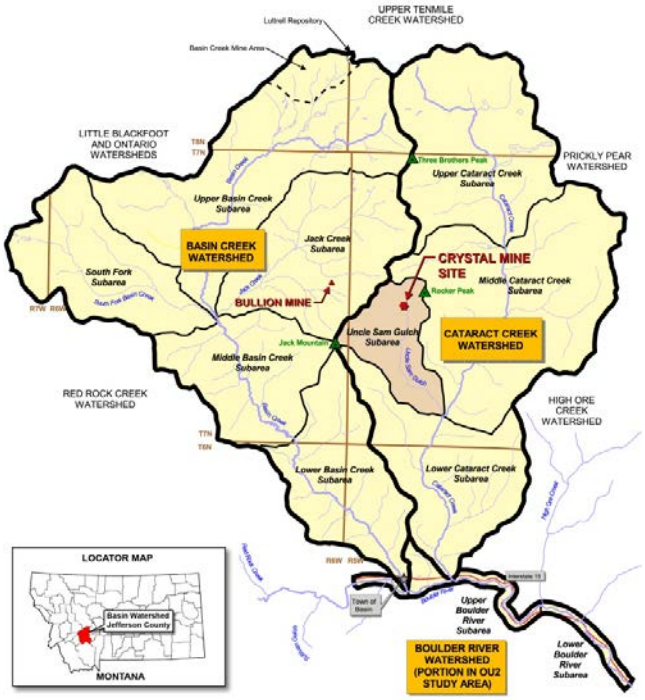
Crystal Mine Operable Unit 5—Proposed Plan

Introduction and Overview

The U.S. Environmental Protection Agency (EPA) Region 8, in consultation with the Montana Department of Environmental Quality (MDEQ), is proposing a plan to conduct an interim cleanup of the abandoned Crystal Mine Site located in the headwaters of Uncle Sam Gulch (USG) Creek, a tributary to Cataract Creek, near the town of Basin, in Jefferson County, Montana. **Exhibit 1** illustrates the Crystal Mine's location within the Cataract Creek Watershed.

The EPA has determined that the owners of the Crystal Mine do not have the financial resources to perform a cleanup of the Site; therefore, the work performed will be federally and State funded. The EPA is the lead agency with MDEQ providing support. Other federal, state, local agencies and public interest groups have participated in the process.

Exhibit 1. Location Map



This Proposed Plan describes the EPA's preferred interim remedy and the other alternatives the EPA considered for cleanup. In accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 as amended, also known as Superfund, this Plan presents the interim remedial strategies proposed by EPA Region 8 for the Crystal Mine to the public for their consideration, review and comment. It fulfills the EPA's requirements under section 117(a) of CERCLA and section 300.430(f)(2) of the National Contingency Plan (NCP). This Proposed Plan highlights key information from the remedial investigation (RI)/feasibility study (FS) Report. The reader should consult the RI/FS reports and administrative record file for more information regarding the proposed remedial action.

EPA invites Public Comment

The EPA and MDEQ may modify their cleanup preferences on the basis of new information or comments from the public. The public is encouraged to review and comment on all of the alternatives. The EPA will then either move forward with the preferred alternative, modify it or select another of the alternatives presented in this plan. Information on how to provide comments or questions to the EPA is provided on page 21 along with site contacts and public meeting details. Page 22 presents a list of commonly used environmental terms and abbreviations.

In general, the proposed remedy for the Crystal Mine site consists of treatment of acid mine drainage (AMD) to remove contaminants before the AMD intercepts Uncle Sam Gulch Creek. Exposed contaminated mine dump materials will be removed and placed in an onsite, lined repository. Exposed natural soils will be contoured and vegetated. Uncle Sam Gulch Creek

channel adjacent to the mine will be cleaned of contaminated soils/sediment, reconstructed and vegetated to prevent excessive erosion. Existing mine structures will be removed and placed in the local Luttrell Repository. Institutional controls (ICs) will be applied to the site and will conclude the sequence of remedial actions.

Site Background

The EPA added the Basin Mining District Superfund Site to the Superfund National Priorities List in October 1999 and subsequently divided the site into subunits called "operable units" (OUs). The EPA has or will develop cleanup plans for each OU. The Basin Watershed (OU2) includes more than 300 abandoned hard rock mine sites located within a 77-square-mile area from the headwaters of Basin and Cataract Creeks to their confluence with the Boulder River. The town of Basin (OU1) is located at the mouth of this watershed, and the EPA completed the cleanup of mining-related impacts in the town in 2002. The Crystal Mine (OU5) is located within the Basin Watershed (OU2), as is the Bullion Mine (OU6). Operable units 5 and 6 are separated by a drainage divide. The mines are located within 2 miles of each other and historically mined the same ore body.

Because the Crystal and Bullion Mine sites, with their associated acid mine drainage (AMD), represent the greatest threat to water quality in the entire Basin Watershed (OU2), the EPA is addressing these OUs first with interim remedial actions. Remedial action for the remainder of the Basin Watershed will follow.

The Crystal Mine OU5 remedy will address principal and low-level threats (AMD and contaminated mine wastes) to human health and the environment associated with potential exposures to contaminants in soil, surface water and other Site media.

The development of the Crystal Mine has a long history, dating back to 1883 when the Green Lode claim was located (staked).

Mining activities were conducted by several different companies from 1885 to 1901. By 1903, the Cataract Copper Mining Company had erected a concentrator and smelting plant that processed 200 tons of ore per day on the Bullion property, and the adit on the Crystal was being extended. The Crystal Mine was reportedly idle from 1926 until 1936. The mine was operated by different companies throughout the 1940s and 1950s. In 1975, the Jack Mountain Mining Company obtained a lease on the Crystal Mine. In 1983, the Bullock Brothers Construction Company sold and shipped ore to the ASARCO Smelter at East Helena, Montana. This was the last known ore shipment for the Crystal Mine.

Surface mining associated with the north trench, stockpiling of waste rock from underground and ground water infiltrating into mine workings have contributed to contamination of site soils, surface water and formation of AMD from the lower adit. **Exhibit 2** illustrates the current foot print of the Crystal Mine and proposed site boundaries. The Site boundaries fall within existing patented mine claims surrounded by the Beaverhead Deerlodge National Forest. The area of disturbance is approximately 20 acres and is bounded on the east side by Uncle Sam Gulch Creek (USG) Creek for approximately 1,000 feet. USG Creek flows north to south, joining Cataract Creek about 2 miles below the Site.

Exhibit 2. Current Footprint of the Crystal Mine OU5 and Proposed Site Boundaries

Interest in cleaning up the mined areas of the Basin Watershed (including the Crystal Mine) extends back to 1989, as documented by water quality studies initiated by the U. S. Geological Survey (USGS) and the Montana Bureau of Mines and Geology. Results concluded that the water flowing down USG Creek was degraded more significantly by the Crystal Mine than by any other influence down to its confluence with Cataract Creek. In 2001 and 2002, the Crystal Mine was the focus of a time critical removal action by the EPA. The action involved the lining and backfilling of a surface mine trench to prevent precipitation and snow melt from infiltrating directly into the mine workings and contributing to acid mine drainage.

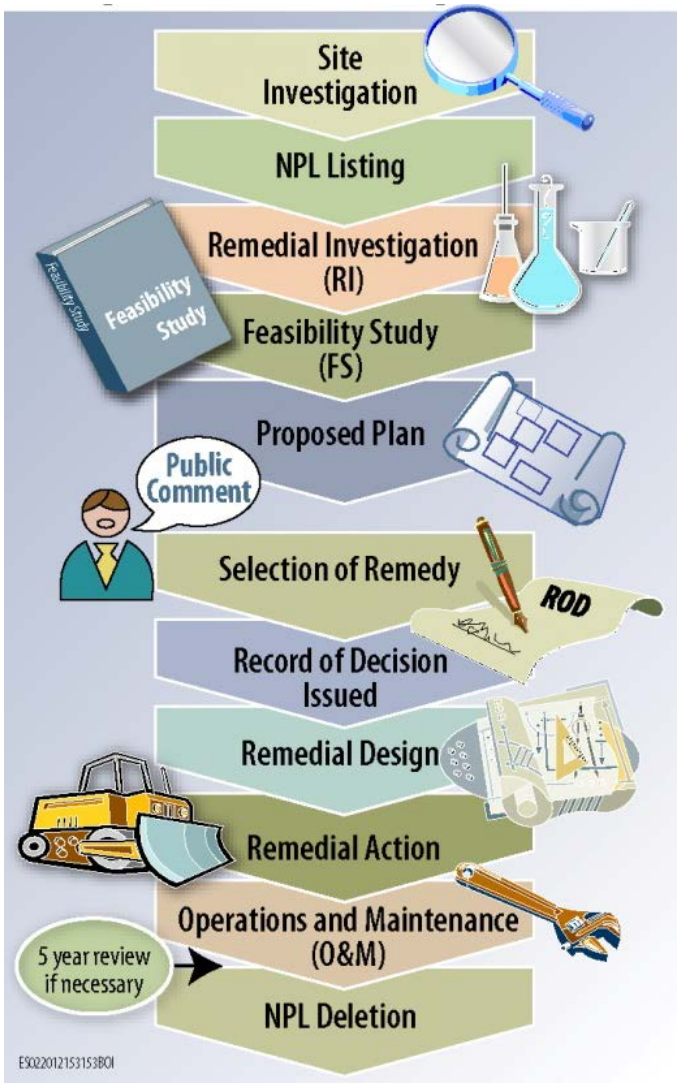
The Superfund Process

For every site designated as a Superfund site, the EPA follows a process that starts with discovery, proceeds through an investigation, and, as warranted, ends with cleanup (see **Exhibit 3**).

