Chapter 5

Mining
Nonpoint Source Management Program

by
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Water Quality Control Division

Prepared in Cooperation with the
Colorado Nonpoint Source Council
Mining Committee

January 10, 2000

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I. INTRODUCTION TO THE NONPOINT SOURCE MANAGEMENT PROGRAM FOR MINING

Mining related nonpoint source (NPS) pollution in Colorado is widespread and diverse. Acid rock drainage is generated from coal and metal mine adits and waste piles, lowering the pH of receiving water and mobilizing heavy metal contaminants. Alkaline runoff, high in salts and sediments, also occurs. Radioactive minerals were mined in several locations in the Colorado Mineral Belt, and extensively in southwestern Colorado. Each location and situation presents unique challenges for nonpoint source pollution prevention, control and remediation.

A statewide inventory of inactive mines estimated that more than 22,000 inactive mine openings exist in Colorado. (See Appendix A). Approximately 170 mine adits are discharging acid rock drainage. A study in 1989 showed that more than 1,300 miles of stream in Colorado are affected by heavy metal contamination. Sediment resulting from past mining and milling activities contributes to the contamination of additional waters and streams. Although the problem is widespread, most mining related water quality problems impact aquatic life, not human health. (See appendix B for water quality standards)

In Colorado, most of the mining related NPS pollution results from inactive metal mines. Mine drainage from abandoned coal mines is responsible for less than 1% of the acid mine drainage problems in the state. Sediment from coal waste and refuse piles can have significant impacts on water quality and aquatic habitats. The areas impacted by abandoned coal mines in Colorado are less widespread than those related to metal mining. Inactive metal mines are generally located near headwater streams in Colorado and consequently, cause the majority of the water quality problems. The management plan has focused upon these sources. In addition, It is also important to evaluate the impact of radioactive constituents in nonpoint source runoff, and the relevance of addressing the remaining radioactive nonpoint source problems with the Section 319 nonpoint source program.

The Mining Committee of the Colorado Nonpoint Source Council serves the state as both an advisor and purveyor of technical expertise in inactive mining issues. The purpose of the committee is to advance efforts to protect and improve water quality, and facilitate the restoration of its beneficial uses, such as recreation, water supply, aquatic life and agriculture. The committee consists of private citizens, federal, state and local governments including: the U.S. Environmental Protection Agency, U.S. Forest Service, Natural Resources Conservation Service, U.S. Bureau of Reclamation, U. S. Geological Survey, State Soil Conservation Board, Colorado Water Quality Control Division and Colorado Division of Minerals and Geology.

II. ENVIRONMENTAL SETTING

Metal mining operations occur in areas that have significant deposits of base and precious metals such as gold, silver, lead, zinc and copper. These same areas typically have high background metal concentrations, as well as sulfur, arsenic and other elements that are associated with heavy metals. The majority of adverse impacts from mining occur in historic mining districts within the mineral belt of Colorado. The mineral belt extends from Boulder south to Silverton. Please refer to the *November 1989, Colorado Non Point Source Assessment Report, Colorado Water Quality Control Division* for additional information.

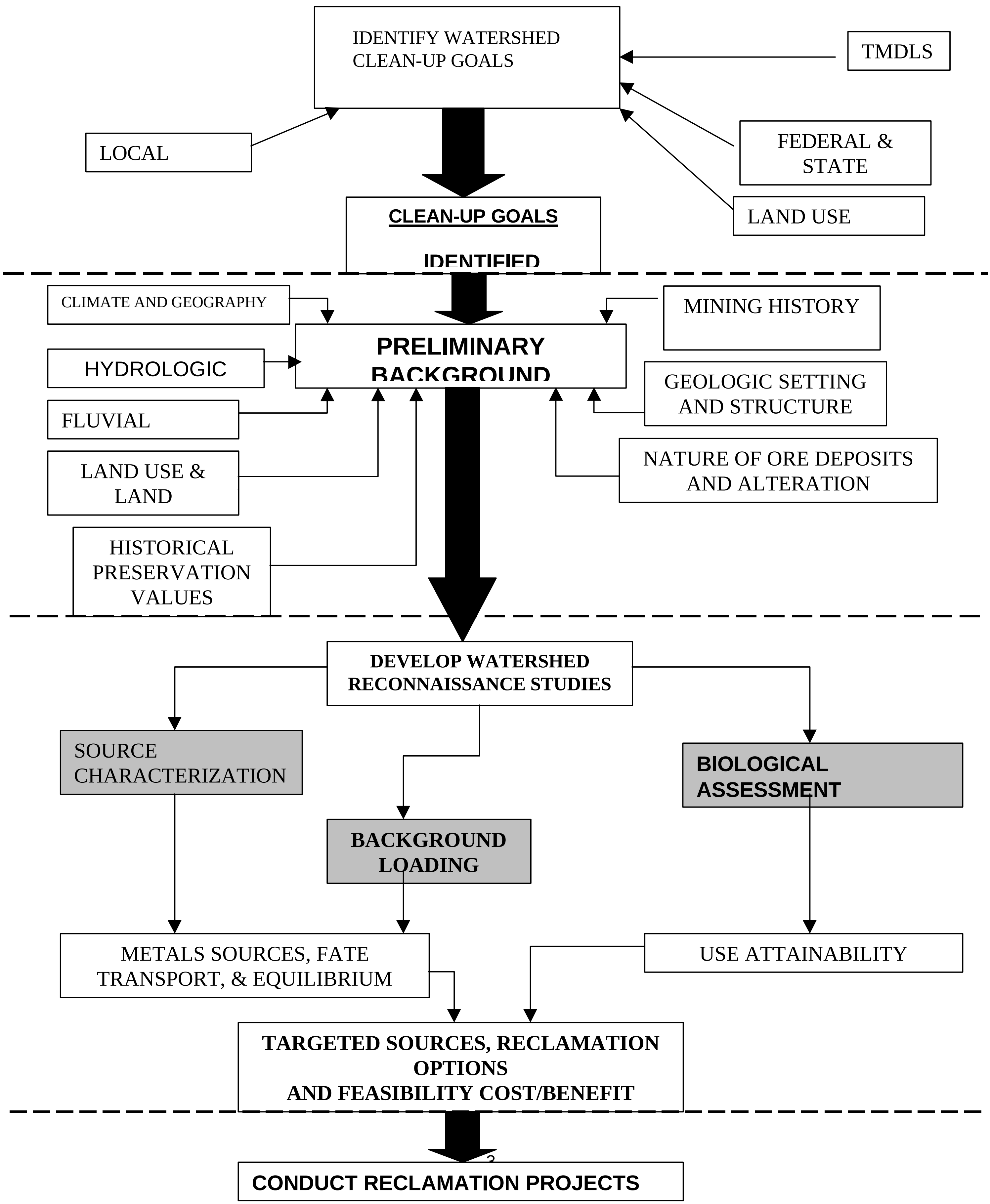
In addition to base and precious metals, Colorado has significant deposits of uranium. There are approximately 3000 known radioactive occurrences in the state. An “occurrence” is defined as any site where the concentration of uranium or thorium is greater than twice the background radioactivity. Substantial uranium mining occurred in scattered areas west of Boulder and Denver and near Canon City. The largest concentrations of mining and milling activities were within the Colorado Plateau in southwestern Colorado. Unlike the predominately acid generating host rocks associated with metal mining, most uranium deposits are in neutral and alkaline settings in sedimentary deposits. These deposits are highly erodable and occur in some of the most arid parts of the state where vegetative cover is difficult to establish.

Mining can accelerate the release of metals and radioactive constituents into the environment. Even without mining, many of these elements occur naturally in heavily mineralized areas and understanding the “background” concentrations of metals and radioactive constituents is critical to assessing and addressing water quality problems.

III. COLORADO’S APPROACH TO NONPOINT SOURCE CONTROL FOR INACTIVE MINE SITES

Colorado’s mining nonpoint source program is designed to address mining water quality impacts which are the result of mining activities that occurred previous to the passage of the Clean Water Act in 1972. The program provides an iterative approach to the control of these sources. This approach begins with the identification of stream segments that exhibit water quality problems from these sources. The process uses a scientific approach to remediation based upon the targeting of sources of pollution through the collection of data, setting goals for remediation efforts, determining clean up strategies, using appropriate regulatory and nonregulatory mechanisms to implement those strategies, and providing follow-up monitoring to determine if the efforts are successful. The following diagram summarizes the process.

COLORADO'S APPROACH TO MINE RECLAMATION



Historic and inactive mine sites present some of the most difficult challenges to water quality improvement in Colorado, and the nation. This is due to the nature of the pollutants, and also to the difficult administrative and legal challenges involved with controlling the sources of pollutants. Without intervention, most of these sites will not be naturally reclaimed. Many of these sites are "orphan sites", or are owned by individuals who were not involved in either the mining activities that created these water quality problems, or the financial benefit from the mining. In addition to these complicating factors, it is important to recognize that the majority of the hardrock inactive mining sites are found in remote locations, at high altitudes, and with a minimal infrastructure of roads and power.

Given this setting, it is important seek solutions that rely upon technologies that are practical for the locations and monetary resources available. In general, the nonpoint source mining program relies upon hydrologic controls and "passive" treatment technologies. These treatment methods are designed to greatly reduce the capital and operating expenses involved in remediation, and may be very effective in reducing certain types of mining nonpoint source problems.

Identification of Mining Impacted Streams

In Colorado, significant work has been done to recognize water bodies which are impacted by mining. *Colorado's Nonpoint Source Assessment, 1989*, the 1998 305(b) *Status of Water Quality Report,* and 1998 303(d) List have focused attention on these streams. However, minimal stream chemistry information was available for most of these reports and studies. Therefore, it is critical to characterize the chemical, physical, and biological health of impacted segments in order to determine the full impacts of these activities and the potential for restoring, or improving classified uses.

Scientific data collection, which characterizes stream health and also the location of the sources of pollution, is a requirement for all of these sites. This information must be gathered prior to taking the next steps and ultimately prescribing actions for the abatement of pollution.

Metal source characterization is critical to the determination of mining related pollutant sources and the prioritization of these sites for cleanup and reclamation. Following is a general description of the source characterization process and sampling considerations. In addition to source characterization, reconnaissance watershed studies should include aquatic and biological assessment as well as background loading investigations.

