NATURAL RESOURCES

INACTIVE AND ABANDONED MINE LANDS— Sunset Mine, Snohomish County, Washington

by Fritz E. Wolff,
Donald T. McKay, Jr.,
and David K. Norman

WASHINGTON
DIVISION OF GEOLOGY
AND EARTH RESOURCES

Open File Report 2002-4
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site location

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This report is available from:

Publications
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Printed on recycled paper
Printed in the United States of America

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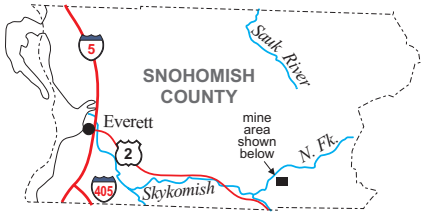

INTRODUCTION

Presently in Washington State there is no systematic database of inactive and abandoned metal mines (Norman, 2000). Previous work by the Department of Natural Resources (DNR) has had a distinctly commodity-oriented focus (Huntting, 1956; Derkey and others, 1990). The current goal is to build a single database and geographic information system (GIS) coverage of major mines in the state. Documentation will focus on physical characteristics and hazards (openings, structures, materials, and waste) and water-related issues (acid mine drainage and/or metals transport). Accurate location, current ownership, and land status information will be included. Acquisition of this information is a critical first step in any systematic approach to determine if remedial or reclamation activities are warranted. Open-File Reports (OFRs) will provide written documentation on mines or groups of mines within specific mining districts or counties.

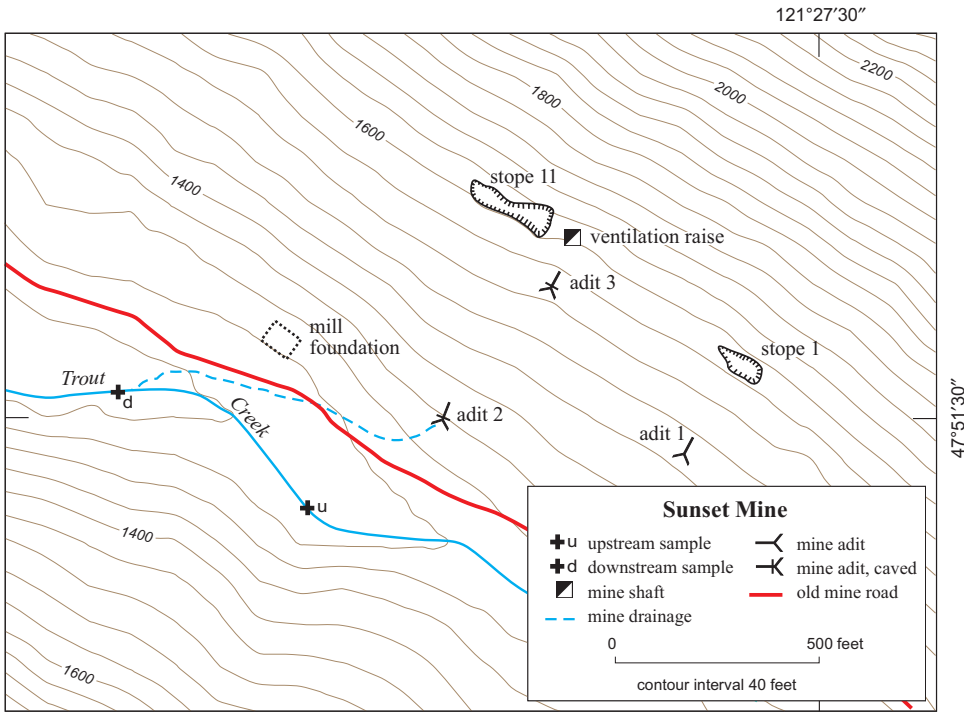

Figure 1. Map showing general location of the Sunset mine in Snohomish County and a site map of the Sunset mine. Entire area of map is within sec. 1, T27N R10E.

Over 3800 mineral properties have been located in the state during the last 100 years (Huntting, 1956). Many are undeveloped prospects of little economic importance. Therefore, in considering the population to include in the Inactive and Abandoned Mine Land (IAML) inventory, we have identified approximately 60 sites that meet one of the following criteria: (a) more than 2000 feet of underground development, (b) more than 10,000 tons of production, (c) location of a known mill site or smelter. This subset of sites includes only metal mines no longer in operation.

