. Public review of the record can be conducted during regular business hours.

The owner and operator of the mines, Zortman Mining, Inc. (ZMI) and Pegasus Gold Corporation (PGC), declared bankruptcy in 1998. Since that time, the BLM and DEQ have worked together with the bankruptcy trustee (serving in the role of mine operator) to implement closure of the mine in a competent manner using the reclamation and water treatment bonds along with other funding sources. With the discharge of the ZMI bankruptcy proceedings on November 10, 2003, an operator of record no longer exists. However, a recent review shows conditions at the Site continue to pose a potential threat to public health or welfare or the environment; on, from, or to lands under the jurisdiction, custody, or control of the BLM (See Part II, Tables 1-3). These conditions meet the criteria for a Removal Action under 40 CFR § 300.415 (b)(2) of the National Contingency Plan (NCP). Executive Orders 12580 and 13016 delegate this authority to the Department of the Interior. Secretarial Order 3201 further delegates the authority to the BLM when the release or potential release of hazardous substances is on or from BLM-managed lands.

At this time, the BLM has identified three Operable Units within the Site. Operable Unit 1 (OU1) is the capture and treatment systems used to recover and treat mine drainage, also known as acid rock drainage (ARD), from the waste rock dumps, leach pad dikes, areas beneath the mine pits, or from historic underground workings. OU1 facilities include: the existing seepage capture systems in Ruby Gulch, Alder Spur, Carter Gulch, Montana Gulch, Mill Gulch, and Sullivan Gulch; the Zortman and Landusky ARD water treatment plants, areas where treated water leaves the plants, and the associated infrastructure serving these facilities including roads, powerlines, pipelines, and current or future backup or supplemental power generation equipment.

Operable Unit 2 (OU2) includes: the leach pad containment areas with residual process solutions; the biological treatment system used to treat leach pad solutions; associated ponds,

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1- For purposes of this Action Memorandum, "the Site" is defined as the combined facilities and infrastructure that exists for the Zortman and Landusky mines (See Attachment 1).

pipelines, pumps and pre- or post-treatment apparatus; and the land application disposal system (LAD).

Operable Unit 3 (OU3) consists of the area of mine disturbance at the Site where reclamation has occurred or is in the process of occurring (Attachment 1).

This action memorandum examines alternatives to the mine drainage seepage capture and treatment systems and to the residual heap process solution treatment bioreactor and LAD system. At this time, the most appropriate course of action is to continue operation of these water treatment systems (OU1 and OU2). Short-term modifications to the systems, such as mixing or aerating the treated water from each system, may be implemented as necessary. All solutions will be treated to the extent practical prior to leaving the site. In addition, technical studies will continue and the BLM may develop an EE/CA should significant changes in the long-term management of OU1 and OU2 be warranted.

It is anticipated that should additional[2] response actions at OU3 be required they will be administered as CERCLA non-time-critical removal actions and addressed in a future EE/CA. Otherwise, general maintenance of reclamation on BLM lands will be implemented as part of enforcement actions conducted under the BLM's surface management regulations and funded by the reclamation bonds.

All CERCLA actions at the Site will continue to be consistent with the preferred reclamation plans from the 2001 Supplemental EIS on Reclamation of the Zortman and Landusky Mines, and the BLM's associated 2002 Record of Decision (ROD). Removal actions will be conducted in conjunction with the DEQ actions at the Site. It is intended that the DEQ continue to conduct water treatment using funds from the reclamation bonds, water treatment trust fund, or with supplemental funding provided by the BLM to maintain year-round function of the operable units. DEQ's water treatment activities meet BLM's removal action objectives.

II. SITE CONDITIONS AND BACKGROUND

A. <u>Site Description</u>

1. Removal Site Evaluation

The Zortman and Landusky mines were open pit, cyanide heap leach, gold mines located in the Little Rocky Mountains of north central Montana. Ore was mined from pits, located mostly on private lands, and stacked in valley fill leach pads, constructed mostly on BLM-administered lands (BLM lands), where standard cyanide heap leach technology was used to extract the precious metals (gold and silver) from the ore. Cyanide solution was applied to the heaps by

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2 - During 2000, the EPA conducted a non-time critical removal of historic mine tailings in nearby King Creek. The tailings were placed in OU3 as subsoil cover to reclaim leach pads at the Landusky Mine. In addition, the BLM/DEQ excavation of historic mine tailings from Ruby Gulch adjacent the Zortman Mine, and the removal of the L85/86 Leach Pad at the Landusky Mine, were BLM abandoned mine land (AML) projects conducted under BLM's CERCLA authority (BLM Handbook H-1703-1).

spray or drip irrigation where gold was dissolved from the ore as the solution percolated through the heaps to sumps at the base of the leach pads. The "pregnant" solution was then pumped to a gold/silver recovery plant. During mining the nonmineralized rock (waste rock) was placed in waste rock dumps, as mine pit backfill, or used in the construction of retaining dikes for the leach pads.

The mines operated from 1979 until 2003 under State-approved Operating Permits, and from 1981 until 2003 under BLM-approved Plans of Operations, although active mining ceased in 1997. In 1998 PGC and ZMI declared bankruptcy and a Federal bankruptcy court appointed a Trustee. Also in 1998 the surety companies (USF&G and National Union Fire Insurance) reached an agreement with the DEQ to fund reclamation and water treatment to the limits of the surety bonds.

In 2002, the BLM and DEQ issued modifications to the operator's (Trustee's) reclamation plans as part of the reclamation plan modification process begun in 1993. These plans were developed over several years in a collaborative effort between BLM, DEQ, EPA, and the Fort Belknap Tribes. The reclamation plans selected in the 2002 ROD were estimated to cost approximately $22.5 million more than the surety bonds. Through removal actions sponsored by the BLM's AML program, DEQ grants, and cost savings under the competitive bidding process, the estimated reclamation earthwork shortfall has been reduced from $22.5 million to $1.53 million.

Estimated water treatment costs for OU1 (ARD capture and treatment) remain substantially greater than the funds available under both the near-term water treatment surety bond and the long-term water treatment trust fund. The present shortage in funds for water treatment is estimated at $4.2 million to cover near-term costs until 2017, with an additional $12.4 million needed in the long-term trust fund, today, in order to ensure the trust fund generates enough revenue to keep OU1 functioning in perpetuity. Since 1999, the BLM has provided the funding to keep these facilities operating because the surety bond has not been adequate to fund operation of the OU1 water treatment plants for the entire year.[3] The 2002 ROD provided that the BLM and DEQ would seek additional funding for water treatment for at least two years. As of May 2004 a permanent source of funding for water treatment has not been secured.

Operable Unit 1 was constructed as part of a 1996 Consent Decree (CD) between the mine operator, State of Montana, EPA, the Fort Belknap Tribes, and Island Mountain Protectors in order to resolve a complaint filed under the federal Clean Water Act and Montana Water Quality Act over discharges from the mines. Since 1999, OU1 has captured and treated over a billion gallons of mine drainage.

While the OU1 water treatment plants have been generally successful in meeting the effluent limits in the Consent Decree (CD at Appendix E) and have removed a large amount of metals and acidity from the mine drainage, they are not always able to meet ambient water quality standards. Nor are they suitable for treating cyanides, which are sometimes detected in the

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3- The surety company distributes funds at the beginning of the calendar year in the amount of $731,321. For years 2000 through 2003, OU1 operating costs have been $843,387; $879,727; $905,899; and $758,267; respectively. Annual cost could increase to over $1.2 million once reclamation is done and sharing of fixed costs with reclamation personnel ceases.

treated water at low levels (<1 mg/L total), usually in the spring. It is imperative that OU1 continue to operate to protect the environment.

Operable Unit 2 is a biological treatment system that was constructed in 2001 to remove selenium, nitrate and cyanide from the process solution remaining in the leach pads. The leach pad process circuits have a combined maximum capacity of approximately 350 million gallons. Prior to surface reclamation the leach pads were accumulating about 100 million gallons per year due to rainfall and snowmelt. In order to prevent overtopping of the process circuit, the solution was treated with hydrogen peroxide, to reduce the cyanide levels, and land applied at the Goslin Flats land application disposal (LAD) site. The elevated nitrate and selenium levels limited the amount of leachate that could be land applied without severely impacting area vegetation and groundwater quality. The biological treatment system was designed to remove the selenium, nitrate, and cyanide so that peroxide pre-treatment and land application disposal would not be necessary; or in the alternative to reduce nitrate and selenium to the point where these constituents would not be limiting factors in LAD.

The biological treatment system has an optimal treatment rate of 75 gpm and has been successful at removing selenium and nitrates to levels where treated process water meets water quality objectives, after mixing with other treated water, and can be directed into area streams. Cyanide reduction has not achieved the same level of success, but natural degradation and dilution within the leaching circuit has reduced total cyanide levels to less than 1 ppm. Presently there are approximately 145 million gallons of residual solution in the leaching circuit requiring treatment with additional accumulations anticipated in the future. While reclamation has slowed the rate in which precipitation recharges the leach pads, it is imperative that leach pad solutions continue to be treated and released in order to maintain adequate storage capacity. Failure to maintain adequate storage capacity in the leach pads could result in breaching of the containment system; either due to a gradual build-up in the solution inventory or from an extreme precipitation event, and the release of untreated leachate. Storage capacity could be maintained either by treating the leach pad solution in the bioreactor, with final disposal via land application at Goslin Flats, or by mixing the bioreactor treated water with either the OU1 influent or treated water.

2. Physical Location

The mines are situated on the crest of the Little Rocky Mountains and straddle the divide between the drainages which flow north toward the Milk River and those that flow south toward the Missouri River (Attachment 1). Elevations range from 3800 to 5600 feet with annual precipitation from 20 to 30 inches.

The Zortman Mine is located in Sections 7, 17, and 18, Township 25 North, Range 25 East, Montana Principal Meridian (Attachment 1a). The LAD area is south of Zortman in Sections 20, 21, and 28. Streams in the Zortman Mine area include Lodgepole Creek which drains to the north, Ruby Gulch which flows south through the town of Zortman, and Alder Gulch a tributary of Ruby Gulch. Flow in Lodgepole Creek is intermittent near the mine but perennial in its lower reaches and support a limited brook trout population several miles from the Site. Flows in Ruby and Alder Gulch are intermittent but may run quite high after storm events or rapid snowmelt. The LAD area at Goslin Flats is adjacent to both Ruby Gulch Creek and Goslin Gulch.

The Landusky Mine is about 1½ miles west of the Zortman Mine and is located in Sections 14, 15, 22, and 23, Township 25 North, Range 24 East, Montana Principal Meridian (Attachment 1b). Streams in the Landusky Mine area include King Creek and Swift Gulch (both tributaries of South Bighorn Creek), which flow northwest onto the Fort Belknap Indian Reservation. There is a Tribal cultural and recreation use area located along South Bighorn Creek about a mile downstream of the northern portion of the Landusky Mine. Montana Gulch, Mill Gulch, and Sullivan Gulch are all tributaries of Rock Creek, which flows to the south. All these streams are intermittent near the mine site. Small brook trout populations exist in perennial segments of both Rock Creek and South Bighorn Creek/Little Peoples Creek, several miles downstream of the mine. There is a BLM campground located along Montana Gulch about half a mile downstream of where treated water from OU1 enters the stream.

3. Site Characteristics

The Zortman Mine disturbance covers approximately 406 acres, of which about 122 acres are on BLM land. Approximately 20 million tons of ore were mined during operations from 1979 through 1994. The mine pits are located on private lands and cover approximately 96 acres. The leach pads and waste rock dumps are located on a mixture of private and BLM-managed lands over the remainder of the site (Attachment 1a).

The Landusky Mine disturbance covers approximately 783 acres, of which about 452 acres are on BLM land. Approximately 117 million tons of ore were mined during operations from 1979 through 1996. The mine pits are located mostly on private lands and cover approximately 235 acres. Virtually all of the leach pads and much of the waste rock are located on BLM-managed lands (Attachment 1b).