Preliminary Information Gathering

Watershed assessment begins with gathering a wide range of information about the watershed. Factors for consideration are:
Mining History
Geologic Setting
Structural Setting Climate & Geography
Stream Hydrology
Land Ownership
Hydrologic Impacts
Current Land Use
Historic Sites
Ore Mineralogy
Ore Deposition
Alteration Mineralogy
Mining Methods

Stream and Mine Discharge Characterization

Surface Water Sampling

The most important characterization tool for streams and mine discharge is surface water sampling. Stream and mine discharge samples provide data to isolate the most important pollutant sources in a watershed and, consequently, can aid in the prioritization of sites and projects. In order for sample data to be meaningful, the data must be accurate and reproducible. Sampling plans and protocols help to assure the accuracy of data by creating standard procedures for data collection and management. Two plans discussed below are the Surface Water Quality Assurance Plan (QAP) and the Sampling Analysis Plan (SAP)

Initial Field Reconnaissance

Some of the factors that may be considered in the initial field reconnaissance studies of streams and mine discharge are:

- GPS/GIS locations of all draining adits/shafts
- Field measurements of pH, conductivity, and temperature
- Flow estimates
- Map flow pathways to streams
- Visual metals indications, precipitates, staining
- Seasonal flow and chemistry variations

Surface Water Quality Assurance Plan (QAP)
The purpose of the QAP is to assure that a uniform set of procedures is followed in the collection, handling, storage and processing of all samples. Following is a list of some of the data that must be included in the QAP**:**

- Target analytes
- Sample collection protocols
- Sample filtration techniques
- Sample preservation and storage
- Acidified bottle/cooler storage
- Transport and retention time

Sampling Analysis Plan (SAP)
The SAP details the logistics and responsibilities associated with the sampling event. Following is a list of some of the items that must be included in the SAP.

- Locations and descriptions of all stream and discharge sampling stations
- Specification and acquisition of all supplies
- Specification and acquisition of all testing and flow measuring equipment
- Training and coordination of workers
- Determination of timing for sampling events

Mine Waste Rock and Tailings Characterization

Mine Waste Sampling
The Quality Assurance Plan (QAP) and the Sampling Analysis Plan (SAP) for the sampling of mine waste are similar to those for surface water sampling in that the goal is to assure that the results are accurate and reproducible. The difference between surface water and mine waste samples is the availability and mobility of metals. Mine waste may contain high levels of heavy metals, however the waste may have a minimal impact on water quality if the metals are not leached from the waste. The chemistry of each waste pile is different and samples can help determine impact that the site has on the watershed.

Initial Field Reconnaissance
Some of the factors that may be considered in the initial field reconnaissance studies of mine waste rock and tailings are:

- GPS/GIS locations of waste deposits
- pH and reactivity of wastes
- Gangue minerals and buffering potential
- Volume estimates of individual deposits
- Visual indications of pollution such as vegetative stress and oxide staining
- Secondary metal oxide formation
- Seepage, contact with water, proximity to streams
- Background radioactive constituent readings

Mine Waste Quality Assurance Plan (QAP)

Some of the factors that must be considered in the Mine Waste Quality Assurance Plan QAP are :

- Target values
- Sample collection protocols
    - Mine waste grab samples
    - Integrated statistical composite sampling
    - Sample preparation and storage
- Testing techniques and methods
    - Leachate and saturated extract methods
    - Acidity/alkalinity determination
- QA/QC Plan
- Scintillometer readings of offsite background materials

Mine Waste Dump Sampling and Analysis Plan (SAP)

Some of the factors that must be included in the mine waste SAP are:

- Locations and descriptions of all sampled mine waste dumps and tailings
- Accurate material volume estimates
- Acquisition of supplies and equipment

Mine-groundwater sources and pathways

Groundwater Source and Pathway Studies

Groundwater source and pathway studies determine the contribution that mine discharge may have to local groundwater systems, and can delineate contaminant pathways.

Initial Field Reconnaissance

Some of the factors that may be considered in the initial field reconnaissance studies preceding mine groundwater sources and pathway sampling are:

- Structural geologic evaluation
    - Faults, fractures, joint systems
    - Porosity and permeability estimates of rock units
- GPS/GIS locations of all springs and seeps
- Temperature surveys of adits and springs
- High-flow and low-flow measurements and comparisons of adit discharges
- Existing well data

Mine Groundwater Sampling and Analysis Plan

- Target Analytes
- Monitoring well installation locations
- Background groundwater quality
  - Mine-pool water quality
  - Flow paths and contaminated plume locations
- Well design specifications
- Well sampling procedures
- Tracer study locations and design of program
  - Fluorescent dye tracing
  - Ionic tracer methods
  - Injection and recovery sampling locations
  - Fate and transport modeling
- Isotopic study design and procedures
  - Identification of appropriate isotopes
  - Geochemical "fingerprinting" water sources

Mine Groundwater Quality Assurance Plan (QAP)

The QAP for groundwater analysis is the same as that for stream and mine drainage characterization.

Setting Goals for Nonpoint Source Mine Projects

Establishing goals for stream segments impacted by inactive mining requires the collection of the data mentioned above. An understanding of the potential of the stream system and its aquatic ecology is also necessary to establish appropriate goals for clean up projects. Generally this means a Use Attainability Analysis for stream segments to determine the appropriate classified uses, the levels of protection for sensitive aquatic species, and the ability of the watershed and site to produce that desired use. Since the establishment of goals may influence the actions taken in local communities, it is important that all stages of the process are conducted with the benefit of local involvement and participation.

Establishing Strategies

Once the goals for a clean up effort are established the next step is to analyze how such goals may be attained. This process of strategizing often involves considering the sources of pollution, the range of possible controls, the effectiveness of those controls, and then comparing the results of various clean up strategies or scenarios against the goal for water quality improvement. This process may be fairly simple, if the number of sites considered are few, but conversely, may be very time consuming and complex if the number or the characteristics of sites are large and highly varied.

Preparing reclamation strategies requires a significant knowledge of the site to determine the potential effectiveness of various control scenarios. Additional specific site characterization work may be required to determine the most appropriate and cost effective means of control. Strategies generally require computer modeling to determine if the composite of various scenarios will allow established goals to be attained. The results of these strategy efforts may be reflected as Total Maximum Daily Loads (TMDLs) for stream segments listed under Section 303(d) of the Clean Water Act.

Implementation of Control Strategies

Once a control strategy is determined for an effected stream segment, the next step is to determine how best to implement those activities to attain the goals. A number of regulatory, nonregulatory, voluntary, and incentive based approaches and programs are available for inactive mine sites. These choices range from voluntary clean up efforts conducted by landowners, to issuance of various types of discharge permits, to Section 319 grant assistance, to removal actions under CERCLA.

The implementation of the strategies may combine these various program elements, or employ a limited number of these options, depending upon the needs and complexity of a particular stream segment or inactive mining site.

Follow up Monitoring

Once implementation of the strategies have begun, it is important to monitor the results of the work performed to determine if the controls applied to the various sites are effective, and eventually, to monitor the stream segment to determine if the established goals are being attained. The time frames for improvements, both on site, and in stream are highly variable, and it is important to recognize that there may be a lag time between the implementation of controls and the realization of results.

IV. BEST MANAGEMENT PRACTICES

Best management practices for mining related nonpoint source pollution in Colorado must address two primary categories of problems: acid rock drainage and sediment from mine and mill wastes.

Acid Rock Drainage

Acidic water forms through the chemical reaction of surface water and shallow groundwater with rock containing sulfur, such as pyrite, forming sulfuric acid. The acid leaches heavy metals from mineralized rock and keeps the metals dissolved in water. Metals are then dispersed in the water draining from the mineralized areas. This acid drainage can adversely impact aquatic and human health when it contacts surface water and groundwater.

Sediment

Sediment resulting from mining and milling activities can contaminate streams, rivers, wetlands and other riparian areas. Sediment loads often contain high concentrations of heavy metals or radioactive constituents that can destroy aquatic habitats as well as release metals and radioactive constituents to the water column. Sediment can also affect suitability of the water for human uses such as agriculture and drinking water.

Basic erosion control and revegetation practices are essential in the implementation and maintenance of the sediment control best management practices. Reclamation projects that disturb tailings or mine waste require a Stormwater Management Plan. The plan specifies specific practices to reduce the potential for erosion of sediment during a storm event.

A wide range of technologies can be applied to the remediation of abandoned or inactive mined lands. The costs of these options vary widely, both for construction and long-term maintenance. Remediation and treatment methods included in this summary are Hydrologic Controls and Passive Treatment Systems.

Purposes of Best Management Practices

1. Manage and control the process of acid water formation and heavy metal dissolution of sulphide ores or wastes that may contaminate surface water and groundwater.

2. Prevent mine and mill waste sediments containing heavy metals or radioactive constituents from entering surface waters.

3. Enhance the natural beauty and visual quality of area.

4. Prevent adverse human health impacts related to windblown tailings.

5. Improve habitat conditions for fish and wildlife.

Who to contact for Assistance in Planning and Implementation of Best Management Practices

The best source of assistance for planning and implementing any best management practice (BMP) will be in the locality where the BMP's are used. Local stakeholder groups, watershed associations and representatives from various natural resource management agencies, whether federal, state or local can assist in developing site-specific recommendations. These recommendations or designs account for the local climate, soils and hydrology of the area, as well as any social or cultural conditions.

Erosion and Sediment Control Practices

Definition

Active mining operations and reclamation projects involving abandoned mine and mill waste sites can significantly affect erosion and sediment rates. Road construction and other surface disturbances remove ground cover and often create steep slopes. Mine and mill waste piles can contribute sediments containing heavy metals and radioactive constituents to surface waters and must be carefully managed during and after reclamation work. Erosion and sediment control practices can mitigate mining-related nonpoint source pollution related to water and wind erosion.

1. Erosion and Sediment Control Planning
Planning should occur early in the site development process and be adjusted throughout site development as needed. Disturbance of mill or mine tailings, even for reclamation purposes, requires a Stormwater Management Plan. These plans should define the erosion and sediment control practices and include a drainage-way protection plan if necessary.

2. Erosion Control
Surface roughening provides temporary stabilization of disturbed areas from wind and water erosion. Dozer basins, and other roughening techniques, enhance revegetation efforts by collecting moisture and providing shelter from wind. These practices are especially important in areas that have received a recent application of topsoil. Establishment of viable vegetative cover should occur as soon as possible on all disturbed areas.

3. Sediment Control Entrapment
These facilities include terracing, straw bale barriers, silt fences, filter strips, sediment traps and sediment basins.

4. Topsoil Preservation and Reuse When constructing disposal pits, topsoil should be stripped and stockpiled for reuse. Six to eight inches of cover is preferable.

5. Soil Amendments
Revegetation success on acidic tailings can be increased if limestone is incorporated into the tailings prior to the application of topsoil. Radioactive tailings are often alkaline and modifying the pH of the tailings to a more neutral level can enhance revegetation success. Application of commercial or organic fertilizers may also increase the success of revegetation efforts on nutrient deficient mine or mill waste piles. Commercial grade diammonium phosphate (18-46-0) should generally be applied at the rate of 300 pounds per acre.

Manure should be dry cow, horse or sheep manure that has been stockpiled a minimum of one (1) year. Manure should not be so caked or lumpy that it cannot be spread uniformly. Manure should be applied at the rate of 30 tons per acre.