We have chosen to use the term *inactive* in the project's title in addition to the term *abandoned* because it more precisely describes the land-use situation regarding mining and avoids any political or legal implications of surrendering an interest to a property that may re-open with changes in economics, technology, or commodity importance.

Creation of the state-managed IAML database is a cooperative effort between DNR, the U.S. Forest Service (USFS), the U.S. Bureau of Land Management (BLM), the U.S. Environmental Protection Agency (EPA), and the Washington Department of Ecology (DOE). DNR's Division of Geology and Earth Resources (DGER) is the lead agency. To date, USFS contracts have been the principal source of funding, with other contributions coming from DNR and EPA.

SUMMARY

The Sunset property is located 7 miles northeast of the town of Index on Trout Creek, a tributary of the North Fork Skykomish River (Fig. 1). As late as 1950, the property included 19 patented claims, 8 unpatented claims, and various section subdivisions of deeded land—a total of 960 acres covering portions of sec. 1, T27N R10E, and sec. 6, T27N R11E. On 25 April 1985, the U.S. Forest Service took possession of the entire property in a land exchange from Murray Pacific Corporation, a forest products entity. The exchange included a title report, environmental assessment, and a reservation for the mine access road to Snohomish County (Pat Toman, USFS, written commun., 2001).

Arthur Egbert discovered the Sunset outcrop in June 1897 (Patty, 1921). That same year, Sunset Copper Co. was formed and remained the principal owner-operator from 1902 through 1935. In 1930, the Radiore Co. performed an electrical conductivity survey on the western and eastern extensions of the Sunset vein. Anomalies indicated additional sulfide mineralization in both directions. In 1935, Sunset Syndicate Corp. leased the mine in order to settle labor liens against the parent company for unpaid wages. Finally, all assets were sold at a bankruptcy sale

in Everett on 20 August 1938 (DGER mine file). Kromona Mines operated a lease during World War II. C. V. Brennan, *dba* Index Mining Co., purchased the mine from Sunset Syndicate in 1948. High winds that year brought down trees everywhere on the property, crushing buildings and ruining equipment (Diebold, 1960). The U.S. Bureau of Mines (USBM) initiated a diamond-drilling program in 1950 that confirmed the presence of copper mineralization near anomalies predicted by the Radiore geophysical survey (Toepfer, 1953). Grandby Mining, Mono Resources, and others leased the property when copper prices increased during the late 1950s and early 1960s. No production quantities from this activity are available. The Sunset mine leads all properties in the state for production of copper from initial production in 1902 to the last documented shipments in 1946. Data from smelter returns indicate a total recovery during this period of 12,912,000 pounds of copper, 156,000 ounces of silver, and 1500 ounces of gold.

Figure 2. Sunset vein mineralization with bornite, malachite, and chalcopyrite (jackknife for scale).

The ore occurs as lenticular masses in six roughly parallel shear zones containing chalcopyrite and bornite (Fig. 2). The host rock is granodiorite, identified as the Oligocene Index batholith (Tabor and others, 1990). The veins strike N60W and dip 80 degrees NE. Most production came from the Sunset vein. It varied from 6 to 30 feet in width, with a pay-streak averaging 6 to 8 feet wide (Campbell, 1938). The mineral suite contains copper oxides and carbonates in addition to sulfides, native copper, and minor amounts of pyrite. The absence of arsenopyrite at the mine presents an interesting departure from ores in the nearby Monte Cristo and Money Creek districts.

The mine was developed by three horizontal adits. Adit 1 was driven in 1898 at an elevation of 1460 feet above mean sea level. It intersected the Sunset vein 120 feet below the discovery outcrop, now a glory hole (Fig. 3). The adit was open and accessible in May of 2002 when the site was visited by DGER personnel. The glory hole is approximately 140 feet long, 30 feet wide, and 50 to 100 feet high. The hanging wall and footwall are vertical. On the east end of the cut, the floor of a large cavern slopes underground at a decline of 40 degrees (Fig. 4). This excavation is identified as stope 1 on mine maps (Campbell, 1938). Significant amounts of country rock and vein material have slabbed off the stope roof and sides. Woodhouse and others (Northwest Underground Explorations, 1997) report the presence of an underground three-story structure occupying the back of the cavern. Viewed from the entrance, this feature appears to be a series of vertically stacked, timber square sets. On the west end of the glory hole, a stream of water cascades from the side wall into a 4-foot opening that appears to be a raise or a surface pathway to stope 3 (Figs. 5 and 6). This opening and a similar one above adit 3 (described below) constitute an extreme hazard to human safety.

