SITE CHARACTERIZATION

Pennsylvania Mine
Summit County, Colorado

EVEN 4830/ ENVS 5100
Abandoned Mine Remediation
Fall 2003
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Pennsylvania Mine, Summit County, Colorado

I. General information

A. Property location
The Pennsylvania Mine is an abandoned base and precious metals mine located on the northwest slope of Decatur Mountain one quarter of a mile south of Peru Creek, in Summit County, Colorado. The property falls within section 20, township 5 south, range 75 west, and can be found on the USGS 7.5 minute series (1:24,000 scale) topographic map of Montezuma, Colorado. The Pennsylvania Mine site is located in a sub-alpine/ alpine environment, between 10,950 and 11,500 feet elevation. Peru Creek flows west into the south fork of the Snake River, which eventually drains into Dillon Reservoir. Peru Creek and the Snake River are both part of the Blue River drainage.

B. Ownership
Land ownership of the Pennsylvania Mine site is mixed, with the predominant contaminated areas and sources on private land. The current owner is Trans-Pacific Tourism, a Littleton, Colorado-based company that purchased the lands from Pennsylvania Gold and Silver Company in 1990. The surrounding and intervening areas are owned by the United States Forest Service (USFS) and managed by White River National Forest (Environmental Protection Agency 1993).

C. Cleanup efforts
The abandoned Pennsylvania Mine is a significant source of water pollution, affecting both Peru Creek and the south fork of the Snake River (Holm et al. 1979). In 1988, the Colorado Division of Minerals and Geology (CDMG) selected the Pennsylvania Mine site for investigation of passive or semi-passive mine drainage treatment strategies. In 1989, the CDMG prepared an initial design for a chemical treatment system to address heavy metals contamination in Peru Creek, funded by the Non-Point Source (NPS) Council of the federal Clean Water Act (CWA). The United States Environmental Protection Agency (EPA) developed the National Monitoring Program under Section 319 of the Clean Water Act to specifically address non-point source pollution. Section 319 objectives are to evaluate the effectiveness of watershed technologies designed to control non-point source pollution and to provide better understanding of non-point source pollution. This provision allows states,
territories, and Indian tribes to receive grants to assess the success of specific non-point source implementation projects. These grants support a wide variety of activities including technical and financial assistance, education, training, technology transfer, demonstration projects, and monitoring.

In September, 1989, the USFS granted a special use permit for construction of a penstock from the main adit to an existing bog for biological treatment. This proved ineffective, and a chemical treatment system was constructed in 1990. It only operated for a short time, however, due to chemical inefficiency, mechanical problems, materials failures, and liability issues. In 1994, CD MG was awarded a Section 319 NPS grant to make necessary design improvements to this system and to build a second-stage sulfate-reducing bacteria polishing treatment system. A Water Quality Control Division (WQCD) contract was issued to cover construction and retrofitting. However, on December 22, 1993, the Environmental Protection Agency (EPA) determined that abandoned mines are point sources of pollution and subject to the National Pollutant Discharge Elimination System (NPDES) permitting program (Stover 1998). Just seven days later, the Federal Court of Appeals for the Ninth Circuit ruled similarly, holding that the owner of an abandoned mine in California who was operating an acid mine drainage treatment system was liable under the CWA for pollution discharge (McAllister 2003, citing Committee to Save Mokelumne River v. East Bay Mun. Utility Dist., 13 F.3d 305 [9th Cir. 1993]). These events effectively passed long-term liability from absentee mine operators to state and local organizations involved in Good Samaritan remediation projects. After federal congressional attempts to exempt Good Samaritans from liability failed, the CD MG, the Colorado Department of Public Health and Environment (CDPHE), and WQCD staff terminated further work on the Pennsylvania Mine project in 1998. Over $170,000 in public and private funds, as well as countless hours of volunteer labor, had been expended on a failed reclamation project (Stover 1998).

II. Site history

A. History of the mining district

1. Mining and mineral development in Summit County, Colorado

After Colorado’s first gold strike in 1858 near Denver, many prospectors continued west across the Continental Divide. In 1860, miners from Georgia discovered gold at what is now called Georgia Gulch, beginning the mining boom in Summit County (Gilliland 1980).
Summit County led Colorado’s placer gold production during the Civil War when the dollar dropped in value and gold was prized as a stable investment and currency. Miners built hundreds of miles of ditches and flumes to divert water from nearby streams into sluices, which required large quantities of water to separate gold from gravel. In the 1860s, companies from the eastern United States bought out many Summit County placer operations and began hydraulic mining. Hydraulic mining tore away hillsides, washed tons of sediment into rivers, and scarred Summit County’s mountains for years. After hydraulic mining ended, gold dredging was often used to extract ore from lakes in Summit County (Gilliland 1980).

Summit County’s second mining boom came in the 1870s in the form of lode mining. In the winter months, cold temperatures, snow, and ice halted placer and hydraulic mining, but with the introduction of lode mining, mineral extraction could continue year-round. Hard-rock silver veins were discovered in Breckenridge, Ten-Mile Canyon, and in the Snake River region at Sts. John Mine. Adits, shafts, and stamp mills, built to carry out the intensive labor of lode mining, became part of the Summit County landscape (Gilliland 1980).

Other mines in the Peru Creek Valley, where the Pennsylvania Mine is located, produced silver, lead, gold, and copper. Southwest of the Pennsylvania Mine, the Delaware, Delaware Extension, and Sunrise mines were established in Cinnamon Gulch, the site of rich ore deposits. Northwest of the Pennsylvania Mine, several veins on Copper Mountain yielded profits for the Tariff and Buda mines (Gilliland 1980).

2. Social and community development in Summit County, Colorado
Several towns grew up in Summit County as miners arrived in the area. Breckenridge, Frisco, Dillon, and Montezuma boasted schools, post offices, hotels, and saloons, and offered provisions, services, and community events for the miners and their families. Montezuma, in the Snake River region and near the Pennsylvania Mine, became a thriving town after its establishment in 1865 (Gilliland 1980). Today these towns are largely resort areas, dependent on the Summit County’s popularity as a skiing and recreation magnet.

B. Past operations at the site
1. Owners and operators
J.M. Hall located the Pennsylvania Mine in 1879. The period from 1879 to 1887 was spent developing the mine. The Decatur Mining Syndicate, a British Mining company, leased the
mine in 1892, and in 1902, the Ohio Mines Company bought the property (Gilliland 1980). Rothschild Company bought the mine in 1906 and further developed it (Brown 2002).