The EPA conducted a focused remedial investigation and focused feasibility study of the Crystal Mine site from 2010 to 2013. Results, conclusions and other relevant information available from previous studies conducted by the USGS and others were incorporated into the following key documents:

- *Crystal Mine OU5 Remedial Investigation Report*. This report contains a characterization of the nature and extent of contamination, and human health and ecological risk assessments.
- *Crystal Mine OU5 Feasibility Study*. This report screens potential remedial options, identifies the most viable remedial alternatives and evaluates them against nine EPA criteria (see Exhibit 9).
- This *Proposed Plan* introduces the final phase of the remedial investigation and feasibility study process for the Crystal Mine by presenting the public with the alternatives evaluated in the focused feasibility study, presenting a preferred alternative and soliciting written and oral comments. The comments will form the basis for the EPA's further evaluation of the ninth alternative criterion, community acceptance, and will influence the selected remedy presented in the record of decision (ROD) to be issued in 2014. The EPA, in consultation with MDEQ, will provide written responses to public comments in a section of the ROD known as the "Responsiveness Summary."

Exhibit 3. Steps in the Superfund Cleanup Process



Site Characteristics

Exhibit 4 shows the prominent site features associated with the Crystal Mine.

Exhibit 4. Prominent Features of the Crystal Mine Site

As shown in **Exhibit 5**, contaminated water from the mouth of the lower adit (tunnel) flows directly into USG Creek. This adit discharge is highly acidic and contains high concentrations of dissolved arsenic, cadmium, copper, lead and zinc. Cadmium, copper and zinc are highly toxic to aquatic organisms.

Exhibit 5. Lower Adit Area Showing Contaminated Discharge Entering USG Creek

The lack of vegetation on the mine site and along riparian areas adjacent to USG Creek (approximately 1,000 linear feet) demonstrates conditions inhospitable for plant growth (see **Exhibit 6**). Steep slopes contribute to excessive erosion by snowmelt and storm generated runoff. The erosion problems contribute large amounts of contaminated sediment, as runoff flows through mine wastes and into the stream, resulting in sustained poor water and sediment quality detrimental to aquatic life and vegetation. The EPA has classified the discharging water from the lower adit as the principal threat waste associated with the Crystal Mine site. Contaminated waste rock represents non-principal threat wastes.

Nature and Extent of Contaminated Areas

The Crystal Mine is located in the headwaters of Uncle Sam Gulch. Before mining, the upper reaches of Uncle Sam Gulch contained primarily evergreen forest dominated by lodgepole pine, Douglas fir, spruce, aspen and common juniper. A variety of small trees, shrubs and grasses was found in scattered open areas and a narrow riparian wetland mantled the stream banks. As mining activities proceeded and wastes were created, the hillside and narrow floodplain were altered significantly. Waste was deposited in the narrow drainage, burying the thin organic-rich top soils under layers of waste rock. Vegetation in the formerly active mine area was decimated. Mine wastes eroded into the stream. Today, after 100 years of mining-related activities, the upper segments of USG Creek are littered with waste containing elevated concentrations of arsenic and heavy metals, along with acid-generating sulfidic material. Contaminants have migrated from the mine waste to soils, surface water and sediments within the floodplain.

Exhibit 6. Barren Floodplain Constrained by Waste Rock Toxic to Plants

What are key areas of concern?

Disturbed both mechanically and chemically, mined areas and waste dumps are located adjacent to USG

Creek for about 1,000 lineal feet. Contaminated water emanating from the lower tunnel intercepts USG Creek in the vicinity of the remnant mine buildings and sediment ponds in the southernmost portion of the mine claim. USG Creek then flows an additional 2 miles south before its confluence with Cataract Creek, one of the major tributaries in the watershed.

What are the contaminants of concern?

The contaminants of concern at the Crystal Mine site are arsenic in soils for human health; and aluminum, antimony, arsenic, cadmium, copper, lead, selenium, silver and zinc in soils and sediments for wildlife. In surface water and ground water discharging to surface water, elevated concentrations of aluminum, cadmium, copper and zinc are of particular concern because of their toxicity to aquatic life and potential toxicity to plants in the floodplain.

How do the contaminants move?

Contaminants in the adit discharge water, the most direct source of contamination, flow directly into USG Creek and degrade sediment and water quality. Contaminants in the mine waste and impacted soils move into the stream through erosion. The wind also transports contaminants around the site, particularly in areas where vegetation is not growing and where mine wastes are disturbed.

Exhibits 7 and **8** show several key features, in and adjacent to the floodplain, including the exposed waste material, and sparse and dead vegetation.

Exhibit 7. Crystal Mine Wastes in Downstream Floodplain—Note Dead Vegetation

Summary of Site Risks

What are human health risks?

Land use along Uncle Sam Gulch is primarily recreational with scattered residential use along lower Cataract Creek. Risks were estimated for the most plausible pathways of human exposure, on the basis of current and reasonably anticipated future land and water uses at Crystal Mine. The EPA evaluated exposure scenarios for intermittent workers, recreational users (adult and adolescents on all-terrain vehicles [ATVs] and non-ATV users), future excavation workers, and hypothetical future industrial worker receptor groups. The rationale for considering these exposure scenarios is presented in Section 6 of the RI.

Exhibit 8. Note Lack of Vegetation on the Crystal and Twin Ore Bin Dumps Adjacent to USG Creek

The conclusion of the Crystal Mine human health risk assessment in the *Crystal Mine Remedial Investigation Report* is that human health risks from arsenic in soils exceed acceptable levels for future workers and current and future recreational users (ATV riders). Property surrounding the Site is managed by the U.S. Forest Service (Beaverhead-Deerlodge National Forest).

What are the ecological risks?

The ecological risk assessment established clear risks to terrestrial and aquatic life along USG Creek, particularly in the section adjacent to the mine. Weathered waste rock and soil generally lack vegetation and present an unacceptable risk to ecological receptor groups potentially exposed to elevated concentrations of metals within the active mine area. USG Creek suffers from excessive bank erosion and the transport of

contaminated sediment downstream from this reach, resulting in elevated sediment yield during periods of high flow.

- Surface water sampling results show that aluminum, cadmium, copper and zinc significantly exceed freshwater acute and chronic water quality criteria. The degraded water quality within USG Creek is not suitable to support aquatic life.
- Historic stream sediment data show that arsenic, cadmium, copper, lead and zinc exist at concentrations high enough to cause adverse effects on stream macroinvertebrates (aquatic life). A benthic macroinvertebrate study conducted in 2010 within USG Creek and Cataract Creek supports this conclusion.
- Contaminants (particularly aluminum, antimony, arsenic, cadmium, copper, lead, selenium, silver and zinc) in soil and sediment are high enough to pose a significant risk to wildlife using the site. Animals ingest the contaminants through consumption of contaminated sediment, soil, water and through the food chain (consumption of contaminated plants or prey).
- Contaminants in soil also pose a significant risk to vegetative communities at the site. Aquatic plants uptake contaminants by absorption of the contaminated water. Contaminant uptake by plants is a well-documented occurrence that prevents or limits vegetative growth

Conclusion – On the basis of the entire administrative record, including historic investigations and the 2010-2013 human health and ecological risk assessments, the EPA concludes that widespread unacceptable terrestrial and aquatic risk exists in USG Creek and large areas of the Crystal Mine OU. The EPA, in consultation with MDEQ, has determined that the preferred remedy identified in this Proposed Plan, or one or more of the other active measures considered in the Proposed Plan, is necessary to mitigate these risks, and protect public health and the environment.

A detailed description of site risks can be found in the "Risk Assessment" section of the *Crystal Mine Remedial Investigation Report*.

