OPEN-FILE REPORT 01-11

History, Geology, And Environmental Setting of the Tweed Mine, Pike/San Isabel National Forest, Chaffee County, Colorado

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FOREWORD

Open-File Report 01-11 describes the history, geology, and environmental setting of the Tweed Mine near Monarch Pass west of Salida. The Tweed Mine lies mostly on private land, but effluent from the mine flows onto U.S. Forest Service-administered land and into the Middle Fork of the South Arkansas River. The U.S. Forest Service selected this site for detailed investigation because of the results of an abandoned mine inventory recently completed by the Colorado Geological Survey. State and Federal agencies and private owners can use this study for developing realistic and cost-effective reclamation plans for the Tweed Mine.

Funding for this project was provided mostly by the U.S. Forest Service (Agreement No. 1102-0007-98-035). Partial funding came through the Water Quality Data program of the Colorado Geological Survey from the Colorado Department of Natural Resources Severance Tax Operational Fund. Severance taxes are derived from the production of gas, oil, coal, and minerals.

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ABBREVIATIONS AND SYMBOLS

ATV	all-terrain vehicle
bk..	book
cm	centimeter
CGS	Colorado Geological Survey
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
cps	counts per second
CR	County Road
°	degree
EE/CA	Engineering Evaluation/Cost Analysis
EDR	Environmental Degradation Rating
EPA	United States Environmental Protection Agency
=	equals
FR	Forest Road
4WD	four-wheel drive
gpm	gallons per minute
<	less than
µg/L	micrograms per liter
µ	microns
µS	microSiemens
mg/L	milligrams per liter
>	more than
NPL	National Priorities List
n/a	not applicable
no.	number
#	number
oz(s)	ounce(s)
p.	page(s)
ppm	parts per million
%	percent
PHR	Physical Hazard Rating
pCi	picoCuries
lb(s)	pound(s)
PBS	Primary Base Series
SH	State Highway
x	times (when factoring ion concentrations or radioactivity)
trec	total recoverable
U.S.	United States
USFS	United States Department of Agriculture - Forest Service
BLM	United States Department of Interior - Bureau of Land Management
v.	volume

INTRODUCTION

During an abandoned mine inventory in 1994, the Colorado Geological Survey (CGS) assigned Environmental Degradation Ratings (EDRs) of 2 (significant environmental degradation) to the Tweed Mine and its associated waste-rock pile. This work was done as part of a statewide inventory of abandoned mines on or having potential environmental impacts to U.S. Forest Service-administered lands. In 1999 the U.S. Forest Service requested more information regarding the Tweed Mine.

Mine features discussed in this report are west of Salida near Monarch Pass (Figure 1) and fall within the "Southwest of Hoffman Park" inventory area (USFS-AMLIP form 12-02-384/4269-3). Adit #100 and associated waste-rock pile #200 are described in detail; other mine features within this inventory area were not considered significant environmental problems and were not included in this study (Appendix).

Information revealed in this study suggests that adit #100 is the lower working of the Tweed Mine. Adit #101 is also considered part of the Tweed Mine and is higher on the hill above adit #100. Mineral Survey No. 18695 indicates that both workings are on patented mining claims (Figure 2). Apparently, this block of patented mining claims was not plotted correctly on the Garfield PBS map (Figure 3). An accurate survey is needed to confirm the location of the patented claim block. Although the Tweed Mine is probably on private land, effluent draining from adit #100 flows onto USFS-administered land and into the Middle Fork of the South Arkansas River.

LOCATION

The "Southwest of Hoffman Park" inventory area (12-2-384/4269-3) is on the northeastern side of the Middle Fork of the South Arkansas River about 2 miles northwest of Garfield. Access is by Forest Road 230, a 4WD road that follows the Middle Fork beginning at U.S. Highway 50 west of Garfield (Figure 1). Elevation is about 10,840 feet at adit #100.

HISTORICAL OVERVIEW

Most of the stream valleys in the Monarch mining district had been prospected for placer gold by the late 1860s. Lode deposits were first discovered about 1878. By 1882 most of the larger deposits were discovered. The district was most active from 1883 until 1893, when the price of silver dropped to $0.70 per ounce and many mines closed. Estimated value of lead-silver-gold ore produced before 1901 was $9 million. Between 1901 and 1949 the value of lead-silver-gold-zinc-copper ore produced was estimated at $4 million. Nearly 50 percent of the total output from the district came from the Madonna Mine. (See Dings and Robinson, 1957, p. 43–44; Heyl, 1964, p. 77.)

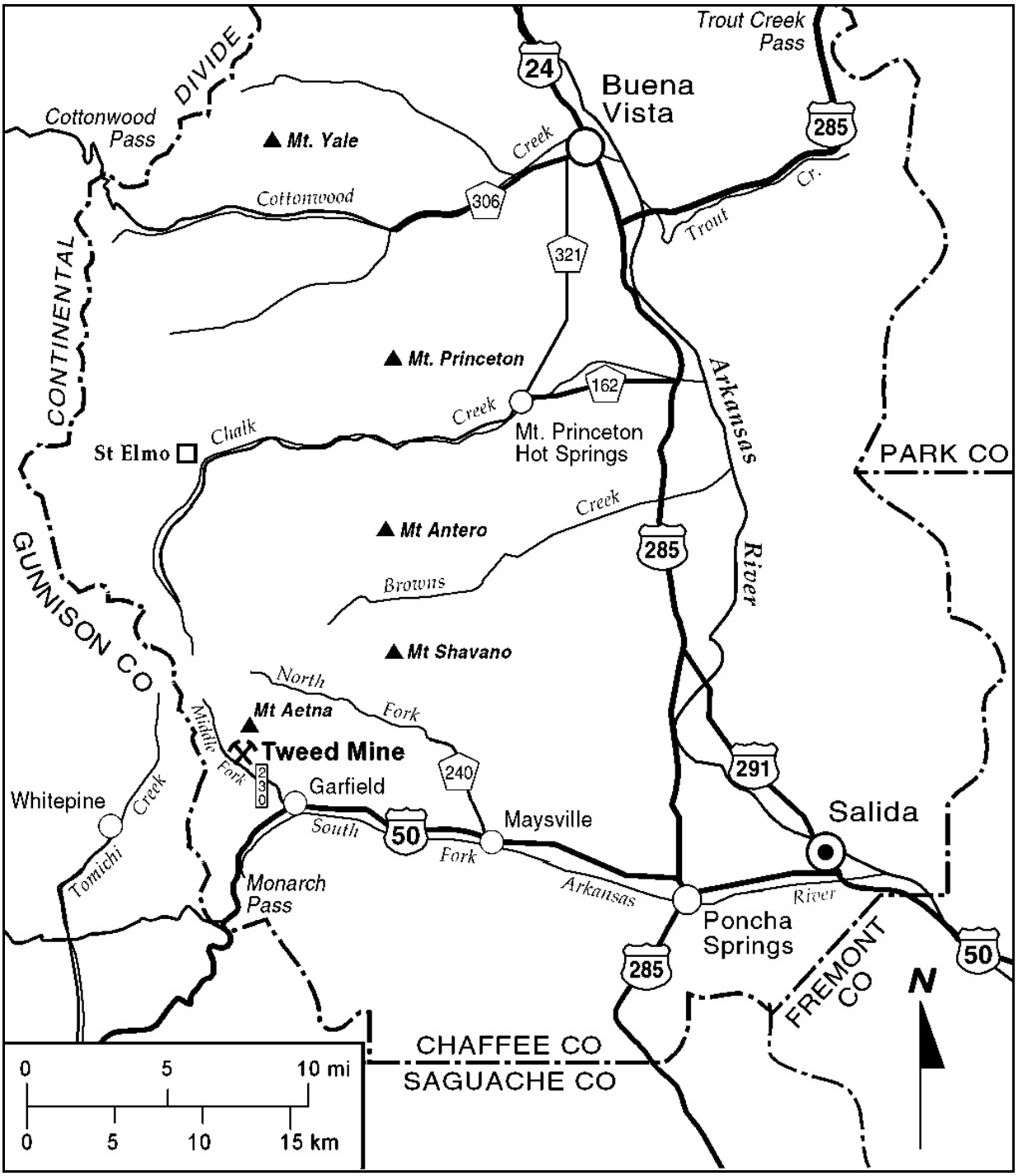


Figure 1. Index map of the Tweed Mine.