2. Type, amount, and time of ores produced
The Pennsylvania Mine yielded gold (594 ounces in 1910, the biggest gold year), silver (138,344 ounces in 1893), lead, copper, and zinc (Gilliland 1980). It was one of the few mines that survived the silver crash of 1893; in fact, its most productive year was 1893, when it recorded a shipment of about 7,000 tons ($319,275 in silver). Between 1893 and 1898, production exceeded $3 million in total earnings (Brown 2002).

3. Structures and features on the site
By the early 1900s, the Pennsylvania Mine was a well-developed, modern mine, functioning on six underground levels. The Rothschild Company constructed a 3,000-foot-long cross-cut tunnel and erected a multi-level, gravity-fed mill with multiple ore crushing machines. Several short aerial trams transported materials from the above adit to the mill. Rail carts brought ore, sorted by quality, out of the mine to one of several storage sheds. Other structures included living quarters, administrative offices, and a dining hall (Gilliland 1980). During the spring of 1898, a large avalanche took out many of the structures, but the mine continued functioning into the 1940s (Brown 2002; Gilliland 1980).

C. Past site characterization and remediation
A 1979 study identified the abandoned Pennsylvania Mine as the most significant source of acid mine drainage (AMD) and heavy metals in the Peru Creek drainage basin (Holm et al. 1979). It projected that if all Pennsylvania Mine metals and acidity were removed from the barren Peru Creek, introduced metal-tolerant trout species would have a 50% survival rate, strongly suggesting that a viable fishery could be reestablished (Stover 1998; Holm et al. 1979). In 1988, the CDMG began investigating the potential of passively treating Pennsylvania Mine AMD in a preexisting bog below the mill (Stover 1998) (Figure 1). A penstock was installed to transport AMD from the main adit above the east ore shed to the bog, but monitoring proved that the mine drainage was too acidic and metallic for passive treatment alone. (EPA 1993; Stover 1998).

By 1990, the CDMG had designed an experimental active treatment demonstration system, funded in part by a CWA Section 319 grant (Stover 1998). Before it entered the bog, mine water from the penstock was mixed with limestone powder in a hydro-powered
combination hopper and ribbon blender/chemical feeder. Through a floor sluice, the limestone-mine water mixture entered a 0.75-foot rip rap channel for further mixing and limited aeration. The mixture then collected in a 75-·90-foot settling pond for sludge separation. However, by 1991, tests revealed much higher than expected limestone needs, in excess of hopper capacity, and AMD had corroded the internal turbine (Boulder Innovative Technologies 1995).

Between 1991 and 1994, the CDMG sought to improve the treatment system. More efficient reagent-grade magnesium oxide was recommended to replace limestone powder for chemical treatment. Constructed wetlands and two sulfate-reducing bacteria reactor beds, were installed below the sedimentation pond for pre-bog biological treatment (CDMG 1992; Boulder Innovative Technologies 1995). A sludge production miscalculation was discovered, requiring development of a plan to backfill sludge in the mine workings (Stover 1998; Stover 1994). Due to CWA liability concerns arising from a key EPA determination and federal court case, however, the CDMG terminated the project in 1998, without having tested the improved treatment system (Stover 1998).

**Figure 1. Pennsylvania Mine major site features**
III. Current site status

A. Description of current site
The Pennsylvania Mine is currently inactive (Stover 1998; Brown 2002). Three historical buildings were observed at the site— a large mill and two small ore sheds (Figure 1). Just east of the mill there also is a small lime addition building, constructed for AMD treatment. Three aerial tram towers stand on the hillside connecting the mill and the west ore shed. Finally, waste rock piles and collapsed adits lie next to both ore sheds.

B. Public health hazards
The three above-mentioned dilapidated wooden buildings present a considerable public health hazard. The east ore shed sits next to the eastern waste rock pile and is in a much degraded condition. An inviting passageway on the lower level is presumably where ore was loaded for transport. Behind this ore shed a debris field contains ore cart tracks, splintered boards, rusty nails, and a small steam boiler.

The west ore shed is farther up the hillside and less accessible, but is similarly dilapidated and flanked by the western waste rock pile. Entry is more difficult but possible. Behind this structure, a large, depressed pile of wood debris covers a collapsed adit (Colorado Mined Land Reclamation Division [CMLRD] 1989; Lovering 1935). It is unclear whether this pile would prevent accidental entry into the mine workings.

The largest of the three structures, a dilapidated mill, is easily accessible. Its lower floor is intact, while upper floors have collapsed and portions of the ceiling and equipment have fallen onto the lower floor. Above, heavy processing equipment such as a steel jaw crusher and ball mill sit amidst a considerable debris pile within the collapsed structure. Outside the mill, at the lower level, are two large steam boilers. About 50 yards uphill from the mill begin a series of three aerial tramway towers connecting the west ore shed. These towers were not inspected, and it is unclear whether they are also in a dangerous condition.

These three structures and their accompanying debris represent a considerable public health hazard to visitors. The general area around the site is popular with backcountry skiers despite avalanche risks (Holm et al. 1979). Fortunately, however, the site itself is remote, accessible only by a rocky dirt road, and it seems to be visited rarely. During a three-hour site visit, approximately 12 vehicles drove by the mine access road, but none entered the site.
C. Environmental hazards

AMD from the main adit pond from the eastern and western waste rock piles and tailings at the site (Figure 1) present considerable environmental hazards. The CDMG treatment system is not operating; mine water was observed draining from the main adit pond in two streams, flowing into Peru Creek. The west adit overflow stream follows the access road. Along the east adit overflow stream, a well-defined, cut channel has formed, with a floodplain of iron-stained soils. When uncovered by peak flows, these soils are susceptible to erosion and wind dispersal, and are a possible source of metal contamination.

The eastern and western waste rock piles may contain heavy metals, due to the relative inefficiency of mining at the site. Wind and water can erode these piles, spreading metal contamination throughout the surrounding area. Below the mill, surface and groundwater flow through tailings and a bog into Peru Creek. Visual and documented evidence suggest that both contribute acidic water to the creek (CDMG 1992). Due to its proximity to the processing mill, this tailings pile is probably composed of pyritic, fine-grained sediments with high surface area.