Figure 3. Discovery glory hole. Floor descends steeply inside cavern of stope 1 (arrow) behind DGER geologist. View to southeast.

Adit 2 was the main haulage level. It is 1200 feet long and has caved a few feet beyond the portal. All workings below this level are flooded. Adit 2 discharges water at the rate of 150 to 450 gpm depending on the season (Fig. 7). A sample taken at this location meets the requirements for ground water for domestic consumption described in WAC 246-290 (see Table 5).

Adit 3 is located a few hundred feet to the west of adit 1 at about the same elevation. The entrance is caved. A ventilation shaft on the adit's centerline is open and unprotected (Fig. 8). It falls 154 feet to the present floor of stope 11. Fifty feet to the west, we encountered another open cut and cavern similar to the one described previously (Figs. 9–11). Scaled mine map distances indicate the back of the stope is approximately 220 feet from the entrance and a distance of 120 feet above draw points on level 1. The stope roof is 15 to 20 feet thick. From this area DGER personnel documented continued subsidence and caving

Figure 4. Surface entrance to stope 1. Floor dips –40 degrees easterly. Vein material is exposed in overhang.

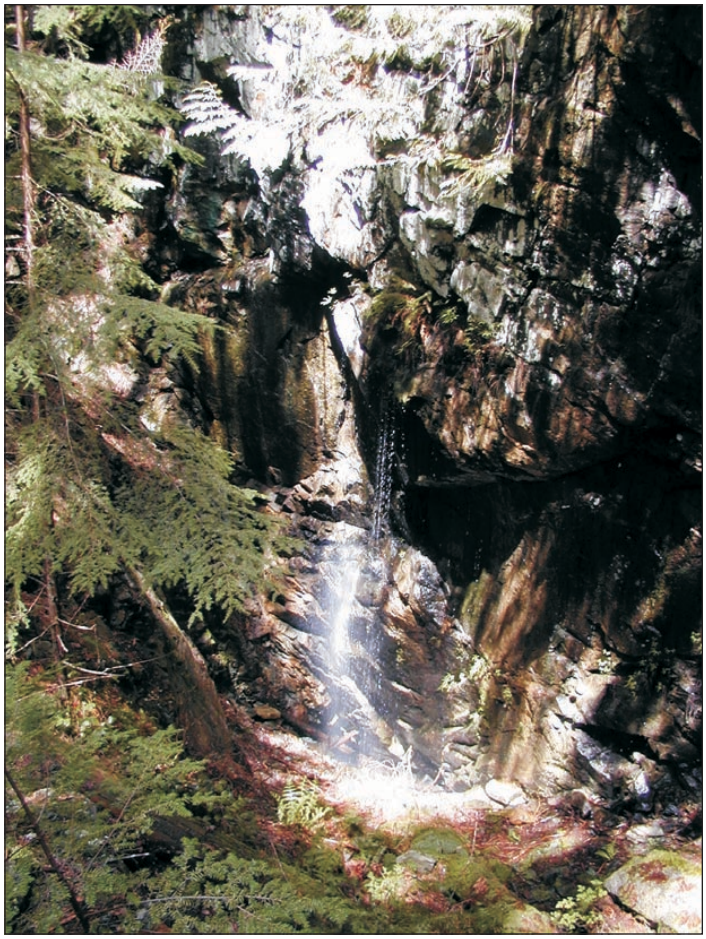

Figure 5. West extension of the discovery glory hole. Bright area beneath waterfall is the opening shown in Figure 6.

400 feet westerly along the vein. Blocks of mineralized granodiorite the size of small pickups slumped off the hanging wall at some time between November 2000 and May 2002 (Fig. 12).

A total of five production levels were developed. Levels 3, 4, and 5 are underwater and drained by the main haulage tunnel, adit 2. The drainage flows across the surface and discharges into Trout Creek opposite the mill footings. Level 5 was the deepest, 335 feet below adit 2. Assay maps indicate strong mineralization on level 5 at the cessation of operations in 1949. Total development at the mine exceeds 12,000 feet. Historical material described several additional openings, which DGER personnel did not find—"Wet" tunnel, Copper King adit, Ravine Tunnel, and Radiore "B" tunnel, which was driven in 1972 by Mono Resources (Campbell, 1938).