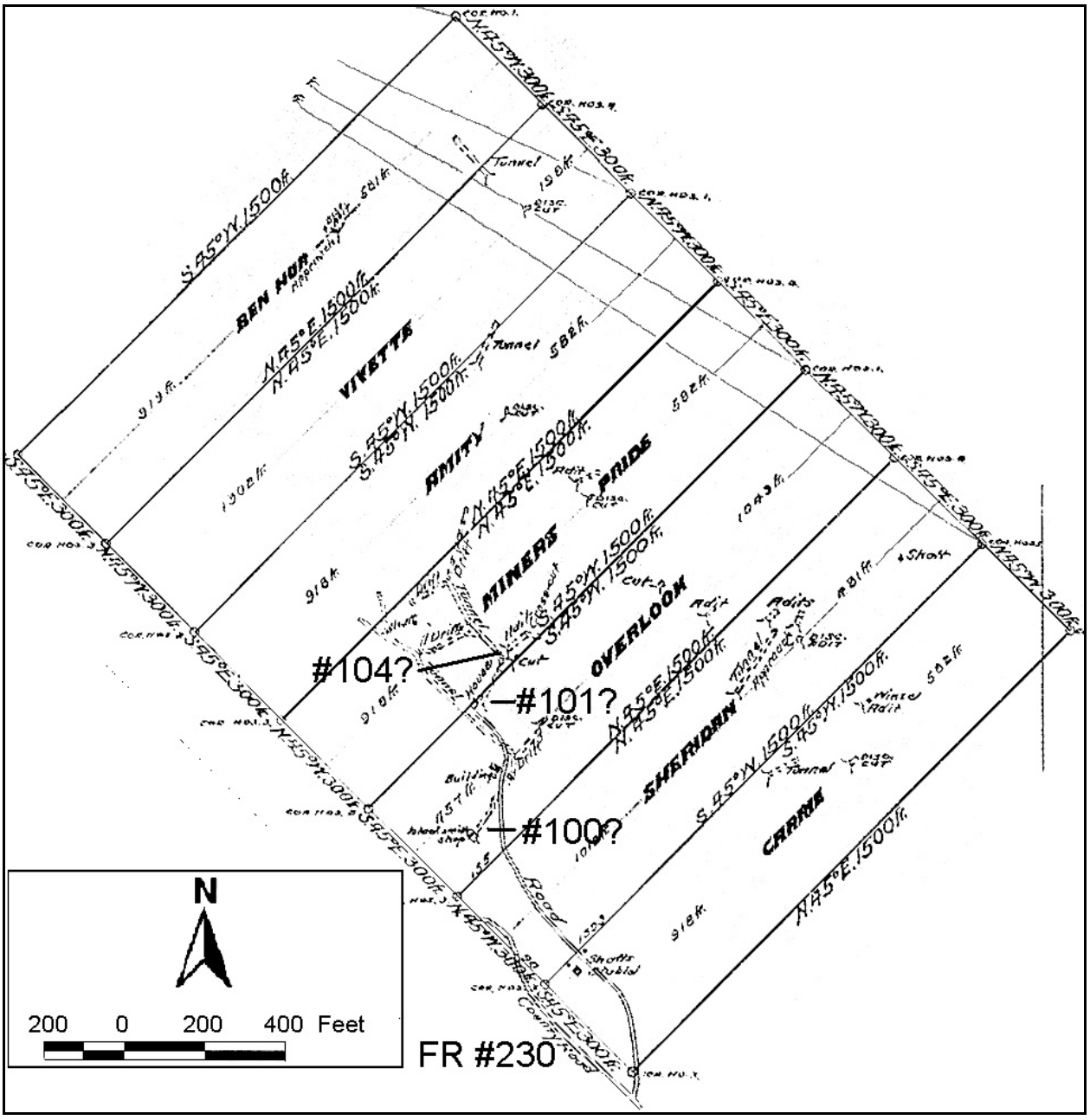


Figure 2. Mineral Survey No. 18695 of the Tweed Group. (Modified; scale is approximate.)

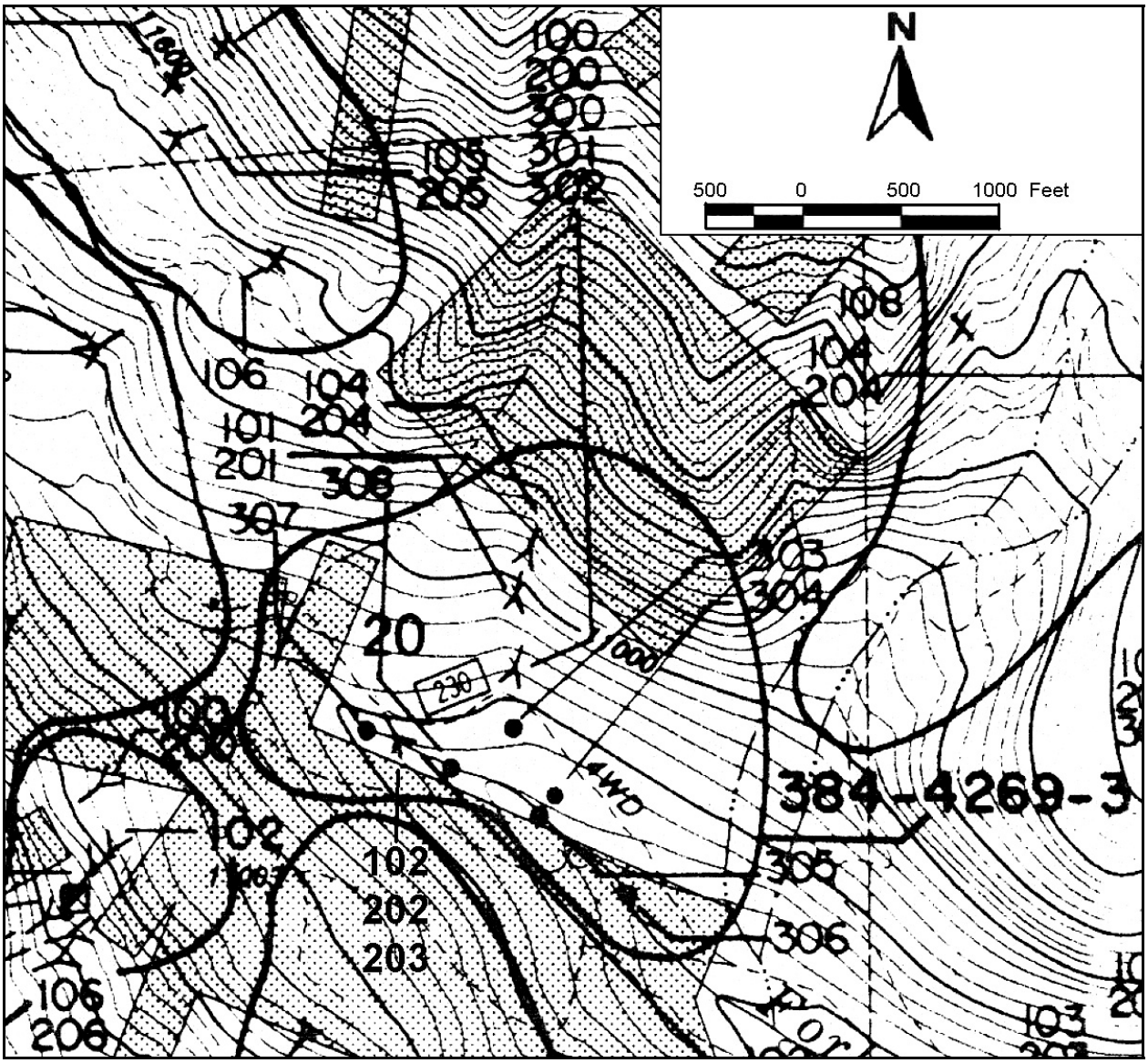


Figure 3. PBS map of part of the Garfield quadrangle showing inventoried mine features in the "Southwest of Hoffman Park" inventory area (12-02-384/4269-3) and patented mining claims. (Scale is approximate; surface openings for the Tweed Mine are adits #100, #101, and #104 of inventory area 384/4269-3; shaded areas represent patented mining claims.)

MINING HISTORY

Summary

Scant information was discovered regarding mining activity at the Tweed Mine. No records of production were found, and any unrecorded production was probably small and not reported in the contemporary newspapers and journals. Claims were staked at this site in 1879, and the mine

was probably intermittently active until 1908. By 1900 underground workings were 800 feet long. When a mineral survey was conducted in 1908 workings at the lower Tweed (adit #100) were about 1,100 feet long, and upper adit #101 was about 800 feet long. No mining activity was reported after the survey, however, the claims were patented in 1910. From 1964 to 1988 various subsidiaries of Kennecott Mining Corporation owned the property and possibly conducted exploration activities, but no underground mining or production was recorded.

Details

In June 1879, W.W. Tweed and Charles A. Tweed located the Iron Crown Lode claim. The Tweeds quitclaimed one-half interest in the claim to J.M. Gibbs in March 1880. W.W. Tweed and Daniel Rouk located the Central Mine Lode claim, adjacent to the Iron Crown, in June 1880. Later in June, the Tweeds quitclaimed one-third interest in the Iron Crown Lode to J.A. Kittring. (See bk. 2, p. 524; bk. 7, p. 341, 347; bk. 8, p. 10.) According to the Rocky Mountain News (November 27, 1880, p. 2), the Tweed Mine in Middle Park was “equally as rich as the Gunshot” with assay values “up in the thousands per ton”. No production was reported, however.

In January 1885 Charles DeGraff located the Overlook and Miners Pride Lode claims over the presumably abandoned Central Mine and Iron Crown Lode claims (bk. 26, p. 365-366). In June DeGraff sold one-third interest in the Overlook and Miners Pride to Frank Tweed, Charles Tweed, and Cap Tweed (bk. 36, p. 187).

In February 1887 C. DeGraff sold one-sixth interest in the Overlook and Miners Pride to W. LeFever, who sold his interest in the claims to Georgia Smith in March. C. DeGraff sold 50 percent interest in the Overlook and Miners Pride to David DeGraff in June. In October, C. DeGraff bought back one-third interest in the claims from the Tweeds. (See bk. 36, p. 505; bk. 53, p. 37; bk. 36, p. 549; bk. 58, p. 31.)

D. DeGraff and LeFever amended the location on the Overlook and Miners Pride Lode claims in 1888, and DeGraff sold one-sixth interest in the claims to LeFever in 1889 (bk. 10, p. 183; bk. 58, p. 180).

A court decision awarded D. DeGraff one-third interest in the Tweed group (including the Overlook and Miners Pride) in a judgement against LeFever in 1894, but then DeGraff sold 50 percent back to LeFever in 1898 and 1899 (bk. 76, p. 527; bk. 112, p. 385; bk. 127, p. 28).

During 1900 LeFever supervised activity at the Tweed group of mines, owned by LeFever, Biddles, and DeGraff. By 1900 the Tweed group had been worked intermittently for almost 20 years, and the adit was 800 feet long. A 30-foot-wide vein containing copper sulfides and several thinner high-grade veins were exposed underground. (See the Denver Times, January 24, 1900, p. 10.) LeFever sold some interest in the Overlook and Miners Pride to William Roller in December 1900 (bk. 112, p. 386).

In January 1904 LeFever sold additional interest in the Overlook and Miners Pride to Roller. In August, LeFever and Roller agreed to sell the Overlook and Miners Pride to Sam Stern for $50,000. This potential deal probably fell through, because LeFever and Roller sold interest in the claims to D. DeGraff in 1905 and 1906. (See bk. 125, p. 504; bk. 127, p. 31, p. 211, p. 336; bk. 133, p. 213.)

In April 1908 the heirs of D. DeGraff sold one-third interest in the Overlook and Miners Pride to Emily DeGraff. Roller sold his interest to LeFever in May. DeGraff (two-thirds ownership) and LeFever (one-third ownership) amended the location on the claims in June. (See bk. 117, p. 582; bk. 127, p. 479; bk. 119, p. 454.) In July Mineral Survey No. 18695 was conducted on the Ben Hur, Vivette, Amity, Miners Pride, Overlook, Sheridan, and Carrie Lodes (Figure 2). On the mineral survey, workings at the lower adit (#100) included over 700 feet of tunnel and 400 feet of drifts. Workings at the middle adit (#101) included 400 feet of tunnel and 400 feet of drift. Both mines originated on the Overlook Lode and undercut parts of the Miners Pride and Amity Lodes. (See Mineral Survey No. 18695, available at the BLM, Colorado State Office.)

In 1910 a patent was granted to DeGraff and LeFever for all seven claims included in Mineral Survey No. 18695 (bk. 50, p. 3).

Several tunnels existed on the Tweed group when visited by the Colorado Geological Survey about 1913. The mines may have been caved, because observations by Crawford (1913, p. 275) only include minerals on the dumps.