No aquatic life was observed in the creek between the east and west adit overflow discharge points to Peru Creek and downstream of the bog. Studies confirm that below the Pennsylvania Mine, Peru Creek contains essentially no aquatic life (Stover 1998; Holm et al. 1979). Water quality sampling has revealed elevated concentrations of the following metals in the stream: cadmium, copper, iron, lead, and zinc (Holm et al. 1979). Cadmium is a known human carcinogen, and lead causes neurological, renal, and cardiovascular disorders (Irwin 1997). Zinc and copper are highly toxic to aquatic species. Visual inspection of milky water and white precipitates on rocks downstream of the tailings and bog suggest the presence of aluminum hydroxides.

Peru Creek is a tributary of the Snake River, which flows into Dillon Reservoir, a major drinking water source and a recreation area. Two small cabins were observed on the main road, about one-eighth of a mile from the site. It is unclear, however, whether these or other homes rely on the creek as a drinking water source.

D. Community concerns

The remote Pennsylvania Mine site is accessible by a rough dirt road. The closest residents are those in the town of Montezuma, about three miles from the site, and seasonal cabin-
owners along the road; cabin-owners rely on well water. Local residents are not concerned about public health or environmental hazards at the Pennsylvania Mine site (personal communication with County Commissioner Gary Lindstrom, November 7, 2003). Other parties, however, have demonstrated concern about water quality. The area’s largest landholder, the USFS, has expressed interest in aiding the restoration of Peru Creek and has helped fund the Pennsylvania Mine treatment system (Challenge cost-share agreement 1990). Local governments such as Summit County and Keystone have expressed similar concern (Pocius 1994). Summit County was awarded a Brownfields grant in 2001 for all of Peru Creek. The Summit County Open Space division is spearheading this effort. Financial donors include Coors Brewing Company and AT&T. In addition, the group Volunteers for Colorado contributed $42,000 worth of labor to the treatment system construction (Chappell 1994). The Snake River Watershed Task Force is working on water quality issues in the entire watershed, which includes Peru Creek. The Keystone Foundation is involved as a major funder of this project. Keystone Ski Resort is also interested in water quality in the watershed, although it has been determined that their use of the water for snowmaking does not spread the AMD contamination (personal communication with County Commissioner Gary Lindstrom, November 7, 2003).

E. Current site characterization and remediation

There is no current site characterization and remediation at the Pennsylvania Mine site. While a final report is not yet available, a research team at the University of Colorado at Boulder is studying the site as part of their research on AMD.

IV. Remediation objectives

A. Hazards to be addressed

The Pennsylvania Mine site has four major hazards, including heavy metals-laden acidic mine waters, dilapidated buildings, hillside waste rock piles, and a tailings field just north of the old mill, all detailed above.

The mine water discharges at a pH of 2.8 from the mine at a rate of 40 to 100 gallons per minute (Stover 1998). This water is contaminated with a variety of heavy metals that have leached from the waste rock and the mine. Mine waters drain into Peru Creek, a former cold-water fishery and a tributary of the Snake River, which eventually flows into Dillon Reservoir (Holm et al. 1979). The major contaminants of concern are cadmium, copper,
iron, lead, and zinc. A visual inspection reveals white precipitates and cloudiness in Peru Creek, indicative of aluminum hydroxides in the water.

Table 1 presents the peak and average dissolved metals concentrations in the water discharged from the main adit just above the upper ore shed (Holm et al. 1979). Peak and average metals concentrations are also given for Peru Creek just below the Pennsylvania Mine (Holm et al. 1979). Background water concentrations in Peru Creek are given as metals concentrations found in Peru Creek above the Pennsylvania Mine (Holm et al. 1979). The EPA water quality standard and maximum allowable threshold concentration (MATC) are also given for comparison.

### Table 1. Dissolved metals concentrations near the Pennsylvania Mine

<table>
<thead>
<tr>
<th>Description</th>
<th>Cd ppb&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Cu ppb&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Fe ppb&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Zn ppb&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Pb ppb&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Al ppb&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penn Mine adit, peak</td>
<td>60</td>
<td>10,600</td>
<td>112,000</td>
<td>75,600</td>
<td>125</td>
<td>12,000</td>
</tr>
<tr>
<td>Penn Mine adit, average</td>
<td>37</td>
<td>7,240</td>
<td>61,500</td>
<td>41,000</td>
<td>104</td>
<td>12,000</td>
</tr>
<tr>
<td>Peru Creek below Penn Mine, peak</td>
<td>7.3</td>
<td>200</td>
<td>1,600</td>
<td>2,200</td>
<td>46</td>
<td>n.a.</td>
</tr>
<tr>
<td>Peru Creek below Penn Mine, average</td>
<td>5.2</td>
<td>133</td>
<td>1,173</td>
<td>1,370</td>
<td>19</td>
<td>n.a.</td>
</tr>
<tr>
<td>Peru Creek background, above Penn Mine, peak</td>
<td>1</td>
<td>32</td>
<td>140</td>
<td>310</td>
<td>14</td>
<td>n.a.</td>
</tr>
<tr>
<td>Peru Creek background, above Penn Mine, average</td>
<td>0.8</td>
<td>14</td>
<td>35</td>
<td>212</td>
<td>7</td>
<td>n.a.</td>
</tr>
<tr>
<td>WQ standard</td>
<td>n.a.</td>
<td>5</td>
<td>1,000</td>
<td>50</td>
<td>4</td>
<td>n.a.</td>
</tr>
<tr>
<td>MATC&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.1/ 40%</td>
<td>62/ 45%</td>
<td>2,000</td>
<td>55.1/ 30%</td>
<td>547/ 55%</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

<sup>a</sup> parts per billion  
<sup>b</sup> MATC given as ppb that will cause a given % mortality in rainbow trout (EPA, Holm et al. 1979)  
n.a. = data not available

As noted above, dilapidated buildings on the mine site present a hazard to recreational users of the area. The east and west waste rock piles (Figure 1) are a source of heavy metal-laden soil. Tailings to the north of the old mill may also pose a hazard to aquatic life due to its potentially acidic and heavy metal-laden leachate discharges to Peru Creek.

### B. Standards to be met

The Pennsylvania Mine site is in a remote alpine environment used for recreation. Peru Creek is classified by the State of Colorado as a class 1 cold aquatic life stream with a class 2 recreation designation (Holm et al. 1979). In order to restore the creek to allow for fish habitation, metal concentrations in Peru Creek downstream of the Pennsylvania Mine must
be less than the concentrations listed for the MATC levels in the previous table. Reduction of metals loading to Peru Creek will include treatment of mine water, as well as interception or treatment of leachate from the mill tailings.