6. Mulch

Certified weed free mulch should be applied to the revegetated areas as soon as possible after seeding has been completed. The mulch should be incorporated into the soil. Disking is the most common method. Tracking across the seeded area with heavy equipment can also be effective. Certified weed free mulch should be applied to the revegetated areas as soon as possible after seeding has been completed.

Hay or straw mulch should be applied uniformly at the rate of two (2) tons per acre over seeded areas. Hydromulch should be applied at the rate of one and a half (1 1/2) tons per acre.

On areas larger than one (1) acre a mulch crimper should be used to stabilize or anchor the mulch into the soil after hay or straw mulch has been spread. The crimper should be equipped with scrapers to keep the blades clean. Spacing of crimper blades should not exceed nine inches (9") on areas less than one acre crimping can be achieved by hand with a suitable tool, such as a spade, on 18" centers.

7. Maintenance

All temporary BMP’s should be maintained and repaired as needed to assure continued performance during the construction phase of the project.

8. Disposition of Temporary measures

All temporary erosion and sediment control measures should be removed within 30 days after final stabilization.

Planning and Implementation Tools

The following references and guides provide the specific information necessary for planning, installing, operating and maintaining the appropriate components to these best management practices.

Denver Regional Council of Governments. 1998. Keeping Soil On-Site. Construction Best Management Practices

International Erosion Control Association.1997. Erosion and Sediment Control Workshop Handbook

Hydrologic Controls

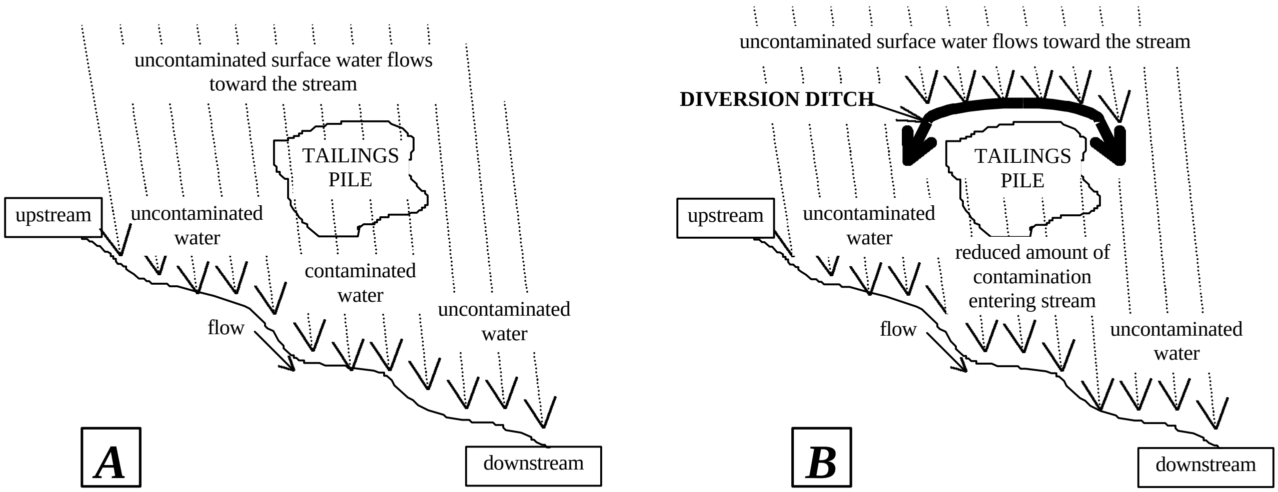
Definition

Hydrologic controls are measures that inhibit or prevent the process of acid formation and/or heavy metal dissolution. If it is possible to prevent water from entering a mine, or from coming into contact with sulphide/radioactive ores or wastes, this can be the best and most cost effective remediation approach. The success of most hydrologic controls depends on developing a geochemical and hydrologic understanding of the mine. Isotope or tracer studies attempt to separate mine impacted waters from unimpacted waters; to determine travel times and pathways of infiltrated snowmelt and rainfall through ground-water flow systems. Tracer studies can also help to develop conceptual understandings of geochemical processes which control the transport and fate of metals in the subsurface. These studies could include sampling ground waters, surface waters, spring and seep waters, adit discharge waters and water in mine workings. This isotopic data enhances the understanding of the sources and hydrologic pathways of waters that enter the mine workings and/or discharge from the mine workings.

Following are best management practices that focus on hydrologic controls to achieve better water quality. While these best management practices are tailored to mine related problems, general sediment and erosion control practices and engineering principles must be employed in the application of these techniques.

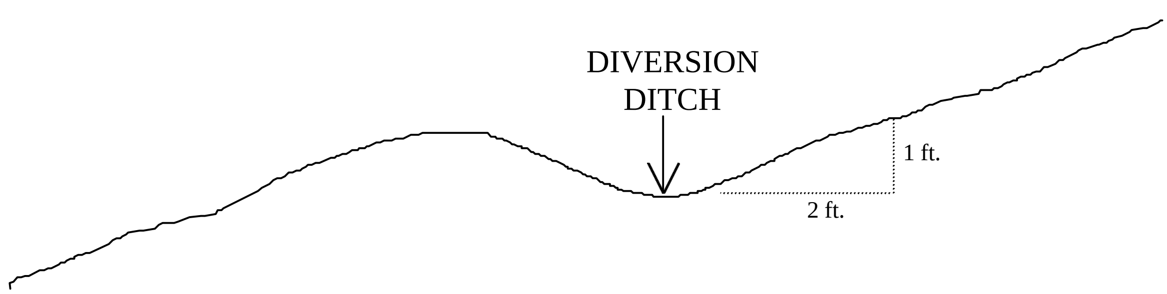
1. Diversion ditches are effective where clean run-on water is degraded by flowing over or through mine waste or into mine workings. Diversion ditches can also be used to intercept shallow ground waters that may enter mine waste. In some cases, mine discharge can be improved by flowing through waste rock. Mine drainage must be sampled above and below a waste rock pile to determine whether or not the waste rock is actually degrading the water quality.

A diversion ditch should be located upstream of the contaminated waste rock or tailings pile and should capture and channel the clean water from uphill around the problem, as shown in Drawing 1. Because the only goal of the ditch is to keep clean water away from contaminated rock or tailings, the length of the ditch depends on the size of the contaminated pile and the topography of the site. The ends of the ditch should be in a place where the clean water will flow away, not come in contact with the contaminated pile.



DRAWING 1 *- Simplified map view of a tailings pile and the quality of surface water flowing into a nearby stream. (Drawing also applies to waste rock piles.)* ***Map A*** *shows that uncontaminated surface water originating uphill of the tailings pile will become contaminated after flowing across or through the contaminated pile.* ***Map B*** *shows that a properly placed diversion ditch will channel the water originating uphill of the pile away from the pile to avoid becoming contaminated. The amount of contaminated flow downhill of the tailings pile entering the stream is then greatly reduced.*

The size of the ditch depends on how much water is expected. The simplest ditches are dug either by hand, using a backhoe, or using the corner of a bulldozer blade to make a triangular cut. Whichever way it is done, care should be taken to dig deep enough to catch incoming shallow groundwater as well as water flowing on the surface. The side walls of the ditch should be smoothed to a slope of 2:1 (2 feet horizontal to 1 foot vertical) or flatter to maintain stability, as shown in Drawing 2.



DRAWING 2 *- Cross section of a diversion ditch showing side slopes at 2:1. To maintain stability, side slopes should be at 2:1 or flatter.*

Ideally, the slope or gradient of the bottom of the ditch should be designed to encourage water to flow freely, while not ponding, but not flow so fast that water erodes and scours the ditch walls. In order to accommodate this, a minimum slope of 100:1 (100 feet horizontal to 1 foot vertical) and maximum slope of 33:1 (33 feet horizontal to 1 foot) vertical is recommended. The bottom of the ditch should be smooth with no pits and holes.

The ditch should be vegetated to slow the water flow and decrease the opportunity for erosion of the ditch by moving water. Seeding of the ditch walls and bottom is easiest during low flow times of the year such as late summer or fall.

If the slope of the ditch must be greater than 33 feet horizontal to 1 foot vertical, then the ditch should be lined with riprap (medium to large rocks) to slow the flow of water and decrease the erosion and scouring along the ditch walls. If riprap is used, it is important to select rocks that are not contaminated by mining and will not degrade the water in the ditch. Often, in high-altitude areas, suitable rocks can be found at the base of steep talus slopes.

Periodic inspection and maintenance is required for continued effectiveness of diversion ditches. Water should be able to flow smoothly along the base of the ditches, should not pond in the ditches, and should not overflow the ditch walls. Ditch maintenance should include cleaning debris out of the ditches, checking the drop in slope of the ditch bottom, and repairing erosion along ditch walls. Generally, inspections should be conducted before and after spring runoff and after major storm events.

2. Mine waste removal and consolidation is effective where there are several small mine waste piles in an area, or where there is a large pile in direct contact with flowing water. The purpose of this BMP is to move the reactive material in the waste rock dump or tailings pile away from water sources. Reducing the potential for water flow through the dump or pile will decrease the formation of contaminants, thereby reducing contamination to nearby water sources.

An area must be found that is away from water sources that can hold the volume of waste rock or tailings to be relocated. The area must be cleared of organic material and contoured to hold the waste rock or tailings. A compacted berm or small dam may be required on the downstream side if the material to be relocated is saturated or will tend to flow when emplaced. Material excavated during preparation of the consolidation area can be used to build the berm or set aside to be used later as a cap for the consolidated pile. Backhoes, excavators, loaders and dump truck may be used to used to relocate waste rock or tailings, depending on the amount of material to be removed and the distance between the original site of the material and the consolidation area. The consolidated pile should be capped using excavated material and revegetated to prevent erosion. Regrading and revegetation of the original site of the waste rock or tailings should also be performed to minimize erosion on the disturbed area.

3. Capping of waste rock or tailings is a protective layer of soil, graded to promote runoff rather than infiltration into the reactive materials. Any minor water or wind erosion that occurs will remove soil from the cap and should not disturb the contaminated waste rock or tailings. This will ultimately improve the water quality downstream of the waste rock or tailings pile, by eliminating the source of contamination. The cap will also provide an uncontaminated soil layer in which vegetation can grow. Vegetation of the cap will further protect the soil and decrease erosion of the cap by slowing the speed at which raindrops hit the soil.

Caps range from simple to complex in design and vary widely in cost. The different types of caps depend on the toxicity of the material to be capped and what materials are available at or near the site. In the majority of cases, simple covers are adequate. Composite covers are used when the material is highly reactive when mixed with surface water. Complex caps are used in situations of highly toxic materials and are often combined with liners under the toxic material.

Simple Cover - The simplest, least expensive type of cap consists of soil obtained at the site. A minimum of 6 inches is desirable, because some erosion may occur before vegetation is established. One foot or greater is optimum. Often, the excavation of diversion ditches will provide the necessary soil for a cap. Glacial till or a good mix of clay, sand and organic matter is ideal. Sometimes a site will have sand in one area and clay in another, which can be mixed. The cap should be graded to a gentle smooth slope to encourage runoff. No extra effort should be made to compact the soil. The material will be sufficiently compacted by the equipment used to grade the cap.