In 1924 E. DeGraff sold her interest in the Overlook and Miners Pride to Francis DeGraff. LeFever's heirs sold their interest in the claims to W. Roller in 1927, and W. Roller sold it to Douglas Roller in 1928. (See bk. 139, p. 41, bk. 185, p. 431; bk. 205, p. 103.)

In September 1930 D. Roller sold one-sixth interest in the Overlook and Miners Pride to Francis DeGraff, who sold it to Flora Nash a week later (bk. 205, p. 201-202).

Chaffee County acquired the Overlook and Miners Pride because of delinquent taxes in 1940 (bk. 237, p. 89).

By 1950 the upper and lower Tweed adits were inaccessible. Total underground workings were calculated at 2,500 feet from the volume of dump material. No production records were found. (See Dings and Robinson, 1957, p. 94-95, plate 1.)

Chaffee County sold the Overlook and Miners Pride to Ray Gilbert in August 1964. Gilbert then sold them to Kennecott Mining Corporation in September (bk. 334, p. 185, 272).

In 1968 Kennecott Mining Corporation sold the Overlook and Miners Pride Lodes to Teepee Oil Company. Teepee Oil sold them to Bear Tooth Mining Company in 1971. (See bk. 361, p. 683; bk. 373, p. 702.)

Kennecott Mining Corporation, parent company of Bear Tooth Mining Company and Bear Creek Mining Company, gave the Overlook and Miners Pride Lodes to Kennecott Corporation in 1987. In 1988 Kennecott sold them to American Gold Resources Corporation. (See bk. 488, p. 170; bk. 499, p. 491.)

Montague Hackett purchased the Overlook and Miners Pride from American Gold Resources Corporation in 1991. In 1993 he sold them to Melinda Hackett, who then sold them back to American Gold Resources Corporation in 1995. (See bk. 519, p. 495; bk. 532, p. 760; Chaffee County Courthouse serial no. 278083.) The Hacketts were probably owners or principal officers of American Gold Resources.

In 1997 American Gold Resources Corporation sold the Overlook and Miners Pride Lodes to Oray Associates. Oray Associates owned the claims in May 1999 (Chaffee County Courthouse serial no. 289617).

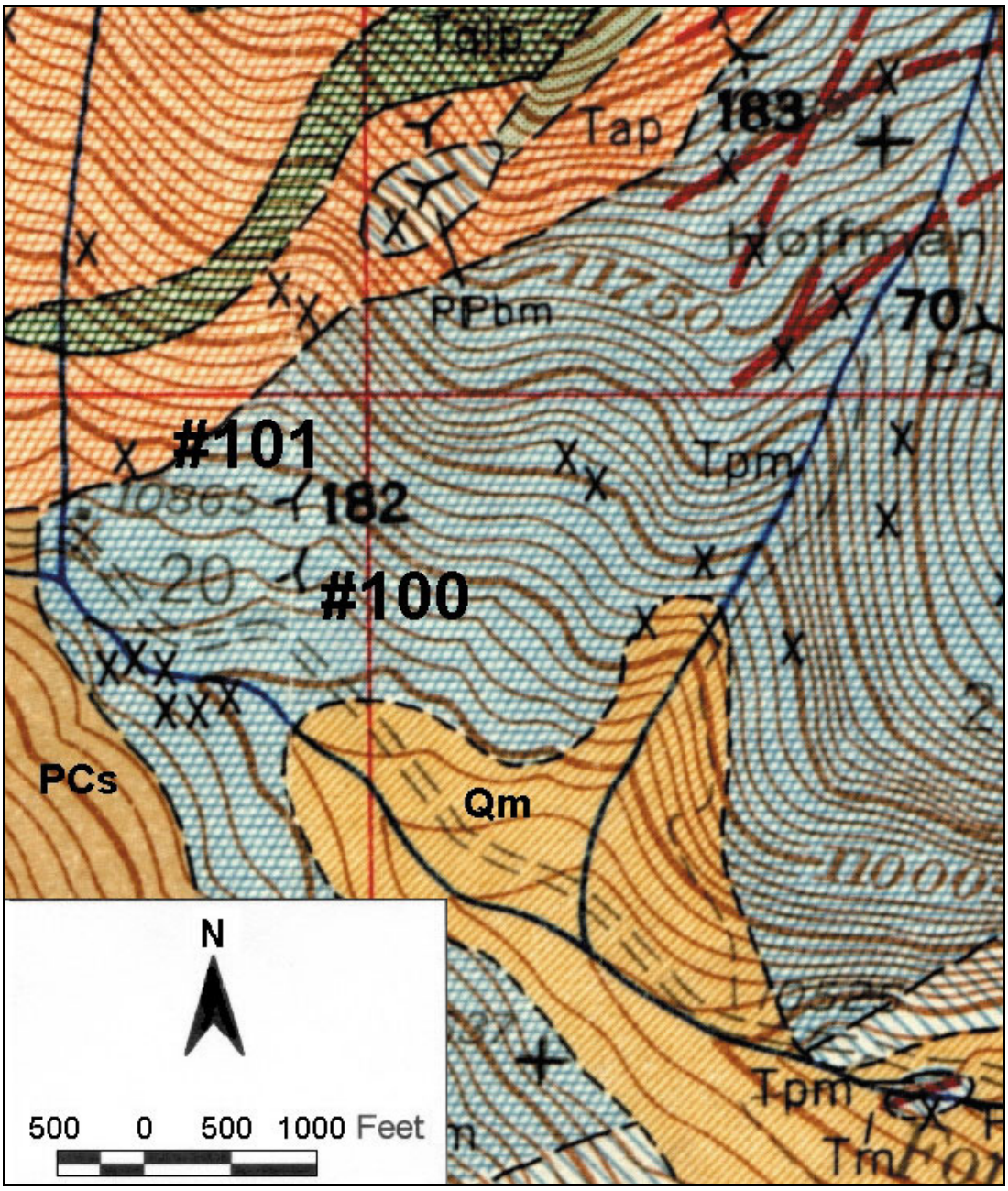
Claim Blocks

Monarch Molybdenum and Resources, Inc. and D&G Mining Company (Harold Downey-general partner) located the Big Bertha claim block in 1968, and in 1985 Jan E. Fay located the Pica #1–5 claim block. Both these claim blocks covered the Tweed Mine, even though it presumably lies on private land. In 1991 the BLM closed the case on the Big Bertha and Pica claim blocks. (See mining claim files, available at the BLM, Colorado State Office.)

GEOLOGY

Geologic maps for this area were published in 1913 (Crawford) and 1957 (Dings and Robinson). A large body of Mount Princeton quartz monzonite crops out at the Tweed Mine, and the ore deposits of the Monarch mining district are probably related to this large Tertiary-age intrusion. This rock unit is typically gray, medium-grained, and is composed of feldspar, quartz, biotite, and hornblende, with minor amounts of titanite (sphene). Fragments of quartz vein up to 5 inches thick containing galena, sphalerite, chalcopyrite, and calcite were observed on the dumps. (See Crawford, 1913, p. 78, 79, 275; Dings and Robinson, 1957, p. 25-27, 94-95.)

The orientation and placement of underground workings shown on Mineral Survey No. 18695 suggest that the veins exposed underground at the Tweed Mine strike north to northeast, similar to those at the nearby Uncle Sam Mine to the northeast (Figure 4).



Qm-Quaternary moraine
Tm (red lines)-monzonite or latite dikes
Tap-Tertiary Mount Aetna quartz monzonite porphyry
Tqlp-Tertiary quartz latite porphyry
Tpm-Tertiary Mount Princeton quartz monzonite
Tgm-Tertiary gneissic quartz monzonite
PPbm-Pennsylvanian and Permian(?) Belden Shale and Minturn Formation
PCs-Precambrian Silver Plume(?) granite
Numbered mines: #70-Hercules; #182-Tweed; #183-Uncle Sam.

Figure 4. Geologic map of the Tweed Mine area. [Modified from Dings and Robinson (1957, plate 1); scale is approximate.]

SITE DESCRIPTION

Adit #100 and associated waste-rock pile #200 in the "Southwest of Hoffman Park" inventory area (384/4269-3) were assigned EDRs of 2 by the CGS during the 1994 site visit. Features #101/201, #104/204, and #102/202/203 were not considered significant environmental problems. Mine features #100/200, #101/201, and #104/204 are part of the Tweed group and are probably located on the patented Overlook and Miners Pride Lode claims (Figure 2). Mine features #102/202/203 are near the Middle Fork of the South Arkansas River, probably on USFS-administered land.

A moderate volume of water flows from collapsed adit #100, through a trench, and into the ruins of a log building, probably the blacksmith shop shown on the mineral survey (Figure 2). The effluent path splits in the building debris; most flows between the two lobes of dump #200, but some water flows west before soaking into the northwest lobe (Figures 5, 6). Some acidic water, which is probably a combination of mine effluent and groundwater that is percolating through the unconsolidated colluvium/soil on this slope, emerges at the toe of dump #200. The volume of these springs is less than 10% of the total water draining from the site. A large marsh below the toe of dump #200 (Figure 7) receives the mine effluent, dump seepage, and some surface runoff from higher on the hill. Water draining from this marsh crosses Forest Road 230 (Figure 8) and enters another marsh that joins the Middle Fork of the South Arkansas River. The portal of adit #100 is about 600 feet from the river.

WASTE AND HAZARD CHARACTERISTICS

Mine effluent is the most serious environmental concern at the Tweed Mine. In July 1994 about 15 gpm of effluent with pH of 6.0 and conductivity of 100 µS/cm was flowing from caved adit #100. Water sample 384/4269-3.300 was collected adjacent to the portal. Lab results indicated that the effluent exceeded State standards in aluminum (34 times), cadmium (10 times), lead (3 times), manganese (19 times), zinc (30 times), iron (8.7 times), and copper (1.3 times). (See Benson and others, 1997, p. 10-11.)

In June 1999 about 12 gpm of effluent with 5.26 pH and 168 µS/cm conductivity flowed from caved adit #100. The effluent channel contained abundant, mostly uncemented red-brown precipitate, some of which was trapped in the plentiful algae. Two water samples were collected adjacent to the portal (384/4269-3.1 and 384/4269-3.2). Lab results showed that the effluent exceeded standards in aluminum, cadmium, fluoride, iron, lead, manganese, and zinc (Table 1). For many parameters, 1999 values were slightly lower than 1994 values, but the difference was generally insignificant.

