RECLAMATION
Managing Water in the West

Site Features Inventory Report

Barite Hill Mine
McCormick, South Carolina

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Bureau of Reclamation
Technical Service Center
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Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Table of Contents

Executive Summary

The Barite Hill mine is an abandoned open pit gold mine located 3 miles south of McCormick, South Carolina. It was operated as a surface mine with cyanide heap-leaching for gold recovery from 1991 until 1995 when mine reclamation was initiated. The company, Nevada Goldfields, suspended site reclamation activities when they filed for Chapter 7 bankruptcy in 1999 leaving portions of the mine reclamation and closure activities uncompleted. Keys to the site were given to the South Carolina Department of Health and Environmental Compliance on July 7, 1999. In addition to the unfinished work, environmental issues are manifesting at the site. At the request of the EPA Region 4, personnel from the Bureau of Reclamation conducted a site inventory over the period March 27 through 29, 2007. Hazardous materials were encountered at the site, as were signs of frequent uncontrolled trespass. The most significant hazardous materials encountered were:

- Two wood pallets containing both opened and unopened bags of caustic soda (used for pH adjustments and for caustic stripping of gold from carbon columns).
- An insulated tank containing caustic solution (used for hot caustic stripping of gold from carbon columns).
- A tank of acid (used for pH adjustments and acid reactivation of carbon columns).
- Three ventilating systems comprised of a fume hood, flue ducts and exhaust fans in the gold recovery/assay building containing heavy metal oxide flue dust. A small melting furnace was on the ground just outside the building and it also was heavily stained with metal oxides.
- The metal oxides also appeared to have contaminated portions of the masonry block building structure.
- A polyethylene tank located in the permanent pad process pond area which was labeled as containing cyanide solution and appeared to contain some fluid.
- A 55-gallon drum labeled “Methyl-ethyl Keytone (MEK)”

All of the above materials except for the cyanide solution tank and MEK were removed during an Emergency Response action conducted on March 28-30 and disposed in the mine pit where their dangerous contents will either react or dissolve and disperse in the acidic water. This removal action was a sound decision given the signs of trespass, there was significant risk of injury and acute poisoning from materials at this site. The potential cyanide solution and the drum labeled MEK were sampled by others for analysis.

The most significant hazard remaining at the site is the Barite Hill open pit excavation. The Barite Hill pit is bounded on three sides by steep rock highwalls and contains an approximately 10-acre lake of metal-laden acid water. A haul road provides access from the west side past an unstable overhanging rock ledge down to the waters edge. This pit presents both physical safety hazards and environmental hazards. The physical safety issues include the potential for people to fall from unstable mine highwalls, potential for crushing by falling rocks, and the potential for drowning in the lake which has formed in the pit.

From an environmental perspective, the pit contains the most acidic water in the world. Recent measurements by the State of South Carolina indicate that the water has a 2.5 pH at the surface but becomes negative in pH at depths of around four feet. Readings as low as -3.9 pH standard units have been observed. The acid water is seeping out of the north side of the pit and making its way to an unnamed tributary of Hawe Creek. The acid seep is estimated to flow at about 5 gallons per minute and has turned the creek brown and stained the rocks with iron hydroxide precipitates. It has killed a segment of the stream and the full extent of the impact is the subject of an investigation being performed by others.

A more significant environmental hazard requiring urgent action is the potential for a sudden uncontrolled release of acid water from the pit. Currently, the water level appears to be approximately 15 feet below the north rim of the pit. The upper most part of this rim is comprised of a narrow berm of soil and weathered bedrock. Should the lake level rise to an elevation where it would spill over this rim, it would rapidly down cut through the soil and loose rock and likely would suddenly release approximately 6 feet of the acid reservoir. The resulting flood surge would be in the range of 40 to 60 acre-feet of water which would flow for about 4.5 miles into an arm of Strom Thurmond Lake. This would result in a large fish kill in the vicinity of the receiving inlet of the lake.

A similar potential for rapid and uncontrolled release of water and contaminated sediments exists with respect to the Process Plant Contingency Pond and two contaminated beaver ponds located downstream of the mine. These other potential sources of flood flow release are much smaller in size, but a failure would be detrimental to the stream environment.