Composite Cover - A composite cap has at least two layers of different soil types. The lower layer lying next to the waste rock or tailings is fine-grained, high density and low permeability. The purpose of this layer is to inhibit water from the surface from seeping into the contaminated pile and forming acid drainage. The upper layer consists of coarser material and is lower in density. The purpose of this layer is to encourage plant growth. This cap should be revegetated once it is in place.

Complex Cover - A complex cover consists of interlayered synthetic filter fabrics and fine and coarse material. The principles of this cap are the same as the simple and composite caps, that is to inhibit water infiltration into the reactive material below and encourage plant growth on the top. The actual design and installation of these caps is site-specific and generally costly.

Capping of the waste rock or tailings should be performed immediately after regrading of the pile in order to minimize the opportunity for erosion. Periodic maintenance requirements include an occasional walk-through of the capped area to identify problems caused by erosion, root penetration, and animal burrowing. Prompt repair of any problems will increase the effectiveness and lifetime of this BMP.

4. Stream diversion is similar to mine waste removal and consolidation. It involves moving the water sources away from reactive materials. In most cases, it is usually preferable to move mining waste rather than move the stream, since the relocated stream can require considerable maintenance, particularly following high flow events. Also, the Army Corps of Engineers may require a permit to relocate the stream.

The construction of this BMP depends largely on the configuration of the stream valley. In general, the valley must be wide and flat to maintain a reasonable distance between the stream and the contaminated rock or tailings when finished. The new stream alignment should not be placed on bedrock and should be slightly deeper than the existing streambed, to encourage the stream to stay in its new channel. Stabilizing measures may be needed along the bank of the new streambed and could include willow plantings, emplacement of tree stumps, riprap and berms.

An effort should be made to make the environment of the new stream segment similar to that of the abandoned stream segment. Native vegetation should be planted or transplanted along the new stream segment. Depending on the length of the new stream alignment, meanders should be incorporated, especially if there were meanders in the original stream segment.

The waste rock or tailings remaining in the abandoned streambed will still be susceptible to erosion from rainfall, snowmelt and wind. Therefore, these should be capped and revegetated to minimize erosion.

Maintenance is a major consideration in stream diversion. The new configuration of the stream should be checked several times during the year and especially after high-flow events, such as spring run-off and flooding due to summer/fall thunderstorms to ensure that the stream is remaining in its new alignment. Areas of excess erosion and possible break-through into the old stream alignment should be repaired immediately.

Points of drainage from the old waste rock or tailings should be identified and sampled through time. Tailings would be expected to continue to de-water over several years because of their small grain size. If the drainage does not decrease over time, the possibility of a buried spring or mine opening should be considered, and the appropriate BMP's should be installed.

5. Bulkhead Seals are another type of preventive or "source control "measure. Bulkhead seals are designed to prevent water from exiting a mine opening by blocking the flow with a dam. For most inactive mines, bulkhead seals are expensive and require considerable geologic and engineering investigation and characterization. Sites that have simple geology, sound rock, and limited subsurface workings may be amenable to this approach.

6. Grouted bulkhead dams or “flume” collectors can be constructed to collect clean inflows, and divert these clean flows out of the mine through a pipeline, thus circumventing metals contaminant producing areas in the mine workings/ orebody. At the designated clean-water inflow location for the checkdam or flume collector, all loose debris on the floor of the drift is removed. Water flow is collected above the checkdam location with berms or temporary diversions, and passed through the work area in a pipe that penetrates through the collection dam at floor level.

Holes may be drilled around the perimeter of the collection dam site to permit pressure grouting of joints and fractures in the floor and both ribs. If the collection dams are designed to collect clean inflows with as little storage or “head” as possible (0.25 to 2 feet), there should be minimal driving pressure forcing the water into joints and fractured rock, possibly negating the need for grouting. After construction of the check dam/ flume, an outlet gate valve can be installed to regulate the outflow.

7. Grout-sealing a fracture inflow zone at a discrete location can prevent groundwater from entering the workings, using proven, existing "ring-grouting" methods and technology.

The concept for this technique is to seal water inflows through a grouting program, similar to those used to seal dam foundations, and control water inflows to active underground mining operations. Grout is pumped under pressure into an array of holes drilled radially out from the drift in and along the plane of the water bearing fracture or fracture zones. The grout enters and seals the fracture pathways that communicate with the mine opening. If engineered and executed correctly, the water is prevented from entering the excavation, and is forced far enough back into the rock away from the mine workings so that it resumes its pre-mining course, flowing around the grout “curtain”.

Depending on conditions and the layout of the workings, care must be taken to ensure the inflows are not simply diverted to a point where they enter another part of the mine. Ideally, the site would be in a position where no other levels are nearby, and where numerous small fractures are draining low-flows of clean groundwater into the workings along a relatively short section of drift.

8. Revegetation is often used in combination with other hydrologic controls. Revegetation by itself can be a very effective method of reducing heavy metal concentrations, particularly where much of the metals come from erosion of mining waste into a stream. Revegetation also reduces the amount of water that infiltrates a waste pile, thereby reducing leachate production.

Planning and Implementation Tools

The following references and guides provide the specific information necessary for planning, installation, operating and maintaining the appropriate components to these best management practices.

Colorado Division of Minerals and Geology .2000. DRAFT-Best Management Practices for Mine and Mill Sites.

Colorado Division of Minerals and Geology.1996.General Bid Specifications

Colorado Division of Minerals and Geology *et al*. 1998. Water Quality Characterization and Assessment for Remediation at Hard Rock Mining Sites, Conference Proceedings
Colorado Ground Water Quality Monitoring Working Group.1992.Ground Water Quality Sampling for NPS Pollution Assessment: A Suggested Protocol

Colorado State University technical references-High Altitude Revegetation workshop

U.S. Forest Service Watershed Conservation Practices Handbook

PASSIVE TREATMENT

Definition

Available technologies that reduce heavy metal pollution and do not require continual electrical or chemical inputs or frequent maintenance operations. Most passive treatments facilitate the precipitation and containment of metals from the mine discharge before the mine discharge can enter and contaminate surface and groundwater.

1. Anoxic limestone drains introduce alkalinity into mine discharges. Anoxic limestone drains (ALD) are constructed by placing coarse limestone (3/4" - 3") inside an adit or in a fully sealed trench outside a discharging mine. In order for an ALD to function properly, the mine discharge must be devoid of oxygen. In the absence of oxygen, iron and other metal hydroxides will not coat limestone. In addition, the mine drainage should be relatively low in dissolved aluminum. Aluminum has been shown to precipitate in ALDs, causing plugging. It is theorized that very coarse limestone (4-6") should provide sufficient pore spaces to minimize or prevent clogging by aluminum. The disadvantage of using larger limestone is the reduced surface area to react with the mine drainage. After the mine drainage exits the ALD, aeration causes precipitation of metals. The increase in pH due to ALDs is site specific, but generally does not exceed two standard units.

2. Aeration and settling ponds promote the precipitation of heavy metals through oxidation processes. This BMP is particularly effective for treating mine drainage water that is high in total suspended solids (TSS), but has a pH close to neutral (7.0). Aerating this type of mine drainage can effectively remove iron and other metals that will co-precipitate or drop out with the iron. This BMP is accomplished by channeling the mine drainage over a series of small waterfalls or drops, which will increase the oxygen content of the water, into a quiet settling pond where the metals will drop out.

Aeration is accomplished by making the water turbulent. Turbulence can be initiated by channeling the drainage down a steep slope, over rough slopes (such as ditches lined with riprap or large rocks) or over a series of drops or small waterfalls.

A settling pond should be located at the base of the aeration channel. Ideally, it is in a naturally low area, but not along or in flowing water. An embankment at the lower end of the pond holds the water in the pond, allowing clean water to flow back into the main stream without eroding the dam. The embankment is generally composed of a mix of rock and soil with larger rocks lining the upstream side and smaller rocks on the top to discourage erosion as the water flows over the top.

Settling ponds should be designed so that the water entering the pond will remain in the pond for a minimum of 24 hours before being discharged. A 24-hour retention period will allow the oxidized metals to precipitate. In order to design the pond for 24-hour retention, the expected flow into the pond must first be measured. This can generally be done with a bucket and stopwatch. Using that flow rate (probably measured in gallons per minute), the amount of water that will flow into the pond in a 24-hour period can be calculated. The pond should be large enough to hold at least that amount. An example calculation for a settling pond is shown. (Note: one gallon equals 0.134 cubic feet.)

EXAMPLE CALCULATION
FOR SIZING A SETTLING POND FOR 24-HOUR RETENTION OF INFLOW

STEP 1: Measure expected flow rate.	▸ 10 gallons/minute (gallons per minute or gpm)
STEP 2: Convert gallons to cubic feet.	▸ 10 gallons X 0.134 cubic feet/gallon = 1.34 cubic feet (cu.ft.)
STEP 3: Calculate expected flow for 24 hour period.	▸ 1.34 cu.ft./min. X 1440 min./24 hr. = 1930 cu.ft. flow in 24 hours

CONCLUSION: The pond must be able to hold 1930 cubic feet of water for 24-hour retention of 10 gpm flow. Therefore, width X length X depth of the pond in feet must be equal to or more than 1930 cubic feet. One possible pond configuration is: width =20 ft., length = 25 feet, depth = 4 ft., so the pond can hold 2000 cubic feet. However, there are countless possible pond configurations. The area available at your site to build a pond will determine the dimensions of the pond.

If, given the area on your site, it is not possible to have a settling pond large enough to retain the water for at least 24 hours or the ground is too rocky or hard to excavate to the necessary depth and size, consider several smaller settling ponds at different elevations, which together will provide a total retention time of at least 24 hours.

This BMP is best used in situations in which the mine drainage water is high in total suspended solids (TSS) and has a pH of near neutral (7.0). Therefore, sampling and testing to determine the pH and suspended metals content of the drainage is advisable to decide if this BMP will work at your site.

Because this is a two-part system, consisting of an aeration channel and settling pond, requirements for space are greater than for other BMP's.

3. Sulfate reducing wetlands are often called bioreactors. These systems treat water through bacterial reduction of heavy metals. Sulfate reducing bacteria (SRBs) use the oxygen in sulfates for respiration, producing sulfides. The sulfides combine with heavy metals to form relatively insoluble metal sulfides. The bacteria derive their energy from a carbon source such as cow manure or mushroom compost. There are many other substrates that are an acceptable source of carbon, but most have a low hydraulic conductivity that can result in short circuiting of the system by the formation of preferential flow paths.

Sulfate reducing bacteria cannot survive in drainage with pH below 4.5. Drainage with a low pH requires treatment to boost the pH before it enters the sulfate-reducing wetland. This can often be achieved by channeling the flow through a lined buried trench filled with chunks of limestone.