Detailed site characterization of both mines and the surrounding environment can be found in two recently completed documents, *Final Environmental Impact Statement, Zortman and Landusky Mines, Reclamation Plan Modifications and Mine Life Extensions* (BLM, DEQ, 1996); and *Final Supplemental Environmental Impact Statement for Reclamation of the Zortman and Landusky Mines* (BLM, DEQ, 2001). These documents contain detailed discussions of the environmental conditions at the site along with an evaluation of reclamation alternatives. The 2001 SEIS discusses remediation methods, treatment options, and costs.

4. Release or Threatened Release into the Environment of a Hazardous Substance, Pollutant, or Contaminant

a. Hazardous Substances

Site characterization, including extensive sampling and monitoring, has revealed that hazardous substances, as defined in section 101 (14) of CERCLA, 42 U.S.C. 9601(14), have been released into the environment. If OU1 or OU2 ceases operation the release of hazardous substances would increase greatly without the benefit of treatment, creating significant environmental damage. This includes the release of solutions containing metals such as arsenic, cadmium, copper, selenium and zinc; plus cyanide complexes, nitrates, and solutions having low pH (acidic) levels.

b. Sampling and Analysis Data

Detailed monitoring of surface and ground water quality at the Site has been conducted since before open pit mining operations began in the late 1970s and continues to date. The Consent Decree contained additional monitoring requirements. There is presently an extensive database with thousands of monitoring results from hundreds of monitoring stations (e.g., Annual Water Resources Monitoring Report for 2003).

Water quality monitoring programs are in place to evaluate reclamation performance as well as the performance of the water treatment and disposal systems associated with OU1 and OU2. Most recently, a "Groundwater and Surface Water Monitoring Plan" (April 2002), also referred to as the "long-term water monitoring plan," or "WMP," was developed over several years by the Hydrology Technical Work Group whose members included technical specialists from BLM, DEQ, EPA, and Fort Belknap. Monitoring requirements contained in the WMP are comprehensive and were designed to replace all of the monitoring programs in the Consent Decree and in the mine plans.

Water quality monitoring data collected through the spring of 2004 shows that treated water from OU1 and OU2, while usually meeting the effluent limits of the CD, does not always meet the water quality standards (Table 1 and Table 2). More importantly, the second column of Tables 1 through 3 shows the quality of water that would be released to the environment if OU1 or OU2 were not in operation.

Table 1. Operating Unit 1 - Zortman Water Treatment Plant.

Parameter	Typical Captured Influent	Typical WTP Treated Water	CD Interim Limit (Daily Max.)	Water Quality Standard*
pH (s.u.)	3.5	7.5	6.0 – 9.0	6.5 – 8.5
TSS (mg/L)	20	25	30	20
Sulfate (mg/L)	3000	2600	na	250
$Cyanide_{(total)}$ (mg/L)	0.015	0.010	<0.005	0.0052
Arsenic (mg/L)	0.080	<0.003	na	0.018
Copper (mg/L)	3.50	0.015	0.30	0.031
Cadmium (mg/L)	0.2	0.005	0.10	0.005
Iron (mg/L)	40	0.5	na	1.0
Lead (mg/L)	0.005	<0.003	0.60	0.015
Manganese (mg/L)	35	3.5	na	0.050
Mercury (mg/L)	ND	ND	0.002	0.00005
Selenium (mg/L)	0.015	0.010	na	0.005
Zinc (mg/L)	5.0	0.05	1.50	0.388

Table 2. Operating Unit 1 – Landusky Water Treatment Plant.

Parameter	Typical Captured Influent	Typical WTP Treated Water	CD Interim Limit (Daily Max.)	Water Quality Standard*
pH (s.u.)	6.0	7.5	6.0 – 9.0	6.5 – 8.5
TSS (mg/L)	20	7	30	20
Sulfate (mg/L)	650	900	na	250
$Cyanide_{(total)}$ (mg/L)	0.05	ND	<0.005	0.0052
Arsenic (mg/L)	0.15	<0.025	na	0.018
Copper (mg/L)	0.03	0.005	0.30	0.031
Cadmium (mg/L)	0.015	0.004	0.10	0.005
Iron (mg/L)	10	0.3	na	1.0
Lead (mg/L)	0.004	<0.003	0.60	0.015
Manganese (mg/L)	4.0	3.0	na	0.050
Mercury (mg/L)	ND	ND	0.002	0.00005
Selenium (mg/L)	0.005	0.005	na	0.005
Zinc (mg/L)	0.80	0.05	1.50	0.388

Table 3. Operating Unit 2 – Bioreactor for Leach Pad Process Solution.

Parameter	Typical Heap Influent	Typical Quality to LAD or OU1	Water Quality Standard*
pH (s.u.)	6.8	7.2	6.5 – 8.5
SAR (units)	17	22	4.5
$Cyanide_{(tot)}$ (mg/L)	0.37	0.29	0.0052
$Cyanide_{(wad)}$ (mg/L)	0.07	0.07	na
Nitrates (mg/L)	82	1.0	10.0
Selenium (mg/L)	0.47	0.06	0.005
Arsenic (mg/L)	0.010	0.002	0.018
Copper (mg/L)	0.100	0.01	0.031
Cadmium (mg/L)	0.75	0.03	0.005
Lead (mg/L)	0.002	ND	0.015
Zinc (mg/L)	2.00	0.75	0.388

*These include primary and secondary standards from a variety of sources and are presented only to assist in characterizing the potential for contaminants in a release. Not necessarily ARARs. See Attachment 3.
ND=non detect, na=not applicable.

c. Mechanism for Past, Present, or Future Release

Past releases of hazardous substances occurred from the water treatment plants and capture systems associated with OU1, and from the LAD component of OU2. Treated water from OU1 has contained elevated total cyanide and metals such as arsenic. Treatment rates average some 450 gpm for the Landusky treatment plant, which runs continuously, and substantially less for the Zortman plant as it only operates about 1 week per month. Previous irrigation at the LAD area contained selenium and nitrates greater than Montana water quality standards. Use of the bioreactor in OU2 has reduced the nitrate and selenium levels that will be present in future applications to the LAD area.

Data on leach pad chemistry shows changing conditions in the leach pad solutions as the alkaline solutions present during leaching give way to the acidity released by the oxidation of sulfide minerals in the spent ore. Pre-treatment of leach pad waters prior to entering the bioreactor has prevented this from becoming an impediment to OU2 operations. If leach pad chemistry changes sufficiently the process solution may be treated in OU1 in addition to the OU2 biological treatment system.

There is the potential that the capture systems will fail to recover all the seepage from upgradient mine facilities. This situation would result in a release. Monitoring is in place to detect failure or inadequate performance of the capture systems. Removal actions could include upgrading the capture systems or placement of additional capture structures.

d. Events or Features that Could Spread or Accelerate Releases

High volume precipitation events and spring runoff could overwhelm the treatment capacity and cause the release of untreated mine drainage and/or leaching solutions. While the OU1 seepage capture systems have been designed to accommodate runoff from a 6.33 inch storm event, there have been three storm events of 6-inches or more since 1986. Precipitation could also accelerate the migration of applied water from the LAD area into shallow groundwater and adjacent streams instead of allowing for the uptake of constituents such as nitrates and selenium by the vegetation, or attenuation of metals in the soil profile.

Power outages could cause a shutdown in the mine drainage capture and treatment system and in the biological treatment system. However, the site is equipped with two backup generators to maintain power to the seepage capture systems and treatment plants. If backup power generation failed, the seven seepage capture systems that are part of OU1, located in six area drainages, would likely overflow within a few hours, releasing untreated mine drainage.

e. Properties that Influence the Rate of Releases

The biological treatment plant was initially designed to treat heap solution at 300 gpm. However, field-testing has shown that optimal treatment occurs at 75 gpm. Because it is a biological treatment system, the flow through rates cannot be easily varied without upsetting the biological activity and treatment efficiency. Therefore, release rates are not expected to change, although treated heap solution could be routed back into the heap containment if the LAD system or OU1 was not online. When nitrate and cyanide levels in the heap solution decline to the extent feasible, LAD of treated water will cease and the biological plant will be dismantled. Long-term bio-treatment of seepage from the leach pads in OU2 is not expected to be necessary as there are finite amounts of nitrates and cyanide left over in the leach pads from mineral processing. If the long-term character of the residual leach pad solution changes (acidifies) it may be more appropriate to treat it in OU1 as mine drainage.

As surface reclamation is completed the volume of precipitation entering waste rock piles, mine pits floors and leach pads will be greatly reduced. This will result in a decrease in the volume of water requiring capture, treatment and disposal at OU1 and OU2. However, the concentration of some contaminants may also increase because there will be less dilution.

5. National Priority List (NPL Status)

The Zortman and Landusky Mines are not now on the NPL list and are not expected to be placed on the list in the future. If OU1 or OU2 were to cease functioning the situation would have to be reevaluated because contaminant levels would be likely to increase considerably.

6. Maps and Graphic Representation

Location maps showing topography, land status and mine site facilities are presented in Attachments 1, 1a, and 1b. Water treatment flowcharts for OU1 and OU2 are in Attachments 2a, 2b, and 2c.

B. Other Action to Date

1. Previous Actions

Previous CERCLA-based removal actions have been conducted at and adjacent to the Site, either by EPA or as part of BLM's abandoned mine land reclamation program.

Beginning in 1999, the BLM provided funding to keep OU1 running in order to remove acidity and metals from mine drainage that was either impacting, or derived from, BLM lands. This action supplemented the monies provided annually by the surety bond and allowed for year-round treatment of mine drainage through 2003.

During 2000, the EPA conducted a non time-critical removal of the historic mine tailings in King Creek. Approximately 60,000 cubic yards of tailings were excavated from the King Creek drainage on the Fort Belknap Reservation along about a 2-mile stream reach from just upstream of the Pow Wow grounds to the Cumberland Dam, immediately downstream of the Landusky Mine. The tailings were hauled to the Landusky Mine and placed on the regraded L80 through L84 leach pads for use as subsoil in the mine reclamation. The EPA prepared an Engineering Evaluation/Cost Analysis (EE/CA) for the project (IT Corp., 1999).

Beginning in 2001, the BLM and DEQ removed the historic mine tailings from Ruby Gulch and restored the streambed as an abandoned mine land reclamation project. Approximately 650,000 cubic yards of tailings were removed from the Ruby Gulch drainage beginning just below the town of Zortman where the county road crosses the stream and continuing upstream some two miles to the Ruby Gulch capture system at the edge of the Zortman Mine.

2. Current Actions

BLM is presently conducting a removal action at the Landusky Mine as part of its abandoned mine reclamation program through an assistance agreement with the DEQ. BLM is excavating the L85/86 leach pad and dike from the Montana Gulch drainage in order to remove a potential source of contaminants that overlie the drainage. This action is consistent with mine reclamation Alternative L4 in the SEIS, but could not be implemented with the mine reclamation bond monies available. This removal action is expected to be complete in 2005.

C. State and Local Authorities' Role

1. State and Local Actions to Date

Over the past twenty years the State and BLM have worked together first as co-regulators under each agency's respective mining regulations, then during the bankruptcy process, and most recently to develop and implement the mine reclamation and water management plans. From early 1999 to date, the DEQ's Environmental Management Bureau has been using the mine reclamation surety bonds and water treatment funds to manage the Site and maintain water treatment activities consistent with this removal action.

The DEQ developed draft MPDES permits for the Site as anticipated by the 1996 Consent Decree. However, due to the discharge of the bankruptcy trustee there is no operator-applicant available to receive the permits.

2. Potential for Continued State/Local Response

The BLM will take the lead in evaluating the Site as it pertains to protection of public lands and will continue working with the DEQ in the removal of the potential contaminants and hazardous substances. Contracting for site management activities will continue to be conducted using the State's contracting process through the DEQ. BLM does not intend to replace the present DEQ activities, but to supplement them as necessary in order to maintain year-round operations and meet ARARs. BLM will provide supplemental funding for the removal action to the DEQ. Site management actions on or affecting BLM lands will be developed jointly with the DEQ. BLM and DEQ plan to enter into an MOU formalizing this working arrangement.