The clean-up standards for the hazards presented at the site should correspond with regulations for an area used exclusively for recreational purposes. The surface structures of the site need to be secured either by reinforcing the buildings (if they have historical significance), fencing in, and posting “Danger” signs around the area, or disassembling and removing the structures. The tailings and waste rock piles along the hillsides should be secured to prevent the spread of soil contamination by wind or water erosion. The piles may potentially be secured by “capping” with additional soil and vegetation, or by removal or rearrangement of the piles.

**C. Historical preservation needs**

The buildings on the Pennsylvania Mine site are in various states of disrepair. They are not considered to have historic value and no historical preservation is planned for any of the buildings on the site (personal communication with Gary Lindstrom, Summit County Commissioner, November 7, 2003 and with Brian Lorsch, Summit County Open Space, November 10, 2003).

**D. Community needs**

As noted above, several groups are involved in various water quality projects that concern the Peru Creek drainage, where the Pennsylvania Mine site is located. An earlier remediation project was terminated due to the 1993 EPA ruling and the Mokelumne River case. In response, Representative Mark Udall (D-CO) introduced the Abandoned Hardrock Mines Act of 2002 (HR 4078, now HR 504), which proposed to reduce the liability of organizations involved with cleaning up contaminated mine sites (Office of Congressman Mark Udall 2002); however, in its present form, the bill’s passage is unlikely (personal communication with Congressman Udall’s office, September 25, 2003). As for public health and environmental issues at the site, the county, local residents, and organizations have not demonstrated concern (personal communication with Gary Lindstrom, Summit County Commissioner, November 7, 2003 and with Brian Lorsch, Summit County Open Space, November 10, 2003).
V. Physical and biological site characteristics

A. Topography
The Pennsylvania Mine is located in the Peru Creek valley on the northwest slope of Decatur Mountain. Steep terrain characterizes the Peru Creek watershed, with elevations ranging from approximately 10,000 to over 14,000 feet. The slope of the mine site ranges from 27% at the main adit to 5% at Peru Creek, with an average slope of 11%. Alluvial deposits and till reveal evidence of glaciation in the U-shaped valley. The Continental Divide is less than one mile southeast of the mine; several avalanche chutes have been identified (Holm et al. 1979). Many peaks in the area, including Ruby Mountain and Brittle Silver Mountain, are above the regional timberline.

B. Geology
Precambrian rocks cover a large portion of the Peru Creek Valley, with Tertiary intrusive rocks occurring in a southwest-northeast trending belt. The Idaho Springs Formation is also present, mostly in the eastern part of the district (Lovering 1935). The Pennsylvania vein strikes N. 20-35° E., and dips steeply to the west in most places. Chiefly comprised of schistose rocks, the vein is located just east of the Montezuma quartz monzonite stock. Quartz schist, quartz biotite schist, injection gneiss, and granite gneiss are common on the lowest level of the vein. Thin dikes of Silver Plume granite, quartz monzonite porphyry, and pyrite are also present (CMLRD 1989).

C. Hydrology
The abandoned Pennsylvania Mine is located on the main stem of Peru Creek, a perennial tributary of the Snake River in the Upper Colorado River Basin (Holm et al. 1979; CDMG 1992). Contained by the Blue River drainage, the Peru Creek watershed encompasses 16 square miles, over half of which is above timberline. From its headwaters, the creek flows 6 miles through a glacial valley to its confluence with the Snake River's south fork. Peru Creek follows a standard hydrograph for snowmelt-fed streams with flow peaking in mid-June (Holm et al. 1979). Nearby perennial tributaries include Cinnamon Gulch, Warden Gulch, and Chihuahua Gulch. A trans-basin diversion tunnel transfers uncontaminated water from the upper reaches of Peru Creek above the Pennsylvania Mine site to Clear Creek (Holm et al. 1979). Few natural wetlands are found in the vicinity of the mine site, most likely due to
soil texture size and/ or local relief characteristics. However, several wetlands and beaver ponds are present in the lower reaches of the creek (CDMG 1992) (Figure 1).

**D. Soils and surficial materials**

The Pennsylvania Mine is surrounded by a high-elevation sub-alpine/ alpine ecosystem. The soils of the mine complex are generally poor, comprised of large quantities of talus and glacial till. Local waste rock piles near the adits and mill site are generally devoid of vegetation. The bog north of the mill site has a high water table and is underlain in part by tailings produced by past milling activities (CMLRD 1989). Additional waste rock piles are located near the east ore shed, also supporting little to no vegetation. Barren soils to the north of this area have also been affected by mine drainage, showing signs of metals precipitation.

**E. Meteorology and climate**

Annual precipitation averages approximately 75 cm/ yr with the majority occurring as snowfall. Snow remains year-round on the higher peaks of the watershed and covers the north slopes of the Peru Creek valley until late June. The site is usually accessible without the aid of skis from July to mid-October. The highest observed temperature in nearby Montezuma was 92º F, although maximum temperatures remain below freezing between November and March. Thunderstorms are frequent in summer.

**F. Biology**

Spruce forests interspersed with aspen groves cover most areas below timberline. The most abundant species are lodgepole pine (*Pinus murrayana*) and Engelmann spruce (*Picea engelmanii*). Alpine fir (*Abies lasiocarpa*) also grows on the site below 11,000 feet. The bog north of the mill site is dominated by three vascular plant species: water sedge (*Carex aquaticus*), hairgrass (*Deschampsia caespitosa*), and bog birch (*Betula glandulosa*) (CMLRD 1989). The Colorado Natural Heritage program presently tracks 50 species of concern in Summit County. Three of these species, whooping crane (*Grus americana*), greenback cutthroat trout (*Oncorhynchus clarki pleuriticus*), and penland alpine bog mustard (*Eutrema penlandii*), are found on the Colorado threatened and endangered species list and may be present within the Peru Creek watershed (Colorado Division of Wildlife, 2003).
VI. Environmental hazards: sources of constituents of concern

A. Mine wastes

An analysis of the mine waste rock has not been found at this time; however, waste rock composition can be roughly extrapolated from the geologic reports of the mine interior. Rocks common in the mine, and thus also in the waste rock piles, are quartz schist, quartz-biotite schist, injection gneiss, granite gneiss, quartz monzonite. Galena, pyrite, chalcopyrite, and quartz are common in the main ore veins. From these geologic minerals, it is clear that copper, iron, and lead are all major constituents of concern. One vein was reported to be stained with manganese, introducing it as a contaminant of concern (CMLRD 1989). Cadmium, zinc, and aluminum are also commonly found in conjunction with the minerals reported above, and are also contaminants of concern in the mine wastes. No mention was made of any alkalinity-producing minerals in the mine, to balance the acid generating capability of the sulfide minerals. However, as minerals such as alumino-silicates may be present in the mine wastes, which release cations to produce alkalinity, more studies of the acid neutralization potential of the mine waste should be conducted.