The network of process ponds are full of water and are overflowing to the environment. Currently, water from the adjacent Process Plant Barren Pond overflows into the Process Plant Contingency Pond and it then seeps out through a fill embankment to an adjacent diversion ditch. Should the Process Plant Contingency Pond fill due to a large storm, it is likely to fail either by overtopping and erosion or by seepage induced internal erosion and piping which would release a significant amount of mud and water (several hundred thousand gallons) offsite.

Two beaver ponds, located downstream of the mine, are capturing and storing contaminants which are escaping the site. One pond lies on the tributary to the north of the mine, the other lies on the tributary to the south and west of the mine. The beaver ponds are not engineered structures. Should the beaver ponds fail in response to a flood event, the metals-contaminated sediments will be transported to and impact Strom Thurmond Lake.

Although the north beaver pond appears to be attenuating the acid flows seeping out of the mine pit, it is likely that this is a temporary situation. In the near future this beaver pond is likely to turn acidic and impacts will be seen further downstream.

The gold ore at the mine contains significant amounts of the mineral pyrite (FeS_2) which oxidizes to form sulfuric acid, also known as acid rock drainage. Acid rock drainage is the most significant environmental issue at the Barite Hill mine. This drainage contains a large amount of iron (evident from iron staining on rocks in surface drainage paths) and other heavy metals. This report has been prepared prior to completion of water sampling and analysis of the pit water; however; experience at many similar sites is that heavy metals such as bismuth, copper, cadmium, selenium, and others will be found in the acid drainage since they are present in other minerals occurring with the pyrite in the site ore and waste rock.

The spent ore and the majority of the waste rock at the site has been placed into clay-capped repositories; however; all of these caps are showing signs of distress from multiple causes including surface erosion, cracking of the clay caps, acid poisoning of vegetation, and incomplete cap construction. Surface drainage diversion ditches, located at the base of the repositories, are showing signs of severe erosion, which if left unchecked will in a few years time cause significant damage to the waste cap structures and significantly increase the volume of acid seepage from these facilities. Acid rock drainage was observed seeping out of the Reusable Heap Leach Pad, Permanent Heap Leach Pad, and the Industrial Solid Waste Landfill and is reporting to the process ponds. Signs of acid rock drainage were also noted at the reclaimed Area A Waste-Rock Repository. In at least two locations small acid seeps are flowing to diversion ditches and leaving the site rather than reporting to the ponds. It is expected that the volume of acid seepage from these sources will increase over time as the caps continue to degrade. Action needs to be taken to restore the integrity of the caps, collect the uncontrolled acid seepage in a controlled manner, and stabilize the eroding diversion ditches.

The most important issues of immediate concern are:

- Stabilizing and reclaiming the acid Barite Hill Pit
- Neutralizing cyanide in the Permanent Heap Pregnant Pond sump
- Completing fencing and posting warning signs in and around the site

Table 1. on the following pages presents a summary of all of the important site features and their associated hazards and environmental issues:

Table 1. Barite Hill Mine Feature Hazards and Environmental Issues.