In implementing this CERCLA action the BLM will continue to perform community relations activities; including those described in the NCP and 40 CFR 300.

III. THREATS TO PUBLIC HEALTH OR WELFARE OR THE ENVIRONMENT, AND STATUTORY AND REGULATORY AUTHORITIES

Concentrations of total cyanide, selenium, nitrate, and metals in the mine drainage and residual heap leaching solutions at the Site present a threat to public health or welfare and the environment. These conditions meet the criteria for a Removal Action under 40 CFR § 300.415(b)(2) of the NCP. The following are toxicity profile summaries from the Risk

Assessment Information System website for the Site contaminants of concern. The formal toxicity profiles are available at the following link: http://risk.lsd.ornl.gov/tox/rap_toxp.shtml

Arsenic

The toxicity of inorganic arsenic (As) depends on its valence state (-3, +3, or +5), and also on the physical and chemical properties of the compound in which it occurs. Trivalent (As+3) compounds are generally more toxic than pentavalent (As+5) compounds, and the more water soluble compounds are usually more toxic and more likely to have systemic effects than the less soluble compounds, which are more likely to cause chronic pulmonary effects if inhaled. One of the most toxic inorganic arsenic compounds is arsine gas (AsH3). It should be noted that laboratory animals are generally less sensitive than humans to the toxic effects of inorganic arsenic. In addition, in rodents the critical effects appear to be immunosuppression and hepato-renal dysfunction, whereas in humans the skin, vascular system, and peripheral nervous system are the primary target organs.

Water soluble inorganic arsenic compounds are absorbed through the G.I. tract (>90%) and lungs; distributed primarily to the liver, kidney, lung, spleen, aorta, and skin; and excreted mainly in the urine at rates as high as 80% in 61 hr following oral dosing (EPA, 1984; ATSDR, 1989; Crecelius, 1977). Pentavalent arsenic is reduced to the trivalent form and then methylated in the liver to less toxic methylarsinic acids (ATSDR, 1989).

Symptoms of acute inorganic arsenic poisoning in humans are nausea, anorexia, vomiting, epigastric and abdominal pain, and diarrhea. Dermatitis (exfoliative erythroderma), muscle cramps, cardiac abnormalities, hepatotoxicity, bone marrow suppression and hematologic abnormalities (anemia), vascular lesions, and peripheral neuropathy (motor dysfunction, paresthesia) have also been reported (U.S. Air Force, 1990; ATSDR, 1989; Franzblau and Lilis, 1989; EPA, 1984; Armstrong et al., 1984; Hayes, 1982; Mizuta et al., 1956). Oral doses as low as 20-60 g/kg/day have been reported to cause toxic effects in some individuals (ATSDR, 1989). Severe exposures can result in acute encephalopathy, congestive heart failure, stupor, convulsions, paralysis, coma, and death. The acute lethal dose to humans has been estimated to be about 0.6 mg/kg/day (ATSDR, 1989). General symptoms of chronic arsenic poisoning in humans are weakness, general debility and lassitude, loss of appetite and energy, loss of hair, hoarseness of voice, loss of weight, and mental disorders (Hindmarsh & McCurdy, 1986). Primary target organs are the skin (hyperpigmentation and hyperkeratosis) [Terada et al. 1960; Tseng et al., 1968; Zaldivar 1974; Cebrian et al., 1983; Huang et al., 1985], nervous system (peripheral neuropathy) [Hindmarsh et al., 1977, 1986; Valentine et al., 1982; Heyman et al., 1956; Mizuta et al., 1956; Tay & Seah, 1975], and vascular system [Tseng et al., 1968; Borgano & Greiber, 1972; Salcedo et al., 1984; Wu et al., 1989; Hansen, 1990]. Anemia, leukopenia, hepatomegaly, and portal hypertension have also been reported (Terada et al., 1960; Viallet et al., 1972; Morris et al., 1974; Datta, 1976). In addition, possible reproductive effects include a high male to female birth ratio (Lyster, 1977).

In animals, acute oral exposures can cause gastrointestinal and neurological effects (Heywood and Sortwell, 1979). Oral LD50 values range from about 10 to 300 mg/kg (ASTDR, 1989; U.S. Air Force, 1990). Low subchronic doses can result in immunosuppression, (Blakely et al., 1980) and hepato-renal effects (Mahaffey et al., 1981; Brown et al., 1976; Woods & Fowler, 1977, 1978; Fowler & Woods, 1979; Fowler et al., 1979). Chronic exposures have also resulted in mild hyperkeratosis and bile duct enlargement with hyperplasia, focal necrosis, and fibrosis (Baroni et al., 1963; Byron et al., 1967). Reduction in litter size, high male/female birth ratios, and fetotoxicity without significant fetal abnormalities occur following oral exposures (Schroeder & Mitchener, 1971; Hood et al., 1977; Baxley et al., 1981); however, parenteral dosing has resulted in exencephaly, encephaloceles, skeletal defects, and urogenital system abnormalities (Ferm & Carpenter, 1968; Hood & Bishop, 1972; Beaudoin, 1974; Burk & Beandoin, 1977).

The Reference Dose for chronic oral exposures, 0.0003 mg/kg/day, is based on a NOAEL of 0.0008 mg/kg/day and a LOAEL of 0.014 mg/kg/day for hyperpigmentation, keratosis, and possible vascular complications in a human population consuming arsenic-contaminated drinking water (EPA, 1991a). Because of uncertainties in the data, EPA (1991a) states that "strong scientific arguments can be made for various values within a factor of 2 or 3 of the currently recommended RfD value." The subchronic Reference Dose is the same as the chronic RfD, 0.0003 mg/kg/day (EPA, 1992).

Acute inhalation exposures to inorganic arsenic can damage mucous membranes, cause rhinitis, pharyngitis and laryngitis, and result in nasal septum perforation (EPA, 1984). Chronic inhalation exposures, as occurring in the workplace, can lead to rhino-pharyno-laryngitis, tracheobronchitis, (Lundgren, 1954); dermatitis, hyperpigmentation, and hyperkeratosis (Perry et al., 1948; Pinto & McGill, 1955); leukopenia (Kyle & Pease, 1965; Hine et al., 1977); peripheral nerve dysfunction as indicated by abnormal nerve conduction velocities (Feldman et al., 1979; Blom et al., 1985; Landau et al., 1977); and peripheral vascular disorders as indicated by Raynaud's syndrome and increased vasospastic reactivity in fingers exposed to low temperatures (Lagerkvist et al., 1986). Higher rates of cardiovascular disease have also been reported in some arsenic-exposed workers (Lee & Fraumeni, 1969; Axelson et al., 1978; Wingren & Axelson, 1985). Possible reproductive effects include a high frequency of spontaneous abortions and reduced birth weights (Nordström et al., 1978a,b). Arsine gas (AsH3), at concentrations as low as 3-10 ppm for several hours, can cause toxic effects. Hemolysis, hemoglobinuria, jaundice, hemolytic anemia, and necrosis of the renal tubules have been reported in exposed workers (ACGIH, 1986; Fowler & Weissberg, 1974).

Animal studies have shown that inorganic arsenic, by intratracheal instillation, can cause pulmonary inflammation and hyperplasia (Webb et al., 1986, 1987), lung lesions (Pershagen et al., 1982), and immunosuppression (Hatch et al. (1985). Long-term inhalation exposures have resulted in altered conditioned reflexes and CNS damage (Rozenshstein, 1970). Reductions in fetal weight and in the number of live fetuses, and increases in fetal abnormalities due to retarded osteogenesis have been observed following inhalation exposures (Nagymajtenyi et al., 1985).

Subchronic and chronic RfCs for inorganic arsenic have not been derived.

Epidemiological studies have revealed an association between arsenic concentrations in drinking water and increased incidences of skin cancers (including squamous cell carcinomas and multiple basal cell carcinomas), as well as cancers of the liver, bladder, respiratory and gastrointestinal tracts (U.S. EPA, 1987; IARC, 1987; Sommers et al., 1953; Reymann et al., 1978; Dobson et al., 1965; Chen et al., 1985, 1986). Occupational exposure studies have shown a clear correlation between exposure to arsenic and lung cancer mortality (IARC, 1987; U.S. EPA, 1991a). U.S. EPA (1991a) has placed inorganic arsenic in weight-of-evidence group A, human carcinogen. A drinking water unit risk of 5E-5(ug/L)-1 has been proposed (U.S. EPA, 1991a); derived from drinking water unit risks for females and males that are equivalent to slope factors of 1.0E-3 (ug/kg/day)-1 (females) and 2.0E-3 (ug/kg/day)-1 (males) (U.S. EPA, 1987). For inhalation exposures, a unit risk of 4.3E-3 (ug/m3)-1 (U.S. EPA, 1991a) and a slope factor of 5.0E+1 (mg/kg/day)-1 have been derived (U.S. EPA, 1992).

Aluminum

Aluminum is a silver-white flexible metal with a vast number of uses. It is poorly absorbed and efficiently eliminated; however, when absorption does occur, aluminum is distributed mainly in bone, liver, testes, kidneys, and brain (ATSDR, 1990).

Aluminum may be involved in Alzheimer's disease (dialysis dementia) and in Amyotrophic Lateral Sclerosis and Parkinsonism-Dementia Syndromes of Guam (Guam ALS-PD complex) (ATSDR, 1990; Goyer, 1991). Aluminum content of brain, muscle, and bone increases in Alzheimer's patients. Neurofibrillary tangles (NFTs) are found in patients suffering from aluminum encephalopathy and Alzheimer's disease. Symptoms of "dialysis dementia" include speech disorders, dementia, convulsions, and myoclonus. People of Guam and Rota have an unusually high incidence of neurodegenerative diseases. The volcanic soil in the region of Guam where the high incidence of ALS-PD occurs contains high levels of aluminum and manganese. Neurological effects have also been observed in rats orally exposed to aluminum compounds.

The respiratory system appears to be the primary target following inhalation exposure to aluminum. Alveolar proteinosis has been observed in guinea pigs, rats, and hamsters exposed to aluminum powders (Gross et al., 1973). Rats and guinea pigs exposed to aluminum chlorohydrate exhibited an increase in alveolar macrophages, increased relative lung weight, and multifocal granulomatous pneumonia (Cavender et al., 1978).

No decrease in reproductive capacity, hormonal abnormalities, or testicular histopathology was observed in male rats exposed to aluminum in drinking water for 90 days (Dixon et al., 1979). However, male rats exposed to aluminum (as aluminum chloride) via gavage for 6 months exhibited decreased spermatozoa counts and sperm motility, and testicular histological and histochemical changes (Krasovskii et al., 1979).

Subchronic and chronic reference doses and reference concentrations have not been derived for aluminum.

Male rats exposed to drinking water containing aluminum (as aluminum potassium sulfate) for a lifetime exhibited increases in unspecified malignant and nonmalignant tumors (Schroeder and Mitchener, 1975a), and similarly exposed female mice exhibited an increased incidence of leukemia (Schroeder and Mitchener, 1975b). Rats and guinea pigs exposed via inhalation to aluminum chlorohydrate developed lung granulomas (Cavender et al., 1978), while granulomatous foci developed in similarly exposed male hamsters (Drew et al., 1974).

The EPA has not evaluated aluminum or aluminum compounds for carcinogenicity, and a weight-of-evidence classification is currently not assigned.

Cadmium

Cadmium is a naturally occurring metal that is used in various chemical forms in metallurgical and other industrial processes, and in the production of pigments. Environmental exposure can occur via the diet and drinking water (ATSDR, 1989).

Cadmium is absorbed more efficiently by the lungs (30 to 60%) than by the gastrointestinal tract, the latter being a saturable process (Nordberg et al., 1985). Cadmium is transported in the blood and widely distributed in the body but accumulates primarily in the liver and kidneys (Goyer, 1991). Cadmium burden (especially in the kidneys and liver) tends to increase in a linear fashion up to about 50 or 60 years of age after which the body burden remains somewhat constant. Metabolic transformations of cadmium are limited to its binding to protein and nonprotein sulfhydryl groups, and various macromolecules, such as metallothionein, which is especially important in the kidneys and liver (ATSDR, 1989). Cadmium is excreted primarily in the urine.