No samples were collected from the small seeps at the base of dump #200 (Figure 5). Water from the seeps had lower pH (4.03 to 4.30) and higher conductivity (210 to 236 µS/cm) than effluent at the portal. Effluent seeping into the dump has increased residence time to react with and dissolve sulfide minerals in the waste rock, lowering the pH and increasing the conductivity.

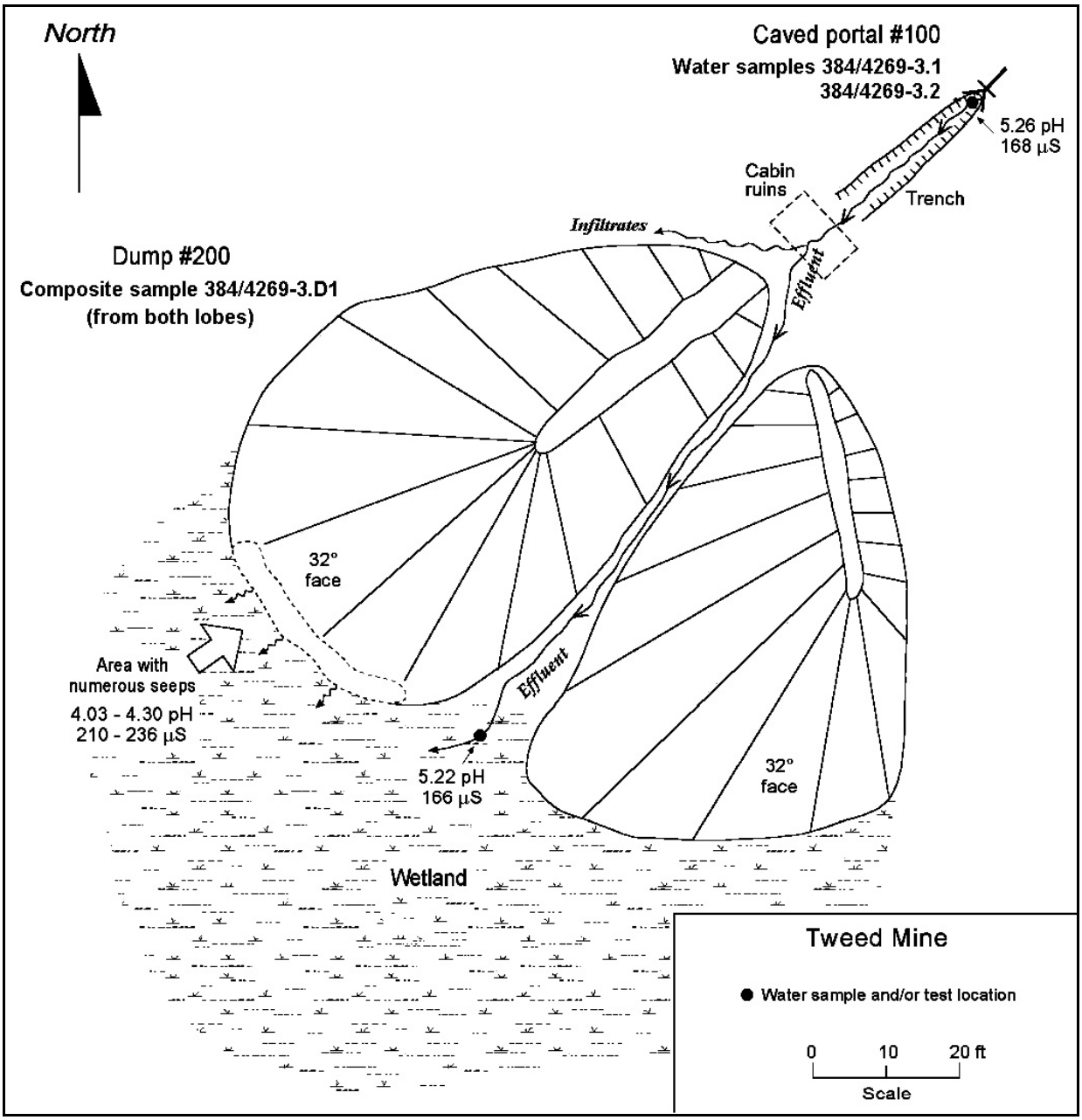


Figure 5. Surface map of the lower Tweed Mine area.

Water sample 384/4269-3.3 was collected adjacent to and above Forest Road 230, and below the marsh at the toe of dump #200. Flow was 8 gpm, pH had dropped to 4.24, and conductivity had increased to 212 µS/cm compared to portal water. Aluminum, zinc, manganese, copper, cadmium, and lead concentrations also increased (Table 1). The lower pH and higher metal concentrations at this sample site may reflect the addition of the dump seepage described in the above paragraph. Although still exceeding standards, iron concentrations were significantly reduced at this site compared to the portal, probably because of the deposition of moderate to abundant amounts of red-brown precipitate along the effluent channel and in the marsh (Figures 6-8).

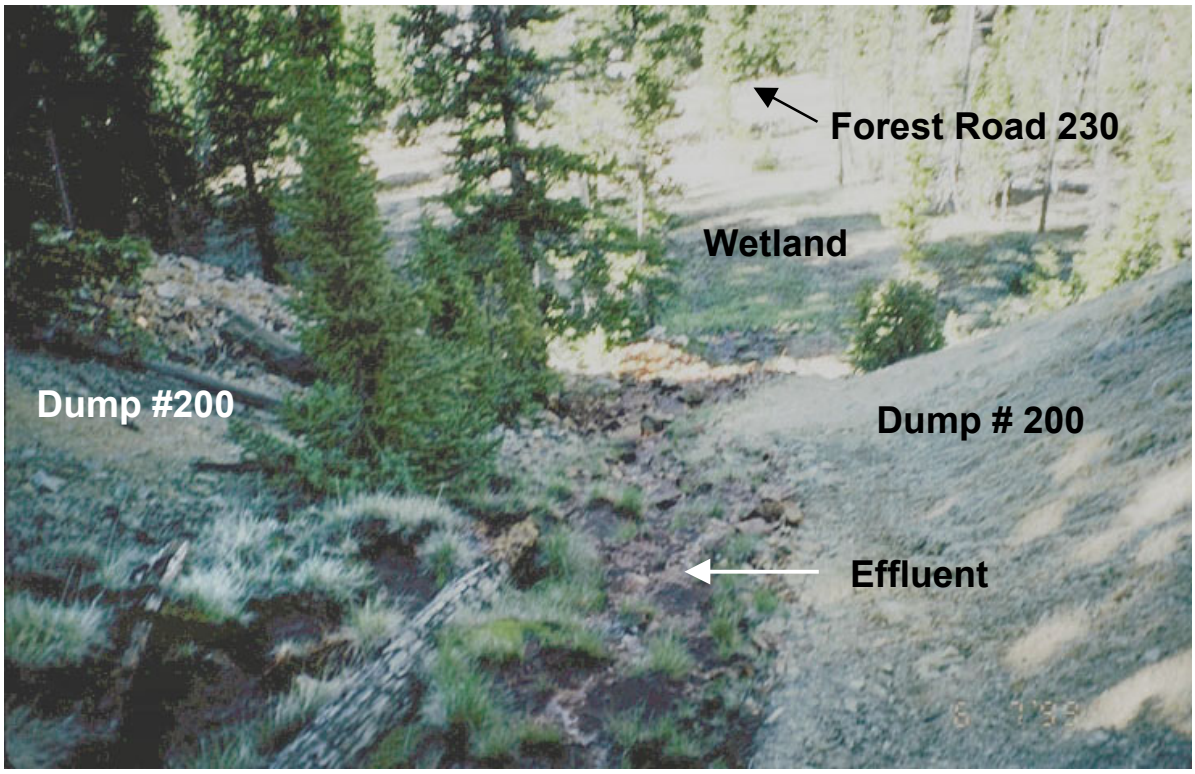


Figure 6. Effluent and dump #200 at the Tweed Mine.

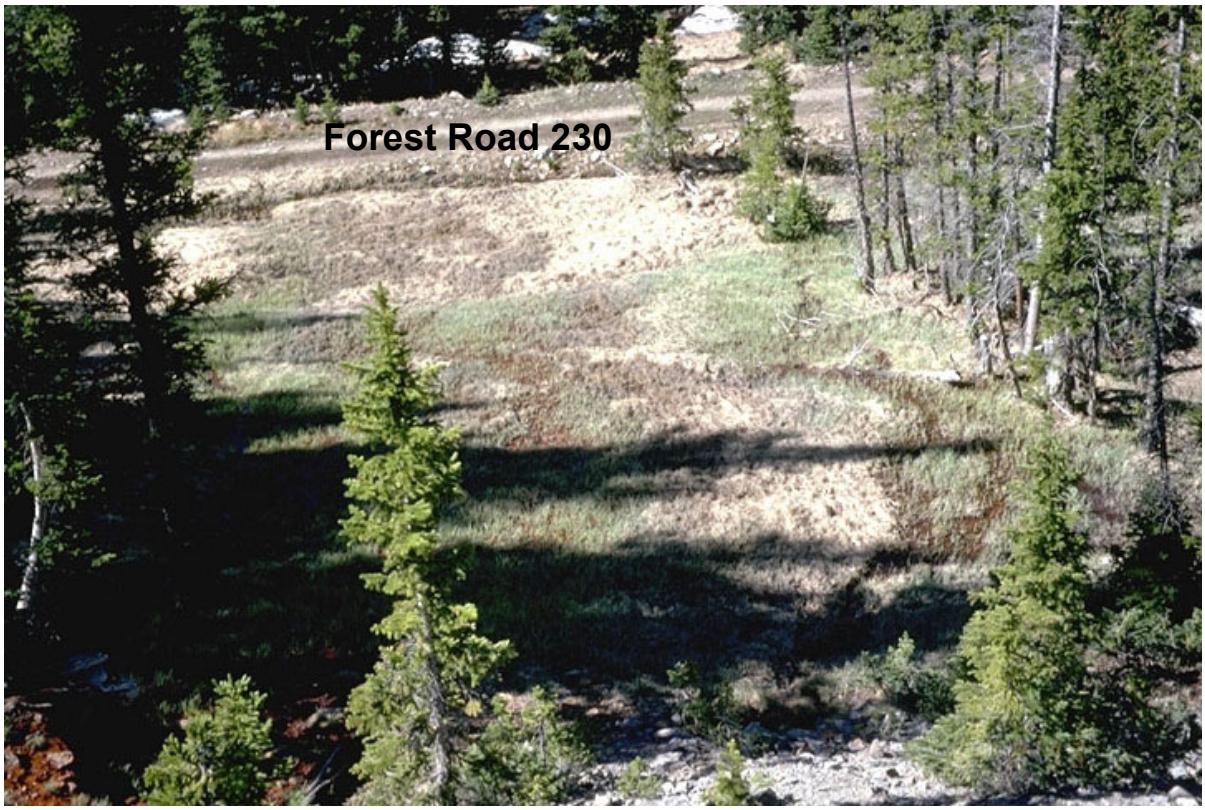


Figure 7. Wetland below dump #200 of the Tweed Mine.