Preliminary Remedial Action Objectives

The final remedial action objectives (RAOs) for site soils, ground water and surface water will be stated in the ROD. The preliminary remedial action objectives (PRAOs) for the Crystal Mine site are as follows:

Mine Wastes and Soils

- Prevent or minimize human exposure to contaminated soils/waste rock where incidental ingestion, dust inhalation or direct contact would pose an unacceptable health risk.
- Prevent or minimize unacceptable risk to ecological systems (including aquatic and terrestrial) from contaminated waste rock/soils containing elevated levels of metals.

Ground Water

The ground water PRAOs proposed for USG Creek, an interim action, are consistent with, and will not preclude, whatever may be chosen as a final remedy for the Basin Watershed OU2. They are as follows:

- Prevent or minimize source water infiltration to the workings.
- Prevent or minimize ground water discharge containing contaminants.

Surface Water

The surface water PRAOs proposed for USG Creek, an interim action, are consistent with, and will not preclude, whatever may be chosen as a final remedy for the Basin Watershed OU2. They are as follows:

- Minimize source water infiltration to the workings.
- Prevent or minimize release of contaminants to surface waters.

Stream Sediment

The PRAOs for sediment in the mine area are as follows:

- Prevent or minimize exposure to contaminants in sediments.
- Prevent or minimize further migration of Site-contaminated source materials or discharges in close proximity to the creek.

Preliminary Remediation Goals

The proposed preliminary remediation goals (PRGs) represent the concentration below which a contaminant does not represent unacceptable risk. PRGs were developed independently for the protection of human health and ecological receptors.

For human health, the EPA considers acceptable exposure levels to be concentration levels of carcinogens that represent an excess upper-bound lifetime cancer risk to an individual of between 10^{-4} (1 in 10,000 probability) to 10^{-6} (1 in 1,000,000 probability) or less; and concentration levels of non-carcinogens that are below toxicity reference doses protective of human health (a hazard index of 1). Achieving a 10^{-6} (1 in 1,000,000 probability) risk is often not possible at western mining sites, where risks from naturally occurring background metals concentrations in site media sometimes occur in the 10^{-4} (1 in 10,000 probability) to 10^{-5} (1 in 100,000 probability) range.

For ecological receptors, the EPA considers acceptable exposure levels to be concentration levels that are below toxicity reference values or benchmarks protective of ecological populations.

PRGs provide numeric goals for the protection of human health and the environment. Determination of PRGs depends on PRAOs, current and reasonably anticipated future land uses, and applicable or relevant and appropriate requirements (ARARs). The EPA is proposing the following remedial cleanup goals below which a 10^{-5} (1 in 100,000 probability) excess cancer risk is not exceeded and exposures are not expected to exceed non-cancer toxicity levels of a hazard index of 1 or less for humans and toxicity reference values for wildlife populations.

The "Risk Assessment" section of the *Crystal Mine Remedial Investigation Report* identified cadmium, copper and zinc in surface water as the primary contaminants of concern posing unacceptable risk to human and ecological receptors at the site. Because this is an interim action, the EPA proposes to waive the surface and ground water quality standards until a final action is taken for the Basin watershed. The final action for the Basin Watershed OU2 will address all ARARs, including DEQ-7 standards for surface and ground water. The EPA believes that the interim action will improve water quality significantly. The Basin Watershed OU2 ROD will consider the effectiveness of the interim ROD for the Crystal site and whether additional measures are needed to meet water quality standards.

Human health PRGs for soil were derived for arsenic—the only human health risk for recreational users (ATV riders and hikers). The PRG for arsenic is based on potential risks derived for the adolescent recreational user (1,241 mg/kg) based on bioavailability and potential inhalation exposure. Potential exposure is limited to areas where mine wastes are exposed

Aluminum, antimony, arsenic, cadmium, copper, lead, selenium, silver and zinc were identified as ecological contaminants of concern in soils and sediment. Potential ecological exposure in soils is limited to areas of exposed mine wastes, and to wildlife species that may burrow or consume food items below the soil surface. Exposure will be mitigated through removal of the contaminated wastes and addition of clean cover material and vegetation.

The proposed PRGs for contaminants in stream sediments in USG Creek address potential risks to benthic infaunal communities, and are provided in **Table 1**. These PRGs are derived from the more restrictive of probable (upper) effects threshold concentrations for protection of sediment infauna and wildlife.

Table 1. Stream Sediment PRGs in mg/kg

Contaminant	Probable Effects Concentration/ Cleanup Screening Level*
Arsenic	33.0
Cadmium	4.98
Copper	149
Lead	128
Nickel	48.6
Zinc	459

Notes:
* Dry Weight
Source: D.D McDonald; C.G. Ingersoll; T.A. Berger. *Development and Evaluation of Consensus Based Sediment Quality Guidelines for Freshwater Ecosystems.* Arch. Environ. Toxicol. 39, 20-31 (2000)

As explained under the PRAOs, stream sediment quality is expected to improve through natural recovery after remedial actions for addressing the primary contaminant source (for example, treatment of mine adit discharge and removal of mine waste/soils eroding into USG Creek).

ARARs provide other standards and criteria for consideration in the remedial action decisions. In addition, because some proposed PRGs may be below naturally-occurring levels of metals, the final PRGs may be based on background concentrations measured at the Site.

Summary of Remedial Alternatives – Description of Alternatives

During the feasibility study, nine primary remedial alternatives were evaluated and are briefly described here. A more detailed description of the alternatives can be found in the feasibility study.

The alternatives were developed to span the range of categories defined by the NCP (40 CFR section 300.430(e)) including, as appropriate:

1. The No Further Action Alternative.
2. A range of alternatives for source control in which treatment is a principal element. Treatment should reduce toxicity, mobility or volume of contaminants. This range includes alternatives that:
    a. Remove or destroy contaminants in order to eliminate or minimize the need for long-term management.
    b. Treat the principal threats, but vary in the degree of treatment and the amount and characteristics of treatment residuals and untreated waste that must be managed.
3. A range of alternatives for source control that involve little or no treatment. These alternatives protect human health and the environment by preventing or controlling exposure to contaminants through engineering controls and land-use controls.

The detailed alternatives address solid media on the mine site or AMD from the lower adit for remedial action.

Media-specific and combined-media alternatives were developed for the Site as a means of implementing a comprehensive cleanup. Technology options for waste rock/impacted soils, and discharging mine water were developed and assembled into nine primary alternatives. The EPA approved the nine primary alternatives as the final list of alternatives to be carried into the detailed analysis of the feasibility study. All alternatives, except No Further Action, include the use of best management practices (BMPs) and institutional controls designed to prohibit residential use of the site, prevent domestic consumption of ground water and to protect the remedy. **Table 2** presents a summary of the nine alternatives.

The preferred remedy for the Crystal Mine site consists of a combination of alternatives which include: removal and onsite disposal of contaminated mining waste and soils (Alternative WR-3), intercepting/diverting “clean” surface water and ground water, and semi-passive treatment of residual AMD (Alternative GW-5) to meet remedial action objectives.

Alternative 1: No Further Action

The No Further Action Alternative would involve no further remedial action or land use controls at the Crystal Mine beyond those currently in place or already undertaken. This alternative provides the baseline conditions against which the other remedial action alternatives are compared. This alternative includes completed and ongoing actions at the mine site including periodic monitoring of water quality (Estimated Cost $231,000).

Waste Rock/Soil Media (WR) Alternatives

Areas of exposed waste rock would be removed or capped as part of any selected remediation action. Where waste rock intercepts/overlays stream banks, the banks would be reconstructed, stabilized and revegetated. Stream banks without impacted soils and with woody vegetation would be slated for no action or for BMPs and land use controls.

Table 2. Components of a Remedy by Alternative

Remedial Components	NA	Alternatives								
		WR1	WR2	WR3	GW1	GW2	GW3	GW4	GW5	GW-6
Improve access and site roads		✓	✓	✓	✓	✓	✓	✓	✓	✓
Cap contaminated soils/waste rock in place		✓								
Excavate/remove contaminated soils waste rock			✓	✓						
Waste disposal in Luttrell Repository			✓				✓	✓	✓	✓
Waste disposal in onsite lined repository				✓						
Cap with clean top soil and revegetate		✓	✓	✓						
Re-open mine adit—construct adit plug					✓		✓	✓	✓	
Construct adit plug through borings						✓				
Construct treatment plant							✓			
Construct treatment quicklime dispenser facilities and piping								✓		
Construct lined settling ponds							✓	✓	✓	✓
Construct treatment cells								✓	✓	✓
Surface water control		✓	✓	✓	✓	✓	✓	✓	✓	✓
Construct erosion control		✓	✓	✓	✓	✓	✓	✓	✓	✓
Reconstruct USG Creek stream channel		✓	✓	✓	✓	✓	✓	✓	✓	✓
Provide periodic monitoring of site		✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes:
WR-1 Waste Rock Capping
WR-2 Excavate and Local Disposal
WR-3 Excavate and Dispose Onsite
GW-1 Mine Plugging—Reopen Mine Adit
GW-2 Remote Mine Plugging
GW-3 Active Treatment
GW-4 Semi-Active Treatment (Quicklime Injection System)
GW-5 Semi-Passive Treatment (Sulfate Reducing Bioreactor)
GW-6 Semi-Passive Treatment (SRBR, Aeration)

Alternative WR-1—Waste Rock Capping (Estimated Cost $4,900,000)

Waste rock dumps would be graded to provide control of surface water runoff. The capping alternative would cover exposed waste rock with a flexible membrane liner, such as high-density polyethylene (HDPE). The liner would then be covered with 24 inches of imported, clean fill material suitable for revegetation. Existing structures and ponds would also be removed to allow for uniform treatment of the waste rock. Overly steep slopes would most likely require regrading or terracing to allow installation of both liner and cover material.