Acute oral exposure to 20-30 g have caused fatalities in humans. Exposure to lower amounts may cause gastrointestinal irritation, vomiting, abdominal pain, and diarrhea (ATSDR, 1989). An asymptomatic period of one-half to one hour may precede the onset of clinical signs. Oral LD50 values in animals range from 63 to 1125 mg/kg, depending on the cadmium compound (USAF, 1990). Longer term exposure to cadmium primarily affects the kidneys, resulting in tubular proteinosis although other conditions such as "itai-itai" disease may involve the skeletal system. Cadmium involvement in hypertension is not fully understood (Goyer, 1991).

Inhalation exposure to cadmium and cadmium compounds may result in effects including headache, chest pains, muscular weakness, pulmonary edema, and death (USAF, 1990). The 1-minute and 10-minute lethal concentration of cadmium for humans has been estimated to be about 2,500 and 250 mg/m3, respectively (Barrett et al., 1947; Beton et al., 1966). An 8-hour TWA (time-weighted-average) exposure level of 5 mg/m3 has been estimated for lethal effects of inhalation exposure to cadmium, and exposure to 1 mg/m3 is considered to be immediately dangerous to human health (Friberg, 1950). Renal toxicity (tubular proteinosis) may also result from inhalation exposure to cadmium (Goyer, 1991).

Chronic oral RfDs of 5E-4 and 1E-3 mg/kg/day have been established for cadmium exposure via drinking water and food, respectively (EPA, 1991). Both values reflect incorporation of an uncertainty factor of 10. The RfDs are based on an extensive data base regarding toxicokinetics and toxicity in both human and animals, the critical effect being renal tubular proteinuria. Confidence in the RfD and data base is high. Inhalation RfC values are currently not available.

The target organ for cadmium toxicity via oral exposure is the kidney (Goyer, 1991). For inhalation exposure, both the lungs and kidneys are target organs for cadmium-induced toxicity (ATSDR, 1989; Goyer, 1991).

There is limited evidence from epidemiologic studies for cadmium-related respiratory tract cancer (ATSDR, 1989). An inhalation unit risk of 1.8E-3 (µg/m3)-1 and an inhalation slope factor of 6.1E+0 (mg/kg/day)-1 are based on respiratory tract cancer associated with occupational exposure (EPA, 1985). Based on limited evidence from multiple occupational exposure studies and adequate animal data, cadmium is placed in weight-of-evidence group B1 - probable human carcinogen.

Copper

Copper occurs naturally in elemental form and as a component of many minerals. Because of its high electrical and thermal conductivity, it is widely used in the manufacture of electrical equipment. Common copper salts, such as the sulfate, carbonate, cyanide, oxide, and sulfide are used as fungicides, as components of ceramics and pyrotechnics, for electroplating, and for numerous other industrial applications (ACGIH, 1986). Copper can be absorbed by the oral, inhalation, and dermal routes of exposure. It is an essential nutrient that is normally present in a wide variety of tissues (ATSDR, 1990; U.S. EPA, 1987).

In humans, ingestion of gram quantities of copper salts may cause gastrointestinal, hepatic, and renal effects with symptoms such as severe abdominal pain, vomiting, diarrhea, hemolysis, hepatic necrosis, hematuria, proteinuria, hypotension, tachycardia, convulsions, coma, and death (U.S. AF, 1990). Gastrointestinal disturbances and liver toxicity have also resulted from long-term exposure to drinking water containing 2.2-7.8 mg Cu/L (Mueller-Hoecker et al., 1988; Spitalny et al., 1984). The chronic toxicity of copper has been characterized in patients with Wilson's disease, a genetic disorder causing copper accumulation in tissues. The clinical manifestations of Wilson's disease include cirrhosis of the liver, hemolytic anemia, neurologic abnormalities, and corneal opacities (Goyer, 1991; ATSDR, 1990; U.S. EPA, 1987). In animal studies, oral exposure to copper caused hepatic and renal accumulation of copper, liver and kidney necrosis at doses of >=100 mg/kg/day; and hematological effects at doses of 40 mg/kg/day (EPA, 1986; Haywood, 1985; 1980; Rana & Kumar, 1978; Gopinath et al., 1974; Kline et al., 1971).

Acute inhalation exposure to copper dust or fumes at concentrations of 0.075-0.12 mg Cu/m3 may cause metal fume fever with symptoms such as cough, chills and muscle ache (U.S. AF, 1990). Among the reported effects in workers exposed to copper dust are gastrointestinal disturbances, headache, vertigo, drowsiness, and hepatomegaly (Suciu et al., 1981). Vineyard workers chronically exposed to Bordeaux mixture (copper sulfate and lime) exhibit degenerative changes of the lungs and liver. Dermal exposure to copper may cause contact dermatitis in some individuals (ATSDR, 1990).

Oral or intravenous administration of copper sulfate increased fetal mortality and developmental abnormalities in experimental animals (Lecyk, 1980; Ferm and Hanlon, 1974). Evidence also indicates that copper compounds are spermicidal (ATSDR, 1990; Battersby et al., 1982).

A Reference Dose (RfD) for elemental copper is not available (U.S. EPA, 1992). However, EPA established an action level of 1300 ug/L for drinking water (56 FR 26460, June 7, 1991). Data were insufficient to derive a Reference concentration (RfC) for copper.

No suitable bioassays or epidemiological studies are available to assess the carcinogenicity of copper. Therefore, U.S. EPA (1991a) has placed copper in weight-of-evidence group D, not classifiable as to human carcinogenicity.

Cyanide

Cyanide most commonly occurs as hydrogen cyanide and its salts--sodium and potassium cyanide. Cyanides are both man-made and naturally occurring substances. They are found in several plant species as cyanogenic glycosides and are produced by certain bacteria, fungi, and algae. In very small amounts, cyanide is a necessary requirement in the human diet. Cyanides are released to the environment from industrial sources and car emissions (ATSDR, 1989).

Cyanides are readily absorbed by the inhalation, oral, and dermal routes of exposure. The central nervous system (CNS) is the primary target organ for cyanide toxicity. Neurotoxicity has been observed in humans and animals following ingestion and inhalation of cyanides. Cardiac and respiratory effects, possibly CNS-mediated, have also been reported. Short-term exposure to high concentrations produces almost immediate collapse, respiratory arrest, and death (Hartung, 1982; EPA, 1985). Symptoms resulting from occupational exposure to lower concentrations include breathing difficulties, nervousness, vertigo, headache, nausea, vomiting, precordial pain, and electrocardiogram (EKG) abnormalities (Carmelo, 1955; El Ghawabi et al., 1975; Sandberg, 1967; Wuthrich, 1954).

Thyroid toxicity has been observed in humans and animals following oral and inhalation exposure to cyanides (Philbrick et al.,1979; EPA, 1984). In animal studies, cyanides have produced fetotoxicity and teratogenic effects, including exencephaly, encephalocele, and rib abnormalities (Doherty et al., 1982; Frakes et al., 1986; Tewe and Maner, 1981b; Willhite, 1982).

Reference doses (RfDs) have been calculated for subchronic and chronic oral exposure to cyanide and several cyanide compounds (EPA, 1990a-e; 1991a-e). The values, derived from a single study, are based on a no-observed-adverse-effect level (NOAEL) of 10.8 mg/kg/day for cyanide in a 2-year dietary study with rats (Howard and Hanzal, 1955). The subchronic and chronic oral RfDs are 0.02 mg/kg/day for cyanide; 0.04 mg/kg/day for sodium cyanide, calcium cyanide, and cyanogen; 0.05 mg/kg/day for potassium cyanide, chlorine cyanide, and zinc cyanide; 0.1 mg/kg/day for silver cyanide; and 0.2 mg/kg/day for potassium silver cyanide. Data were insufficient to derive a reference concentration (RfC) for cyanide.

No suitable cancer bioassays or epidemiological studies are available to assess the carcinogenicity of cyanide. Therefore, EPA (1991b) has placed cyanide in weight-of-evidence group D, not classifiable as to human carcinogenicity.

Nitrates

Nitrates are produced by natural biological and physical oxidations and therefore are ubiquitous in the environment (Ridder and Oehme 1974). Most of the excess nitrates in the environment originate from inorganic chemicals manufactured for agriculture. Organic molecules containing nitrate groups are manufactured primarily for explosives or for their pharmacological effects (Stokinger 1982). Exposure to inorganic nitrates is primarily through food and drinking water, whereas exposure to organic nitrates can occur orally, dermally, or by respiration (Stokinger 1978). The primary toxic effects of the inorganic nitrate ion (NO3-) result from its reduction to nitrite (NO2-) by microorganisms in the upper gastrointestinal tract (Johnson and Kross 1990, Bouchard et al. 1992). Nitrite ions can also be produced with organic nitrate exposure; however, the primary effect of organic nitrate intake is thought to be dependent on the production of an active nitric oxide (NO-) radical (Waldman and Murad 1987). Organic nitrates are metabolized in the liver resulting in an increase in blood nitrites (Murad 1990). Nitrates and nitrites are excreted primarily in the urine as nitrates (Hartman 1982).

The primary toxic effect of inorganic nitrates is the oxidation of the iron in hemoglobin by excess nitrites forming methemoglobin. Infants less than 6 months old comprise the most sensitive population (Hartman 1982, Bouchard et al. 1992). Epidemiological studies have shown that baby formula made with drinking water containing nitrate nitrogen levels over 10 mg/L can result in methemoglobinemia, especially in infants less than 2 months of age. No cases of methemoglobinemia were reported with drinking water nitrate nitrogen levels of 10 mg/L or less (Bosch et al. 1950, Walton 1951, Shuval and Gruener 1972). A secondary target for inorganic nitrate toxicity is the cardiovascular system. Nitrate intake can also result in a vasodilatory effect, which can complicate the anoxia resulting from methemoglobinemia (Ridder and Oehme 1974). Decreased motor activity was reported in mice given up to 2000 mg nitrite/L in drinking water, and persistent changes in EEG recordings were observed in rats exposed to 100 to 2000 mg nitrite/L in drinking water. However, exposure of rats to 3000 mg nitrite/L in drinking water for 2 years did not result in any gross or microscopic changes in brain tissue. The data indicate that these central nervous system effects are not related to methemoglobin levels (Shuval and Gruener 1972).

The importance of the primary and secondary targets are reversed with organic nitrates, several of which have long been used for their vasodilatory effects in the treatment of angina pectoris in humans (Murad 1990). Large doses of organic nitrates, however, can also produce methemoglobinemia (Andersen and Mehl 1973). Epidemiological studies have shown that chronic or subchronic exposure to organic nitrates results in the development of tolerance to the cardiovascular effects of these compounds. This apparent biocompensation has caused serious cardiac problems in munitions workers exposed to organic nitrates when they are suddenly removed from the source of exposure (Carmichael and Lieben 1963).

An epidemiological study correlated the number of congenital malformations of the central nervous system and musculoskeletal system of babies with the amount of inorganic nitrate in the mother's drinking water (Dorsch et al. 1984). Other studies, however, do not support these associations, and the presence of unidentified teratogenic factors in the environment could not be ruled out. Inorganic nitrate and nitrite have been tested for teratogenicity in rats, guinea pigs, mice, hamsters, and rabbits. No teratogenic responses were reported; however, fetotoxicity attributed to maternal methemoglobinemia was observed at high doses (4000 mg nitrate/L in drinking water) (Sleight and Atallah 1968, Shuval and Gruener 1972, FDA 1972a, b, c).

A Reference Dose (RfD) of 1.60 mg/kg/day (nitrate nitrogen) for chronic oral exposure was calculated from a NOAEL of 10 mg/L and a LOAEL of 11-20 mg/L in drinking water, based on clinical signs of methemoglobinemia in 0-3-month-old infants (Bosch et al. 1950, Walton 1951). It is important to note, however, that the effect was documented in the most sensitive human population so no uncertainty or modifying factors were used (EPA 1994).