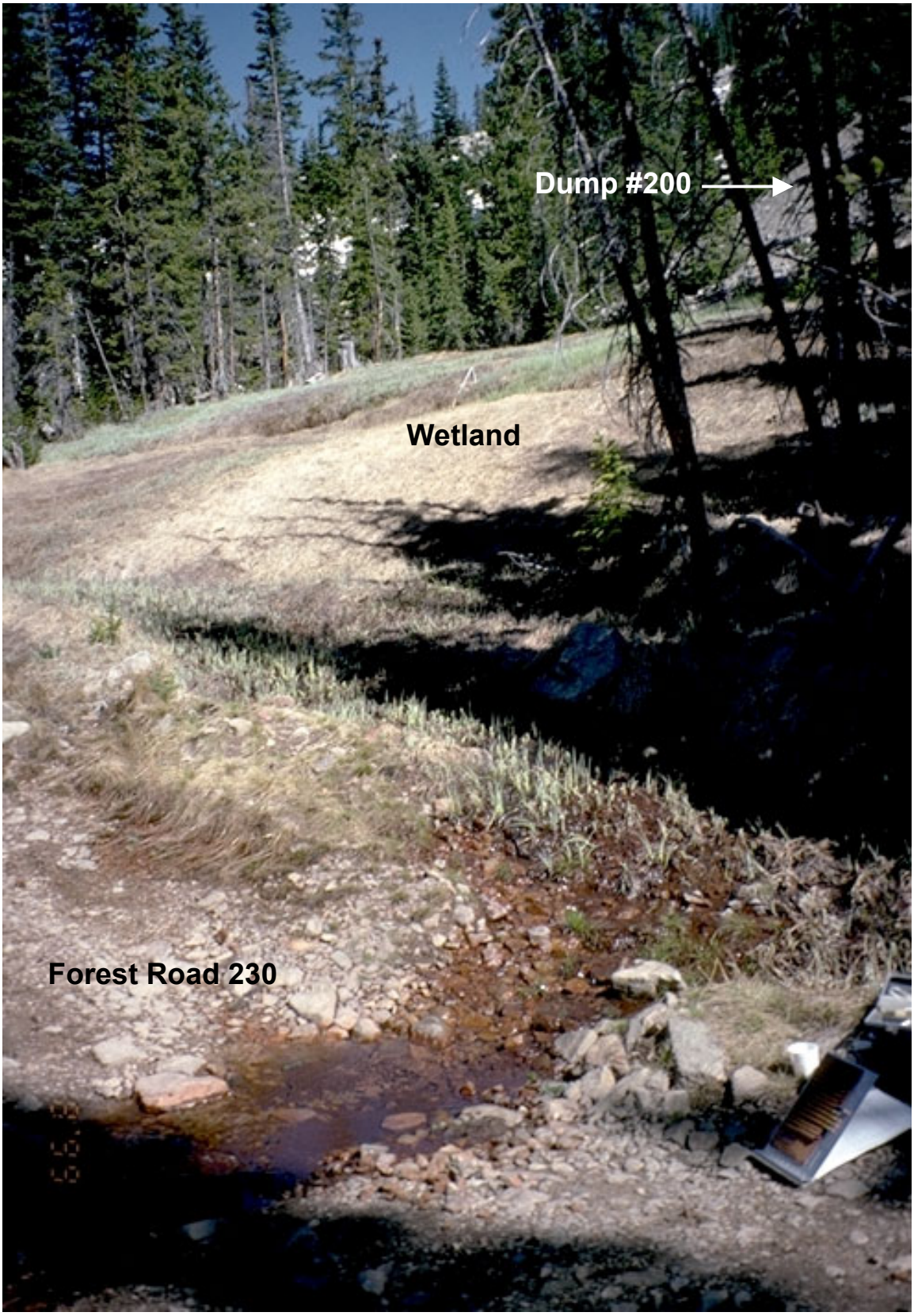


Figure 8. Effluent and wetland runoff crossing Forest Road 230.

After crossing Forest Road 230, the effluent spread into another marsh that extended to Middle Fork of the South Arkansas River. In June of 1999 mine water was dispersed and mixed with snowmelt and other water in the swamp and did not flow in a traceable channel. This wetland drained into the river over a width of at least 100 feet with no obvious "point of entry." This lower wetland had no significant accumulations of precipitate. Water tested in the marsh had 5.16 pH and 131 µS/cm conductivity.

To determine the impact of mine effluent to the river, water samples were collected from Middle Fork of the South Arkansas River above (384/4269-3.4) and below (384/4269-3.5) its junction with the lower wetland. Conductivity and pH in the river showed little change from above to below the confluence with effluent from the Tweed Mine (Table 1). Metal concentrations in the samples were similar. Zinc concentration increased about 10 percent at the downstream site and exceeded State standards at both the upstream and downstream sample locations. All of the other analyzed parameters fell within standards for both samples.

Waste-rock pile #200 contained about 1,400 cubic yards and comprised mostly oxidized, yellow and gray, poorly cemented, sand- and gravel-size altered granodiorite with minor to moderate amounts of pyrite. Dings and Robinson (1957, p. 94-95) reported quartz vein material, chalcopyrite, sphalerite, and galena on the dump. Lab results for composite sample 384/4269-3.D1 from dump #200 indicate that the waste rock is weakly to moderately mineralized with anomalous manganese, zinc, copper, lead, and molybdenum (Table 2). The sample had moderate potential acidity and slightly higher neutralization potential, which combined for a net acid-base potential of +3.0 tons $CaCO_3$/1,000 tons. Paste pH was alkaline also, at 8.07.

MIGRATION PATHWAYS

Groundwater Pathway

Granitic rocks underlie the Tweed Mine. Faults, fractures, and fissures cut these rocks, allowing for infiltration of surface water and migration of groundwater. Some of these structural features are mineralized with metallic sulfide minerals. Because of the faulted and fractured nature of the bedrock, water from the Tweed Mine and associated mineralized veins almost certainly reaches aquifers associated with Middle Fork of the South Arkansas River. Given the extensive workings, the moderate discharge (12 gpm) from the Tweed Mine suggests that subsurface flow through the mine is minor, especially in comparison to the flow rate of Middle Fork.

Table 1. Analytical data for water samples from the Tweed Mine area.

Sample	12-02-384/4269-3.1, Tweed Mine (6/8/99)				12-02-384/4269-3.2, Tweed Mine, Duplicate (6/8/99)			
Parameter	Concentration/ measurement	Standard	Factor above standard	Load (grams/day)	Concentration/ measurement	Standard	Factor above standard	Load (grams/day)
Flow (gpm)	11.7				11.7			
pH (standard units)	5.26				5.26			
Conductivity (µS/cm)	168.0				168.0			
Alkalinity (mg/L CaCO3)	<10.00				<10.00			
Hardness (mg/L CaCO3)	46	None	N/A		47	None	N/A	
Aluminum (trec) (µg/L)	2,700	None	N/A	172.2	2,700	None	N/A	172.2
Antimony (trec) (µg/L)	<1.0	6.0	Below standard	N/A	<1.0	6.0	Below standard	N/A
Arsenic (trec) (µg/L)	<1.0	10.0	Below standard	N/A	<1.0	10.0	Below standard	N/A
Iron (trec) (µg/L)	2,600	1,000.0	2.6	165.8	2,600	1,000.0	2.6	165.8
Thallium (µg/L)	<1.0	0.5	Not detected	N/A	<1.0	0.5	Not detected	N/A
Zinc (trec) (µg/L)	1,600	2,000.0	Below standard	102.0	1,600	2,000.0	Below standard	102.0
Aluminum (µg/L)	2,700	87.0	31.0	172.2	2,700	87.0	31.0	172.2
Cadmium (µg/L)	5.1	0.6	8.2	0.3	5.2	0.6	8.2	0.3
Calcium (mg/L CaCO3)	37	None	N/A	2,359.7	38	None	N/A	2,423.5
Chloride (mg/L)	<20.0	250.0	Below standard	N/A	<20.0	250.0	Below standard	N/A
Chromium (µg/L)	<10	11.0	Below standard	N/A	<10	11.0	Below standard	N/A
Copper (µg/L)	<4.0	6.1	Below standard	N/A	<4.0	6.3	Below standard	N/A
Fluoride (mg/L)	5.50	2.0	2.8	350.8	5.80	2.0	2.9	369.9
Iron (µg/L)	2,500	300.0	8.3	159.4	2,500	300.0	8.3	159.4
Lead (µg/L)	6.0	1.3	4.6	0.4	6.0	1.4	4.4	0.4
Magnesium (mg/L)	2.30	None	N/A	146.7	2.30	None	N/A	146.7
Manganese (µg/L)	890	50.0	17.8	56.8	900	50.0	18.0	57.4
Nickel (µg/L)	<20	53.3	Below standard	N/A	<20	54.2	Below standard	N/A
Potassium (mg/L)	2.1	None	N/A	133.9	2.1	None	N/A	133.9
Silicon (mg/L)	18.0	None	N/A	1,148.0	18.0	None	N/A	1,148.0
Silver (µg/L)	<0.2	0.0	Not detected	N/A	<0.2	0.0	Not detected	N/A
Sodium (mg/L)	4.40	None	N/A	280.6	4.40	None	N/A	280.6
Sulfate (mg/L)	47	250.0	Below standard	2,997.5	55	250.0	Below standard	3,507.7
Zinc (µg/L)	1,600	55.3	28.9	102.0	1,600	56.3	28.4	102.0

Table 1. Analytical data for water samples from the Tweed Mine area—continued.