Some ponding on the cells is desirable, because it discourages plant growth; however, the ponding should not approach the top of the berm. Plants will introduce an additional source of oxygen and the system works best in an oxygen-deficient environment.

Generally, a sulfate-reducing wetland is placed behind a berm or small earthen dam. The wetland cell behind the berm must be lined with either compacted clay or with a PVC or HDPE geomembrane liner. A thin layer of gravel (about 3 inches) is placed on the lining and perforated collection pipes are buried within this layer. The drainage will enter at the top of the system, but must exit at the base of the system to ensure that the drainage flows through the substrate material and is exposed to the SRBs. A geotextile fabric (permeable fabric) should be placed on top of the gravel layer. This will keep the material above the fabric from piping into the gravel layer below. The substrate or treatment layer is placed on the geotextile to a depth of about 3 to 6 feet. The substrate can consist of cow manure, mushroom compost, sawdust or in some cases soils from on the site depending on their permeability. Mine drainage enters the system through a pipe buried just beneath the top of the substrate. Size of the wetland depends on the amount of metals and pH of the drainage, the volume of the drainage, and the area available to install the wetland. Other “upflow” wetland treatment systems can be constructed using the same basic materials.

Sulfate reducing wetlands should generally not be constructed near population centers. These systems commonly produce excess hydrogen sulfide, which can cause undesirable odors up to mile from the system.

When initially started, organics in the substrate discolor the treated water for several months, making water quality appear worse than that entering the system.

4. Oxidation wetlands are what most people think of as "wetlands". They differ from sulfate reducing systems in that metals are precipitated through oxidation, and aquatic plants must be established. This treatment method is applicable where the pH of the mine drainage is approximately 6.5 or higher, and where metals concentrations in the drainage are primarily a problem during summer months. Aeration is an important part of this system. The plant materials provide aeration and, when they die, provide adsorption surfaces, along with sites for algal growth.

A periodic inspection of the wetland system should be conducted to ensure that the flow is spread throughout the wetland and channelization has not occurred. Channelization problems should be corrected as soon as possible to achieve the maximum treatment this system can offer.

Metals will precipitate as the drainage is treated in the wetland. Wetlands, properly designed for the metals content of the drainage being treated, generally have a life of 20 to 30 years, after which time the accumulated metals will begin to slow the flow and the treatment will not be as effective. This metals sludge must be removed and properly disposed of in either a landfill or an on-site lined and capped trench, or sold for re-processing if the metals content is sufficient.

5. Aqueous lime injection is a passive method to introduce neutralizing agents into mine drainage. This system requires a clean water source. Clean water is passed through a pond containing neutralizing agent, and then the high pH effluent is mixed with the mine drainage before it enters a settling pond. This system can be cost effective if alkaline waste such as kiln dust or fly ash is available. Although still in the experimental phase, the method holds promise for some mine sites.

6. Limestone water jets are an aerobic method of accelerating the dissolution of limestone. In situations where mine drainage flows down a steep slope, the discharge can be piped, and the resultant head can produce a high-pressure water jet. The high-pressure jet can be either sprayed onto loose crushed limestone, or passed upward through a vessel containing limestone. In both situations, the limestone does not become coated because of abrasion by the water jet, and agitation of the surrounding blasts. The system using a vessel can result in higher alkalinity in the effluent due to greater abrasion. Both system types are in the experimental phase.

7. Mechanical injection of neutralizing agents involves a powered mechanical feeder/ dosing system for dispensing neutralizing agents. This type of system requires frequent maintenance, may produce significant quantities of metal sludge, and should be considered "semi-passive". Power for the feeder can come from wind, solar, or hydropower. Mechanical systems are generally considered only where there are no options for truly passive alternatives.

Any high pH material can be used in this type of system. Because of cost effectiveness and sludge characteristics, the most common neutralizing agent used is finely ground limestone.

8. Electro-Kinetics is a newer semi-passive method to remove metals from mine drainage. There are several forms of this treatment currently being developed. The electro-kinetic method uses low-maintenance, self-regenerating resins to remove metals from mine discharge. Different metals can be separated by using ion specific resins. Electricity is used to strip metals from the resins, producing sludge, and allowing re-use of the resin.

9. Land Application is a method designed to use natural metals attenuation processes in soils and subsoils to remove metals. Plant uptake and soil exchange capacity act to tie up and remove metals. This method is most effective where mine discharge can be spread over a large area to infiltrate into relatively thick soils or unconsolidated deposits. Drainage should be neutral or near neutral to avoid plant toxicity. This alternative is also effective for discharges with high iron and/or aluminum, and where pH is approximately 4.5 or above.

Planning and Implementation Tools

Colorado School of Mines Technical Resources. See the Resources section for complete list.

V. PRIORITIES AND GEOGRAPHIC PERSPECTIVE

There are four priorities for Colorado's inactive mine program. These priorities are often combined in individual actions and projects. These priorities are:

1.) To abate known water quality impairments resulting from nonpoint source pollution.

2.) To prevent significant future threats to water quality from inactive mine sites.

3.) To develop and implement new and existing technologies for water quality restoration.

4.) To provide information and education to key decision-makers and landowners about the importance of nonpoint source initiatives.

These four priorities are incorporated into a geographic context to target the most critical needs for specific watersheds.

Targeting Tools

State water quality standards are the underlying framework for water quality management in Colorado. Targeting tools that must be considered in the mining nonpoint source management program are the 1998 303(d) List, the Unified Watershed Assessment (UWA), the Nonpoint Source Assessment report and other Water Quality Control Division policy or guidance documents. In developing the management program, these documents have been used to determine priorities for implementing nonpoint source activities for inactive mining. The segments listed in Colorado's 303(d) list, and the category 1 and 2 watersheds, as listed in the Unified Watershed Assessment, stand as the official priorities for the program. All of these documents and their future updated submittals are incorporated as portions of this management program.

State Water Quality Limited Waters

State water quality standards are the yardstick used by the Water Quality Control Division to assess the status of a waterbody or stream segment. The state compares recent information regarding the physical, chemical and biological condition of a stream segment with the associated water quality standards. Where technology-based effluent limits in discharge permits alone are not stringent enough to assure that water quality standards are met, these stream segments are designated water quality limited and added to the 303(d) list. This list of impaired water of the state is updated every two years.

The 303(d) list includes the identification of the specific component (e.g. metal or sediment) that targets the specific water quality problem for a given segment. Total maximum daily loads (TMDL) are required for all components on all stream segments in the 303(d) list. The TMDL process must quantify the pollutant sources and allocate allowable loads to the contributing sources.

Evaluation of nonpoint sources is an essential component of the TMDL process. Stream segments on the 303(d) list will be targeted for nonpoint source controls. Mining related nonpoint sources have a significant impact on the water quality of streams in Colorado and will be given a high priority in this process.

Source Water Protection Program

Colorado is a headwaters state. Over 80 percent of the state's surface water supplies originate in the upper portions of the mountainous river basins. The Colorado Source Water Assessment and Protection Program delineates seven major river basins (Arkansas, Colorado, Rio Grande, Republican, San Juan, South Platte, Yampa and White). Most of these basins are impacted by mining and will be addressed in the assessment and implementations portion of the source water program.

Unified Watershed Assessment

The Clean Water Action Plan developed a watershed restoration strategy that resulted in Colorado defining priority watersheds through a unified watershed assessment process. Category 1 watersheds are those larger eight digit watersheds as mapped by the U.S. Geological Survey requiring the most restoration from a combination of point and nonpoint sources. Most of the category 1 watersheds in Colorado have identifiable nonpoint sources related to mining and will be a priority of the Mining Nonpoint Source Management Program.

Public Involvement/Watershed Approach

The trend in water quality management is toward a watershed-based approach, which is reflected in this program. The watershed-based approach has led to a number of local and regional initiatives with diverse organizational models and functional roles.

Initiatives have focused on site-specific restoration projects for targeted sources of pollution, information sharing and consolidation of water quality monitoring efforts. The priorities of individual stakeholder groups and government agencies must continually be modified to reflect new data derived from sampling and monitoring activities. Local watershed groups are expected to continue to play a critical role in nonpoint source water quality management programs.

Project Prioritization

The Mining Committee of the Colorado Nonpoint Source Council evaluates prospective 319 projects to determine the value of each submitted project while considering the four priorities and geographic/watershed needs stated in this plan. The Colorado Nonpoint Source Council has developed a detailed report card to assist in this project evaluation. The report card considers a variety of factors ranging from the technical feasibility of a project to its financial value. The results of this effort are presented to the Council for consideration in the allocation of 319 funds.

VI. GOALS AND OBJECTIVES

The goals and objectives listed below can only be accomplished in the specified time frame **if sufficient funds are allocated to these action items and if the regulatory climate encourages local and government participation.**

The relationship of the goals to the Association of State and Interstate Water Pollution Control Administrators and the Environmental Protection Agency's Nine Key Elements are listed. Specific information on the Nine Key Elements can be found in the Management Program Document. **Please see Appendix C-Milestone Table for a summary of goals, objectives, and action Items and associated time frames. Please see Appendix D for a summary of goals and their relationship to the nine key elements.**

GOAL 1 Develop watershed reconnaissance studies for impacted watersheds to assess and characterize mining-related NPS Problems and to identify future threats to water quality. *(Key elements 1,2,3,5,7)*

Objective 1.1 Identify and determine restoration goals in watersheds impacted by present and future mining related NPS pollution
Time Frame: By 2005

Action 1.1.1: Use the 303d list, 305b report and the Unified Watershed Assessment report to focus the inventory
Time Frame: Completed

Action 1.1.2: Conduct outreach activities to solicit input from local stakeholders and public on watershed concerns

Time Frame: Ongoing

Action 1.1.3: Consult federal and state agencies for input on regulations and concerns
Time Frame: Ongoing

Action 1.1.4: Identify sources of radioactive nonpoint pollutant sources
Time Frame: By 2005

Objective 1.2: Conduct source characterization studies for watersheds impacted by mining related non-point sources
. *Time Frame: By 2010*

Action 1.2.1: Conduct stream and mine discharge characterization studies
Time Frame: By 2010

Action 1.2.2: Conduct mine waste rock and tailings characterization studies
Time Frame: By 2010

Action 1.2.3: Conduct mine groundwater pathways characterization studies
Time Frame: By 2010

Action 1.2.4: Conduct aquatic and biological assessments of targeted watersheds
Time Frame: By 2010

Action 1.2.5: Conduct background loading studies for targeted watersheds
Time Frame: By 2010

Objective 1.3: Rank and prioritize individual mine sites for reclamation and water quality improvement projects
Time Frame: By 2010

Action 1.3.1: Use source characterization data in conjunction with aquatic and biological assessment, background loading investigations, public input and cost benefit analysis to prioritize sites for reclamation
Time Frame: By 2010

Accomplishments-Characterization studies and prioritization have been conducted in the following watersheds: Animas, Upper Arkansas, Clear Creek, French Gulch, Rio Grande, Lower Colorado and Snake River.

