

4 Best Management Practices (BMPs)

This section describes BMPs that are applicable to the treatment of inactive or abandoned mines. The following information is based on the informational booklet *Best Practices in Abandoned Mine Land Reclamation: The Remediation of Past Mining Activities* produced by the State of Colorado Department of Natural Resources, Division of Minerals and Geology (2002). The *Best Practices in Abandoned Mine Land Reclamation* booklet provides more detailed information for each BMP, including advantages, disadvantages, initial cost estimates, and maintenance considerations.

4.1 Overview

BMPs are management strategies implemented in an effort to control, mitigate, or reclaim degraded environments. The BMPs presented here present a diversity of potential solutions to mine site reclamation in the Snake River watershed. Due to the complexity of mine reclamation, including the need to address waste rock and tailings, surface water, groundwater, sediments, and safety hazards, no “silver-bullet” technology currently exists to remediate all mines in the same manner. Rather, a collection BMPs are generally applied simultaneously or in series to complete remediation of a site. Additional research into the specific hydrology, contamination type, and contaminant transport pathways of each site will be necessary before embarking on a cleanup project. Effectiveness is also, to a degree, site specific. In most situations, it is as difficult to determine the exact contribution of a site to stream degradation as it is to determine the improvement created by implementation of a specific BMP.

Reclamation and treatment methods presented in this Plan include the following:

- 1) Surface and Subsurface Hydrologic Controls. These are generally preventative measures intended to inhibit the processes of acid formation or toxic metal dissolution by minimizing or eliminating the contact of water with mine wastes, particularly sulfide minerals. Surface hydrologic controls include surface and groundwater diversion features, mine waste removal, consolidation, and stabilization, capping, and revegetation.
- 2) Passive Treatment. Passive-treatment techniques refer to a range of low maintenance drainage treatment strategies. Passive-treatment BMPs include anoxic limestone drains, settling ponds, sulfate reducing wetlands, oxidation wetlands, aeration, and neutralization systems.

4.2 Mining BMPs

This section describes numerous mining-related BMPs that commonly are implemented as remedial actions for pollutant reductions from anthropogenic-related mining impacts in the Rocky Mountain region.

4.2.1 Surface and Subsurface Hydrologic Controls

4.2.1.1 Waste-Rock/Tailings Consolidation, Removal, and Stabilization

Waste-rock or tailings removal and consolidation, often aided by stabilization in the form of cribbing, cementation, or riprap cover, serves to move the reactive mine wastes away from areas of possible contact with water. This preventative measure tends to be effective in areas where there are several small waste piles near one another, or where waste piles are in direct contact with surface water.

4.2.1.2 Waste-Rock/Tailings Regrading

Regrading of waste-rock and tailings piles to a gentle slope (generally, a ratio of three feet horizontal to one foot vertical) reduces erosion of the piles by water, wind, frost, and animal action. Erosion reduction, in turn, promotes vegetation growth and decreases the transport and spread of waste materials.

4.2.1.3 Waste-Rock/Tailings Capping

Capping of waste-rock or tailings piles refers to covering the consolidated, regraded piles with a protective layer of clean, non-acid generating soil. This protective layer prevents or reduces water infiltration into the reactive mine waste materials, thereby slowing the processes of acid generation and metal leaching. In addition to clean soil, which reduces infiltration and promotes vegetation growth, caps may consist of synthetic filter fabrics, geotechnical materials such as clay liners, and acid neutralization materials such as limestone gravel.

4.2.1.4 Vegetation

Hardy vegetation growing on waste rock or tailings piles helps to protect the pile from erosion and reduces water infiltration into the pile. In addition, vegetative covers improve underlying soil by adding nutrients, providing wildlife habitat, and in some cases they may improve the aesthetics of any given site.

4.2.1.5 Bulkhead Seals and Plugs

Bulkhead seals and plugs are closure structures that seal off open mine portals through which mine waters flow. Following closure, the mine workings behind the seal or plug flood with mine water. If the mine workings completely fill with water, oxygen is no longer available and chemical reactions that produce acidity and dissolved metals are stalled. Bulkhead seals generally refer to closures structures that allow managers to open or close a portion of the seal, allowing mine water to flow out of the mine in a controlled manner. Plugs, on the other hand, simply block all mine waters into the workings and do not allow for the controlled release of water.

4.2.1.6 *Diversion Ditches*

Diversion ditches channel clean surface water around the source of contamination, or intercept shallow groundwater that may interact with mine workings or mine wastes. These ditches are applicable in situations where rainwater, snowmelt, or other surface or subsurface flow is degraded by flowing over or through mine workings or mine wastes.

4.2.2 *Passive Water Treatment Techniques*

4.2.2.1 *Chemical Amendment*

Chemical amendments may be used, generally in conjunction with other BMPs, to control the acidity of mine drainage or clean water that infiltrates into acid-generating waste piles or mine workings. Generally, chemical amendments involved adding a basic (high pH) material such as lime to the water. Lime may be added directly to the water, or may be introduced indirectly as reactive limestone gravel.

4.2.2.2 *Anoxic Limestone Drains*

Acidic mine water may be routed through an anoxic limestone drain (ALD) in order to reduce acidity and remove metals from the system by precipitation. A method of chemical amendment, ALDs are ditches lined with limestone to neutralize the mine water, and buried in order to block oxygen from the atmosphere from interacting with the water.

4.2.2.3 *Aeration and Settling Ponds*

Water aeration and subsequent settling in a pond is a two-part system to reduce the dissolved metal content of mine water. Aeration, which is often accomplished by routing the mine water over a series of small waterfalls, increases the oxygen content of the water. When this water is then captured in a quiescent settling pond, metals can precipitate out of the water solution as solids that accumulate on the floor of the pond. This method generally requires that the mine water is low in acidity. This BMP may need to be combined with chemical amendments such as lime addition that decrease acidity.

4.2.2.4 *Sulfate-Reducing Wetlands*

Sulfate-reducing wetlands rely on common bacteria found in decomposing organic material to remove metals from mine water. Sulfate-reducing bacteria (SRBs) utilize oxygen in the water for metabolism, initiating chemical reactions that lead to the precipitation of toxic metals in the water as metal sulfides. Wetlands stocked with organic materials such as compost or manure promote the healthy growth of a SRB community, which aids in maintaining the function of the system. Advanced systems referred to as sulfate reducing bioreactors act in the same way, but utilize less space. Sulfate reducing bioreactor efficiency in a particular application is site specific. However, effectiveness in metals removal has been above 90% in certain applications (Leviathan Mine, 2006).