Feature Name	Physical Hazards	Environmental Issues	Comments
Barite Hill Pit (Main Mine Pit)	Potential for persons to fall from steep unstable highwalls, crushing by rocks falling from the highwalls, drowning in the pit lake.	Acid generating rock in fills and highwall areas. Pit lake contains heavy-metal laden acid water which is seeping to receiving waters to the north.	Potential for catastrophic failure and release of acid water in a flood wave is the sites most significant risk. Dangerous highwalls should be fenced.
Rainsford Pit	None	Acid plume forming in the backfill.	If the acid plume is not mobile there are no significant issues associated with this pit.
Industrial Solid Waste Landfill	None	Acid seepage to receiving pond, another acid seep on west side causing erosion and discharge to eroded diversion ditch, uncompleted cap area recharging water into fill and eroding the cap.	Uncontrolled acid seepage, cap erosion and erosion in adjacent diversion ditch will lead to extensive erosion damage to the cap in the future. This will accelerate acid seepage discharge.
Waste Rock Disposal Area A	None	Acid seepage beginning to poison vegetation on the north side. Erosion of the perimeter diversion will soon extend into the cap.	This facility was not completely inspected. Uncontrolled acid seepage, cap erosion and erosion in adjacent diversion ditch will eventually lead to extensive erosion damage to the cap. This will accelerate acid seepage discharge.
Reusable Heap Leach Pad	None	Acid seepage flows into pond, uncontrolled acid seepage on north side causing erosion.	Uncontrolled acid seepage and erosion is minimal in extent at this time.
Permanent Heap Leach Pad	None	Acid seepage along southeast toe area has killed vegetation and is causing erosion damage to the cap. Erosion, rutting, and cracking of the upper portion of the cap due to trespass ATV use. Erosion from failed bedding under riprap lining in down chute from storm water bench.	Repairs to this facility are needed now to control toe area acid seeps and repair all erosion problems. Severe erosion damage to the cap by large storm events will soon begin to occur and delay will greatly increase repair costs.

Feature Name	Physical Hazards	Environmental Issues	Comments
Mine Office	Ice chest behind building has potential for child entrapment.	None, however disposal may require asbestos testing of floor and ceiling tiles.	More useful documents remain in this building and should be retrieved prior to disposal.
Water Treatment Plant	Overhead door is damaged and inoperable, potential for metal sheeting to fall.	Caustic and acid stored near each other. Site open to trespass. The initial Removal Action has abated these chemical issues.	Building provides significant shelter and could be useful to contractors for future site actions.
Gold Assay and Melting Furnace Building	None	Ventilation systems for assay hood, melting furnace flue ducts, etc. contain metal oxides. Acute poisoning risk from lead oxide and other heavy metal oxides in flue dusts has been abated by Removal Action.	Building has been removed.
Process Plant Foundations	None	Potential for cyanide leaks to underlying soil and groundwater.	Risk is very low, soil covered by concrete slab and spill containment directed to ponds during mine operation. Slab prevents access to underlying soil. No action needed.
Pole Barn Storage Shed	Cuts and punctures from broken glass, sharp metal edges, and many boards with nails.	Barrel labeled MEK	Barrel has been sampled. Other debris should be disposed of.
Crusher Area	None	Prussian blue (ferrocyanide) coatings on bedrock indicate cyanide spills. Potential for cyanide leaks to underlying bedrock.	Given natural bedrock propensity to turn acidic and high iron content, the risk of free cyanide is low. No action recommended.
Process Plant Pregnant Pond	Slippery liners, potential for falling in and drowning.	None.	Repair gaps in Contingency Pond fencing and post warning signs. Need for environmental actions depends upon analysis results.

Feature Name	Physical Hazards	Environmental Issues	Comments
Process Plant Barren Pond	Slippery liners, potential for falling in and drowning.	None.	Repair gaps in Contingency Pond fencing and post warning signs.
Process Plant Wash Pond	Slippery liners, potential for falling in and drowning.	None.	Repair gaps in Contingency Pond fencing and post warning signs.
Process Plant Carbon Pond	Slippery liners, potential for falling in and drowning.	None.	Repair gaps in Contingency Pond fencing and post warning signs.
Process Plant Contingency Pond	No liner, a few feet of standing water. Low potential for drowning. Fencing gaps allows easy access to all of the Process Plant area ponds.	Overtopping or seepage induced failure of embankment fill will cause sudden release of pond water and sediment.	Breach fill embankment to prevent catastrophic failure. Restore integrity of pond area fencing on northwest and south sides and post warning signs.
Permanent Heap Pregnant Pond	Slippery liners, potential for falling in and drowning.	Analysis by others indicates that water in the leak detection sump contains 30 ppm cyanide concentrations.	Cyanide at dangerous concentration. Need to neutralize the cyanide in the leak detection sump.
Permanent Heap Rinse Pond	Slippery liners, potential for falling in and drowning.	The water is near neutral but acid seeps from Permanent Heap Leach Pad are flowing into it.	This pond will be the first process pond at the site to turn acid which is likely to happen in the next 5 to 10 years.
Permanent Heap Barren Pond	Slippery liners, potential for falling in and drowning.	Full pond overflows offsite. Acid seepage inflows from Industrial Solid Waste Repository to this pond. Tank on north side may contain cyanide solution, analysis by others is pending.	This pond will turn acid in the future.
Topsoil Stockpile Area	None	Slaked lime storage in this area generates high pH runoff. Area not reclaimed.	Because of acid seeps from other site sources, the high pH runoff is not a concern for downstream areas.
Clay Soil Borrow Pit	Steep highwall and standing water, there is a potential for falls and drowning.	Pond and adjacent clay soil are not reclaimed, no surface drainage outlet.	Needs to be reclaimed. May be feeding water into the adjacent acidic Barite Hill Pit.