Sample	12-02-384/4269-3.3, Tweed Mine (6/8/99)				12-02-384/4269-3.4, Tweed Mine-Middle Fork (6/8/99)			
Parameter	Concentration/ measurement	Standard	Factor above standard	Load (grams/day)	Concentration/ measurement	Standard	Factor above standard	Load (grams/day)
Flow (gpm)	8.0				7,200.0			
pH (standard units)	4.24				6.99			
Conductivity (µS/cm)	212.0				66.0			
Alkalinity (mg/L CaCO3)					18.00			
Hardness (mg/L CaCO3)	52	None	N/A		25	None	N/A	
Aluminum (trec) (µg/L)	3,200	None	N/A	138.7	68	None	N/A	2,668.8
Antimony (trec) (µg/L)	<1.0	6.0	Below standard	N/A	<1.0	6.0	Below standard	N/A
Arsenic (trec) (µg/L)	<1.0	10.0	Below standard	N/A	<1.0	10.0	Below standard	N/A
Iron (trec) (µg/L)	770	1,000.0	Below standard	33.4	45	1,000.0	Below standard	1,766.1
Thallium (µg/L)	<1.0	0.5	Not detected	N/A	<1.0	0.5	Not detected	N/A
Zinc (trec) (µg/L)	2,000	2,000.0	Below standard	86.7	66	2,000.0	Below standard	2,590.3
Aluminum (µg/L)	3,200	87.0	36.8	138.7	52	87.0	Below standard	2,040.9
Cadmium (µg/L)	7.8	0.7	11.6	0.3	<0.3	0.4	Below standard	N/A
Calcium (mg/L CaCO3)	41	None	N/A	1,776.8	23	None	N/A	902,685.6
Chloride (mg/L)	<20.0	250.0	Below standard	N/A	<1.0	250.0	Below standard	N/A
Chromium (µg/L)	<10	11.0	Below standard	N/A	<10	11.0	Below standard	N/A
Copper (µg/L)	200.0	6.7	29.7	8.7	<4.0	3.7	Not detected	N/A
Fluoride (mg/L)	5.00	2.0	2.5	216.7	0.46	2.0	Below standard	18,053.7
Iron (µg/L)	730	300.0	2.4	31.6	18	300.0	Below standard	706.4
Lead (µg/L)	8.0	1.5	5.2	0.3	<1.0	0.6	Not detected	N/A
Magnesium (mg/L)	2.60	None	N/A	112.7	0.60	None	N/A	23,548.3
Manganese (µg/L)	1,100	50.0	22.0	47.7	<4	50.0	Below standard	N/A
Nickel (µg/L)	<20	57.9	Below standard	N/A	<20	33.8	Below standard	N/A
Potassium (mg/L)	2.1	None	N/A	91.0	<1.0	None	N/A	N/A
Silicon (mg/L)	18.0	None	N/A	780.0	2.5	None	N/A	98,118.0
Silver (µg/L)	<0.2	0.0	Not detected	N/A	<0.2	0.0	Not detected	N/A
Sodium (mg/L)	4.30	None	N/A	186.3	0.97	None	N/A	38,069.8
Sulfate (mg/L)	71	250.0	Below standard	3,076.8	12	250.0	Below standard	470,966.4
Zinc (µg/L)	2,000	60.6	33.0	86.7	63	33.3	1.9	2,472.6

Table 1. Analytical data for water samples from the Tweed Mine area--continued.

Sample	12-02-384/4269-3.5, Tweed Mine Middle Fork Below (6/8/99)			
Parameter	Concentration/ measurement	Standard	Factor above standard	Load (grams/day)
Flow (gpm)	7,200.0			
pH (standard units)	6.98			
Conductivity (µS/cm)	61.0			
Alkalinity (mg/L CaCO3)	17.00			
Hardness (mg/L CaCO3)	26	None	N/A	
Aluminum (trec) (µg/L)	73	None	N/A	2,865.0
Antimony (trec) (µg/L)	<1.0	6.0	Below standard	N/A
Arsenic (trec) (µg/L)	<1.0	10.0	Below standard	N/A
Iron (trec) (µg/L)	36	1,000.0	Below standard	1,412.9
Thallium (µg/L)	<1.0	0.5	Not detected	N/A
Zinc (trec) (µg/L)	75	2,000.0	Below standard	2,943.5
Aluminum (µg/L)	60	87.0	Below standard	2,354.8
Cadmium (µg/L)	<0.3	0.4	Below standard	N/A
Calcium (mg/L CaCO3)	23	None	N/A	902,685.6
Chloride (mg/L)	<1.0	250.0	Below standard	N/A
Chromium (µg/L)	<10	11.0	Below standard	N/A
Copper (µg/L)	<4.0	3.7	Not detected	N/A
Fluoride (mg/L)	0.48	2.0	Below standard	18,838.7
Iron (µg/L)	17	300.0	Below standard	667.2
Lead (µg/L)	<1.0	0.6	Not detected	N/A
Magnesium (mg/L)	0.63	None	N/A	24,725.7
Manganese (µg/L)	<4	50.0	Below standard	N/A
Nickel (µg/L)	<20	33.9	Below standard	N/A
Potassium (mg/L)	<1.0	None	N/A	N/A
Silicon (mg/L)	2.7	None	N/A	105,967.4
Silver (µg/L)	<0.2	0.0	Not detected	N/A
Sodium (mg/L)	1.00	None	N/A	39,247.2
Sulfate (mg/L)	13	250.0	Below standard	510,213.6
Zinc (µg/L)	70	33.4	2.1	2,747.3

The closest permitted wells to the Tweed Mine are about 2 miles away, to the southeast and south-southeast (Colorado Division of Water Resources records, July 2000). One of these wells, in the northeast quarter of the southwest quarter of section 27, was permitted for domestic use, yields 15 gpm, and is only 12 feet deep. This well location plots high on the slope above and north of the town of Garfield, at least 600 feet above Middle Fork. Because of its elevation and its distance from the Tweed Mine, this well is probably not affected by groundwater associated with the Tweed. The other well within 2 miles of the Tweed Mine lies near the South Arkansas River (southeast quarter of the northwest quarter of section 33) and was permitted for commercial use by the Colorado Department of Transportation. This well is upstream of the confluence of Middle Fork with the South Arkansas and is not affected by Tweed Mine groundwater.

Table 2. Analytical data for a composite sample of waste-rock pile #200 of the Tweed Mine. (Waste rock was collected from about 4 to 6 inches deep on an approximate 10-foot grid.)

Analyzed Parameter	Sample 384/4269-3.D1
Paste pH	8.07
Neutralization potential (tons $CaCO_3$/1,000 tons)	11.8
Potential acidity (tons $CaCO_3$/1,000 tons)	8.8
Net acid-base potential (tons $CaCO_3$/1,000 tons)	3.0
Al_2O_3 (%)	8.87
CaO (%)	1.25
Fe_2O_3 (%)	3.67
K2O (%)	4.31
MgO (%)	1.16
Na_2O (%)	0.89
Sulfur (%)	0.57
Antimony (ppm)	4
Arsenic (ppm)	5
Beryllium (ppm)	3
Boron (ppm)	<1
Cadmium (ppm)	1.1
Cobalt (ppm)	8
Copper (ppm)	109
Gold (ppm)	0.016
Lead (ppm)	180
Lithium (ppm)	28
Manganese (ppm)	1035
Mercury (ppm)	0.59
Molybdenum (ppm)	48
Nickel (ppm)	5
Phosphorus (ppm)	397
Silver (ppm)	4.2
Strontium (ppm)	121
Vanadium (ppm)	52
Zinc (ppm)	296

Fourteen additional wells, permitted mostly for household or domestic use (6 household, 5 domestic, 2 commercial, and 1 industrial use), are within 4 miles of the Tweed Mine. Four of the 14 wells are downstream of the Tweed Mine, within the Garfield townsite near the confluence of Middle Fork and the South Arkansas River. At least 2 of these 4 are on the south side of the South Arkansas River. Because of distance and dilution, it is unlikely that groundwater from the Tweed Mine would cause any detectable degradation to these 4 wells.

Regarding the other 10 wells within a 4-mile radius of the Tweed, 7 are along the South Arkansas River upstream of its confluence with Middle Fork; and 3 are west of the Continental Divide. These wells are not hydrologically connected to the Tweed Mine.

Surface Water Pathway

About 10 to 20 gpm of water emerging from the Tweed Mine is degraded with respect to aluminum, iron, cadmium, fluoride, lead, manganese, zinc, and occasionally copper. After dump seepage is added to the effluent, which then flows through a natural wetland, acidity and most trace metal concentrations increase.

Middle Fork, which is 600 feet from the mine, has a flow rate more than 2 orders of magnitude greater than the effluent and shows only minor chemical changes from upstream to downstream near the Tweed Mine. In June 1999 many metals were below detection limits at the upstream and downstream sample sites. However, zinc concentration increased about 10 percent at the downstream site and slightly exceeded State standards at both sample locations. Zinc load at the portal was less than 0.25 lb/day, which was about 4 percent of the zinc load in Middle Fork upstream of the influence of the Tweed. Zinc load in Middle Fork below the confluence of Tweed effluent increased about 0.75 lb/day, which was more than the measured load at the portal. These inconsistent results may reflect further degradation of effluent by water seeping from dump #200, and possibly a contribution of degraded groundwater from the mine that does not surface and has not been measured.

Effluent from the Tweed Mine and seepage from its dump have a small, but measurable effect on Middle Fork of the South Arkansas River. It was not determined if aquatic life is impacted by the slight increase in zinc concentration.

Soil Exposure Pathway

No one lives within a mile, and no one works within 200 feet of the Tweed Mine. Garfield, the nearest community with year-round residents, is about 2 miles away, but seasonally occupied cabins lie within 0.5 mile of the mine. Access to this area is via a 4WD road, and it is unlikely that this site receives many visitors. Exposure times for visitors are brief, and metal concentrations in dump #200 are generally low. The soil exposure pathway is not considered a significant risk.

Air Exposure Pathway

No evidence of windblown particulates or wind erosion was observed at the site. Although uncemented, the dump surface is mostly composed of sand and gravel or larger material. In addition, much of the year dump #200 is covered by snow. The air exposure pathway is considered insignificant because of the larger size of most surface material, no evidence of wind erosion, and the lack of long-term exposure to the public.

CONCLUSIONS

The Tweed Mine discharges a moderate volume of degraded water. Effluent sampled at adit #100 exceeded water-quality standards in aluminum, manganese, zinc, iron, cadmium, fluoride, lead, and sometimes copper.

Although paste pH and acid-base accounting tests of waste rock indicate the material is alkaline, pH decreased, and concentrations of aluminum, zinc, manganese, copper, cadmium, and lead increased in water below dump #200 compared to the portal water. Residence time and localized areas of oxidizing and weathering sulfide minerals within the dump may account for this further degradation of mine drainage. Iron concentration decreased, probably because of the deposition of iron precipitate along the effluent channel and in the wetland immediately below dump #200.

Samples from Middle Fork of the South Arkansas River both above and below the confluence with the effluent from the Tweed Mine were similar. Zinc slightly exceeded standards at both locations, but increased about 10 percent below the confluence with mine waters.