Alternative WR-2—Excavate and Local Disposal (Luttrell Repository) (Estimated Cost $7,663,000)

Approximately 60,000 cubic yards of waste rock from existing dumps and the Mammoth Road area would be removed and transported to the local Luttrell Repository. Approximately 6 acres of land area would be affected. Haul roads would be upgraded. Replacement soils would cap the area and they would be revegetated.

Alternative WR-3—Excavate and Dispose Onsite (Estimated Cost $5,252,000)

This alternative is similar to WR-2 with the exceptions described in the following text.

- A repository would be constructed in the vicinity of the Crystal Trench. The repository would be designed with adequate capacity to handle waste rock from the onsite waste dumps and source areas. An onsite loop road would be upgraded and used to transport the material to the onsite repository. The repository would be capped with an impermeable liner and covered with 24 inches of cover and top soil, and revegetated. Replacement soil from a clean borrow source would be required to cover all excavated waste rock areas.

Ground Water Media Alternatives

Ground water (GW) media alternatives would either block the flow from the adit, or control or treat the flow before it enters USG Creek, while engaging in some form of source water control to prevent or limit water from entering the mine workings, where possible. Two alternatives are considered for blocking the flow of AMD. Both involve sealing the mine adit with a concrete plug. One approach would reopen the lower cross-cut adit to strategically place a plug in competent rock to seal the lower mine workings. The other would install a plug in the lower workings remotely through directional drilling and grouting from the surface. Three treatment options are also evaluated. All would control the flow of AMD by blocking the adit and piping water to a treatment facility. Treatment options vary from an active, fully staffed plant to an unstaffed passive system.

Alternative GW-1—Mine Plugging Through Reopened Mine Adit (Estimated Cost $7,791,000)

- This alternative would employ the construction of a plug within the lower adit (tunnel) to seal mine water within the mine. The resulting flooding behind the plug would prevent air from entering the mine through the adit, potentially reducing oxidation and generation of AMD. After the mine adit is sealed, the surrounding area would be monitored to determine if new ground water discharge points have developed or if significant changes to the local ground water flow occur. Several monitoring wells would be located downgradient from the mine plugs. Ground water monitoring upgradient of the mine would provide background data for comparison. Additionally, surface water both downgradient and upgradient of the mine site would be routinely monitored to determine effectiveness of the plug.

Alternative GW-2—Remote Mine Plugging Through Borings from the Surface (Estimated Cost $12,320,000)

A second alternative for mine plugging would be implemented by drilling down from the surface to collapse a targeted section of the mine tunnel and fill voids in the collapsed section through high-pressure grouting to complete an impervious plug. This approach provides the advantage of not having to reopen the mine adit to gain physical access to the section of interest. The disadvantage is the technical difficulty of accomplishing this task and completing a competent seal that would hold back mine water. As with Alternative GW-1, periodic reconnaissance for new seeps and ground water monitoring downgradient of the mine would be implemented upon completion of the hydraulic plug to ensure that the plug is working and contaminated ground water is not escaping from the mine. Several monitoring wells would be located downgradient from the mine plug. Ground water monitoring upgradient of the mine would provide background data for comparison. Additionally, surface water both downgradient and upgradient of the mine site would be routinely monitored to determine effectiveness of the plug.

Alternative GW-3—Active Treatment of AMD (Estimated Cost $7,738,000)

Alternative GW-3 would consist of an active treatment process to treat AMD at the mine site. A high-density sludge (HDS) plant, a standard technology for treating AMD, would be designed and constructed. To control the rate of AMD influent into the plant, a single mine plug would be constructed inside the adit to block the flow of ground water discharge. Chemically-resistant pipes running through the plug would transmit a constant volume of the AMD to the HDS plant. During periods of high ground water discharge, the plug would act like a dam, storing the AMD within the mine until it could be treated. Only adit discharge would be collected and diverted to the treatment plant. Construction of the HDS plant would require that a permanent source of

electrical power be provided to the site, resulting in the installation of aboveground transmission lines running to the mine site. The HDS plant would require year-round operation by a part-time operator. Upgraded access roads to the mine sites would provide site access from late spring through the early fall until snow starts to accumulate. Once snow has blocked access to the sites for automobiles or trucks, an alternative means of winter transportation such as snowmobiles or tracked vehicles would be required to access the site for ongoing operations and maintenance.

Alternative GW-4—Semi-Active Treatment of AMD (Quicklime Injection System) (Estimated Cost $5,079,000)

Alternative GW-4 would consist of a semi-active AMD treatment process. The treatment process would be sequenced as described in the following text.

- Mine discharge from the lower adit would be blocked by an adit plug, collected and piped to the quicklime injection system where a mechanical system would inject quicklime into the stream. The mechanical injection system would be driven by a water wheel powered by the adit discharge.
- The quicklime injection system effluent stream would mix while passing through a "V" ditch lined with riprap. The ditch would be routed into one of two lined settling ponds where metals would co-precipitate with hydroxide and oxyhydroxide floc and settle out. Effluent from the primary settling pond would drain into a secondary settling pond which would allow for additional settling time. Effluent from the secondary settling pond would drain directly into USG Creek. As necessary, the settling ponds would be drained and the hydroxide sludges on the bottom would be excavated and placed on drying beds nearby. Once dried, the sludge would be hauled to the Luttrell Repository located on the northern boundary of the watershed. The drying beds would drain into the primary settling ponds. Alternative GW-4 would require periodic maintenance (approximately weekly) to ensure the system is operating properly. Additionally, depending on the quicklime injection system and storage capacities of the system, the quicklime would need to be resupplied once or twice each year.

Alternative GW-5—Semi-Passive Treatment of AMD (Sulfate Reducing Bioreactor) (Estimated Cost $4, 432,000)

Alternative GW-5 would be a three-stage semi-passive system utilizing a pH adjustment cell, a sulfate reducing bioreactor (SRBR) and a clarification pond. As with Alternatives GW-3 and GW-4, an adit plug would be installed to control flow through a pipe and a control valve. Two parallel treatment trains would be installed to allow for one to be out of service for maintenance or repairs while the other served treatment needs. Only adit discharge would be collected and diverted to the treatment plant. The three stages of the treatment process are as follows:

- **pH Adjustment Cell (Stage 1).** The pH adjustment cell would consist of three layers and is designed to increase AMD to a pH greater than 6. Details of the cell are described in depth in the focused feasibility study.
- **SRBR (Stage 2).** The SRBR consists of a series of horizontal flow-through cells where sulfate concentrations are reduced by sulfatereducing bacteria. Proper pH and mine water retention time within each cell are critical to the success on this stage. Conceptual design details of the cells are described in the Feasibility Study.
- **Clarification (Stage 3).** The clarification pond represents the third stage of treatment and would allow settling of sludges and organic materials formed in the prior two stages. Effluent from the SRBR cells would be discharged into the 6-foot-deep end of the pond which offers storage for settling sludges. At the shallow end of the pond, native aquatic vegetation would provide biological filtering. Periodically, sludge that settles in the deep end of the clarification pond would be excavated, and dried on drying beds which would drain into the clarification pond. The dried waste would be transported to the Luttrell Repository for disposal.

Alternative GW-6—Semi-Passive Treatment of AMD (SRBR, Aeration Systems, Oxidation/Settling Ponds, Wetlands, and Discharge) (Estimated Cost $3,832,000)

Alternative GW-6 would be a five-stage semi-passive treatment system utilizing (1) an SRBR, (2) aeration system, (3) oxidation/ settling ponds, (4) wetland, and

(5) discharge to USG Creek. GW-6 incorporates a slightly different semi-passive design by omitting a separate pH adjustment cell. Unlike Alternatives GW-2 through GW-5, an adit bulkhead would not be installed to control flow through a pipe and control valve. Discharge from the adit would be captured and flow through a pipe, but would be allowed to flow freely throughout the year.