Leachability tests to determine how available the metals in the waste rock are to extraction have not been found for the site. Additional testing should be done on the waste rock to determine its leachability. Waste rock piles encompass an approximate volume of 30000-100000 m³ based on observations of the site, with approximately one-third located in the eastern waste rock pile and two-thirds in the western waste rock pile.

B. Mill wastes

No data has been located on the exact mill waste composition, leachability, or volume. A composition similar to waste rock is expected, with potentially higher concentrations of lead and copper due to their preferential transport to the mill for processing. Mill wastes may have undergone some leaching during the milling process in order to extract metals, in which case the tailings could have fewer metals than the waste rock. The volume of the mill wastes is largely unknown. Apparently, the mill wastes were dumped on top of the bog, though to what extent is not known. Considering that thousands of tons of ore were processed in this mill over the years, the extent of the mill tailings is likely to be very large, and further quantification of these wastes should be conducted.
C. Mining-related industrial wastes

Prior to the construction of the mill, the ore was shipped off-site for processing. The mill itself was powered by electricity. The ore-processing method is unknown but was most likely flotation. No previous reports have noted additional site contamination from mining related industrial wastes.

D. Discharging mine openings

Mine water from the site’s extensive internal workings drain through level F and discharge at the collapsed adit at a continuous rate of 40 to 150 gallons per minute (Stover 1998; Boulder Innovative Technologies 1995; CMLRD 1989) (Figure 1). A 1990 analysis of the adit water reported a pH of 2.8, alkalinity of 0, and a conductivity of 1510 µmhos (CDMG 1992) The adit discharge showed the following seasonal variation in metals concentrations of contaminants of concern (Baeseman 2003).

Table 2 Seasonal variability*

<table>
<thead>
<tr>
<th>Sampling date</th>
<th>Zn ppm(^a)</th>
<th>Pb ppm</th>
<th>Cd ppm</th>
<th>Ni ppm</th>
<th>Mn ppm</th>
<th>Fe ppm</th>
<th>Cu ppm</th>
<th>Al ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/22/2003-winter</td>
<td>24.5</td>
<td>b.d.</td>
<td>0.1</td>
<td>0.13</td>
<td>28.7</td>
<td>14.5</td>
<td>1.5</td>
<td>12.1</td>
</tr>
<tr>
<td>6/6/2003-spring melt</td>
<td>13.5</td>
<td>b.d.</td>
<td>0.060</td>
<td>0.076</td>
<td>13.0</td>
<td>5.1</td>
<td>1.6</td>
<td>12.7</td>
</tr>
<tr>
<td>7/21/2003-summer</td>
<td>72.6</td>
<td>0.064</td>
<td>0.47</td>
<td>0.34</td>
<td>67.1</td>
<td>99.3</td>
<td>11.4</td>
<td>b.d.</td>
</tr>
</tbody>
</table>

*Unpublished data generated by Jen Baeseman, University of Colorado, 2003
\(^a\)parts per million
b.d.= below detection limit

From this data, it appears that lower metal concentrations occur during spring snowmelt. Although flow measurements are not available, these lower concentrations may correlate with higher flows. This further indicates that the mine may receive recharge from the surface, which could be mitigated by plugging openings such as upper adits. If this does not adequately diminish flows, or if the recharge area is limited, a capillary barrier which limits infiltration of precipitation and snowmelt could be installed to decrease the amount of water reaching the mine.
VII. Environmental hazards: pathways of constituents of concern

A. Water

1. Water transport at the site

Mine water discharges from the collapsed main adit, level F, collecting in the main adit pond (Figure 1). Mine water then flows into Peru Creek from the east and west adit overflow streams. This is the primary water pathway at the site. Like the creek, mine drainage is very responsive to seasonal snowmelt (Boulder Innovative Technologies 1995). For example, in summer, after the spring melt season, the main adit discharged elevated metals concentrations, and iron oxide staining was observed in the east adit overflow stream floodplain (Table 2).

There are several secondary water pathways at the site. Overland flow, acidic and metal-laden from contact with eroded waste rock piles, drains into Peru Creek (EPA 1993; Holm et al. 1979). In addition, the bog drains into the creek, through both surface and groundwater flow. Water sampling revealed that the bog contains elevated metal concentrations from fine-grained pyritic tailings just below the mill and from overland flow (CDMG 1992). While the bog has been heavily studied, there is no groundwater data for other areas of the Pennsylvania Mine site. It seems likely, however, that mine water and infiltrating surface flow over the entire site percolate through the soil and bedrock into Peru Creek.

Finally, researchers have identified snowmaking at Keystone Ski Resort as a complex pathway that transports elevated concentrations of metals into previously pristine areas; water from the Snake River, some flowing from Peru Creek, is used to make snow, eventually melting and contaminating the ski area’s soils and draining streams (Todd et al. 2003).

2. Water quality at the site

As previously discussed, water from the Pennsylvania Mine’s main adit discharges at a pH of 2.8 and contains elevated metal concentrations including cadmium, copper, iron, lead, and zinc (Stover 1998; Holm et al. 1979) (Table 1). While it is assumed that there is some groundwater seepage from within the mine, the main adit is the primary discharge source (Stover 1998). Water in the bog is also contaminated. Even before mine water from the main
adit pond was diverted into the bog, it was nearly saturated with metals (CDMG 1992). Furthermore, bog groundwater had a pH less than 4.0, and the bog surface water had a pH averaging less than 3.5 (CDMG 1992). No other water quality data for the site was discovered.

3. Downstream water quality effects
Peru Creek has poor natural buffering ability because the watershed’s granitic bedrock contributes little alkalinity (Holm et al. 1979). Even during snowmelt peak flows, metal concentrations remain high, apparently because overland flow in the watershed makes contact with eroded waste rock and tailings piles at abandoned mines such as the Pennsylvania Mine site (Holm et al. 1979; EPA 1993).