A 250-ton-per-day mill constructed in 1919 used water-washed concentrating tables and flotation cells. Smelter returns indicate the mill produced a concentrate of 33 percent copper, close to the theoretical composition of pure chalcopyrite. A comparison of mill heads, averaging between 3 and 4 percent copper, and mill tails, averaging 0.2 percent copper, indicate a total recovery of approximately 95 percent.

A photo taken in 1929 shows the mill discharging tailings on the north bank of Trout Creek and into the creek itself (Fig. 13). Periodic flooding in Trout Creek has washed any remnant tailings downstream. This photo was taken at a high point in the Sunset mine's operation and shows a highly self-contained camp with bunkhouse, dining hall, assay office, sawmill, concentrator, blacksmith forge, and shop. Only the concrete mill foundation remains at present (Fig. 14). The site of former bunkhouse and dining hall is overgrown with alder and brush (Fig. 15).

Figure 6. A 4 x 4 foot opening above stope 3. The log is approximately 1 foot in diameter.

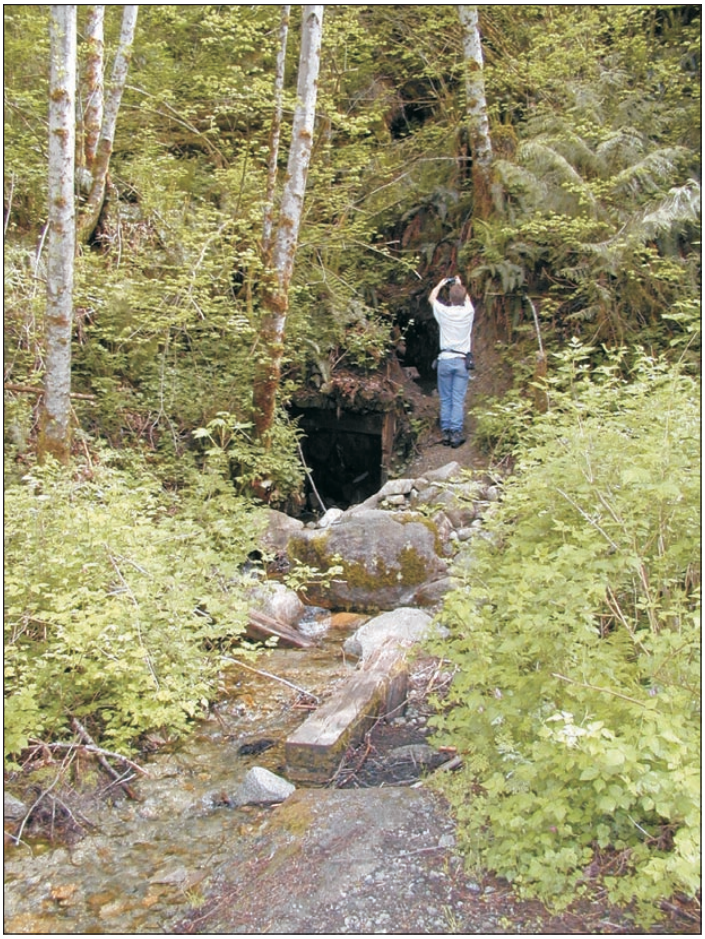

Figure 7. *(above left)* Main haulage level, adit 2. The tunnel is caved beyond the DGER geologist. A discharge stream is in the foreground.

Figure 8. *(above right)* Ventilation raise on the centerline of adit 3. Backpack for scale.

Figure 9. (*below right)* Overhang at open cut connected to adit 3. Fir trees above the highwall are about 2 feet in diameter. View is to the southeast.

GENERAL INFORMATION

Name: Sunset mine

MAS/MILS sequence number: 05306110334

Access: Two-wheel drive road to the junction of North Fork Skykomish Road and mine access road. Four-wheel drive vehicle or walk to mine site.