Evaluation of Alternatives

The Superfund law and regulations require that the EPA, in consultation with MDEQ, evaluate and compare the remedial cleanup alternatives based on the nine NCP criteria. These nine criteria are derived from the Superfund law, especially section 121 of CERCLA, 42 U.S.C. § 9621, and are promulgated in the NCP at 40 CFR section 300.430(f)(1)(€(E). Exhibit 10 presents the nine criteria.

Exhibit 10. The EPA's Evaluation Criteria

The EPA'S Evaluation Criteria

Threshold Criteria—Must be Addressed

1. Overall protection of human health and the environment—*must be protective of human health and the environment.*
2. Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)—includes State and federal regulations; where ARARs cannot be met, a waiver is required

Balancing Criteria—Must be Considered

1. Long-term effectiveness and permanence
2. Reduction of toxicity, mobility and volume
3. Short-term effectiveness
4. Implementability
5. Capital and operating and maintenance cost

Modifying Criteria—Must be Considered

1. State acceptance
2. Community acceptance

Any selected remedy must meet the **threshold criteria** of "overall protectiveness of human health and the environment" and "compliance with ARARs or appropriate justification for use of the CERCLA ARAR waivers." Only those alternatives that meet these criteria are considered further by the EPA. The **balancing criteria of** long-term effectiveness and permanence; reduction of toxicity, mobility or volume through treatment; short-term effectiveness; implementability; and cost are used by the EPA to identify and consider major trade-offs among the alternatives. Two of these criteria—long-term effectiveness and permanence, and reduction in toxicity, mobility or volume through treatment—are emphasized by the NCP and the EPA guidance. The **modifying criteria**—State acceptance and community acceptance—are evaluated as the preferred remedy is selected, to the extent that information is available, and then more thoroughly evaluated after the public comment period.

The EPA evaluates these criteria in detail in both the "Detailed Analysis" and the "Comparative Analysis of Alternatives" sections of the feasibility study, which contains more detailed information. The EPA, in consultation with MDEQ, formally evaluated these nine alternatives using the threshold and balancing criteria. A separate summary of Waste Rock and Ground Water Alternatives is provided in the following text; however, some combination of these alternatives is needed to reduce unacceptable risks at the Site.

Overall Protection of Human Health and the Environment

With the exception of Alternative 1 (No Further Action), all proposed alternatives would provide some protection for human health and the environment by eliminating, reducing or controlling risk. However, combining a waste rock alternative with a groundwater alternative provides more comprehensive protection.

Soil and waste rock PRAOs are met by Waste Rock alternatives. Alternatives WR-1 (Waste Rock Capping), WR-2 (Waste Rock Excavation and Disposal), and WR-3 (Waste Rock Excavation with Onsite Disposal) would control exposure risks by capping or removing waste rock at the site, thereby blocking or removing the exposure pathway to human and aquatic receptors.

Surface water and ground water PRAOs are met by ground water alternatives. The ground water alternatives proposed in the feasibility study protect human health and environment. Alternatives GW-1 (Mine Sealing through Reopened Adit) and GW-2 (Mine Sealing by Remote Means) would attempt to control the exposure risks by capturing the ground water flow within the mine workings (tunnels) and preventing it from discharging to areas where exposures could occur. If successful, these alternatives would have the potential to provide a high measure of risk reduction by breaking the exposure pathway to potential human and aquatic receptors. The risks associated with these alternatives include allowing untreated ground water to build up behind the plugs, potentially creating a large pressure. As the pressure head grows, so does the potential for plug failure and seepage around the plug and grout curtain, as well as the creation of new springs downgradient of the mine as contaminated ground water moves through fractures within the host rock. Both alternatives are highly dependent on effectiveness of the plug construction and surrounding geology.

Alternatives GW-3 (Active Treatment), GW-4 (Semi-Active Treatment) and GW-5/GW-6 (Semi-Passive Treatment) address human health and environmental protection by capturing and treating (active, semi-active and semi-passive processes) the point source discharge of AMD from the mine adit, removing a major contributor to the COCs at the site. With proper operation and maintenance these alternatives are more conventional and are more certain of overall protection of human health and the environment than the other alternatives. However, they carry perpetual operation and maintenance requirements that, if left unaddressed, could result in process upsets and unanticipated releases/exposure risks.

As previously stated, some combination of the soil and water alternatives is needed to fully protect human health and the environment.

ARARS

Appendix B in the Feasibility Study contains an analysis and discussion of potential ARARs for the Crystal Mine. Because the EPA is selecting an alternative at the Crystal Mine as an interim measure, compliance with surface and ground water ARARs is waived until all five OUs comprising the Basin Mine Area NPL Site are complete. However, proposed remedial actions taken at the site should contribute to overall compliance with surface water and ground water standards. All other ARARs not waived by this interim action, will be met by each alternative, except Alternative 1.

Long-Term Effectiveness and Permanence

Alternative NFA (No Further Action) would leave existing conditions at the Crystal Mine unchanged. This alternative would be least effective compared to the action alternatives in the long term.

Alternative WR-1 (Waste Rock Capping), WR-2 (Waste Rock Excavation and Disposal) and WR-3 (Waste Rock Excavation with Onsite Disposal) would provide varying degrees of long-term effectiveness with WR-1 (capping) being less effective than WR-2 (removal) and WR-3 (relocation). The long-term effectiveness of the removal alternative would be expected to be high with the only variable being how thoroughly the waste rock and contaminated soils were removed. Capping is expected to be less effective, relying on proper installation of a cap and proper maintenance and monitoring to ensure long-term effectiveness.

The long-term effectiveness of Alternatives GW-1 and GW-2 would potentially range in contaminant removal efficiencies from as low as 25 percent to as high as 90 percent. The large range is because of uncertainties about the competence of fractured bedrock surrounding the underground workings, lack of information concerning geologic conditions and potential sources within the mine workings, and uncertainties concerning the efficiency of the grout curtain. Alternative GW-1 would provide greater effectiveness and permanence than Alternative GW-2 because of the controlled nature of the plug construction. Ground water seepage around and through the grout curtain can occur over time as ground water head pressure builds behind the grout curtain. Over time, grout curtain and plug material would degrade because of the corrosiveness of the ground water and likely require some form of maintenance approximately every 10 years.

Alternative GW-3 would offer the greatest long-term effectiveness because of the process control that is available to the plant operator. Typical removal efficiencies at similar HDS treatment plants at other

mine sites are often greater than 99 percent. Operational upsets within the treatment system would reduce the removal efficiencies at times, but could be readily diagnosed and corrected by the operator. Telemetry and system alarms allow for rapid operation and maintenance response by the operator in the event of a treatment system upset. Alternative GW-3 requires the greatest level of operations and maintenance effort to ensure long-term effectiveness.

Alternative GW-4 offers the potential for 85 to 95 percent effectiveness of removal of contaminants. Upsets within the system could be diagnosed and corrected by trained operators. However, because of the lower level of operation and maintenance required, and the lack of telemetry or alarms, upsets within the treatment system would take longer to discover, diagnose and correct when compared to Alternative GW-3. Also, as sludge precipitates out and collects in the primary and secondary settling ponds, the retention time would drop, which would affect the long-term effectiveness of the system. Proper operations and maintenance for the treatment ponds and process would contribute significantly to the long-term effectiveness and permanence of this treatment alternative.

Alternative GW-5 and GW-6 would offer 75 to 90 percent long-term effectiveness. The reduced effectiveness is the result of anaerobic biological processes not being as reliable as chemical precipitation. Upsets within the treatment system could go longer without being identified and managed when compared to Alternatives GW-3 and GW-4. Proper operations and maintenance for the treatment ponds/cells and process would contribute significantly to the permanence of these treatment alternatives.

Reduction of Toxicity, Mobility or Volume of contaminants through Treatment

Alternative 1 (No Further Action) would not provide any treatment and therefore would have no effect on toxicity, mobility or volume of contaminants.

None of the waste rock alternatives include treatment. Therefore, they do not reduce toxicity, mobility or volume through treatment.