Several water quality studies of Peru Creek have been conducted. Despite the presence of other abandoned mines in the Peru Creek watershed, all studies agree that the major source of contamination is the Pennsylvania Mine (CDMG 1992). Sampling has revealed elevated concentrations of the metals cadmium, copper, iron, lead, and zinc in the stream (Holm et al. 1979) (Table 1). Copper and zinc levels year-round exceed rainbow trout chronic toxicity tolerability (Stover 1998). Furthermore, the main adit discharge contains high levels of aluminum (Tables 1 and 2). Although no measure of aluminum concentrations in Peru Creek was discovered, visual inspection found milky water and white precipitates on rocks downstream of the tailings and bog, suggesting the presence of aluminum hydroxides.

This contamination has devastating results on aquatic life. Below the mine site, Peru Creek is a barren stream. A bio-assessment counted only three individual macroinvertebrates downstream from the confluence of the east and west adit overflow streams, and no fish were observed (Stover 1998). The site’s water quality effects are prevalent further downstream as well. Even in the south fork of the Snake River, immediately downstream of the Peru Creek confluence, a bio-assessment found only three brook trout (Stover 1998). While other abandoned mines in the Peru Creek watershed likely contribute to this downstream degradation, the Pennsylvania Mine has repeatedly been identified as the major contributor of acidic, metal-laden mine water (CDMG 1992; Stover 1998). In addition, the Snake River flows into Dillon Reservoir, a major drinking water source, but significant dilution eliminates human health risks (EPA 1993). Finally, no data concerning stream sedimentation was discovered. The presence of large waste rock piles and historic clear-
cutting at the site, however, probably result in stream sedimentation during peak overland flows.

**B. Air**

1. **Air transport at the site**

Air transport at the site is likely to be mostly from west to east, up the main valley towards the nearby Continental Divide and away from the closest populated areas. The Pennsylvania Mine is located on a northern slope perpendicular to the main west-east airflow. Assuming this area follows typical Colorado mountain wind patterns, local winds around the site will blow up the slope during the day and down the slope during the night (Bliss et al. 2003). Human receptors investigating the abandoned mine buildings will be downslope, or upwind of the waste rock piles during the day, and safe from the majority of contaminated wind-blown dust from the piles. People climbing on the waste rock piles themselves will be at greater risk of inhaling contaminated dust.

The area is snow covered much of the year, reducing exposure of the waste rock and tailings to wind erosion, and mitigating the effects of air-transported metal contaminants to human and ecological receptors.

2. **Air quality at the site**

Air quality at the site is most likely very good. Normal mountain breezes encountered during a site visit were not of sufficient strength to blow dust from the waste rock piles or from east and west adit overflow stream precipitates. The waste rock piles contain mainly larger grain sizes resistant to wind erosion. The adit overflow precipitates are composed of finer particles distributed along the sides of the adit overflow stream, and in the adit overflow floodplain. However, these sediments are located in lower-lying areas amongst trees, which act as windbreaks, lessening the wind erosion. Tailings are covered in vegetation, both moss and plants, mitigating wind erosion affects from this source.

3. **Downstream air quality effects**

Downstream air quality effects are likely to be minimal due to the small amount of windborne dust and to the few downstream (up-valley) receptors. Dust deposition on plants and animals downwind could be a potential exposure pathway, however observations at the site did not reveal this to be a major ecological exposure pathway. There is a weak airborne
pathway for contaminants, but receptors are located at a distance sufficiently far away, or are 
affected so slightly, that this pathway is negligible.

C. Land

1. Contamination of surface sediments

Three main land areas have been contaminated by mining activities at the Pennsylvania Mine 
site. These include the eastern and western waste rock piles, the east and west adit overflow 
stream beds and floodplains, and the mill tailings which extend into the bog located to the 
north of the mill building. Soil contaminant concentrations have not been discussed in 
previous reports reviewed thus far. Visual inspection of the waste rock piles revealed that 
many sulfides were present, and could potentially leach metals. The lack of plant growth 
along the adit overflow streambeds and floodplains indicate that metal concentrations in 
these soils are likely in excess of the levels tolerable by native plant species. The tailings 
north of the mill are covered in plant growth, indicating that at least the layer of soil closest 
to the surface in this area contains metals concentrations that can be tolerated by plants. 
Contaminated water issuing from these tailings and into Peru Creek indicate one of three 
possibilities: contaminated layers of tailings are located beneath the rooting depth of the 
plants; the plants are able to live with levels of soil contamination that pollute Peru Creek; or 
the contaminated waters entering Peru Creek do not originate from contaminated soils in 
this area.

2. Accessibility of site to potential receptors

The Pennsylvania Mine site is accessible by a four-wheel drive road, though some two-wheel 
drive vehicles are able to negotiate this road. The waste rock piles, adit overflow streambeds 
and floodplains, and tailings are all easily accessible by a short walk from a vehicle. The Peru 
Creek valley in general is a popular camping location during the summer months. Presently, 
families could easily recreate in the vicinity of the mine, and it would be possible for the 
unattended child to play in and eat contaminated soil and for adults to come into dermal 
contact with contaminated soil. Animals frequent the area, as evidenced by deer tracks in the 
est adit overflow stream bank, and other signs of terrestrial animal life.
VIII. Environmental hazards: observed and potential impacts to receptors and applicable standards

A. Human exposure

1. Ingestion

Due to the relative isolation of the Pennsylvania Mine site, ingestion of contaminants through undiluted mine discharge water or soil will not occur to the same receptor group on long-term basis. Hikers in the area could take water from Peru Creek, and be exposed to some heavy metals. Depending on the extent of water purification prior to ingestion, the amount of heavy metals ingested by hikers will vary. Boiling or chemical treatment (iodine or chlorine tablets) will not remove any heavy metals, while some filters with granulated activated carbon (GAC) portions will remove some metals (Johnson 2003). Ingestion of soil through dust and small amounts of consumed soil are not likely to be substantial enough to cause negative health affects. Hazardous metals at the site include lead, cadmium, and silver, all of which could cause negative health effects were they to be ingested. Downstream of the mine site, Peru Creek is significantly diluted. Drinking from Peru Creek once or twice is not likely to have deleterious health affects; however pregnant women and children are at greater risk of negative health affects from lead, but the concentrations of this metal are very low and are unlikely to be of concern (Irwin 1997). It has been determined that there is no risk to the Dillon Reservoir, a drinking water source downstream of the creek, as a result of the large dilution that occurs.