Status of mining activity: none (BLM LR 2000 database)

Claim status: no mining claims

Current Ownership: U.S. Forest Service (USFS)

Surrounding land ownership:
Mount Baker /Snoqualmie National Forest (USFS)

Location and Map Information

Mine name	County	Mine location	1:24,000 map	1:100,000 map	Longitude	Latitude
Sunset	Snohomish	sec.1, T27N R10E	Baring	Skykomish River	121.4614	47.8583

Directions

Drive east on State Route 2 and turn left on the North Fork Skykomish River Road approximately 6 miles past Gold Bar. Continue 4.9 miles from the town of Index and cross the Trout Creek bridge. At this point a primitive road leads uphill to the east, switchbacking sharply to the south. This road can be traversed by motorized all terrain vehicles or four-wheel-drive vehicles, but deep erosion has rendered the track problematical for use by other vehicles. To walk to the mine, park near a steel gate at the road entrance. Ignore the logging road that angles off to the left one mile from the car park. Stay on the main stem road another ¾ mile until you break out of thick alder on the north side of Trout Creek next to a large concrete footing, which is the site of the former Sunset mill. The adit 2 haulage tunnel is located at the foot of the hill about 400 feet to the east of the mill site. Adits 1 and 3 lie above adit 2 to the north and east (Fig. 1). To locate these features, contour east from the haulage tunnel about 100 feet to where the remains of a brush-covered road leads uphill and switchbacks to the left. Open cuts and stopes caved to the surface above these adits are located 200 feet directly upslope from the portals.

Figure 10. Entrance to stope 11. Note the mineralized vein on the wall on the left side of the photo (arrow). View is to the northeast.

Mine Operations Data

Type of mine: underground with mill

Commodities mined: copper, with recoverable values in silver and gold

Geologic setting: A series of roughly parallel mineralized veins in shear zones of the Index batholith. The country rock is granodiorite (Tabor and others, 1982).

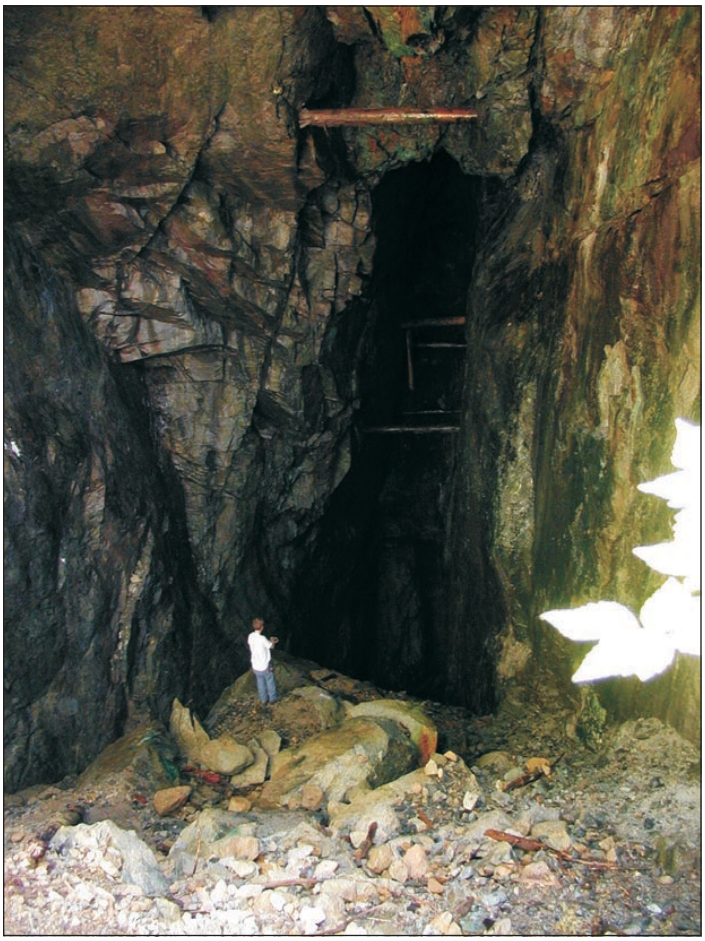

Figure 11. Entrance to stope 11 on vein centerline. Note the 1-foot-diameter stulls overhead. The back of the stope is 220 feet distant. View is to the east.

Figure 12. Recent highwall failure (arrow) and subsidence along the vein's western extension.

Figure 13. Sunset mine and camp operations in 1929. Lee Pickett photo from DGER photo files.

Ore minerals: chalcopyrite ($CuFeS_2$) and bornite (Cu_5FeS_4); native copper and silver have been reported (Derkey and others, 1990)

Non-ore minerals: minor pyrite, quartz, talc, marcasite, chlorite

Host rock: granodiorite

Period of production: 1902–1905, 1916–1930, 1937–1941, 1946

Development: Five levels developed from three principal adits and 12,000 feet of drifts, stopes, and winzes. Approximately 6200 feet of the total occurred on the Sunset vein, accessed on level 2. Levels 3, 4, and 5 were 1200 feet, 2250 feet, and 500 feet long respectively.