Alternatives GW-3 (Active Treatment), GW-4 (Semi-Active) and GW-5/GW-6 (Semi-Passive) would all offer reduction of toxicity, mobility and volume as a result of treatment. GW-1 and GW-2 do not reduce toxicity and volume, in a direct, human-administered sense. Implementing GW-1 and GW-2 would flood the mine workings. The consequence of this action would be a reduction in acid mine drainage (toxicity), stopping the point discharge (reduce mobility of contaminants—assuming water doesn't break through to the surface at some other location) and disseminating mine water in bedrock fractures less permeable than the point discharge (then volume is reduced). All other GW treatment alternatives would reduce the toxicity, mobility and volume of arsenic and other metals in the AMD. Sludges and wastes are created as a byproduct of all three treatment alternatives and must be properly disposed of in a local repository. The predicted treatment efficiency of each alternative reflects its ability to reduce toxicity, mobility and volume of contaminants in the AMD. The predicted treatment efficiency of each alternative is as follows:

- No Further Action—no reduction
- Mine Plugging—25 to 90 percent reduction
- Active Treatment—greater than 99 percent reduction
- Semi-Active Treatment—potential 85 to 95 percent reduction
- Semi-Passive Treatment (Sulfate Reducing Biological Reactor)—potential 75 to 90 percent reduction

Alternative GW-3 would offer the greatest amount of control of sludges by drying the sludges as part of the treatment process. Alternatives GW-4, GW-5 and GW-6 would require excavation and drying of sludges prior to disposal. In addition, some of the excavated materials may need pre-treatment to deal with metals leachability prior to disposal at the Luttrell Repository. Because Alternative GW-5 and GW-6 have less control, resulting in the potential for greater mobility of COCs when compared to Alternative GW-4, Alternative GW-4 is rated higher than Alternatives GW-5 and GW-6.

Because of the lack of any treatment process, Alternatives 1, GW-1 and GW-2 are rated lower than Alternatives GW-3, GW-4 and GW-5/GW-6.

Short-Term Effectiveness

Alternative 1 (No Further Action) would leave existing conditions at the Crystal Mine unchanged; therefore, it has no short-term construction risk.

Alternatives WR-1 (Waste Rock Capping), WR-2 (Waste Rock Excavation and Disposal) and WR-3 (Waste Rock Excavation with Onsite Disposal) would all initially carry some short-term safety risk because of the transport and operation of construction equipment. Potential risk of short-term exposure to contaminants mobilized by earth-moving operations is also a concern with these two alternatives. Safety risks can be mitigated by proper planning and proper implementation of health and safety plans for onsite workers. Precautions to inform the residents of Basin of the construction and to keep the general public away from the Site would also be implemented to help reduce the risk to the community. Alternatives WR-2 and WR-3 would require moving more contaminated materials and clean material than WR-1. Therefore, WR-1 has fewer short-term impacts.

Alternatives GW-1 and GW-2 would initially carry some short-term safety risk because of the transport and operation of construction equipment. While working around and in the mines, safety of workers is a concern. Potential exposure risk from contact of AMD is also a concern in the short-term with these two alternatives. Safety risks can be mitigated by proper planning and implementation of health and safety plans for onsite workers. Informing residents of Basin about the construction and keeping the general public away from the site would help reduce the risk to the community. Depending on the condition of the mines, construction might be completed in one field season versus the two field seasons predicted for the other alternatives. Because of the inherent risk in mine tunnel construction, Alternative GW-1 is considered to have greater short-term impacts than Alternative GW-2.

Alternative GW-3 would require improving the access road to the site to allow for year-round site access. Structures to house the treatment process and store additives would need to be built. This alternative would carry short-term safety concerns similar to those discussed for Alternatives GW-1 and GW-2. The safety concerns would be mitigated in a similar manner. Construction would probably require two field seasons, but the treatment process should be fully effective when complete.

Alternatives GW-4, GW-5 and GW-6 would impose the greatest amount of short-term impacts on the mine sites and the local populations. Implementation of these alternatives would carry safety concerns similar to those previously described, but would need to be applied over two construction seasons. Residents of Basin would be informed to help reduce the risk to the community. Unlike Alternative GW-3, several years may be required after construction is complete before these systems meet their optimal treatment efficiencies.

Implementation of either Alternative GW-4, GW-5, or GW-6 would have the lowest short-term effectiveness of the alternatives considered. Alternative GW-3 would result in the greatest increase in local traffic and, thereby, pose a greater safety risk to the local community.

Implementability

Alternative 1 (No Further Action) would leave existing conditions at the Crystal Mine unchanged; therefore, it has no implementability issues.

Waste Rock Alternatives

Technical Feasibility. Alternative WR-1 (Waste Rock Capping), WR-2 (Waste Rock Excavation and Disposal) and WR-3 (Waste Rock Excavation with Onsite Disposal) would require standard earth-moving techniques. Placement of a liner in Alternative WR-1 would require a specialty contractor, and grading and benching steep areas of the site would be challenging for alternatives. The technical challenges of liner installation make WR-1 more difficult, and therefore WR-2 and WR-3 are ranked as more technically feasible.

Administrative Feasibility. Administrative feasibility constraints to Alternatives WR-1, WR-2 and WR-3 would include obtaining a special use permit for improving U.S. Forest Service-maintained access roads to the mine sites. The long-term monitoring and maintenance program associated with Alternatives WR-1 and WR-3 is assumed to be 30 years. Alternative WR-1 would not require hauling contaminated materials and, therefore, is considered more implementable than WR-2 and WR-3.

Availability of Services and Materials. The services and materials required for Alternatives WR-1, WR-2 and WR-3 are the same except for the liner in Alternatives WR-1 and WR-3, and the need for specialized transport vehicles to safely haul wastes to Luttrell Repository in Alternative WR-2. The installation of the liner at capped areas with steep slopes in Alternative WR-1 justifies a lower score than the other two alternatives because of the need for more skilled/specialized services and more liner material. Therefore, Alternative WR-1 is ranked below Alternatives WR-2 and WR-3.

Ground Water Alternatives

Technical Feasibility. Alternative GW-1 would require specialized services to re-open mine portals and construct safe entry points into the mines. Assessment and inspection of the adits for evaluation of seepage and recharge and strategic placement of mine plugs would require special mining expertise and equipment. Alternative GW-2 would require specialized services to place underground explosives. Drilling and injecting of the grout curtain around the adit plugs are also technically feasible but challenging considerations associated with Alternative GW-2. Alternatives GW-1 and GW-2 are equivalent in technical implementability. Technical feasibility constraints associated with Alternative GW-3 would be the construction and operation of the treatment plant, and providing power to the site. Since these constraints are dependent on hiring appropriate contractors and not on site-specific variables, Alternative GW-3 is considered more technically implementable than all of the other GW alternatives.

Technical feasibility challenges associated with Alternatives GW-4, GW-5 and GW-6 are installing the treatment ponds/cells, installation of liners and collection of contaminated ground water. These alternatives are considered equivalent in technical implementability, below Alternative GW-3 and above Alternative GW-1 and GW-2.

All proposed alternatives (with the exception of Alternative 1) are consistent with the long-term remedial plan for the watershed cleanup.

Administrative Feasibility. All of the ground water alternatives would require a special use permit for improving U.S. Forest Service-maintained access roads. In addition, waste sludges generated by the treatment alternatives may need to be stabilized or treated prior to placement in a repository. Alternatives GW-1 and GW-2, with no sludge generation, would be equivalent and slightly more implementable than Alternatives GW-3, GW-4, GW-5 and GW-6. Alternatives GW-3, GW-4, GW-5 and GW-6 would be equivalent and slightly harder to implement than Alternative 1 and GW-1 and GW-2.

Availability of Services and Materials. Most of the services and materials associated with the implementation of Alternatives GW-1 and GW-2 would be available regionally. Specialized drilling services required by Alternative GW-2 would be more difficult to obtain than the other features of the alternatives; therefore, Alternative GW-2 is ranked below Alternative GW-1 in availability of services and materials.

Alternative GW-3 would require the construction of a water treatment plant which would require specialized supply and services available regionally. Alternative GW-3 is ranked lowest of the five ground water alternatives in availability of services and materials.

Alternatives GW-4, GW-5 and GW-6 would require specialized construction capabilities available regionally. These alternatives are equivalent and ranked above Alternative GW-3, but below Alternatives GW-1 and GW-2.

Cost

Alternative 1 (No Further Action) is the lowest-cost alternative at $231,000. Costs associated with design and construction of the waste rock alternatives are $4.9 million for Alternative WR-1 (Waste Rock Capping), $7.7 million for Alternative WR-2 (Waste Rock Excavation with Local Disposal) and $5.3 million for Alternative WR-3 (Waste Rock Excavation and Onsite Disposal).

The cost for the ground water alternatives (from least to most costly) are $3.8 million for Alternative GW-6 (Semi-Passive Treatment [modified]), $4.4 million for Alternative GW-5 (Semi-Passive Treatment), $5.1 million for Alternative GW- 4 (Semi-Active Treatment), $7.7 million for Alternative GW-3 (Active Treatment), $7.8 million for Alternative GW-1 (Mine Sealing through Reopened Adit) and $12.3 million for Alternative GW-2 (Mine Sealing by Remote means).