2. Inhalation

The site is not near a residential community, but routine breathing of dust from the site could be unhealthy. Some of the metals, i.e. cadmium, may be the most dangerous to humans when inhaled (Risk Assessment Information System). Workers installing any remediation systems should be aware of this risk and wear respirators when moving contaminated soils. Harmful substances have been and continue to be released from the Pennsylvania Mine site (EPA 1993). Hikers or other recreational users of the area could also inhale heavy metal-laden dust.

3. Dermal absorption

The dermal absorption factors for the constituents of concern at the Pennsylvania Mine site are 0.001 (Risk Assessment Information System), thus 1/1000 of the metals in the dust or
soil that a person's skin is exposed to are actually absorbed, and only the absorbed fraction is harmful. The chronic reference dose for dermal contact for these contaminants is relatively high, on the order of 0.001 to 0.1 mg/kg/day, with the exception of cadmium (the reference dose is the maximum mass in mg of contaminant per kg of body weight a person can be exposed to per day without experiencing negative non-carcinogenic health effects) (Risk Assessment Information System). Due to the high reference dose required for negative non-carcinogenic health affects to occur, the low absorption of these metals, and the small amount of exposure time, little human risk from dermal exposure is expected. Despite cadmium's low reference dose of $5.00 \times 10^{-6}$ mg/kg/day (0.000005 mg/kg/day), little risk is expected because the soil dusts are not likely to contain high concentrations of cadmium. Reports showing soil concentrations of metals have not yet been found.

B. Aquatic organisms
The aquatic life of the Peru Creek below the Pennsylvania Mine is essentially non-existent (Holm et al. 1979). Copper and zinc are present in levels above the chronic toxicity tolerable for fish, but downstream of the mine, macroinvertebrates can be found. Peru Creek is described as a Cold Water-Class 1 fishery, and Recreation Secondary Contact (CMLRD 1989). Cold Water-Class 1 fishery are waters that currently are capable of sustaining a wide variety of cold water biota, including sensitive species, these waters could sustain such biota but for correctable water quality conditions (CMLRD 1989). Recreation Secondary Contact are waters suitable or intended to become suitable for recreational uses on or about the water which are not included in the primary contact subcategory, including but not limited to fishing and other streamside or lakeside recreation (Environmental Protection Agency). Aquatic organisms are the most sensitive species to these metals. Elevated levels of cadmium, copper, lead, nickel, and zinc can cause reproductive and developmental problems (Irwin 1997).

C. Terrestrial organisms
Several terrestrial animal species inhabit the Pennsylvania Mine area. Deer tracks, beaver dams, and squirrels were observed. Birds may eat soil to aid in their digestion, and thus ingest contaminants. Herbivorous and omnivorous animals may eat plants that have accumulated metals from the soil or ingest contaminated soil while grazing on plants near the ground. Bioaccumulation may also occur through the food chain, affecting carnivores,
and omnivores that eat animals that have ingested these metals. An assessment of current terrestrial organism health affects has not been located, however potential impacts from elevated levels of cadmium, copper, lead, nickel, and zinc include thinner egg shells, cancers (from cadmium and lead) and growth and reproductive problems (Irwin 1997).

IX. Community issues

A. Evidence of exposure and toxicity

No evidence of exposure or toxicity for humans was discovered, nor did any of the reports consulted identify such concerns. The Pennsylvania Mine site is remote, accessible only by a rocky, dirt road. Use of this road varies seasonally; it is impassable when snow-covered and can be four-wheel-drive-dependent during wash-outs. At least in summer, however, visual observation suggests that this road is frequently used. Trailheads are nearby, and hikers may drink water from Peru Creek (EPA 1993). In winter, the area is popular with cross-country skiers (Holm et al. 1979; CDMG 1992). Thus, despite the surrounding area’s recreational popularity, it is unclear how many people, if any, turn off the road and visit the site.

There are no towns or communities in the site’s immediate vicinity. Summit County has zoned the site rural, A-1, which only allows uses compatible with agriculture and ranching (Truckey 2003; Summit County 2003). Although Peru Creek water flows into Dillon Reservoir, a major drinking water source, significant dilution eliminates human health risks (EPA 1993). Two summer cabins along the road were observed, but it is unknown if they rely on water from Peru Creek or an aquifer gaining from the creek. If additional development requiring water from wells or the from the creek were to occur near the site, exposure and toxicity would have to be re-examined. Summit County will update the Snake River Master Plan in 2004 whereby the site’s land-use designation could change to allow more intensive human use (Truckey 2003).

B. Perception of risk

There appears to be little perception of risk regarding exposure and toxicity to humans from the site. Apart from hikers and other backcountry recreationists, there are no known users of Peru Creek water immediately downstream from the Pennsylvania Mine adit discharge (EPA 1993). There are no towns or communities in the site’s immediate vicinity, the area is undeveloped, and there is no current evidence of exposure and toxicity. Although, Peru Creek flows into Dillon Reservoir, a major drinking water source, significant dilution
eliminates human health risks (EPA 1993). The CDMG clean-up operations at the site were based on mitigating perceived environmental rather than public health hazards (Stover 1998).

C. Perception of responsibility
There appears to be little perception or acceptance of responsibility for the site. No party has publicly accepted responsibility or remediated the site’s contamination. While the CDMG developed a treatment system, once the threat of long-term site liability arose, the CDMG disavowed responsibility by terminating its site operations. The site owner, Trans-Pacific Tourism, has done nothing more than grant the CDMG permission to enter for reclamation activities, possibly demonstrating perception, but no acceptance of responsibility (CDMG 1992). Trans-Pacific did not own the Pennsylvania Mine during its working years; the truly responsible parties from the site’s productive years have long since died, dissolved, sold out, or disappeared.

D. Economic effects of remediation vs. no action
No data were discovered that analyzed the economic effects of undertaking remediation versus taking no action at the site. Clearly, however, the CDMG decided that liability burdens exceeded remediation benefits when it terminated site remediation. In order to perform a cost-benefit analysis of this decision, further study is required. Potential issues are how much more money above the $170,000 already spent is needed to complete and maintain the treatment system. What burdens and benefits of remediation may be quantified economically? Would further investment at the Pennsylvania Mine reap technological benefits for other abandoned mine remediation projects? What economic value would result from a restored, fishable Peru Creek? What future development would be impaired by the stream contamination? Considering the number of abandoned mines in Colorado, what proportion of limited state resources does remediation of the mine deserve? Nonetheless, in the current economy, without community demand for cleanup and the risk of perpetual liability, taking no further action at the Pennsylvania Mine is, in a purely economic analysis, the prudent decision.