The possible carcinogenicity of nitrate depends on the conversion of nitrate to nitrite and the reaction of nitrite with secondary amines, amides, and carbamates to form N-nitroso compounds that are carcinogenic (Bouchard et al. 1992). Experiments with rats have shown that when given both components, nitrite and heptamethyleneimine, in drinking water, an increase in the incidence of tumors occurs (Taylor and Lijinsky 1975). Human epidemiological studies, however, have yielded conflicting evidence. Positive correlations between the concentration of nitrate in drinking water and the incidence of stomach cancer were reported in Columbia and Denmark (Cuello et al. 1976, Fraser et al. 1980). However, studies in the United Kingdom and other countries have failed to show any correlation between nitrate levels and cancer incidence (Forman 1985, Al-Dabbagh et al. 1986, Croll and Hayes 1988). Nitrate has not been classified as to its carcinogenicity by the EPA, although it is under review (EPA 1994).

<u>Selenium</u>

Selenium is an essential trace element important in many biochemical and physiological processes including the biosynthesis of coenzyme Q (a component of mitochondrial electron transport systems), regulation of ion fluxes across membranes, maintenance of the integrity of keratins, stimulation of antibody synthesis, and activation of glutathione peroxidase (an enzyme involved in preventing oxidative damage to cells). Recommended human dietary allowances (average daily intake) for selenium are as follows: infants up to 1 year, 10-15 µg; children 1-10 years, 20-30 µg; adult males 11-51+ years, 40-70 µg; adult females 11-51+ years, 45-55 µg; pregnant or lactating women, 65-75 µg. There appears to be a relatively narrow range between levels of selenium intake resulting in deficiency and those causing toxicity.

Selenium occurs in several valence states: -2 (hydrogen selenide, sodium selenide, dimethyl selenium, trimethyl selenium, and selenoamino acids such as selenomethionine; 0 (elemental selenium); +4 (selenium dioxide, selenious acid, and sodium selenite); and +6 (selenic acid and sodium selenate). Toxicity of selenium varies with valence state and water solubility of the compound in which it occurs. The latter can affect gastrointestinal absorption rates.

Gastrointestinal absorption in animals and humans for various selenium compounds ranges from about 44% to 95% of the ingested dose (Thomson and Stewart, 1974; Bopp et al., 1982; Thomson, 1974). Respiratory tract absorption rates of 97% and 94% for aerosols of selenious acid have been reported for dogs and rats, respectively (Weissman et al., 1983; Medinsky et al., 1981). Selenium is found in all tissues of the body; highest concentrations occur in the kidney, liver, spleen, and pancreas (Schroeder and Mitchener, 1971a; Schroeder and Mitchener, 1972; Jacobs and Forst, 1981a; Julius et al., 1983; Shamberger, 1984; Echevarria et al., 1988). Excretion is primarily via the urine (0-15 g/L); however, excretory products can also be found in the feces, sweat, and in expired air.

In humans, acute oral exposures can result in excessive salivation, garlic odor to the breath, shallow breathing, diarrhea, pulmonary edema, and death (Civil and McDonald, 1978; Carter, 1966; Koppel et al., 1986). Other reported signs and symptoms of acute selenosis include tachycardia, nausea, vomiting, abdominal pain, abnormal liver function, muscle aches and pains, irritability, chills, and tremors. Acute toxic effects observed in animals include pulmonary congestion, hemorrhages and edema, convulsions, altered blood chemistry (increased hemoglobin and hematocrit); liver congestion; and congestion and hemorrhage of the kidneys (Smith et al., 1937; Anderson and Moxon, 1942; Hopper et al., 1985).

General signs and symptoms of chronic selenosis in humans include loss of hair and nails, acropachia (clubbing of the fingers), skin lesions (redness, swelling, blistering, and ulcerations), tooth decay (mottling, erosion and pitting), and nervous system abnormalities attributed to polyneuritis (peripheral anesthesia, acroparaethesia, pain in the extremities, hyperreflexia of the tendon, numbness, convulsions, paralysis, motor disturbances, and hemiplegia). In domesticated animals, subchronic and chronic oral exposures can result in loss of hair, malformed hooves, rough hair coat, and nervous system abnormalities (impaired vision and paralysis). Damage to the liver and kidneys and impaired immune responses have been reported to occur in rodents following subchronic and/or chronic oral exposures (Ganther & Baumann, 1962; Beems & van Beek, 1985; NCI, 1980a; Tinsley et al., 1967; Harr et al., 1967; Schroeder, 1967).

Selenium is teratogenic in birds and possibly also in domesticated animals (pigs, sheep, and cattle), but evidence of teratogenicity in humans and laboratory animals is lacking (ASTDR, 1989). However, adverse reproductive and developmental effects (decreased rates of conception, increased rates of fetal resorption, and reduced fetal body weights) have been reported for domesticated and laboratory animals (Harr & Muth, 1972: Wahlstrom & Olson, 1959; Schroeder & Mitchener, 1971b).

The Reference Dose (RfD) for chronic oral exposures is 0.005 mg/kg/day for both selenium and selenious acid (EPA, 1992a, 1992b). The subchronic RfDs for these compounds are the same as the chronic RfDs (EPA, 1992c).

In humans, inhalation of selenium or selenium compounds primarily affects the respiratory system. Dusts of elemental selenium and selenium dioxide can cause irritation of the skin and mucous membranes of the nose and throat, coughing, nosebleed, loss of sense of smell, dyspnea, bronchial spasms, bronchitis, and chemical pneumonia (Clinton, 1947; Hamilton, 1949). Other signs and symptoms following acute inhalation exposures include lacrimation, irritation and redness of the eyes, gastrointestinal distress (nausea and vomiting), depressed blood pressure, elevated pulse rate, headaches, dizziness, and malaise (ATSDR, 1989). In animals, acute inhalation exposures also result in severe respiratory effects including edema, hemorrhage, and interstitial pneumonitis (Hall et al., 1951; Dudley and Miller, 1937) as well as in splenic damage (congestion, fissuring red pulp, and increased polymorphonuclear leukocytes) and liver congestion and mild central atrophy (Hall et al., 1951). Information on toxicity of selenium in humans and animals following chronic inhalation exposures is not available, and subchronic and chronic inhalation Reference Concentrations have not been derived.

Epidemiologic studies in humans havation between chronic oral exposures to selenium and an increased incidence of death due to neoplasms. Some studies have indicated that selenium may have anti-neoplastic properties (see Whanger, 1983; Hocman, 1988). In studies on laboratory animals, selenites or selenates have not been found to be carcinogenic; however, selenium sulfide produced a significant increase in the incidence of hepatocellular carcinomas in male and female rats and in female mice and a significant increase in alveolar/bronchiolar carcinomas and adenomas in female mice following chronic oral exposures (NCI, 1980c). EPA has placed selenium and selenious acid in Group D, not classifiable as to carcinogenicity in humans (U.S. EPA, 1992a and 1992b), while selenium sulfide is placed in Group B2, probable human carcinogen (U.S. EPA, 1992d). Quantitative data are, however, insufficient to derive a slope factor for selenium sulfide. Pertinent data regarding the potential carcinogenicity of selenium by the inhalation route in humans or animals were not located in the available literature.

<u>Zinc</u>

Zinc is used primarily in galvanized metals and metal alloys, but zinc compounds also have wide commercial applications as chemical intermediates, catalysts, pigments, vulcanization activators and accelerators in the rubber industry, UV stabilizers, and supplements in animal feeds and fertilizers. They are also used in rayon manufacture, smoke bombs, soldering fluxes, mordants for printing and dyeing, wood preservatives, mildew inhibitors, deodorants, antiseptics, and astringents (Lloyd, 1984; ATSDR, 1989). In addition, zinc phosphide is used as a rodenticide.

Zinc is an essential element with recommended daily allowances ranging from 5 mg for infants to 15 mg for adult males (NRC, 1989).

Gastrointestinal absorption of zinc is variable (20-80%) and depends on the chemical compound as well as on zinc levels in the body and dietary concentrations of other nutrients (U.S. EPA, 1984). In individuals with normal zinc levels in the body, gastrointestinal absorption is 20-30% (ATSDR, 1989). Information on pulmonary absorption is limited and complicated by the potential for gastrointestinal absorption due to mucociliary clearance from the respiratory tract and subsequent swallowing. Zinc is present in all tissues with the highest concentrations in the prostate, kidney, liver, heart, and pancreas. Zinc is a vital component of many metalloenzymes such as carbonic anhydrase, which regulates CO2 exchange (Stokinger, 1981). Homeostatic mechanisms involving metallothionein in the mucosal cells of the gastrointestinal tract regulate zinc absorption and excretion (ATSDR, 1989).

In humans, acutely toxic oral doses of zinc cause nausea, vomiting, diarrhea, and abdominal cramps and in some cases gastric bleeding (Elinder, 1986; Moore, 1978; ATSDR, 1989). Ingestion of zinc chloride can cause burning in the mouth and throat, vomiting, pharyngitis, esophagitis, hypocalcemia, and elevated amylase activity indicative of pancreatitis (Chobanian, 1981). Zinc phosphide, which releases phosphine gas under acidic conditions in the stomach, can cause vomiting, anorexia, abdominal pain, lethargy, hypotension, cardiac arrhythmias, circulatory collapse, pulmonary edema, seizures, renal damage, leukopenia, and coma and death in days to weeks (Mack, 1989). The estimated fatal dose is 40 mg/kg. Animals dosed orally with zinc compounds develop pancreatitis, gastrointestinal and hepatic lesions, and diffuse nephrosis.

Gastrointestinal upset has also been reported in individuals taking daily dietary zinc supplements for up to 6 weeks (Samman and Roberts, 1987). There is also limited evidence that the human immune system may be impaired by subchronic exposures (Chandra, 1984). In animals, gastrointestinal and hepatic lesions, (Allen et al., 1983; Brink et al., 1959); pancreatic lesions (Maita et al., 1981; Drinker et al., 1927a); anemia (ATSDR, 1989; Fox and Jacobs, 1986; Maita et al., 1981); and diffuse nephrosis (Maita et al., 1981; Allen et al., 1983) have been observed following subchronic oral exposures.

Chronic oral exposures to zinc have resulted in hypochromic microcytic anemia associated with hypoceruloplasminemia, hypocupremia, and neutropenia in some individuals (Prasad et al., 1978; Porter et al., 1977). Anemia and pancreatitis were the major adverse effects observed in chronic animal studies (Aughey et al., 1977; Drinker et al., 1927a; Walters and Roe, 1965; Sutton and Nelson, 1937). Teratogenic effects have not been seen in animals exposed to zinc; however, high oral doses can affect reproduction and fetal growth (Ketcheson et al., 1969; Schlicker and Cox 1967, 1968; Sutton and Nelson, 1937).

The reference dose for chronic oral exposure to zinc is under review by EPA; the currently accepted RfD for both subchronic and chronic exposures is 0.2 mg/kg/day based on clinical data demonstrating zinc-induced copper deficiency and anemia in patients taking zinc sulfate for the treatment of sickle cell anemia (EPA, 1992). The chronic oral RfD for zinc phosphide is 0.0003 mg/kg/day (EPA, 1991a), and the subchronic RfD is 0.003 mg/kg/day (EPA, 1992).

Under occupational exposure conditions, inhalation of zinc compounds (mainly zinc oxide fumes) can result in a condition identified as "metal fume fever", which is characterized by nasal passage irritation, cough, rales, headache, altered taste, fever, weakness, hyperpnea, sweating, pains in the legs and chest, leukocytosis, reduced lung volume, and decreased diffusing capacity of carbon monoxide (ATSDR, 1989; Bertholf, 1988). Inhalation of zinc chloride can result in nose and throat irritation, dyspnea, cough, chest pain, headache, fever, nausea and vomiting, and respiratory disorders such as pneumonitis and pulmonary fibrosis (ITII, 1988; ATSDR, 1989; Nemery, 1990). Pulmonary inflammation and changes in lung function have also been observed in inhalation studies on animals (Amur et al.,1982; Lam et al., 1985; Drinker & Drinker, 1928).