State Acceptance and Community Acceptance

State and community acceptance will be evaluated through the community involvement process. As members and representatives of the State and community provide comments, remedial action alternatives will be re-assessed and potentially modified. State and community concerns will be considered by the EPA during preparation of the interim Record of Decision.

The town of Basin (OU1) and the Basin Watershed (OU2) were the subject of intensive study and landowner and community input during the early to mid-2000s when the town underwent a remedial cleanup, and a remedial investigation/feasibility study was conducted on the watershed (the Crystal Mine site was included in this process). This information and recent discussions with residents were very important in the development of the preferred alternative. These criteria will be more formally considered again after public comment is received on the Proposed Plan.

Key Guidance Documents

Key guidance documents used in the study and evaluation of remedial options for the Site are as follows:

- The NCP regulations (found at 40 CFR section 300, and the statutory requirements of CERCLA—especially section 121 of CERCLA, 42 U.S.C. § 9621) are the mandatory requirements that the EPA and MDEQ must follow in selecting a remedy.
- In addition, the EPA uses guidance as appropriate in the remedy selection process. Key guidance documents used for the Crystal Mine (OU5) are as follows:
  - *A Guide to Selecting Remedial Superfund Actions*, OSWER No. 9355.0-27FS (EPA, April 1990)
  - *A Guide to Principal Threat and Low Level Threat Wastes*, OSWER No. 9380.3-06FS (EPA, November 1991)
  - *Rules of Thumb for Superfund Remedy Selection*, OSWER No. 9355.0-69 (EPA, August 1997)
  - *Incorporating Citizen Concerns into Superfund Decision Making*, OSWER No. 9230.0-18 (EPA, January 1991)
  - *The Role of Cost in the Superfund Remedy Selection Process*, OSWER No. 9200.3-23FS (EPA, September 1996)
  - *A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents*, OSWER No. 9200.1-23P (EPA, July 1999).

These and other guidance documents are available at http://www.epa.gov/superfund/policy/remedy/index.htm. Copies are available from the EPA upon request.

Preferred Remedy

Preferred Remedial Actions to Address Environmental Risks and Pathways

The preferred remedy for the Crystal Mine combines efforts to minimize surface water from entering the mine workings with two feasibility study alternatives: WR-3 (Waste Rock Excavation and Onsite Disposal) and GW-6 (Semi-passive Treatment of AMD). This brings surface water control, AMD treatment, waste rock removal and disposal and slope/stream bank stabilization into an overall cleanup approach. Removal will focus on specific areas where severe contamination complicates or prevents reestablishment of vegetation, thereby increasing the risk of further erosion of contaminants. These areas contain contaminated mining wastes that represent a threat to the environment.

These actions, in combination, are expected to significantly reduce contamination entering USG Creek. They will also improve vegetation and slope stability, and natural productivity at the Crystal Mine site. Furthermore, they will provide a protective interim action in a reasonable period of time and at a reasonable cost, and will be consistent with a final remedy for the Basin watershed.

General Cleanup Strategy and Sequencing

Remedial Strategy - The preferred remedy, a combination of two remedial alternatives (WR-3 and GW-6), will need to be implemented in phases to

accommodate the short construction season at this high-altitude site. The cleanup strategy will encompass the following actions:

- An onsite repository will be designed and constructed over a portion of the Crystal Trench area. It will receive wastes generated from opening and stabilizing the mine portal, as well as from the removal of the various site dumps. When waste removal is complete, the repository will be capped with an impervious liner, covered with topsoil, and planted with native vegetation. Large rock and woody debris will be scattered throughout the repository surface to discourage ATV disturbance and minimize erosion.
- Wastes and contaminated soil associated with the dump areas and encroaching on the stream will be removed and placed in the onsite repository. Contaminated mine structures and the sediment ponds will be dismantled. Liners and sludge in the ponds will likely be transported to the local Luttrell Repository. After removal of the mine wastes, the disturbed areas will be regraded, capped with topsoil and revegetated. Streambank reclamation actions will use removal and recontouring, along with BMPs, channel reconstruction and the planting of native woody and herbaceous vegetation to secure the banks.
- Surface water influence on ground water will be evaluated and actions taken to intercept and convey surface water away from mine workings.

The source water recharge area is large and geologically complex. Source water control efforts for this interim ROD will be implemented within the Site boundaries, as described below:

Phase 1

- Review existing information and confirm extent of mine workings on the existing mine maps. Look for additional information on the extent of the mine workings. Take note of specific mine features not observed during the RI that may have "daylighted" or created a surface expression that would allow water to enter the workings.
- Perform a final site reconnaissance to find, identify and map "daylighted" mine workings that could potentially act as a conduit for surface water into the mine. Utilize information obtained during the RI process to assist with the reconnaissance.
- Investigate and evaluate surface water inflow and contaminant release locations.
- Identify strategic locations for drainage ditches to capture and convey snowmelt and rainfall away from areas above the underground workings.

Phase 2

- Design seals for mine features identified in Phase 1.
- Design water control features that quickly and efficiently convey snowmelt and storm runoff away from areas above the underground workings and into adjacent drainages to limit ponding and infiltration.
- Design and evaluate surface water and ground water control options.

Phase 3

- Construct surface and ground water seals, ditches, and water control and conveyance features.
- Continue to monitor lower adit discharge to gauge impact on flow.

Phase 4

- Design the passive treatment system, using flow rates adjusted after source water control actions have been implemented.
- Develop institutional controls to prohibit residential use, prevent installation of drinking water wells and to protect the remedy.
- Construction and post-construction monitoring of water quality and other environmental parameters will be required.
- The lower adit portal will be reopened and stabilized to allow safe working conditions. Equipment and mucked waste from the initial construction will be staged near the entrance during construction. BMPs will be applied to the portal and staging area. Site access will be restricted through fencing to prevent unauthorized personnel from entering the construction area. Mine waste will be placed in the onsite repository.

- The nature and extent of contaminated sediment in USG Creek represents considerable exposure to ecological receptors. Removal of source materials along the mine-impacted reach and natural processes, such as high annual spring flows, will mitigate risk to the aquatic environment. Without active sediment contributions from the mine area, the bank and channel sediment deposits beyond the southern boundary of the site will remediate through scour, mixing and other natural recovery processes, which will be monitored. Stream sediments will not be actively remediated beyond the southern boundary of the Site.
- The semi-passive treatment system will be constructed as described under Alternative GW-6.
- The mining claims associated with the Crystal Mine are still in private ownership, but the EPA will work with the State and the landowners to develop institutional controls that prevent future residential development of this property, prevent use of the contaminated ground water for drinking water or in a manner that contaminates surface water, and to protect the remedy.

Sequencing Remedial Activities – In general, the proposed sequence of remedial actions for the Crystal mine is presented in the following text. This sequence may change once remedial design begins and the allocation/timing of funding becomes clearer.

1. Improve access roads to and from the Site. Prepare a design of an onsite repository. Complete bench scale testing for a semi-passive water treatment system. Design a semi-passive water treatment system.
2. Construct the onsite repository. Remove and haul contaminated waste rock and soils to the repository.
3. Design/construct source water control conveyance features to divert water away from underground workings and integrate into the soil stabilization and revegetation actions. Re-construct and stabilize Uncle Sam Gulch Creek channel adjacent to the mine.
4. Construct the semi-passive water treatment system. As previously stated, because of the location of the lower discharging adit and steep topography, the water treatment system may extend onto a small portion of U.S. Forest Service land south of the Site.
5. Former contaminated waste rock dump locations will be graded and covered with adequate topsoil to support growth of a native vegetative community. Boulders and large woody debris will be strategically placed to enhance revegetation and discourage ATV use. Best management practices will be used to reduce erosion until vegetation is re-established.
6. Begin operation of the passive treatment system, and monitor and maintain all aspects of the completed remedy.

The cost of the preferred remedy is estimated to be in the range of $7 million to $9 million. As previously stated, the actual sequencing of remedial actions will depend on EPA funding. Remedial actions will be implemented in accordance with anticipated funding levels until the project is complete.

Remedial Actions to Address Human Health

The Proposed Plan identifies the following actions, which are necessary to ensure protection of human health at the Crystal Mine OU5 and are otherwise appropriate under CERCLA.

- The nature and extent of mine waste and impacted soils at the Site are defined by the remedial investigation and are significant for a number of contaminants. For the protection of human health and wildlife, EPA selected alternative WR-3. Contaminated mine waste and soils will be removed and disposed of in an onsite repository to prevent or reduce exposure. Exposure pathways blocked by this action include incidental ingestion, dust inhalation or direct contact that pose an unacceptable health risk.
- The Site is located above 8000 feet in elevation in steep mountainous country and is unlikely to be a desirable permanent residential setting. The EPA will work with the landowner to assure residential development does not occur at the Site through institutional controls.
- Institutional controls to prevent ground water use onsite will be developed by the EPA with the assistance of the State and Jefferson County, to prevent domestic use of the local surface and ground water.