Laboratory and field tests show that water quality is worse below the dump and the adjacent wetland compared to water at the portal, suggesting that this natural wetland is not effectively reducing metal concentrations. Diverting effluent away from dump #200 may measurably improve water quality in the wetland below the Tweed Mine, and possibly in Middle Fork of the South Arkansas River.

Although air and soil pathways are not significant problems, covering dump #200 with topsoil and revegetating would eliminate these exposure pathways.

Because of its age and its highly visible location, this site may have historical importance that should be considered in any reclamation plan.

REFERENCES

Benson and others, 1997, USFS-abandoned mine land inventory project, final summary report, San Isabel National Forest-Salida Ranger District: Colorado Geological Survey unpublished report, 44 p.

Crawford, R.D., 1913, Geology and ore deposits of the Monarch and Tomichi districts: Colorado Geological Survey Bulletin 4, 317 p.

Dings, M.G., and Robinson, C.S., 1957, Geology and ore deposits of the Garfield quadrangle, Colorado: U.S. Geological Survey Professional Paper 289, 110 p.

Heyl, A.V., 1964, Oxidized zinc deposits of the United States Part 3 Colorado: U.S. Geological Survey Bulletin 1135-C, 98 p.

APPENDIX: Abandoned Mine Inventory Form for the Tweed Mine

WS

USFS-AMLI FIELD DATA FORM DE

LOCATION AND IDENTIFICATION

(1) **ID#:** 02- 08- 12 - 2 - 384 / 4269 - 3
rgn st fst rd xutm yutm area#

(2) **Sitename:** Southwest of Hoffman Park

(3) **Other name/reference:** Crawford 1910, CGS Bull.-1

2 (4) **Highest priority Environmental Degradation occurring in this area:**
1=extreme; 2=significant; 3=potentially significant; 4=slight; 5=none

M 3 (5) **Highest priority Mine Hazard noted in this area:**
E=emergency; 1=extreme danger; 2=dangerous; 3=potentially dangerous; 5=no significant hazard

M (6) **Commodity:** C=coal; U=uranium; M=metals; I=industrial material.
(Metal or Indust. material type: gold, silver, lead, zinc)

(7) **Quad name and date:** Garfield

(8) **County:** Chaffee

(9) **2° map:** Montrose

(10) **Water Cataloguing Unit #:** 11020001

(11) **Mining district/coal field:** Monarch

(12) **Land survey location:** - - C sec 20, T 50N, R 6 E

(13) **Receiving stream:** Middle Fk. South Arkansas flowing into South Arkansas River
nearest named stream next named

(14) **Elevation (ft):** 11000

2 (15) **General Slope:** 1=0-10°; 2=11-35°; 3=greater than 35°

M (16) **Regional terrain:** R=rolling or flat; F=foothills; T=mesa; H=hogback; M=mountains; S=steep/narrow canyon

J (17) **Type of access:** N=no trail; T=trail; J=jeep road; G=gravel road; M=paved road; P=private/restricted road

G (18) **Quality of access for construction vehicles:** G=good; M=moderate; P=poor; X=very poor

(19) **Nearest town on map:** Garfield

2.3 (20) **Road distance from nearest town** (#.# miles)

(21) **Nearest road** (name and/or #): FR-230
FR=forest rd; CR=county rd; SH=state highway; I=interstate

Distance to following types of public uses (#.# miles):

0 (22) Road FR-230

— (23) Dwelling (year-round)

— (24) Campground/picnic area

1.5 (25) Marked trail Trail 1422

0.3 (26) Other public use (explain) Summer cabins

ENVIRONMENTAL INFORMATION

D (27) **Vegetation density adjacent to site:** D=dense; M=moderate; S=sparse; B=barren

P (28) **Vegetation type adjacent to site:** B=barren; W=weeds; G=grass; R=riparian S=sagebrush/oakbrush/brush; J=juniper/piñon; A=aspen; P=pine/spruce/fir; T=tundra

N (29) **Evidence of intentional reclamation:** Y=yes; N=no (if yes, use comments)

2.0 (30) **Size of disturbed area in acres**

N (31) **Potential historical structures in area:** Y=yes; N=no (if yes, use comments)

N (32) **Positive evidence of BATS:** G=guano; I=insect remains; B=bat sighting; O=other(use comments); N=no (use comments to expand on any positive evidence;"No" only indicates absence of positive evidence, **not** absence of bats)

(33) **Recorded by/date:** M. A. SARES 7/20+21/94

ADITS, SHAFTS, AND OPENINGS

Feature Nos.		(100)	101	102	103	104	105	106	107	108	109	110	111
Type of Feature		A	A	A		A							
Opening Size (ft)	H	–	–	–		1							
	W	–	–	–		3							
Depth (ft)		–	–	–		15+							
Condition		F	F	F		P							
Drainage		W	N	N		N							
Access Deterents		N	N	N		N							
Deterent Condition		–	–	–		–							
Ratings	Env. Deg.	(2)	5	5		5							
	Hazard	5	5	5		3							
Photo	Roll No.	B-94	B94	B94		–							
	Frame No.	11	27	25		–							
Comments?		Y	Y	Y		Y							

DUMPS, TAILINGS, AND SPOIL BANKS

Feature No.		(200)	201	202	203	204	205	206	207	208
Type of Feature		D	D	D	D	D				
Plan view Dimension (ft.)	L	40	95	24	60	20				
	W	55	40	17	15	30				
Volume (yds)		1400	1700	40	80	200				
Steepest Slope Angle (dgr)		32	35	35	N/A	34				
Steepest Slope Length (ft)		50	50	36	N/A	28				
Size of Materials		S,G	SGL	SGL	SGL	SGL				
Cementation		U	U	U	U	U				
Vegetation Type		P	G,P	B	P	G				
Vegetation Density		S	S	B	M	S				
Drainage		W	N	N	N	N				
Stability		S	S	S	S	S				
Water Erosion	of Feature	RS	S	S	S	S				
	Storm Runoff	N	N	S	C	N				
Wind Erosion		N	N	N	N	N				
Radiation Count		–	–	–	–	–				
Access Deterents		N	N	N	N	N				
Deterent Condition		–	–	–	/	–				
Ratings	Env. Deg.	2	5	5	4	5				
	Hazard	5	5	5	5	5				
Photo	Roll No.	B-94	B94	B94	B94	–				
	Frame No.	12,13	28	25	26	–				
Comments?		Y	Y	Y	Y	Y				
Soil Sample No.										

DRAINAGE/WATER SAMPLES

Item Nos.	300	301	302	303	304	305	306
Adit/Shaft/Dump No./Other=0 (If other location, describe in comments)	100	200	200	200	200	200	300
pH (standard units)	6.0	6.1	4.3	4.5	4.6	7.0	6.9
Conductivity (uS)	100	100	100	100	100	<50	<50
Flow (gpm)	15	15	6	10	1	Other	Other
Method of Flow Measure	E	E	E	E	E	E	E
Date Flow/Sample (m/d/y)	7/20/94	7/20/94	7/20/94	7/21/94	7/21/94	7/21/94	7/21/94
Location of Sample/Flow	A	B	B	B	B	RU	RD
Evidence of Toxicity in Site Drainage	P	P	P	P	P	N/A	N/A
Evidence of Toxicity in Receiving Stream	N/A	N/A	N/A	N/A	N/A	N	N
Distance from Stream (ft)	900	850	850	600	50	0	0
Comments?	Y	Y	Y	Y	Y	Y	Y
Lab Water Sample No.	384/4269-1.300						

GPS READINGS

Ptr. No.	Location
100	Lat. N 38° 34' 17.2" pdop 5.0 Long. W 106° 19' 18.7" 4sat
	Lat. Long.
	Lat. Long.
	Lat. Long.
	Lat. Long.
	Lat. Long.
	Lat. Long.
	Lat. Long.
	Lat. Long.
	Lat. Long.

see next page for more waste rocks

DIAGRAM OF PROBLEM AREA (Locate all adits, shafts, dumps, prospects, etc. on topo map.)

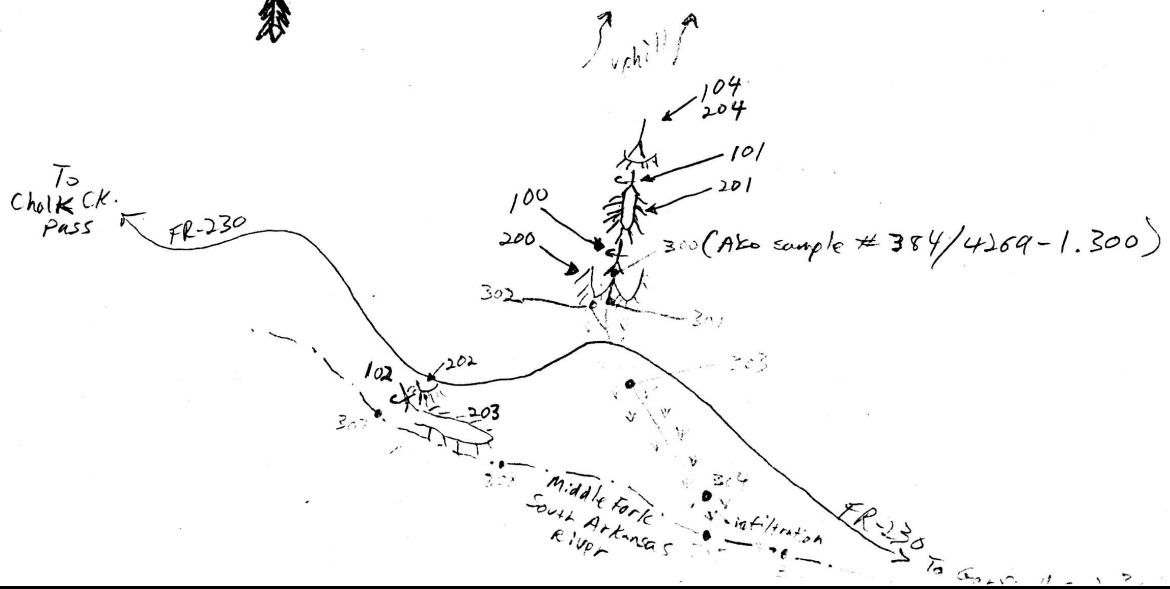
Check off upon completion: ___ north arrow; ___ scale bar or general size noted; ___ direction to nearest trail/road/town noted; ___ significant mine features numbered

7.7
20 cfs

Adit | shaft | prospect hole | building | dump or tailings | collapsed adit and shaft | fence

N

600 ft.