Although "metal fume fever" occurs in occupationally exposed workers, it is primarily an acute and reversible effect that is unlikely to occur under chronic exposure conditions when zinc air concentrations are less than 8-12 mg/m3 (ATSDR, 1989). Gastrointestinal distress, as well as enzyme changes indicative of liver dysfunction, have also been reported in workers occupationally exposed to zinc (NRC, 1979; Stokinger, 1981; EPA, 1991a; Guja, 1973; Badawy et al., 1987a); however, it is unclear as to what extent these effects might have been caused by pulmonary clearance, and subsequent gastrointestinal absorption. Consequently, there are no clearly defined toxic effects that can be identified as resulting specifically from pulmonary absorption following chronic low level inhalation exposures. Animal data for chronic inhalation exposures are not available. An inhalation reference concentration has not been derived for zinc or zinc compounds (EPA, 1992).

No case studies or epidemiologic evidence has been presented to suggest that zinc is carcinogenic in humans by the oral or inhalation route (EPA, 1991a). In animal studies, zinc sulfate in drinking water or zinc oleate in the diet of mice for a period of one year did not result in a statistically significant increase in hepatomas, malignant lymphomas, or lung adenomas (Walters & Roe, 1965); however, in a 3-year, 5-generation study on tumor-resistant and tumor-susceptible strains of mice, exposure to zinc in drinking water resulted in increased frequencies of tumors from the F0 to the F4 generation in the tumor-resistant strain (from 0.8 to 25.7%, vs. 0.0004% in the controls), and higher tumor frequencies in two tumor-susceptible strains (43.4% & 32.4% vs. 15% in the controls) (Halme, 1961).

Zinc is placed in weight-of-evidence Group D, not classifiable as to human carcinogenicity due to inadequate evidence in humans and animals (EPA, 1991a).

A. Threats to Public Health or Welfare

Without a removal action the threat of direct exposure exists through the ingestion of cyanide, selenium, and heavy metal compounds that may expose the human and animal population to the toxic effects. The following factors from § 300.415 (b)(2) of the NCP form the basis for our determination of the threat presented, and the appropriate action to be taken:

> (i) Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants;
>
> (ii) Actual or potential contamination of drinking water supplies or sensitive ecosystems;
>
> (iv) High levels of hazardous substances, pollutants, or contaminants in soils largely at or near the surface, that may migrate;
>
> (v) Weather conditions that may cause hazardous substances or pollutants or contaminants to migrate or be released; and,
>
> (vii) The unavailability of other appropriate federal or state response mechanisms to respond to the release.

B. Threats to the Environment

Mine drainage derived from Site waste rock piles, heap dikes, and mine pits, if not captured and treated potentially affects several groups of ecological receptors. The first group includes aquatic life in the seven local streams emanating from the mining area. The second group of receptors includes wildlife that may ingest water in area streams with elevated metal content that could bio-accumulate, potentially reaching toxic levels. The third group of potential receptors is individuals recreating at or near streams impacted by mine drainage. Because the communities of Zortman, Landusky, and the Montana Gulch Campground are all located within a mile of the potential releases, residents or visitors could come in contact with water containing elevated metal content. Streams on the north side of the mountains have fewer mine facilities, receive less mine drainage or runoff, and experience greater dilution or attenuation prior to reaching recreation areas or communities.

Several ecological receptors are potentially affected by residual contaminants in treated heap water associated with the LAD. The first group includes aquatic life associated with local streams located downgradient of the LAD areas in Ruby and Goslin drainages. The second group of receptors is native terrestrial plants at the Site whose ability to grow in soil affected by the LAD may be limited by relatively high concentrations of nitrates, selenium, metals and salts in the land applied water. The third group of receptors are cattle or wildlife that forage in the LAD area and may be exposed to on-site contamination either through direct contact with contaminated soil, plant forage, standing water, and sediments, or indirectly through consumption of organisms (algae, aquatic insects, or animals) feeding in the area.

Cyanide, selenium, and metals are found on-site in elevated levels, are hazardous substances as defined in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended, Section 101(14), and are listed in 40 CFR Section 302.4 "List of Hazardous Substances and Reportable Quantities".

IV. ENDANGERMENT DETERMINATION

Actual or threatened releases of hazardous substances from the Zortman or Landusky mines, if not addressed by implementing the response action selected in the action memorandum, may present an imminent and substantial endangerment to public health or welfare, or the environment.

V. PROPOSED ACTIONS AND ESTIMATED COSTS

A. Proposed Actions

1. Proposed Action Description

The proposed actions are designed to mitigate the potential threat at the Zortman and Landusky mines. The proposed actions for this Removal Action are time-critical and consist of continued operation of OU1 and OU2. This includes continued capture and treatment of mine drainage as well as continued treatment and disposal of leach pad solutions.

a. Site Assessment

The BLM and DEQ have been conducting extensive water quality, soils, and vegetation monitoring. Water quality monitoring will be conducted initially in accordance with the April 2002 WMP; although the plan may be modified as conditions warrant. Monitoring plans and sampling and analysis results are available for review at the BLM office in Lewistown or the DEQ office in Helena.

Various configurations for the LAD irrigation system have been tested in an effort to maximize attenuation of contaminants in the soil. These include changing the sprinkler heads for a more even distribution, rotating the areas under irrigation, and limiting land application to the summer growing season. The present LAD configuration is considered adequate. The LAD is shut-down in the winter to eliminate impacts to surface water. Year round operation of the LAD was considered as a means to get rid of all the leaching solutions as soon as possible, but was eliminated due to the potential for increased impacts to surface water and the present availability of in-heap storage for winter precipitation.

As noted, ZMI and Pegasus Gold constructed the seepage capture systems and water treatment plants as part of the 1996 Consent Decree. Since then the systems have undergone several evaluations in order to optimize treatment efficiency. Initial difficulty with arsenic removal at the Landusky plant appears to have been resolved. Automation of treatment plant systems may be appropriate to lower costs but would not alter their performance.

b. Removal and Disposal

The Proposed Actions consist of continued capture, treatment, and disposal of mine drainage and heap process solution to the extent feasible. Schematic flow charts of the water capture and treatment systems are shown in Attachments 2a, 2b, and 2c.

The seepage capture systems located on BLM lands in Ruby Gulch, Alder Gulch, Carter Gulch, Montana Gulch, Mill Gulch, and Sullivan Gulch will continue to be used to capture mine drainage derived from upgradient BLM lands, and from private lands that could affect BLM lands. Captured mine drainage will be routed to one of two lime precipitation water treatment plants where it will be treated to remove metals and reduce acidity; and then piped to BLM land in the Montana Gulch and Ruby Gulch drainages. Although the Zortman treatment plant is located on private lands, it will be used to treat mine drainage either derived from BLM lands, or that would have impacted BLM lands. The outfall from the Zortman treatment plant is on BLM land and is part of the Site.

Virtually all of the heap leach pads are on BLM lands. Heap process solution will continue to be treated in the bioreactor located on the L87/91 leach pad to remove nitrates, selenium, and cyanide, to the extent feasible. Treated heap solution will then be routed either to the LAD area on private lands at Goslin Flats where the State has land application rights, or mixed with pre-treatment or post-treatment mine drainage and piped to Montana Gulch on BLM lands. Direct discharge is preferred to LAD if the quality of mixed OU1 and OU2 water is acceptable.

2. Contribution to Remedial Performance

The proposed actions will not adversely affect any future removal or remedial actions but will support and complement any future removal or remedial actions. The proposed actions are consistent with the selected alternatives in the 2001 Supplemental EIS on Reclamation of the Zortman and Landusky Mines.

3. Description of Alternative Technologies

The lime-precipitation treatment technology, used to treat mine drainage in OU1, was selected by the parties (DEQ, EPA, Fort Belknap, Island Mountain Protectors, and ZMI) to the 1996 Consent Decree. While other treatment technologies for mine drainage exist, such as semi-passive wetland systems, reverse osmosis, anoxic drains, etc., none are judged to be feasible, reliable, or affordable enough to handle the volume of water requiring treatment at the Site with the degree of success presently being achieved. Should either the amount of mine drainage, or level of contaminants, significantly decrease in the future, alternate treatment technologies may become practical.

During 2000 and 2001, the interagency technical working group on mine reclamation evaluated a series of different proposals for treatment of heap process solution. The technology ultimately decided upon was the present biological treatment system (OU2). The purpose of this treatment was the targeted reduction in cyanide, selenium and nitrate contaminants reporting to the LAD area, which were the constituents limiting application of heap process solutions at that time. Mixing of the OU2 treated water with OU1 water (either before or after lime treatment) will reduce residual contaminants to acceptable levels.

Other treatment technologies have been considered to supplement the existing bio-treatment plant. In particular, reverse osmosis may be used to reduce the salinity of land-applied solutions. However, the added time and expense of getting such a system online, plus the difficulty in disposing of the produced waste brine, do not justify the use of reverse osmosis at this time.

Various configurations for irrigation application and sprinkler head types have been tested over the last five years in order to arrive at a LAD management plan that maximizes the attenuation of contaminants in the soil while limiting effects on LAD area vegetation. The current configuration is considered adequate.

4. Engineering Evaluation/Cost Analysis (EE/CA)

An EE/CA was not prepared for this specific removal action. However, the 2001 Supplemental EIS contains an analysis of the capture and treatment systems associated with OU1 and OU2; and constitutes the EE/CA "equivalent" cited in 40 CFR 300.415(b)(4)(i).

5. Applicable or Relevant and Appropriate Requirements (ARARs)

This Removal Action will attain, to the extent practicable, considering the exigencies of the situation, applicable or relevant and appropriate requirements (ARARs) of federal and state laws. The identified ARARs are shown in Attachment 3. The assessment of ARARs included review by the Montana DEQ.

Section 300.415(i) of the National Contingency Plan require that removal actions attain Applicable or Relevant and Appropriate Requirements (ARARs) under federal or state environmental laws or facility siting laws, to the extent practicable considering the urgency of the situation and the scope of the removal. In addition to ARARs, the lead Agency may identify other federal or state advisories, criteria, or guidance to be considered for a particular release.

ARARs are either applicable or relevant and appropriate. Applicable requirements are those standards, requirements, criteria, or limitations promulgated under federal or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, or contaminant found at a site and would apply in the absence of a CERCLA cleanup. Relevant and appropriate requirements are those standards, requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that are not applicable to a particular situation but apply to similar problems or situations, and therefore may be well suited requirements for a response action to address.

ARARs are divided into contaminant specific, location specific, and action specific requirements. Contaminant specific ARARs are listed according to specific media and govern the release to the environment of specific chemical compounds or materials possessing certain chemical or physical characteristics. Contaminant specific ARARs generally set health or risk based numerical values or methodologies which, when applied to site-specific conditions, result in the establishment of numerical values. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment.

Location specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of cleanup activities because they are in specific locations. Location specific ARARs generally relate to the geographic location or physical characteristics or setting of the site, rather than to the nature of the site contaminants.

Action specific ARARs are usually technology or activity based requirements or limitations on actions taken with respect to hazardous substances.

Only the substantive portions of the requirements are ARARs. Administrative requirements are not ARARs and do not apply to actions conducted entirely on-site. Provisions of statutes or regulations that contain general goals expressing legislative intent but are non-binding are not ARARs. In addition, in instances like the present case where the cleanup is proceeding in stages, a particular phase of the remedy may not comply with all ARARs, so long as the overall remedy does meet ARARs to the extent practicable.

Under Section 121 of CERCLA, 42 U.S.C. §9621, only those state standards that are more stringent than any federal standard are considered to be an ARAR provided that these standards are identified by the state in a timely manner. To be an ARAR, a state standard must be "promulgated," which means that the standards are of general applicability and are legally enforceable. The State of Montana ARARs set forth in Attachment 3 have been identified with the cooperation and assistance of the DEQ.

a. Non-Compliance with ARARs

The preferred Response Action selected for the cleanup of mining-related impacts at the mine sites will comply with ARARs to the extent practicable. Surface water and groundwater quality is expected to temporarily degrade to some extent by implementation of the preferred alternative, although not to the extent it would degrade if no response action were taken. This action includes continued monitoring for evaluating any further actions at the Site. Implementing the preferred Response Action will not hinder future Response Actions that may be required at the Site.