GOAL 2 Protect surface and groundwater by developing and implementing water quality restoration and preservation projects using BMP’s to:

A) return streams impacted by mining to designated uses
B) prevent significant threats to water quality from future nonpoint source activities (*Key elements 2-5,7)*

Objective 2.1: Develop water quality restoration and preservation projects for mine sites that have been characterized as a high priority
Time Frame: By 2015

Action 2.1.1:Use site characterization and water quality data to determine existing applicable existing BMP's and develop new BMP's for use in water quality projects
Time Frame: By 2015

Objective 2.2: Implement Best Management Practices at mine sites that have been characterized as a high priority for watershed restoration or preservation
Time Frame: By 2020

Action 2.2.1: Obtain funding for mining related water quality reclamation and improvement projects
Time Frame: By 2015

Action 2.2.2: Conduct watershed restoration projects
Time Frame: By 2020

Objective 2.3: Monitor NPS mining projects following grant approval and evaluate the success of the Best Management Practice

Action 2.3.1: Develop a progress report form, review and distribute to funding agencies
Time Frame: By 2000

Action 2.3.2: *M*onitor all completed NPS 319 water quality reclamation and Improvement projects
Time Frame: 5 years after project completion

Accomplishments: **Please see Appendix E for a summary of completed projects**

GOAL 3 Build long-term partnerships to enhance cooperation between industry, environmental groups, and government in restoration of Inactive Mined lands *(Key elements 2,3,6-8)*

Objective 3.1: Create a regulatory framework within which industry and private groups can participate in water quality restoration or preservation projects with appropriate liability protection
Time Frame: Ongoing

Action 3.1.1: Support Good Samaritan legislation and provide information to Legislators, Congress and other policy making bodies on nonpoint source issues, particularly those related to mining
Time Frame: Ongoing

Action 3.1.2: Support Orphan Sites Program
Time Frame: Ongoing

Objective 3.2: Encourage local participation in water quality restoration and preservation projects
Time Frame: Ongoing

Action 3.2.1: Develop volunteer opportunities at NPS projects
Time Frame: Ongoing

Action 3.2.2: Assist in the formation of watershed groups by providing information and technical assistance
Time Frame: Ongoing

Objective 3.3: Actively support federal agency efforts to improve and protect water quality in Colorado
Time Frame: Ongoing

Action 3.3.1: Develop interagency task orders and agreements to implement water quality restoration and preservation projects
Time Frame: Ongoing

Action 3.3.2: Meet with representatives of federal agencies to share information and develop strategies to assure compliance with State goals and objectives
Time Frame: Ongoing

Action 3.3.3: Coordinate with appropriate land management agencies the monitoring activities in stream segments identified on 303(d) list
Time Frame: Ongoing

Objective 3.4: Actively participate in and support the NPS 319 program
Time Frame: Ongoing

Action 3.4.1: Serve as an advisory group to the NPS Council and advocate appropriate projects that pertain to Mining related Non Point Source pollution
Time Frame: Ongoing

Action 3.4.2: Review and update the Mining Nonpoint Source Management program
Time Frame: Ongoing, every five years

Accomplishments:

Partnerships-The following companies have become partners by contributing materials, labor or cash: Coors Brewing Company, Berry Trucking & Excavating, BF Goodrich, Buckley Construction, Calco, Inc, Colorado Trout Unlimited, Cyprus Amax Coal Company, Homestake Mining Co., Kaess Contracting, Penn Gold and Silver, Rahkra Mushroom Farms, Stone Forest Industries, Sutherland Construction, T.H.E. Consultants, Volunteers for Outdoor Colorado, Western Diversified.

Memorandum of Understanding (MOU)-The State of Colorado; Division of Minerals and Geology , Department of Public Health and the Environment; and the EPA have developed a means toward Comprehensive Environmental Response Compensation and Liability Act (CERCLA) liability protection for several projects by creating an MOU between the State and the EPA.

Cooperative Agreements between the Division of Minerals and Geology and the USFS and Bureau of Land Management have been signed to complete watershed restoration projects in the Animas Basin.

Please see Appendix F for a list of associations, watershed groups and forums.

GOAL 4 Educate and Inform Target Audiences (*key elements 2,3)* regarding all aspects of NPS Mining Projects.

Objective 4.1: Facilitate transfer and dissemination of 319 NPS project results
Time Frame: Ongoing

Action 4.1.1: Develop BMP Handbook
Time Frame: 2000

Action 4.1.2: Develop BMP Video
Time Frame: 2000

Action 4.1.3: Develop standard reporting format for project sponsors
Time Frame 2000

Action 4.1.4: Participate in Watershed Associations
Time Frame: Ongoing

Action 4.1.5: Coordinate and attend field trips, workshops and conferences
Time Frame: Ongoing

Action 4.1.6: Distribute resources to target audiences such as mining associations, watershed groups and county planning departments
Time Frame: Ongoing

Objective 4.2: Coordinate, develop and support NPS mining information and education products and services
Time Frame: By 2005

Action 4.2.1: Coordinate museum exhibits related to mining related nonpoint sources
Time Frame: Ongoing

Action 4.2.2: Provide financial and technical assistance to projects which involve youth in the reclamation process
Time Frame: Ongoing

Action 4.2.3: Publish articles in youth oriented publications such as the Colorado Reader
Time Frame: 2005

Objective 4.3: Develop and conduct demonstration projects that generate and test technologies and alternative reclamation strategies for addressing NPS pollution from abandoned mine areas in order to establish successful treatment methods
Time Frame: Ongoing

Action 4.3.1: Develop partnerships to create and implement demonstration projects
Time Frame: Ongoing

Action 4.3.2: Serve as an advisory group to the NPS Council and recommend projects that demonstrate new technologies
Time Frame: Ongoing

Action 4.3.3: Assist project sponsors in procuring funding from a wide range of sources including the state revolving loan funds, severance tax funds, federal Office of Surface mining funds, cost sharing and 319 funds
Time Frame: Ongoing

Accomplishments: Three Acid Rock Drainage Workshops completed
Logan School Information and Education Project completed
Children's Museum Exhibit completed
Video on Best Management Practices completed
Western Mining Museum Exhibit Funded

VII. IMPLEMENTATION

The Nonpoint Source Program brings together regulatory, non-regulatory, voluntary, and incentive efforts to improve water quality. Some of the regulatory tools defined in the Clean Water Act and CERCLA can help watershed groups or agencies define priorities and find possible solutions for remediation projects. However, some of the most significant impediments to advancing voluntary and incentive-based projects are related to regulatory issues. Some of the tools available for remediation of inactive mining sites are discussed below.

Comprehensive Environmental Response Compensation and Liability Act (CERCLA))

CERCLA is a very powerful legal mechanism that can achieve dramatic remediation results, but due to its legal framework is best used at sites of extensive mining problems, where no path to remediation is visible. CERCLA is effective due to its legal authorities to pursue potentially responsible parties (PRPs) to pay for the costs involved in remediation. The legal authority found in joint and several liabilities, as described in CERCLA, can result in expensive remediation efforts that are generally the result of court orders.

The fear of liability imposed by CERCLA, which could accrue to parties working on a remediation project, has hampered work under Section 319 at inactive mining sites. In 1992, three projects were delayed as a result of potential liability concerns related to CERCLA. Cooperators were advised to avoid involvement in any 319 projects that pertained to the cleanup of inactive mines or risk perpetual liability for maintenance of the mine areas. The State of Colorado and the EPA responded to these concerns and developed procedures for administering the 319 funds. These procedures are detailed in a Memorandum of Understanding (MOU) between the EPA and the State of Colorado. If followed, these procedures put projects into compliance with the removal action requirements of CERCLA. The MOU has served as a prototype for similar agreements between the EPA and other states.

Clean Water Act Authorities

The Clean Water Act provides opportunities for control of inactive mining sites through several different means, but it also presents enormous challenges in terms of instituting passive treatment facilities for draining adits and tunnels, and difficult challenges for dealing with stormwater pollution. The Clean Water Act provides authority for the permitting of nearly all aspects of pollution at inactive mining sites; however, the practical reality of instituting such permits generally makes this option unattainable. Often individuals who never benefited from production of the mines own these sites, and, because the mine is inactive, there is no source of funds generated by the facility to provide for treatment. The Section 319 program offers an opportunity in these difficult situations to assist with these problems.

Section 319 funding can be very helpful in pursuing remediation at mining sites where both the CERCLA and Clean Water Act liability concerns can be accommodated. Often this requires specific MOUs with the EPA, or the use of stormwater permits to allow the work to proceed.

Perhaps the most difficult obstacle to overcome is drainage from adits and tunnels at inactive sites. The fear of liability prevents any agency or party unassociated with these sources from becoming involved in their remediation.

Good Samaritan Legislation

There is currently no provision in the Clean Water Act which protects participants from liability in reclamation projects that treat surface or groundwater impacted by mine-related NPS pollution. The EPA, environmental organizations, the mining industry, the State of Colorado and other western states have made a concerted effort to draft "Good Samaritan" legislation addressing liability issues. The present version of the "Good Samaritan" legislation would address environmental and liability concerns by requiring a permit to conduct reclamation activities. The legislation outlines reasonable conditions for obtaining and terminating the permit and has support from environmental coalitions. It is hoped that the Congress will favorably address this issue in 2000. In the meantime, Colorado is continuing to work with EPA and other regulatory agencies to assess and characterize specific mining NPS problems and, in certain cases, implement reclamation projects.

Local Watershed Initiatives

Currently there are more than 30 local watershed-based initiatives in the state. The watershed initiatives bring together diverse groups, or stakeholders, who have a presence or interest in a given watershed, and provide a vehicle for achieving common goals. Some watershed groups have successfully participated in the 319 grant process. Watershed groups can provide a local framework and important direction in the identification and characterization of NPS problems.   The mining committee serves as a technical advisor and resource base to these groups.

Orphan Sites and Voluntary Clean-Up Programs

Colorado's Voluntary Clean-up and Orphan Sites Programs provide market-based incentives and opportunities for private entities to reclaim abandoned mine sites. The Orphan Sites Program encourages companies to adopt and reclaim an inactive mine site in exchange for some form of credit.