DRAINAGE/WATER SAMPLES

Item Nos.	307	308				
Adit/Shaft/Dump No./Other=0 (If other location, describe in comments)	203	203				
pH (standard units)	7.7	7.7				
Conductivity (uS)	<50	<50				
Flow (gpm)	N/A	N/A				
Method of Flow Measure	E	E				
Date Flow/Sample (m/d/y)	7/21/94	7/21/94				
Location of Sample/Flow	RU	RD				
Evidence of Toxicity in Site Drainage	N/A	N/A				
Evidence of Toxicity in Receiving Stream	N	N				
Distance from Stream (ft)	0	0				
Comments?	Y	Y				
Lab Water Sample No.						

GPS READINGS

Ftr. No.	Location
	Lat. Long.
	Lat. Long.
	Lat. Long.
	Lat. Long.
	Lat. Long.
	Lat. Long.
	Lat. Long.
	Lat. Long.
	Lat. Long.
	Lat. Long.

DIAGRAM OF PROBLEM AREA (Locate all adits, shafts, dumps, prospects, etc. on topo map.)

Check off upon completion: ___ north arrow; ___ scale bar or general size noted; ___ direction to nearest trail/road/town noted; ___ significant mine features numbered

Adit shaft X prospect hole building dump or tailings collapsed adit and shaft fence

●81. Local person interviewed _____
Name Address

●82. Name and address of person desiring a copy of this form: _____

●83. Describe the minimum work needed to mitigate any public health, safety, welfare, or environmental problems observed at the site. Note specific reclamation activities along with an estimated cost and time period to implement each activity described. Code costs as: 1= less $10,000; 2= $10,000 to $100,000; 3= $100,000 to $500,000; 4= more than $500,000. Code estimated time to complete the activity as: 1= less than 1 month; 2= 1 to 12 months; 3= 1 to 3 years; 4= over 3 years

Cost	Time	Recommended reclamation activity
3	2	Re-route site drainage from adit 100 around dump 200
		and install constructed wetlands to help remediate
		drainage

●84. Comments relating to geology, health, safety, welfare, environmental, or restoration problems of a certain feature. All comments must be keyed to mine feature # or drainage/water sample item #.

100 - fully collapsed, draining moderately poor quality water, and the flow is significant.
200 - water flow from adit drains over the middle of the for the full length and has eroded a large gully into the dump - abundant pyrite and Fe-staining in dump
300 → abundant yellowish red precipitate - water quality is moderately poor, but appears very contaminated some grass and sedge are present in drainage, no insects seen in water
301 → Test of water flowing over dump at the base of the dump. pH has increased by 0.1 unit. (See photos B94-12B)
302 → Test of water seeping from base of dump separate from surface water. Significantly lower pH than other site water, probably due to seepage through and residence time in pyritic dump material.
303 → Test in site drainage in marshy area below road. Poor quality water
304 → Test in site drainage about 20 ft. above infiltration point. Still poor quality water
305+306 → These tests indicate that water in Middle Fork South Arkansas River is affected by site drainage from 100+200; pH drops 0.1 units. Flow of River is about 20 cfs.
101 → Collapsed adit has left a 25' subsidence scar in hillside. Dilapidated cabin in front
201 → Large dump is orange-yellow in color with abundant hematite + manganite + pyrite
102 → A collapsed adit with a subsidence swale above close to road level. Subsidence feature is 12'x12'x7' deep
202 → Related to 103, this is conspicuous yellow dump near FR-230
203 → This dump also related to 103, extends for 60 ft along Middle FK South Arkansas River and is in contact with stream. can't affect by dump 203. Flow is 20 cfs
307+308 → Water tests of Middle Fork South Arkansas show no significant

-if more comments use back of page → See back of page

General Comment (on whole inventory area or group of mine features): _____

A significant amount of water is being discharged from site 100/200. The water out of the portal of 100 is not extremely degraded, but abundant orange ferric oxy-hydroxide precipitate line the site drainage. Below the dump, dump seeps add significant acidity to the site drainage and creates a large marshy area with abundant plants which extends all the way to the Middle Fork South Arkansas River. This site drainage does have an affect on the river. Re-routing site drainage away from the dump and installing constructed wetlands is recommended for remediation of the site.

-if more comments use back of page →

OFFICE/LITERATURE INFORMATION

●41. Owner of surface _____
●42. Last known operator _____
●43. Estimated production _____
●44. Dates of production _____
●45. Literature not cited in comments _____
●46. Citation of any historical register listing _____

Comments (Cont.)

104 → Partially collapsed adit has a small opening, but is outside of a well travelled area

204 → orange-yellow dump, with hematite, pyrite, & manganite abundant.

Salida RD

COLORADO DEPARTMENT OF HEALTH
INORGANIC CHEMISTRY LABORATORY
4210 E 11TH AVE. DENVER, CO 80220
(303)691-4726

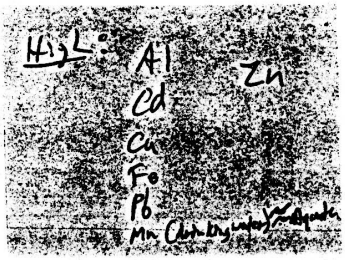
DATE: 09/13/94
REPORTED BY: JRS

SAMPLE NUMBER: 946401
SAMPLE DESCRIPTION: MATT SARES COLO GEOLOGICAL SURVEY

ADDRESS : 1313 SHERMAN ST #715
DENVER, CO 80203

COUNTY: CHF
PHONE : 3038663487

COLLECTED BY: MATT SARES
WHERE: 12-10-384/4269-X.300
DATE SAMPLED: 07/21/94
DATE RECEIVED: 07/26/94
BOTTLES: 250M 250NEUT
TYPE: 7
COMMENTS: SOUTHWEST OF HOFFMAN PARK



ANALYSIS RESULTS

ALKALINITY TOT	U 10	mg/L
ALUMINUM	3000	ug/L
ARSENIC	U 1	ug/L
BARIUM	10	ug/L
CADMIUM	7	mg/L
CHROMIUM	U 10	ug/L
COPPER	9	ug/L
HARDNESS, TOT. ***	52	mg/L
IRON	2600	ug/L
LEAD	0.005	mg/L
MANGANESE	970	ug/L
NICKEL	U 20	ug/L
SILVER	U 0.2	ug/L
SULFATE	68	mg/L
ZINC	1800	ug/L

U VALUES = LESS THAN
*** AS CaCO3

CODES FOR TABULAR INFORMATION

ALL TABLES: If appropriate code is not listed, use: **N** = none or no; **N/A** = not applicable; **UNK** = unknown; **O** = other, explain in #84

ADITS, SHAFTS, & OPENINGS

- Type of feature: **A** = adit; **S** = vertical shaft; **I** = incline shaft; **P** = prospect hole; **ST** = stope; **G** = glory hole; **SU** = subsidence feature; **PT** = open pit; **O** = other, explain in #84.
- Condition: **I** = intact; **P** = partially collapsed or filled; **F** = filled or collapsed; **N** = feature searched for but not found (mine symbol on map)
- Drainage: **N** = no water draining; **W** = water draining; **S** = standing water only (note at what depth below grade)
- Access deterents: **N** = none; **S** = sign; **F** = fence; **C** = sealed or capped; **D** = open door or hatch; **L** = locked door or hatch; **G** = open grill; **O** = other, explain in #84.
- Deterent condition: **P** = prevents access; **D** = discourages access; **I** = ineffective
- Ratings: Hazard: **E** = emergency; **1** = extreme danger; **2** = dangerous; **3** = potential danger; **5** = no significant hazard
  Env. Deg.: **1** = extreme; **2** = significant; **3** = potentially significant; **4** = slight; **5** = none
- Comments?: **Y** = yes; **N** = no

DUMPS, TAILINGS, AND SPOIL AREAS

- Type of feature: **D** = mine dump; **T** = mill tailings; **W** = coal waste bank; **S** = overburden or development spoil pile; **DS** = dredge spoil; **HD** = placer or hydraulic deposit; **H** = highwall; **P** = processing site
- Size of materials: **F** = fine; **S** = sand; **G** = gravel; **L** = cobbles; **B** = boulders
- Cementation: **W** = well cemented; **M** = moderately cemented; **U** = uncemented
- Vegetation Type: **G** = mixed grass; **S** = sagebrush/oakbrush/brush; **J** = juniper/piñon; **A** = aspen; **P** = pine/spruce/fir; **T** = tundra; **R** = riparian; **F** = tilled crops; **B** = barren/no vegetation; **W** = weeds
- Vegetation Density: **D** = dense; **M** = moderate; **S** = sparse; **B** = barren
- Drainage: **N** = no water draining; **W** = water draining across surface; **S** = standing water only; **SP** = water seeping from side of feature
- Stability: **U** = unstable; **P** = potentially unstable; **S** = stable
- Water erosion: of Feature: **N** = none; **R** = rills; **G** = gullies; **S** = sheet wash
  Storm Runoff: **C** = in contact with normal stream; **S** = near stream or gully, but only eroded during storm or flood; **N** = no storm/flood runoff erosion
- Wind erosion: **N** = none; **D** = dunes; **B** = blowouts; **A** = airborne dust
- Radiation Count: **N** = none taken; record value of reading if taken
- Access deterents: **N** = none; **S** = sign; **F** = fence; **O** = other, explain in #84
- Ratings: Hazard: **E** = emergency; **1** = extreme danger; **2** = dangerous; **3** = potential danger; **5** = no significant hazard
  Env. Deg.: **1** = extreme; **2** = significant; **3** = potentially significant; **4** = slight; **5** = none
- Comments?: **Y** = yes; **N** = no

DRAINAGE/WATER SAMPLES

- Adit/Shaft/Dump No./Other: Indicate Feature No. associated with water information; **0** = other, explain in comments
- Flow (cfs): record seeps as 0.01 cfs (Rule of Thumb: a cfs ≈ one full-blast garden hose)
- Method of flow measure: **E** = estimate; **T** = bobber/stopwatch/x-section; **W** = weir; **D** = catchment; **F** = flow meter
- Location of sample and flow: **A** = immediately adjacent to adit/shaft; **B** = below dump/tailings; **C** = immediately above confluence with receiving stream; **SW** = standing water in/on feature; **RU** = receiving stream upstream of feature; **RD** = receiving stream dowmstream of feature;
- Evidence of toxicity: **N** = none; **A** = absence of benthic organisms; **W** = opaque water; **P** = yellow or red precipitate; **S** = suspended solids; **D** = salt deposits
- Comments?: **Y** = yes; **N** = no