6. Project Schedule

Capture and treatment of mine drainage is underway and will continue as designed until mine drainage ceases or changes character such that treatment is not warranted. Treatment will be conducted year round and is anticipated to continue for at least five years at present rates.

Treatment and disposal of heap solutions is also underway. LAD of treated heap solution will continue until the fall when inclement weather reduces land application efficiency. In lieu of land application, treated heap solution from the bioreactor may be mixed and treated with mine drainage throughout the year. Treatment of heap solutions will not be required in the long-term. As leach pad solution levels are drawn down over the next two years and surface reclamation limits infiltration, only intermittent treatment of heap solutions will be necessary.

B. Estimated Costs

Tables 4 and 5 show the estimated costs in connection with the proposed CERCLA removal actions. The costs are for a one-year period and would continue on an annual basis at a similar rate in the short-term.

Table 4. Estimated Costs for Operable Unit 1, Mine Drainage Capture and Treatment.

Major Work Category	Zortman Plant Costs	Landusky Plant Costs	Total Projected Costs
Power and Fuel	$103,000	$121,000	$224,000
Labor	67,000	593,000	660,000
Lab Analysis	31,000	31,000	62,000
Pumps and Supplies	102,000	131,000	233,000
Reagents	88,000	11,000	99,000
Annual Total Costs	**$391,000**	**$887,000**	**$1,278,000**

Of the $1,278,000 annual cost the DEQ surety bond will cover $731,321 per year through year 2017. After 2017, a trust fund is available that will partially offset costs. Absent the development of cost-saving measures or changes in the character of the mine drainage, the net cost of the removal action is estimated at approximately $547,000 per year for OU1.

Table 5. Estimated Costs for Operable Unit 2, Heap Solution Bioreactor and LAD.

Major Work Category	Bioreactor Costs	LAD Costs	Total Projected Costs
Power and Fuel	$15,000	$167,000	$182,000
Labor	42,000	271,000	313,000
Lab Analysis	27,000	58,000	85,000
Pumps and Supplies	25,000	40,000	65,000
Reagents	136,000	2,000	138,000
Annual Total Costs	**$245,000**	**$538,000**	**$783,000**

Most of the near term annual $783,000 needed to run the bioreactor and LAD will be covered by the reclamation bond. As shown in Table 5, the majority of costs are associated with running the LAD system. Blending of OU2 treated water in OU1 will eventually eliminate the costs of the LAD system. As the amount of heap solutions decrease over time the annual cost is expected to decline. Within the next few years the need for selenium and nitrate treatment in the bioreactor will decrease with a commensurate decrease in OU2 costs.

VI. EXPECTED CHANGE IN THE SITUATION SHOULD ACTION BE DELAYED OR NOT TAKEN

Delayed or no action will increase the public health risks and threats to the environment because the hazardous substances on-site pose a health risk to children or adults who recreate near the Site, as well as to aquatic resources and area wildlife.

During calendar year 2003 the capture and treatment systems in OU1 treated over 320 million gallons of mine drainage with elevated metals and acidity that would have entered area streams. Failure to take the removal action will place OU1 in a nonoperational status for part of the year, resulting in the untreated discharge of mine drainage in similar amounts and quality to that recovered in 2003 (See Tables 1 and 2, Typical Captured Influent column).

Also during 2003 almost 100 million gallons of heap process solution were treated and land applied at the Goslin Flats LAD area. Failure to continue the removal action could place OU2 in a nonoperational status, with several undesirable consequences. Shutting down the bioreactor will adversely affect the biological organisms used to remove nitrate, selenium and cyanide. Restarting the system will be more difficult and costly. Should the shutdown continue, failing to treat and remove the leach pad solutions will leave the present heap solution inventory at some 145 million gallons, and increasing. Because the system can store about 350 million gallons, overtopping would not occur immediately; however, there would be a significant decrease in storage capacity available to contain a storm event. As solution accumulates it will eventually have to be treated or the system will overtop. A lengthy shutdown in the treatment system may make the bioreactor ineffective due to changes in the chemistry of leach pad solutions.

VII. OUTSTANDING POLICY ISSUES

None.

VIII. RECOMMENDATION

Conditions at the Zortman and Landusky mine Site meet the NCP Section 300.415(b)(2) criteria for a Removal, and I recommend your approval of the proposed removal actions:

Scott Haight (signature)
Scott Haight
On-Scene-Coordinator

6/21/2004
Date

I concur with the recommendation to implement the proposed action as described in this Action Memo for the Zortman and Landusky mine Site removal actions:

Mark K. Albers
Field Manager

6/22/04
Date

I approve the proposed action as described in this Action Memo for the Zortman and Landusky mine Site removal actions:

Martin C. Ott
State Director

06/25/04
Date

ATTACHMENTS:

1 - Site Maps, 3 pages
2 - Water treatment system flow charts, 3 pages
3- ARAR Tables, 10 pages

SUPPLEMENTAL DOCUMENTS:

Support/reference documents that may be helpful to the reader and/or have been cited in this report may be found in the Administrative Record at the Lewistown Field Office, Airport Road, Lewistown, Montana, phone number (406) 538-7461. The following reference documents may be particularly useful:

Agency for Toxic Substances and Disease Registry, 1998. Petitioned Public Health Assessment for Kings Creek (a/k/a Fort Belknap Indian Reservation/Zortman Mining Incorporated).

BLM/DEQ, 1996. Final Environmental Impact Statement, Zortman and Landusky Mines Reclamation Plan Modifications and Mine Life Extensions.

BLM/DEQ, 2001. Final Supplemental Environmental Impact Statement for Reclamation of the Zortman and Landusky Mines, Phillips County, Montana.

BLM/DEQ, 2002. Record of Decision for Reclamation of the Zortman and Landusky Mines, Phillips County, Montana. 77 p.

Consent Decree, September 27, 1996. United States and the State of Montana, Plaintiffs vs. Pegasus Gold Corporation and Zortman Mining Inc. CV 95-95-BLG-JDS; and Gros Ventre Tribe, Fort Belknap Community Council, and Island Mountain Protectors, Plaintiffs vs. Pegasus Gold Corporation and Zortman Mining Inc. CV 95-96-BLG-JDS.

HydroSolutions and Gallagher. 2001. Supporting documentation report for Zortman and Landusky SEIS.

IT Corporation, September 1999. Engineering Evaluation/Cost Analysis Report, King Creek, Phillips and Blaine Counties, Montana. Prepared for U.S. EPA and U.S. Army Corps of Engineers.

Spectrum Engineering, March 2004. Zortman/Landusky Mines - 2003 Annual Water Resources Monitoring Report and 2003 Annual Interim Ground Water Report.

Spectrum Engineering, Monthly Mine Drainage Monitoring Reports, January through April 2004. Zortman/Landusky Mines.

Zortman and Landusky Mines Ground Water and Surface Water Monitoring Plan, April 2002, Interagency Technical Working Group.

Attachments 1 through 2c

Attachment 1. Zortman-Landusky Site Boundary Map

Attachment 1a. Zortman Mine – Facilities & Land Status Map

Attachment 1b. Landusky Mine – Facilities & Land Status Map

Attachment 2a. OU1 – Zortman Water Treatment - Process Flow Schematic

Attachment 2b. OU1 – Landusky Water Treatment - Process Flow Schematic

Attachment 2c. OU2 – Heap Solution Bioreactor Flow Diagram - Process Flow Schematic

Attachment 3

Identification of Applicable or Relevant and Appropriate Requirements Zortman and Landusky Mines Time-Critical Removal Action			
Standard, Requirement Criteria Or Limitation	**Citation**	**Description**	**ARAR Status**
Federal Contaminant Specific:			
Safe Drinking Water Act National Primary Drinking Water Regulation National Secondary Drinking Water Regulations	 40 USC § 300 40 CFR Part 141 40 CFR Part 143	 Establishes health-based standards (MCLs) for public water systems. Establishes welfare-based standards (secondary MCLs) for public water systems.	Not an ARAR. Defer to State Standards Not an ARAR, not enforceable standards.
Clean Water Act Water Quality Standards	 33 USC 1313(c) 40 CFR Part 131	 Water Pollution Prevention & Control EPA's requirements for state water quality standards.	Not an ARAR since the State has primary responsibility over this program and has promulgated water quality standards for the designated beneficial uses.
Federal Location Specific:			
National Historic Preservation Act	16 USC § 470; 36 CFR Part 800; 40 CFR Part 6.310(b)	Requires Federal Agencies to take into account the effect of any Federally-assisted undertaking or licensing on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register of Historic Places and to minimize harm to any National Historic Landmark adversely or directly affected by an undertaking.	Applicable
Archaeological and Historic Preservation Act	16 USC § 469; 40 CFR ' 6.301(c)	Establishes procedures to provide for preservation of historical and archaeological data which might be destroyed through alteration of terrain as a result of a Federal construction project or a Federally licensed activity or program.	Applicable
Historic Sites, Buildings and Antiquities Act	36 CFR § 62.6(d)	Requires Federal agencies to consider the existence and location of landmarks on the National Registry of Natural Landmarks to avoid undesirable impacts on such landmarks.	Applicable
Protection of Wetlands Order	40 CFR Part 6	Avoid adverse impacts to wetlands.	Applicable
Migratory Bird Treaty Act	16 USC § 703 et seq.	Establishes a federal responsibility for the protection of international migratory bird resource.	Applicable

Identification of Applicable or Relevant and Appropriate Requirements Zortman and Landusky Mines Time-Critical Removal Action			
Standard, Requirement Criteria Or Limitation	**Citation**	**Description**	**ARAR Status**
Fish and Wildlife Coordination Act	16 USC § 661 et seq.; 40 CFR Part 6.302(g)	Requires consultation when Federal department or agency proposes or authorizes any modification of any stream or other water body and adequate provision for protection of fish and wildlife resources.	Applicable
Floodplain Management Order	40 CFR Part 6	Requires Federal agencies to evaluate the potential effects of actions they may take in a floodplain to avoid the adverse impacts associated with direct and indirect development of a floodplain, to the extent possible.	Relevant and Appropriate
Bald Eagle Protection Act	16 USC §§ 668 et seq.	Establishes a federal responsibility for protection of bald and golden eagles. Requires consultation with the FWS.	Applicable
Endangered Species Act	16 USC §§ 1531-1543; 40 CFR Part 6.302(h); 50 CFR Part 402	Requires action to conserve endangered species within critical habitat upon which species depend. Includes consultation with FWS.	Applicable
Federal Action Specific:			
Federal Land Management and Policy Act Prevent unnecessary or undue degradation of federal lands	43 CFR 3809	Requires approved reclamation plan for mining operations including plans for post-closure management (includes water treatment when necessary)	Relevant and Appropriate
Clean Water Act National Pollutant Discharge Elimination System	33 USC §§ 1342 40 CFR Parts 122	Requires permits for the discharge of pollutants from any point source into waters of the United States.	Relevant and - Appropriate
Resource Conservation and Recovery Act	40 CFR Part 264	Provisions regarding run-on and run-off controls	Not an ARAR. Removal action will not create a RCRA TSD facility.
Occupational Safety & Health Act Hazardous Waste Operations And Emergency Response	29 USC § 655 29 CFR 1910.120	Defines standards for employee protection during initial site characterization and analysis, monitoring activities, materials handling activities, training & ER.	Applicable
Federal Mine Safety and Health Act MSHA Safety and Health Standards, Surface Metal and Nonmetal Mines	30 CFR Part 56	Defines standards for employee protection during mining, mineral processing, and reclamation activities.	Applicable to reclamation activities