The Voluntary Clean-Up Program, pursuant to HB94-1299, allow landowners to reclaim a property and obtain a certification from the State that   no further action is required". This certificate insures that , when used for the purposes identified in the voluntary clean-up plan, the site does not pose an unacceptable risk to human health or the environment

Partnerships

One of the goals of the committee is to demonstrate the success of partnerships between private individuals, government and communities in addressing environmental problems related to abandoned mines and associated nonpoint source pollution. Sponsors of mining related 319 projects have cooperated with the following agencies, corporations and individuals on previous reclamation projects:

Animas River Stakeholders Group
Berry Trucking & Excavating
Buckley Construction
Bureau of Reclamation
Calco, Inc.
Chaffee County
City of Creede
Clear Creek Watershed Forum
Colorado Division of Minerals and Geology
Coors Brewing Company
Cyprus Amax Coal Company
Gilpin County
Homestake Mining Co.
Kaess Contracting
Mineral County
Natural Resource Conservation Service
Penn Gold and Silver
Rahkra Mushroom Farms
San Juan RC& D
State Soil Conservation Board
Stone Forest Industries
Summit County
Sutherland Construction
T.H.E. Consultants
U.S. Forest Service
U.S. Environmental Protection Agency
U.S. Geological Survey
Volunteers for Outdoor Colorado
Western Diversified
Willow Creek Stakeholders

Federal and State Initiatives/ Financial Resources

Federal land management agencies have completed an inventory of their lands and have identified the most significant water quality problems. Agencies such as the U.S. Bureau of Land Management, U.S. Forest Service and the U.S. Geological Survey have established agency funding sources for characterization and remediation of mining related nonpoint source pollution which are located on federal lands.

Federal agencies such as the Environmental Protection Agency provide funds for nonpoint source work with 319 grants funds and Regional Geographic Initiative Grants. Funds are available through the Federal Office of Surface Mining (OSM) to address problems related to past coal mining operations. The funds come from fees paid by current coal mining operations. The fees are placed in a trust fund by OSM and 50 percent of these monies can be returned to the state for reclamation projects. The funds are administered by the Colorado Division of Minerals and Geology, Inactive Mine Reclamation Program (IMP).

State initiatives include the state Revolving Loan Fund and State severance tax funds and the State also allocates lottery proceeds to environmental projects through the organization known as Great Outdoors Colorado. The State continues to cooperate with various federal and private agencies by providing watershed characterization studies, technical assistance, project design and project management.

Implementation Milestones

The success of the Mining Committee and the NPS Council are dependent upon the continual pursuit of the goals and objectives previously outlined. The structure of the organization must be flexible and capable of responding to new technological, political and cultural environments. In order to accomplish the goals and objectives of the NPS Council and the State, the Mining Committee must continue to:

1. Function as a distinct group of individuals, government entities and other stakeholders who have an interest in the special issues related to mining related NPS pollution. Because of the diversity of the problems related to mining NPS pollutants, the solutions may be technologically complex and vary according to the site. The Mining Committee must provide a forum for the discussion of mining issues and the development of solutions while recognizing the impacts that mining has on other features of a watershed.

2. Function as part of the larger group of individuals, government entities and stakeholders whose mission is to address all categories of NPS pollution throughout the entire state. The Mining Committee must participate in the development and implementation of policies and procedures that address all NPS issues.

3. Assist in obtaining and delegating funds for reclamation projects that address NPS pollution.

VIII. MONITORING AND EVALUATION

There are two levels of monitoring and evaluation of NPS projects. One aspect is focused on the contribution a project makes towards accomplishing the greater goal of improving water quality throughout the state. The other aspect pertains to the individual project goals and if they were achieved. It is often difficult to evaluate the impacts of NPS mining projects on a wide geographic basis because the majority of individual problem sites appear in clusters in historic mining areas. Also, highly mineralized mining areas often have high levels of contamination resulting from the natural processes of weathering and erosion. Consequently, it is often not possible to isolate the impacts of an individual reclamation project site. In addition to water quality data on metals and pH, other parameters for evaluation may include monitoring the health of associated biota, sedimentation and aesthetic appeal of a disturbed area.

IX. INFORMATION NEEDS AND STRATEGIES

New technologies and existing best management practices for inactive mines are presently being developed and tested in demonstration projects. Because of the diversity of the problems related to abandoned mines, the solutions are technologically complex and vary according to the specific characteristics of the site. The educational element of the mining committee's goals are focused on raising public awareness of the impacts that acid rock drainage and mine waste have on water quality and disseminating information about successful reclamation techniques to targeted groups such as landowners, mining companies, associations and local governments.

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Appendix A
Colorado Inactive Mine Reclamation Program Abandoned Mine Inventory - 1980

County	Coal	Non-Coal
Archuleta	14	5
Boulder	183	3,600
Chaffee	0	150
Clear Creek	0	3,041
Conejos	0	35
Custer	0	1,827
Delta	36	4
Dolores	0	210
Douglas	5	40
Eagle		
El Paso	153	15
Fremont	279	50
Garfield	13	17
Gilpin	0	5,100
Grand	0	3
Gunnison	15	200
Huerfano	178	0
Jackson	8	35
Jefferson	48	100
Lake	0	550
La Plata	60	52
Larimer	15	254
Las Animas	202	2
Mesa	33	150
Mineral	0	200
Moffat	31	15
Montezuma	26	10
Montrose	2	1,281
Ouray	0	350
Park	49	295
Pitkin	3	750
Rio Blanco	22	10
Rio Grande	0	30
Routt	77	44
Saguache	0	800
San Juan	0	500
San Miguel	7	737
Summit	0	604
Teller	0	1,100
Weld	36	0
TOTAL	1,485	22,166

APPENDIX B
WATER QUALITY STANDARDS

Class 1 Aquatic Life Standards for Metal

Metals * Water Hardness or Alkalinity (mg/1)

(ug/1)	0-100	100-200	200-300	300-400	400+		
Al(sol)	100	100	100	100	100		
As	50	50	50	50	50	100	50
Be	10	300	600	900	1100	100	
Cd	0.4	1	5	10	15	10	10
Cr III	100	100	100	100	100	100	50
Cr VI	25	25	25	25	25	100	50
Cu	5	10	10	20	40	200	1000
Fe	1000	1000	1000	1000	1000	300(sol)	
Pb	4	25	50	100	150	100	50
Mn	1000	1000	1000	1000	1000	200	50(sol)
Hg	0.05	0.05	0.05	0.05	0.05	2	
Ni	50	100	200	300	400	200	
Se	50	50	50	50	50	20	10
Ag	0.10	0.10	0.15	0.20	0.25	50	
Zn	50	50	100	300	600	2000	5000

Agricultural Standards for Metals

Contaminants		Standards
Aluminum	(Al)[df]	5.0 mg/l
Arsenic	(As)[d]	0.1 mg/l
Beryllium	(Be)[d]	0.1 mg/l
Boron	(B)[dg]	0.75 mg/l
Cadmium	(Cd)[d]	0.01 mg/l
Chromium	(Cr)[d]	0.1 mg/l
Cobalt	(Co)[d]	0.05 mg/l
Copper	(Cu)[d]	0.2 mg/l
Fluoride	(F)[d]	2.0 mg/l
Iron	(Fe)[d]	5.0 mg/l
Lead	(Pb)[df]	0.1 mg/l
Lithium	(Li)[dh]	2.5 mg/l
Manganese	(Mn)[d]	0.2 mg/l
Mercury	(Hg)[df]	0.01 mg/l
Nickel	(Ni)[d]	0.20 mg/l
Nitrite	(NO_2-N)[df]	10 mg/l as N
Nitrite & Nitrate	(NO_2+NO_3-N)[df]	100 mg/l as N
Selenium	(Se)[d]	0.02 mg/l
Vanadium	(V)[d]	0.1 mg/l
Zinc	(Zn)[d]	2.0 mg/l
pH		6.5-8.5

Human Health Standards

Contaminants		Standards
Antimony	(Sb)[d]	0.006 mg/l
Asbestos		7,000,000 fibers/Liter
Arsenic	(As)[d]	0.05 mg/l
Barium	(Ba)[d]	2.0 mg/l
Beryllium	(Be)[d]	0.004 mg/l
Cadmium	(Cd)[d]	0.005 mg/l
Chromium	(Cr)[d]	0.1 mg/l
Cyanide [Free]	(CN)	0.20 mg/l
Fluoride	(F)[d]	4.0 mg/l
Lead	(Pb)[d]	0.05 mg/l
Mercury	(Hg)[d]	0.002 mg/l
Nickel	(Ni)[d]	0.1 mg/l
Nitrate	(NO_3)[d]	10.0 mg/l as N
Nitrite	NO_2)[d]	1.0 mg/l as N
Total Nitrate+Nitrite		10.0 mg/l as N
Selenium	(Se)[d]	0.05 mg/l
Silver	(Ag)[d]	0.05 mg/l
Thallium	(Tl)[d]	0.002 mg/l

APPENDIX C
MILESTONE TABLE

	1999	2000	2005	2010	2015	2020
Goal 1-Watershed Assessment						
Inventory Watersheds to Determine Mine-related pollutant sources	Portions complete		Target Date for Completion			
Site Characterization	Portions complete			Target Date for Completion		
Site Prioritization	Portions complete			Target Date for Completion		
Goal 2-Project Development and Implementation						
Develop Projects using BMP's to address high priority sites	Portions complete				Target Date for Completion	
Obtain funding for projects	Portions complete				Target Date for Completion	
Implement Projects	24 projects complete					Target Date for Completion
Develop Monitoring Form	Portions complete	Target Date for Completion				
Monitor completed projects	Portions complete	Five years after project completion				
Goal 3-Partnerships	1999	2000	2005	2010	2015	2020
Good Samaritan Legislation	Bill drafted					
Support Orphan Sites Project	Ongoing					
Develop Volunteer Opportunities	Ongoing					
Formation of Watershed Groups	Portions complete		Target Date for Completion			
Develop MOU's with Federal Agencies	5 complete	Ongoing				
Assure Federal Compliance with State Goals	Ongoing					
Coordinate Monitoring Efforts	Ongoing					
Participate in NPS Council	Ongoing					
Program Review	Review	Program Updated	Review	Review	Review	

APPENDIX C
MILESTONE TABLE CONTINUED

Goal 4-Information and Education	1999	2000	2005	2010	2015	2020
BMP Handbook		2000				
BMP Video	Complete					
Attend Watershed Meetings	Ongoing					
Organize Field Trips, Workshops, Conferences	12 Complete	Ongoing				
Distribute Resources to Target Audiences	Ongoing					
Provide funds to schools for water quality projects	Logan School Projects Complete					
Publish in youth oriented publications	Portions complete		Target Date for Completion			
Coordinate Museum Exhibits	Children's Museum Complete		Western Mining Museum Exhibit Completion			
Conduct Demonstration Projects	Ongoing					

APPENDIX D
SUMMARY OF NINE KEY ELEMENTS/ GOALS

Key Elements	
1. Explicit short and long-term goals, objectives and strategies	Four long-term goals and associated objectives and short-term action strategies are outlined in the report. These goals focus on the watershed approach while addressing local issues
2. Strong working partnerships and collaboration	Goals 1 and 2 rely on watershed groups and a variety of federal, state and local governments to characterize, prioritize and address nonpoint source problems. Goal 3 specifies action items to build long-term partnerships and to enhance cooperation between industry, environmental groups, and government in the restoration of inactive mined lands. This includes creating a regulatory framework that encourages participation, establishing volunteer opportunities and watershed groups and coordinating with federal agencies. The establishment of partnerships requires awareness and understanding of the issues. Goal 4 outlines specific Information and Education objectives and action strategies that will facilitate develop of partnerships.
3. A balanced approach to management of impaired or threatened waters	All four goals combine to provide a balanced approach to the management of the waters of the state. The goals include specific action items that reflect a wide spectrum of concerns and focus on the watershed approach while addressing local issues. Goals 1 and 2 use scientific methodologies for the evaluation and characterization of impaired and threatened waters. Goal 3 specifies action items that encourage participation of a wide range of individuals and groups. Goal 4 focuses on informing and educating target audiences about mining related nonpoint source pollution.
4. Abate known water quality impairments and prevent significant threats	Goal 2 outlines specific objectives for developing and implementing projects which will address present problems and prevent future threats to water quality using Best Management Practices.