Production: 12,912,000 pounds of copper, 1,500 ounces of gold, and 156,000 ounces of silver. The production at present day metal prices would be valued at $11.5 million.

Mill data: The mill used a combination of gravity concentration tables and flotation cells. Its capacity

Figure 14. Mill foundation. Former waste-rock site in foreground was washed away during Trout Creek flooding. Note machine gun bullet holes in foundation.

Table 1. Mine features. – – –, no data; **, data from DGER mine map file; *, numbered photos online at http://www.wa.gov/dnr/htdocs/ger/iaml/02-4/

Description	Condition	Fenced (yes/no)	Length (feet)	Width (feet)	Height/ depth (feet)	True bearing	Elev. (feet)	Longitude	Latitude	Digital photo*
adit 1	open	no	225**	5	7	N48E	1460	121.4615	47.85682	DSCN2827.JPG
adit 2	caved	no	1200**	5	7	N40E	1360	121.4639	47.8569	P5240109.JPG
adit 3	caved	no	200**	5	7	N40E	1530	121.46267	47.85803	– – –
ventilation raise	open	no	4	6	154	– – –	1620	121.4626	47.85819	P5240122.JPG
surface cut above adit 3	open	no	350	40	50–100	N60W	1640	121.4635	47.85861	P5240124.JPG
open stope adjacent to east of above feature	open	no	75	40	100	N60W	~1640	121.4626	47.8582	P5240131.JPG
surface cut above adit 1	open	no	140	30–50	50–100	N60W	1560	121.4611	47.85707	DSCN2860.JPG
open stope adjacent to east of above feature	open	no	100	40	50+	N60W	~1560	121.4607	47.85738	P5240113.JPG

was 250 tons per day. Water for milling and electrical power was diverted at an upstream take-out point on Trout Creek and conveyed to the mill through 4100 feet of flume and wood-stave pipe. Maps prepared in 1938 indicate that the mining company installed a 22-foot dam at the outlet of Sunset Lake, increasing the storage capacity of the lake by 52 million cubic feet, thus insuring a 60-day supply of water to the flume. A similar but smaller dam was built in the outlet of Trout Lake, the headwaters of Trout Creek. The maps indicate that construction at these facilities was "70% complete in 1929" (Campbell, 1938). The bulk of mill tailings appear to have been deposited on a narrow strip of Trout Creek streamside land and washed away by periodic high water.

Table 2. Mine structures. *, numbered photos online at http://www.wa.gov/dnr/htdocs/ger/iaml/02-4/

Description	Longitude	Latitude	Elevation (feet)	Condition	Digital photo*
mill footings	121.4652	47.85723	1310	concrete intact, nothing remains of the mill itself	DSCN2878.JPG Fig. 14

Figure 15. Site of former bunkhouse and dining hall. View to the south.

PHYSICAL ATTRIBUTES

Features: see Table 1

Materials: wood stave pipe, narrow gage rail

Machinery: none

Structures: see Table 2

Presence of unstable slopes, walls, waste rock, tailings, or impoundments: The open stopes and surface cuts described in Table 1 create an extreme hazard to human safety. The highwalls, which are vertical, stand 50 to 100 feet above the floor. Blocks of granodiorite continue to spall off the sidewalls of the surface cuts and overhead of the open stopes. The open stopes form caverns 50 to 100 feet high. We estimate the distance between the ground surface and the stope ceilings to be about 15 to 20 feet.

Analysis of tailings and dumps: none

Waste rock, tailings, or dumps in excess of 500 cubic yards: yes

Reclamation activity: Mining debris, buildings, and equipment have been removed. Second-growth forest has established a strong presence in formerly logged areas on the claims. Mill tailings and waste rock dumps shown in historical photos near adit 2 and the mill have been inundated at various times by high water in Trout Creek and washed downstream. Brush, red alder, and hemlock have taken hold at the location of former bunkhouses, shop buildings, and mine roads (Fig. 15).

VEGETATION

The site is overgrown with plants, trees, and wildflowers typical of the Cascade Montane Forest Zone. A unique assemblage of mosses, ferns, and sedges has been established on the sidewalls and floor of the discovery glory hole described above.