Identification of Applicable or Relevant and Appropriate Requirements Zortman and Landusky Mines Time-Critical Removal Action			
Standard, Requirement Criteria Or Limitation	**Citation**	**Description**	**ARAR Status**
State Contaminant Specific:			
Montana Water Quality Act Regulations Establishing Ambient Surface Water Quality Standards	75-5-101 et seq., MCA ARM 17.30.601 et seq. ARM 17.30.637	Establishes Montana's laws to prevent, abate and control the pollution of state waters. Provides the water use classification for various streams and imposes specific water quality standards per classification. Provides that surface waters must be free of substances attributable to industrial practices or other discharges that will: (a) settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines; (b) create floating debris, scum, a visible oil film or globules of grease or other floating materials; (c) produce odors, colors, or other conditions which create a nuisance or render undesirable tastes to fish or make fish inedible; (d) create concentrations or combinations of materials which are toxic or harmful to human, animal, plant or aquatic life; (e) create conditions which produce undesirable aquatic life.	Applicable Applicable Applicable
Montana Groundwater Pollution Control System Regulations	ARM 17.30.1011 ARM 17.30.1006	Applies nondegradation requirements to any activity which could cause a new or increased source of pollution to state water Classifies groundwater into Classes I through IV based on the present and future most beneficial uses of the groundwater and states groundwater is to be classified to actual quality of actual use, whichever places the groundwater in a higher class.	Applicable Applicable

Identification of Applicable or Relevant and Appropriate Requirements Zortman and Landusky Mines Time-Critical Removal Action			
Standard, Requirement Criteria Or Limitation	**Citation**	**Description**	**ARAR Status**
Clean Air Act Of Montana	75-2-101, MCA	Montana policy is to achieve and maintain such levels of air quality as will protect human health and safety and, to the greatest degree practicable, prevent injury to plant and animal life and property.	Applicable
Air Quality Regulations	ARM 17.8.206	Establishes sampling, data collection, and analytical requirements to ensure compliance with ambient air quality standards.	Applicable
	ARM 17.8.222	No person shall cause or contribute to concentrations of lead in the ambient air which exceed the following 90-day average: 1.5 micrograms per cubic meter of air.	Applicable
	ARM 17.8.220	No person shall cause or contribute to concentrations of particulate matter in the ambient air such that the mass of settled particulate matter exceeds the following 30-day average: 10 grams per square meter.	Applicable
	ARM 17.8.223	No person may cause or contribute to concentrations of PM-10 in the ambient air which exceed the following standards: 1) 24-hr. avg. : 150 micrograms per cubic meter of air, with no more than one expected exceedance per year; 2) Annual avg.: 50 micrograms per cubic meter of air.	Applicable
Occupational Health Act of Montana	50-70-101, et. seq., MCA	The purpose of this act is to achieve and maintain such conditions of the work place as will protect human health and safety	Applicable
Occupational Air Contaminants Regulations	ARM 17.42.102	Establishes maximum threshold limit values for air contaminants believed that nearly all workers may be repeatedly exposed day after day without adverse health effects.	Applicable
Occupational Noise Regulations	ARM 17.42.101	Addresses occupational noise levels and provides that no worker should be exposed to noise levels in excess of the specified levels.	Applicable

Identification of Applicable or Relevant and Appropriate Requirements Zortman and Landusky Mines Time-Critical Removal Action			
Standard, Requirement Criteria Or Limitation	**Citation**	**Description**	**ARAR Status**
State Location Specific:			
Floodplain and Floodway Management Act	76-5-401, MCA	Lists the uses permissible in a floodway and generally prohibits permanent structures, fill, or permanent storage of materials or equipment.	Applicable
Floodplain Management Regulations	76-5-402 MCA	Lists the permissible permanent structures that are allowed in the floodplain excluding the floodway, if they are permitted and meet certain minimum standards.	Applicable
	76-5-403, MCA	Lists certain uses which are prohibited in a designated floodway, including any change that will cause water to be diverted from the established floodway, cause erosion, obstruct the natural flow of water, or reduce the carrying capacity of the floodway, or the concentration or permanent storage of an object subject to flotation or movement during flood level periods.	Applicable
	ARM 36.15.216	The factors to consider in determining whether a permit should be issued to establish or alter an artificial obstruction or nonconforming use in the floodplain or floodway are set forth in this section.	Applicable
	ARM 36.15.602	Specifies uses requiring permits for allowing obstructions in the floodway.	Applicable
	ARM 36.15.603	Proposed diversions or changes in place of diversions must be evaluated by the DNRC to determine whether they may significantly affect flood flows and, therefore, require a permit.	Applicable
	ARM 36.15.604	Prohibits new artificial obstructions or nonconforming uses that will increase the upstream elevation of the base flood 0.5 of a foot or significantly increase flood velocities.	Applicable

Identification of Applicable or Relevant and Appropriate Requirements Zortman and Landusky Mines Time-Critical Removal Action			
Standard, Requirement Criteria Or Limitation	**Citation**	**Description**	**ARAR Status**
Floodplain Management Regulations (continued)	ARM 36.15.605	Identifies artificial obstructions and nonconforming uses that are prohibited within the designated floodway except as allowed by permit and includes "a structure or excavation that will cause water to be diverted from the established floodway, cause erosion, obstruct the natural flow of water, or reduce the carrying capacity of the floodway..." Solid waste disposal and storage of highly toxic, flammable, or explosive materials are also prohibited.	Applicable
	ARM 36.15.701 and 703	Describes allowed uses in the flood fringe. Prohibited uses within the flood fringe (i.e., areas in the floodplain, but outside of the designated floodway) areas including solid waste disposal and storage of highly toxic, flammable or explosive material.	Applicable
	ARM 36.15.801	Allowed uses where floodway is not designated.	Applicable
Montana Solid Waste Management Act and Regulations	75-10-201, MCA ARM 17.50.505	Specifies the requirements that apply to the location of any solid waste management facility	Applicable
Endangered Species	87-5-106, 107,111, MCA ARM 12.5.201	Fish and wildlife resources are to be protected and no construction project or hydraulic project shall adversely affect game or fish habitat.	Applicable
State Action Specific:			
Montana Water Quality Act	75-5-605, MCA	It is unlawful to cause pollution of any state waters, to place any wastes in a location where they are likely to cause pollution of any state waters, to violate any permit provision, to violate any provision of the Montana Water Quality Act, to construct, modify, or operate a system for disposing of waste (including sediment, solid waste and other substances that may pollute state waters) which discharges into any state waters without a permit or discharges waste into any state waters.	Applicable

Identification of Applicable or Relevant and Appropriate Requirements Zortman and Landusky Mines Time-Critical Removal Action			
Standard, Requirement Criteria Or Limitation	**Citation**	**Description**	**ARAR Status**
MPDES Permit Requirements	ARM17.30.1342-1344	Sets forth the substantive requirements applicable to all MPDES and NPDES permits. Includes the requirement to properly operate and maintain all facilities and systems of treatment and control.	Relevant and Appropriate
	ARM 17.30.1203 and 1344	Technology-based treatment for MPDES permits.	Relevant and Appropriate
Nondegradation of Water Quality	75-5-303, MCA	Existing uses of state waters and the level of water quality necessary to protect the uses must be maintained and protected.	Relevant
	75-5-317, MCA	Provides exemption that allows changes of existing water quality resulting from emergency or remedial activity designed to protect the public health or the environment.	Relevant
	ARM 17.30.705(2)(a)	Provides that for any surface water, existing and anticipated uses and the water quality necessary to protect these uses must be maintained and protected.	Relevant
<u>Clean Air Act Of Montana</u> Air Quality Requirements	75-2-101, MCA	Montana's policy is to achieve and maintain such levels of air quality as will protect human health and safety and, to the greatest degree practicable, prevent injury to plant and animal life and property.	Applicable
	ARM 17.8.308	No person shall cause or authorize the production, handling, transportation or storage of any material unless reasonable precautions to control emissions of airborne particulate matter are taken.	Applicable
	ARM 17.8.604	Lists certain wastes that may not be disposed of by open burning.	Applicable
	ARM 17.8.1401-1404	Sets forth emission standards for hazardous air pollutants	Applicable

Identification of Applicable or Relevant and Appropriate Requirements Zortman and Landusky Mines Time-Critical Removal Action			
Standard, Requirement Criteria Or Limitation	**Citation**	**Description**	**ARAR Status**
Montana Solid Waste Management Act	75-10-201, et seq, MCA	Public policy is to control solid waste management systems to protect the public health and safety and to conserve natural resources whenever possible.	Relevant and Appropriate
Solid Waste Management Regulations	ARM 17.50.523	Solid waste must be transported in such a manner as to prevent its discharge, dumping, spilling or leaking from the transport vehicle.	Relevant and Appropriate
Montana Metal Mine Reclamation Act	82-4-301 et seq. MCA	Describes reclamation plan requirements and access rights. Disturbed areas must be reclaimed to utility and stability comparable to areas adjacent, except existing facilities may be left in place if they are valuable for an approved post-mining use.	Relevant and Appropriate Relevant and Appropriate
Montana Strip and Underground Mine Reclamation Act	82-4-231, MCA	Sets forth objectives that require the operator to prepare and carry out a method of operations plan to reclaim and revegetate the land affected by his operation	Relevant and Appropriate
	82-4-233, MCA	Requires that after the operation has been backfilled, graded, topsoiled and approved, the operator shall establish a vegetative cover on all impacted lands. Specifications for the vegetative cover and performance are provided.	Relevant and Appropriate

Identification of Applicable or Relevant and Appropriate Requirements Zortman and Landusky Mines Time-Critical Removal Action			
Standard, Requirement Criteria Or Limitation	**Citation**	**Description**	**ARAR Status**
Hydrology Requirements	ARM 17.24.631	Reclamation operations must be planned and conducted to minimize disturbance and prevent damage to the prevailing hydrologic balance.	Relevant and Appropriate
	ARM 17.24.633	Specifies that sediment controls must be maintained until the disturbed area has been restored and revegetated.	Relevant and Appropriate
	ARM 17.24.634	Drainage design shall emphasize premining channel and floodplain configurations that blend with the undisturbed drainage system above and below; will meander naturally; remain in dynamic equilibrium with the system; improve unstable premining conditions, provide for floods, provide for long term stability of the landscape; and establish a premining diversity of aquatic habitats and riparian vegetation.	Relevant and Appropriate
	ARM 17.24.635-637	Sets forth requirements for temporary and permanent diversions.	Relevant and Appropriate
	ARM 17.24.641	Sets methods for preventing drainage from acid-and toxic-forming wastes into ground and surface waters.	Relevant and Appropriate

Identification of Applicable or Relevant and Appropriate Requirements Zortman and Landusky Mines Time-Critical Removal Action			
Standard, Requirement Criteria Or Limitation	**Citation**	**Description**	**ARAR Status**
Top Soiling, Revegetation, and Protection of Wildlife and Air Resource Regulations	ARM 17.24.703	Materials other than, or along with, soil for final surfacing of spoils or other disturbances must be capable of supporting the approved vegetation and postmining land use.	Relevant and Appropriate
	ARM 17.24.713	Specifies that seeding and planting of disturbed areas must be conducted during the first appropriate period for favorable planting after final seedbed preparation; but not longer than 90 days after topsoil placement.	Relevant and Appropriate
	ARM 17.24.714	According to this section, as soon as practical, a mulch or cover crop must be used on all regraded and resoiled areas to control erosion, to promote germination of seeds, and to increase moisture retention of soil until permanent cover is established.	Relevant and Appropriate
	ARM 17.24.716	Establishes methods of revegetation	Relevant and Appropriate
	ARM 17.24.718	Soil amendments must be used as necessary to aid in the establishment of permanent vegetation; irrigation, management, fencing, or other measures may also be used after review and approval by the dep't.	Relevant and Appropriate
	ARM 17.24.751	Required site activities must be conducted so as to avoid or minimize impacts to important fish and wildlife species, including critical habitat and any threatened or endangered species identified at the site.	Relevant and Appropriate
	ARM 17.24.761	Section requires fugitive dust control measures for site preparation and reclamation operations.	Relevant and Appropriate