APPENDIX D CONTINUED

5. Identify waters and watersheds impaired or threatened and establish a process to address these waters	Goal 1 provides specific action items for identification, characterization and prioritization of impacted watersheds and the determination of future threats. The 303d list, 305b report and the Unified Watershed Assessment Report as well source characterization data, aquatic and biological assessment data, background loading investigation data, public input and cost/benefit analysis will be used to identify and prioritize threatened and impaired waters. Goal 2 provides action items that will facilitate the development of a process to address the priority concerns.
6. Review, upgrade and implement program components	Goal 3 specifies the programmatic obligation of the mining subcommittee. The committee will review and update the management program every five years.
7. Identify federal lands and objectives	Goals 1 and 2 of the Mining Nonpoint Source Management Program address all impacted or threatened waters of the state, regardless of ownership. Goals 1, 2 and 3 contain specific action items for encouraging cooperation with federal agencies.
8. Efficient and effective management and implementation program	Goal 3 specifies action items that pertain to the commitment of the mining committee to the Nonpoint Source 319 Program. The committee retains the identity of a distinct group of individuals and government agencies with a concern for nonpoint source pollution related to mining and functions as part of a larger group to improve water quality in the state.
9. Five Year Feedback Loop	The Water Quality Control Divisions' review and upgrade process has been established as a feedback loop using the Nonpoint Source Council

APPENDIX E
SUMMARY OF PROJECTS

Projects Completed With 319 Funds

Project Site	County	Products	Project Date	Project Sponsor/ Funding Source	Watershed
Pennsylvania Mine	Summit	Neutralization treatment and wetland polishing systems installed. Facility never operated due to NPDES liability concerns.	Initiated 1989 Terminated 1998	DMG/ 319 Funds	Upper Colorado
Gamble Gulch	Gilpin	Mine waste and mill tailings were removed from the creek, limed, topsoiled and revegetated. Wetland constructed to treat acid mine drainage.	1990	DMG/319 Funds	South Platte
South Mosquito Creek/North London	Park	Removed tailings from creek channel, limed, topsoiled and revegetated. Constructed diversion ditches and settlement ponds.	1991	DMG/319 Funds	South Platte
East Willow Creek	Mineral	Diverted stream channel away from mine waste piles. Created passive treatment system, consisting of a 3-celled wetland, for neutralizing acid mine drainage.	1991	DMG/ 319 Funds	Rio Grande
Chalk Creek	Chaffee	Removed mill tailings from creek. Covered tailings with rock and manure, revegetated. Reclaimed wetland below tailings.	1991	DMG/ 319 Funds	Arkansas
Ophir	San Miguel	High and Low flow samples taken.	1995	DMG/ 319 Funds	Lower Colorado
St. Mary's	Clear Creek	Constructed ALD to treat mine drainage from Alice Glory Hole. Intercepted groundwater flow prior to metal contamination.	1995	DMG/319 Funds	South Platte
Bonanza Mine	Saguache	Removed mill tailings from drainage to authorized waste disposal facility	1996	CDPHE, USFS, Landowner/ 319, Private Funds	Rio Grande
Mineral Creek/ Targeting and Characterization	San Juan	High and Low flow samples taken. Detailed loading analysis report	1997	CDPHE, DMG/ 319 Funds	Lower Colorado
Cement Creek/ Targeting and Characterization	San Juan	High and Low flow samples taken. Detailed loading analysis report	1998	DMG/319 Funds	Lower Colorado
Lower Animas Targeting and Characterization	San Juan	High and Low flow samples taken. Detailed loading analysis report	1998	DMG/319 Funds	Lower Colorado
London Extension	Park	Constructed neutralizing treatment system. Diversion ditches, settling pond spillway constructed. Landowner holds NPDES permit.	1998	DMG/ 319 Funds	South Platte
Anchor/Pozo	Clear Creek	Removed tailings away from drainages. Applied lime, topsoil and revegetated.	1998	DMG/319 Funds	South Platte
Upper Animas Targeting and Characterization	San Juan	High and Low flow samples taken. Detailed loading analysis report	1999	DMG/319 Funds	Lower Colorado
Willow Creek	Mineral	High and Low flow samples taken. Detailed loading analysis report	Funded in 1999	Willow Creek Stakeholders/ 319 Funds	Rio Grande
Mineral Creek	San Juan	Remove mine waste from drainages and revegetate.	Construction in 1999	San Juan RC& D/ 319 Funds	Lower Colorado
Silver Wing Mine	San Juan	Construct biological treatment system for acid mine drainage	Funded in 1999	Landowner/ 319 Funds	Lower Colorado
Mammoth Tunnel	San Juan	Construct settling pond treatment facility for acid mine drainage	Funded in 1999	Landowner/ 319 Funds	Lower Colorado
Mary Murphy	Chaffee	Groundwater tracing and hydrologic investigations completed. Source control project work to intercept clean groundwater inflows before metal contamination occurs is underway	2001	DMG/319 Funds	Arkansas
Coal Basin	Pitkin	Steep slope revegetation	2001	DMG 319 Funds	Lower Colorado

APPENDIX E CONTINUED

Projects Completed With Other Funding Sources

Project Site	County	Products	Project Date	Project Sponsor/ Funding Source	Watershed
Thompson Creek	Pitkin	Constructed wetland to demonstrate the treatment of acid mine drainage	1987	DMG/ AML Program Funds	Upper Colorado
Alice	Clear Creek	Backfilled glory hole with limestone and tailings which were removed from the creek.	1988	DMG/ AML Program funds	South Platte
Boston Mine	La Plata	Constructed wetland to demonstrate the treatment of acid coal mine drainage	1992	DMG/AML Program Funds	Lower Colorado
MRRC Mine	San Juan	Removed mine waste from stream. Constructed ALD to treat mine drainage	1994	Landowner	Lower Colorado
Black Eagle	Clear Creek	Capped and revegetated mill tailings	1994	Landowner/ Private Funds	South Platte
Marshall #5 Mine	Boulder	Constructed wetland to demonstrate the treatment of acid coal mine drainage	1995	DMG/ AML Program Funds	South Platte
Burleigh Tunnel	Clear Creek	Bioreactor and Wetland treatment system constructed	1995	CDPHE, EPA/ Superfund Monies	South Platte
Joe and Johns Adit	San Juan	Opened mine portal to capture and quantify mine drainage.	1998	BLM/ BLM Funds	Lower Colorado
Galena Queen	San Juan	Constructed upland diversion ditches.	1998	DMG/ OSM Funds	Lower Colorado
Virginia Canyon	Clear Creek	High and Low flow samples taken. Detailed loading analysis report	1999	DMG/ Regional Geographic Initiative Funds	South Platte
Minnesota Gulch	San Juan	Mine dump volumetrics and chemistry, site survey, underground survey and inflow characterization, Reclamation Plan and execute reclamation of site	Field work completed, reclamation plan being developed	CDMG/ BLM funded task order	Animas Basin/ Cement Creek
Kansas City Mines	San Juan	Mine dump volumetrics and chemistry, site survey, underground survey and inflow characterization, Reclamation Plan and execute reclamation of site	Field work completed, reclamation plan being developed	CDMG/ BLM funded task order	Animas Basin/ Cement Creek
Belcher Gulch	San Juan	Mine dump volumetrics and chemistry, site survey, , Reclamation Plan and execute reclamation of site, possible hydrologic source controls on creek	Field work completed, reclamation plan being developed	CDMG/ BLM funded task order	Animas Basin/ Mineral Creek
Brooklyn Mine	San Juan	Mine dump volumetrics and chemistry, site survey, underground survey and inflow characterization, Pilot paste-backfill feasibility analysis and plans, Develop Reclamation Plan	On hold due to new landowner/BLM – USFS negotiations	CDMG/ BLM funded task order	Animas Basin/ Mineral Creek
Bandora Mine	San Juan	Hydrologic controls of mine discharge, infiltration gallery, site reclamation	On Hold due to BLM/USFS clearance issues	CDMG/ BLM funded task order	Animas Basin/ Mineral Creek
Bonner Mine	San Juan	Relocate mine dumps from drainage, reclaim and revegetate site	On Hold due to BLM /USFS clearance issues	CDMG/ BLM funded task order	Animas Basin/ Mineral Creek

Education/Outreach Projects

***** Four Acid Rock Drainage Conferences Workshops

***** Logan School Project

* Children’s Museum Exhibit

* Video and Brochure on Best Management Practices

APPENDIX F
ASSOCIATIONS WATERSHED GROUPS

Regional/Areawide/State	***Local Associations and Authorities***	***Forums/ Initiatives***
	Statewide	
Water Quality Control Division	County Government Offices- Health Department, Land Use	Water Quality Forum
Division of Minerals and Geology	County Historic Preservation Boards	Colorado Environmental Coalition
Division of Wildlife	League of Women Voters	
State Historic Preservation Office	Sierra Club	
Environmental Protection Agency	Colorado Mining Association	
Office of Surface Mining		
Bureau of Land Management		
United States Forest Service		
Department of Energy		
United States Geological Survey		
United States Bureau of Reclamation		
	South Platte	
Denver Regional Council of Governments	Clear Creek Watershed Association	Clear Creek Forum
North Front Range Water Quality Planning Association	Northern Conservancy District	Jamestown Watershed Group
	Central Conservancy District	Clear Creek County Mining Association
	Cherry Creek Watershed Association	Boulder County Metal Mining Association
	Arkansas	
Pikes Peak Area Council of Governments		Upper Arkansas Watershed Council
	Upper Colorado	
Northwest Colorado Council of Governments	Summit Water Quality Committee	Roaring Fork Watershed Coalition
	Eagle River Watershed Plan Committee	Snake River Watershed Group
	Routt County Water Quality Committee	
	Lower Colorado	
	San Miguel Watershed Coalition	Animas Stakeholders
		Willow Creek Stakeholders
		Rio Grande Alliance
		Gunnison River/Rio Grande Valley Water Quality Forum