E. Role of federal regulatory and land management agencies
The Pennsylvania Mine site is privately owned. Nonetheless, two federal agencies play a role in future activity at the site. The first, EPA, enforces the Comprehensive Environmental
Response, Compensation, and Liability Act (CERCLA), which provides for the remediation of releases of hazardous substances. Under the act, EPA can undertake or compel responsible parties to undertake emergency removal and remediation actions at contaminated abandoned mine sites such as the Pennsylvania Mine. To do so, EPA must place the site on the National Priorities List, an inventory of the nation’s most hazardous sites, and determine that there are no responsible parties who can pay for removal or remediation (Findley 1996).

It is unclear whether the Pennsylvania Mine site is a feasible candidate for CERCLA action. Its national priority is undetermined, and the financial viability of responsible parties is unknown. Even so, CERCLA plays an additional role at the site. The act’s joint and several liability provisions impose liability upon site owners and operators who cause the release of a hazardous substance, even if that release results from remediation actions (McAllister 2003; Findley 1996). CERCLA, however, likely allows Good Samaritans such as the CDMG to contract with EPA for non-emergency cleanup, without incurring liability (McAllister 2003). If the statutory procedures are followed, then CDMG or other Good Samaritans should not incur CERCLA liability at the Pennsylvania Mine site.

EPA also is responsible for enforcing the CWA’s provisions. Although it has delegated much of its CWA management authority to the State of Colorado, EPA still has oversight and enforcement power (McAllister 2003; Findley 1996). For example, Colorado’s requirements cannot be less strict than EPA’s. Also, EPA can issue CWA Section 319 grants for nonpoint source abatement (McAllister 2003). These grants were used for many years at the Pennsylvania Mine, funding the inactive treatment system (Stover 1998).

More importantly, EPA can make an administrative determination on CWA interpretation as to whether a particular pollutant source is point source as defined by the act. Courts typically uphold these determinations (McAllister 2003). In 1993, EPA determined that runoff from mine waste piles and adits were point sources of pollutants, therefore requiring NPDES permits (McAllister 2003; Stover 1998). This decision had far-reaching impacts; fearing perpetual CWA liability arising from maintaining a NPDES permit, Colorado terminated its remediation at the Pennsylvania Mine in 1998 (Stover 1998). EPA could reverse its position, either broadly or for the Pennsylvania Mine specifically (Gellhorn 1997). Even so, a good Samaritan still could face CWA liability: a disgruntled stakeholder...
could file a citizen suit challenging EPA’s determination and gain an unfavorable judicial interpretation, as in the Mokelumne River case (McAllister 2003).

Second, the USFS manages the National Forest land surrounding the Pennsylvania Mine. Even though the site is privately owned, it could be regulated by the USFS under specific congressional delegation (Coggins 2002). Also, the USFS has discretion to allow site owners or operators to occupy or use its land by granting a special use permit, as CDMG received for the penstock installation (Coggins 2002; Stover 1998). Finally, the USFS has authority to sue responsible parties for natural resource damages on its land that resulted from contaminant migration (McAllister 2003; Findley 1996). As with EPA’s broader CERCLA authority, this power is largely irrelevant at the site unless a financially solvent responsible party were identified.

F. Role of state regulatory and management agencies

The Colorado Department of Public Health and the Environment (CDPHE) plays a key role at the Pennsylvania Mine by managing the state’s CWA program. It sets ambient water quality and total maximum daily load (TMDL) standards, issues NPDES-type permits, and works with EPA on Section 319 grant distribution (CDPHE 2003; McAllister 2003). As a result, any future point source discharge permit for the site will have to be issued by the CDPHE. Should the site again be designated a nonpoint source, then the CDPHE may seek additional Section 319 remediation funding.

X. Data needs

A. Water transport and quality

Several questions remain to be answered regarding water quality at the Pennsylvania Mine site. The bog present at the site clearly predates the bioreactor beds installed in the original treatment project, but its origin—whether it is in fact a natural wetland or if it occurred as a natural reaction to the tailings pile that now partially covers it—is unclear. It is assumed that the mill wastes were dumped on top of the bog, although the amount is unknown. An analysis of the extent of the tailings deposited on top of the bog (if that was in fact the case) would aid in the design of a remediation project. Other than the bog, which has been heavily studied, there is no groundwater data for other areas of the Pennsylvania Mine site.

No data has been located on mill waste composition, leachability, or volume. Additional sampling and measurements are required. Previous reports have not discussed soil
contaminant concentrations, which would aid in the remediation design. Additionally, no data was located on stream sedimentation.

**B. Air transport and quality**

Air quality at the Pennsylvania Mine site is assumed to be good. The potential source of air contamination is dust from waste rock. No studies have been found that address air quality, however, so this may need to be verified.

**C. Community exposure and toxicity**

No further data needs have been identified.

**D. Community attitudes about risk, toxicity, history, landscape, and remediation**

Summit County Open Space and Trails department was awarded a Brownfields Grant in 2001 for assessment and restoration of the Peru Creek basin. The project aims to improve and restore the natural ecosystem and enhance recreational opportunities (Summit County 2001). It is unclear to what extent this project affects the Pennsylvania Mine site.
References


October 20, 2003

Dr. Joseph Ryan  
County Engineer  
Dr. David Stiller  
County Geologist  
Summit County Government  
P.O. Box 68  
Breckenridge, CO 80424

Dear Sirs:

Attached is our report, Site Characterization I and II: Pennsylvania Mine, Summit County, Colorado. As you requested, this report contains a review of the mining and ownership history, current status, geology, hydrology, water quality, and human and ecological health risks of the abandoned the Pennsylvania Mine site.

Should the Summit County Commission decide to move forward, we can prepare a design alternatives report that will examine remediation plans for the site. Our current schedule would allow us to complete such a report by November 17, 2003, while working under the previously agreed billing rate.

Thank you for allowing us to participate in a possible remediation of the abandoned Pennsylvania Mine site. If you have any questions or require further assistance, please contact us at your convenience.

Sincerely,

Timothy Fazekas  
Jonathan Fero  
Jessica Lage  
Peter McCarthy  
April Tumey  
Abandoned Mine Remediation Team
Map 1 - Regional Map
Map 3 - Site Map

SUMMIT COUNTY

ARAPANO NATIONAL FOREST
U.S.A.

Adjacent 2091-200

2091-200
SEC. 20, T.53S., R.7E W

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Map 4 - Pennsylvania Mine Workings