The Role of Institutional Controls

Institutional controls (ICs) will consist of a combination of legal and administrative controls, physical controls and informational controls (community awareness activities) to restrict access and use of contaminated areas and to provide public awareness of risks from exposure. The legal and administrative land-use controls will be tailored to the property to provide protection of human health and to maintain the integrity of the remedy to the extent possible.

As described in the discussion of the preferred remedy, ICs are important parts of the selected remedy. Presented here is a general description of the ICs that the EPA sees as necessary for the remedy. The EPA and MDEQ will carefully evaluate these aspects of the remedy during the public comment period. The ROD will provide a more detailed description of ICs, after consideration of public comment. The ICs are generally described as follows:

- Educational efforts for recreational users concerning the need to prevent incidental soil intake or ingestion of surface water in the vicinity of the Crystal Mine site. The EPA plans to work with local and county officials for implementation of this program.
- Prevention of ground water use for domestic consumption or activities that may spread the ground water contamination at the operable unit. Several mechanisms could be used to implement this control (for example, local and county ordinances, or specific deed restrictions or easements on contaminated land).
- Restrictions that protect the remedy and promote the appropriate management of revegetated areas so that recreational use of these areas can occur, while the important revegetation efforts are protected, comply with ARARs and are sustained over time.
- Restrictions that prevent residential or commercial use, because the soil cleanup level is based upon recreational exposure.
- Fencing may be needed to discourage public access to the AMD treatment system.
- Boulders and large woody debris may be needed to discourage ATV users from disturbing the onsite repository and re-vegetated areas.

In order to track and measure progress toward achieving cleanup goals at the Crystal Mine site, a monitoring program that includes physical, chemical and biological components is essential. It should be structured properly to detect and evaluate improvements and failures.

On the basis of information currently available, the EPA believes that the preferred remedy meets the threshold criteria and provides the best balance of tradeoffs among the other alternatives with respect to the balancing and modifying criteria. The EPA expects the preferred remedy to satisfy the following statutory requirements of CERCLA section 121(b):

- Be protective of human health and the environment.
- Comply with ARARs, except for those waived.
- Be cost effective.
- Use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable.
- Satisfy the preference for treatment as a principal element, or explain why the preference for treatment will not be met.

The EPA, in consultation with MDEQ, also considers general program goals and expectations found in the NCP at 40 CFR section 300.430(a) when proposing a preferred remedy and ultimately selecting a final remedial action. Section 430(a)(1)(iii)(A) and the EPA guidance states EPA's expectation that principal threat wastes will be addressed with reliable "treatment." The semi-passive treatment for AMD provided by alternative GW-6 meets this expectation. For non-principal threat wastes, such as mobile waste on steep hillsides, this means removal and safe, permanent disposal away from perennial sources of water.

Section 430(a)(1)(iii)(F) emphasizes the importance of restoring ground water to beneficial uses or, at least, preventing migration and exposure to contaminated ground water. Preventing surface water from migrating through the mineralized zone and intercepting the mine workings would eliminate the production of AMD. However, the fractures and preferential flow paths of

water through those fractures is very complex and extensive as shown by the RI. The RI demonstrated that ground water enters the workings from multiple locations throughout the length and depth of the three-dimensional site. Based on the RI studies, EPA has concluded that it is not possible to completely prevent ground water recharge from entering the mine workings.

This led the EPA, in consultation with MDEQ, to propose a preferred alternative that uses semi-passive treatment of AMD to mitigate contaminated mine water impacts to surface water. This preferred alternative contributes to compliance with ARARs and provides for over 90 percent reduction in volume of contaminants impacting surface water.
Section 430(a)(1)(i) describes an important goal of maintaining protection over time, and the slope stabilization after removal of wastes, and stream bank repair and reconstruction portion of the remedy will meet this goal.

Preferred Remedy Implementation

Timing of the remedial actions is an important implementation issue. The construction season for a high elevation site such as the Crystal Mine is approximately 4 months. This will need to be considered in planning the action if the remedy is to be implemented, in the shortest period of time. The overall timeline for this project is projected to be 2 to 3 years. This estimate may change during the design and construction phase.

Community Involvement

Written Comments

Send written comments to:

Crystal Mine OU5 Comments
Kristine Edwards
U.S. EPA Region 8 Montana Office
10 W. 15th St.; Suite 3200
Helena, MT 59626

You may also comment in-person on the record at the public meetings listed below.

Public Meeting

The EPA will hold a public meeting on March 19, 2014, from 6:30 to 8:30 p.m., at the Basin School House in Basin, Montana.

This will be an opportunity to provide written or oral comments.

Who to Contact with Questions or Concerns

U.S. Environmental Protection Agency
Kristine Edwards, Remedial Project Manager
(406) 457-5021
Edwards.kristine@epa.gov

Montana Department of Environmental Quality
Dick Sloan, State Project Manager
(406) 841-5046
RSloan@mt.gov

Public Comment Period

The EPA will accept written comments on this Proposed Plan beginning on March 7, 2014, and ending on April 21, 2014. The EPA will make its final decision on the cleanup only after considering public comments. At the end of the comment period, the EPA will include a responsiveness summary addressing the comments in the ROD. The EPA will place all written comments and the Responsiveness Summary in EPA's Administrative Record for the Crystal Mine OU5.

Documents

The Administrative Record for the site contains the documents that have been used to make decisions on how to clean up the site. The record can be reviewed at:

EPA Records Center
10 West 15th Street, Suite 3200
Helena, MT 59626
Phone: (406) 457-5046
Monday through Friday

Some repositories have a microfilm version of the record.

Information Repositories
Boulder Community Library
202 S. Main, P.O. Box 589
Boulder, MT 59623

Useful Terms

Understanding environmental cleanup may be confusing for the average person. The following definitions of terms commonly used will assist your understanding of this document.

Term	Definition
Acid Mine Drainage	Mine drainage is metal-rich water formed from a chemical reaction between water and rocks containing sulfur-bearing minerals. The runoff formed is usually acidic and frequently comes from areas where ore or coal mining activities have exposed rocks containing pyrite, a sulfur-bearing mineral. Metal-rich drainage can also occur in mineralized areas that have not been mined.
Applicable and relevant or appropriate requirements (ARARs)	Any standard, requirement, criteria or limitation under federal environmental law or more stringent promulgated standard, requirement, criteria or limitation under State environmental or facility siting law that is legally 'applicable' to the hazardous substance (or pollutant or contaminant) concerned or is 'relevant and appropriate' under the circumstances of the release.
Exposure	The amount of pollutant present in a given environment that represents a potential health threat to living organisms.
Exposure Pathway	How contaminants move from sources to humans and environmental receptors via paths such as dermal contact, ingestion or inhalation.
Institutional Controls	Non-engineered instruments, such as administrative and legal controls, that help minimize the potential for human exposure to contamination and/or protect the integrity of the remedy.
Land Use Controls	Land-use controls typically consist of a combination of institutional controls (legal and administrative controls), access controls (physical controls) and community awareness activities to restrict access and use of contaminated areas and provide awareness of risks from exposure.
National Priorities List (NPL)	EPA's list of the most serious uncontrolled or abandoned hazardous waste sites identified for possible long-term remedial action under Superfund. A site must be on the NPL to receive money from the Trust Fund for remedial action.
Operable Unit (OU)	A designation based on geography or other characteristics that defines a specific area of a site and enables the Superfund process to move forward in different areas at different times, speeding up the overall cleanup process at the site.
Operation and Maintenance (O&M)	Activities conducted after a Superfund site action is completed to help sustain the effectiveness of the remedial action.
Present Value	The present worth (of a sum payable in the future) calculated by deducting interest that will accrue between the present and future date.
Remedial Action (RA)	The actual construction or implementation phase of a Superfund site cleanup that follows remedial design.
Record of Decision (ROD)	A public document that explains which cleanup alternative(s) will be used for the final remedy at the NPL site.
Remedial Investigation (RI)	An in-depth study designed to gather data needed to determine the nature and extent of contamination at a Superfund site; establish site cleanup criteria; identify preliminary alternatives for remedial action; and support technical and cost analyses of alternatives typically described in more detail in a co-associated Feasibility Study (FS).
Superfund	The program that funds and carries out EPA hazardous waste emergency and long-term removal and remedial activities. These activities include establishing the NPL, investigating sites for inclusion on the list, determining their priority and conducting and/or supervising cleanup and other remedial actions.
Watershed	A watershed is literally any sloping surface that sheds water, but the proper definition (Webster's) implies a topographic divide that sheds water into two or more drainage basins. Watershed is synonymous with drainage basin or catchment.