WILDLIFE

See Table 3

WATER QUALITY

Surface waters observed: Trout Creek, North Fork Skykomish River, and flow emanating from adit 2

Proximity to surface waters: 0 feet to Trout Creek

Domestic use: none

Acid mine drainage or staining: none

Water sample data: see Table 4

Water sample results: see Table 5

Surface water migration: Discharge from the main haulage tunnel, adit 2, migrates across the historic dump area, past the mill site, and into Trout Creek. Seasonal discharge from adit 1 infiltrates 40 feet from portal.

Table 3. Bat survey

Opening	Aspect	Air temp. at portal	Air flow: exhaust	Air flow: intake	Bats or bat evidence	Date of observation
adit 1	N48E	65°F	yes	no	no	24 May 2002
open stope above adit 1	N60W	65°F	no	no	no	24 May 2002
open stope above adit 3	N60W	71°F	no	no	no	24 May 2002

Table 4. Surface water field data

Description	Flow (gpm)	Conductivity (μS/cm)	pH	Bed color	Temp	Elev. (ft)	Longitude	Latitude
water from adit 2	50–450	133	5.9	natural	45°F	1360	121.46394	47.8569
Trout Creek, upstream from mine site	9000	22	5.5	natural	36°F	1300	121.4652	47.8564
Trout Creek, below mine site	9000	39	5.5	natural	36°F	1275	121.467	47.85717

Table 5. Surface water analysis. Metal concentrations are in μg/L, uncorrected for hardness; hardness is in mg/L. ≤, indicates metal was not detected; the number following is the practical quantitation limit above which results are accurate for the particular analysis method—the metal could be present in any concentration up to that limit and not be detected. – – –, no data

PART 1: ANALYSIS BY USEPA METHOD 6010, INDUCTIVELY COUPLED PLASMA					
Sample location	**Arsenic**	**Copper**	**Lead**	**Zinc**	**Hardness**
discharge from adit 2, main haulage	≤10	64	≤10	33	– – –
Trout Creek upstream from mine site	11	26	≤10	28	– – –
Trout Creek downstream from mine site	19	96	≤10	27	– – –
PART 2: APPLICABLE WASHINGTON STATE WATER QUALITY STANDARDS					
Type of standards (applicable Washington Administrative Code)	**Arsenic**	**Copper**	**Lead**	**Zinc**	**Hardness**
Surface water standards (WAC 173-201A, Standard for aquatic life in surface freshwater, chronic level maximums at 100 mg/L hardness)	190	11.4	2.5	104	100
Ground water standards (WAC 246-290, Washington State Department of Health, standards for ground water, domestic consumption)	50.0	1300	15	5000	– – –

ACKNOWLEDGMENTS

Bob Fujimoto and Pat Toman of the U.S. Forest Service contributed information on the land transfer and prior ownership at the Sunset mine. The estate of E. A. Magill contributed Sunset mine maps showing exploration drilling performed by various companies in the 1950s. Our editor Jari Roloff expedited the time required for documentation by providing a template and made suggestions contributing to the readability of the publication.

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Appendix

PHOTOGRAPHIC DOCUMENTATION

Photos (JPEG format) listed in tables and photo log may be found on our website at http://www.wa.gov/dnr/htdocs/ger/iaml/02-4/.

METHODS

We recorded observations and measurements in the field. Longitude and latitude were recorded in WGS 84 decimal degree format. Literature research provided data on underground development, which was verified in the field when possible.

All water samples were collected as simple grab samples in pre-cleaned 500 mL HDPE bottles with preservative and kept on ice for transport to Sound Analytical Services, Inc. (SAS). Soil samples from dumps or tailings were taken from subsurface material and double bagged in polyethylene. Chain of custody was maintained.

Water and soil samples were analyzed for arsenic, cadmium, copper, iron, lead, and zinc by inductively coupled plasma/mass spectrometry (ICP/MS) following USEPA Method 6010. Samples were analyzed for mercury by cold vapor atomic absorption (CVAA), USEPA Method 7470 (water), and Method 7471 (soil).

Holding times for the metals of interest were observed (28 days for mercury, 180 days for other metals). Instrument calibration was performed before each analytical run and checked by standards and blanks. Matrix spike and matrix spike duplicates were performed with each set.

FIELD EQUIPMENT

Garmin GPS III+, handheld GPS unit
Litmus paper, range 0–14, and 4–7
Hanna Instruments DiST WP-3 digital conductivity meter and calibration solution
Taylor Model 9841 digital thermometer
barometric altimeter
digital camera
binoculars
flashlight