Feature Name	Physical Hazards	Environmental Issues	Comments
Surface Drainage Ditches	None	Severely eroded diversion ditches have near vertical sides and the ditches continue to headcut into reclaimed areas.	Need to stabilize the near vertical banks of these channels before they form gullies up into the repository caps.
Sediment Pond	Potential for drowning.	None	Contains clean water which may be need for site construction activity such as dust control and rinsing equipment. Eventually the dam should be removed and the area reclaimed.
Wetland Areas	None	The wet pond area north of the Industrial Solid Waste Landfill may be feeding water into that facility.	Evaluate possibility of water levels in the wetland/pond area infiltrating into the Landfill.
Groundwater Wells	None	Most well caps are not locked.	Lock all well caps.
HDPE Pipe	None	None	Pipeline conveyances installed around the site and pipe stockpiles may be needed for future solution handling – retain.
Debris Piles	Cuts from sharp edges, punctures from boards with nails, pinching and crushing from shifting metal debris.	None	Dispose of debris piles.

Introduction

This report provides a detailed inventory of the features and facilities at the Barite Hill mine in McCormick, South Carolina. The purpose of the inventory is to gather factual information about the site features, gather and assemble relevant records, and identify various environmental issues and physical hazards in support of further mine reclamation and closure activities.

Bureau of Reclamation personnel traveled to the site to gather relevant documents and drawings, and conduct a two-day intensive inventory of site features and infrastructure. The inventory team consisted of Michael Gobla, P.E. a mining and geotechnical engineer, Margaret Lake, a chemist, and Kathleen Power, an environmental compliance specialist. The inventory and on-site record gathering activities were performed on March 27, 28, and 29, 2007. The information contained in this inventory report represents current site conditions as of March 29, 2007. Some portions of the site are covered with thick stands of thorny shrubs and dense stands of trees which made it impossible to gain access on foot for complete review of all site features. Portions of the site features have not been completely inspected.

During the inventory work, personnel from other organizations were on site to perform limited amounts of site water sampling and to sample and identify potentially hazardous materials. The results of the water sampling and analyses are not included in this report and will be provided by others.

Barite Hill was operated as a surface mine with cyanide heap-leaching for gold recovery starting in 1991. Mining ended in October 1994, and leaching and gold recovery ended in 1995 when mine reclamation was initiated. The company, Nevada Goldfields, suspended site reclamation when they entered into bankruptcy in 1999. The gold ore and much of the waste rock at the mine contains significant amounts of pyrite which is the source of acid rock drainage at the site.

Location

The Barite Hill mine is located in a wooded area 3 miles south of McCormick, South Carolina. It is north of road 30 and lies between US highways 378 and 221. It lies on a northeast trending ridge above unnamed tributaries to Hawe Creek as shown in Figure 1. Elevations vary from a high of approximately 510 feet at ridge tops to lows around 400 feet along the tributaries of Hawe Creek.

Climate

The site is located in a region of high precipitation. According to mine permit documentation (Water, Waste and Land, Inc., 1989), the annual average precipitation is 47 inches and annual evaporation is 46 inches. The wettest year on record is data from Clark Hill Dam which experienced 76.28 inches of precipitation. The storm water facilities were designed using a 100-year, 24-hour precipitation event of 8 inches.

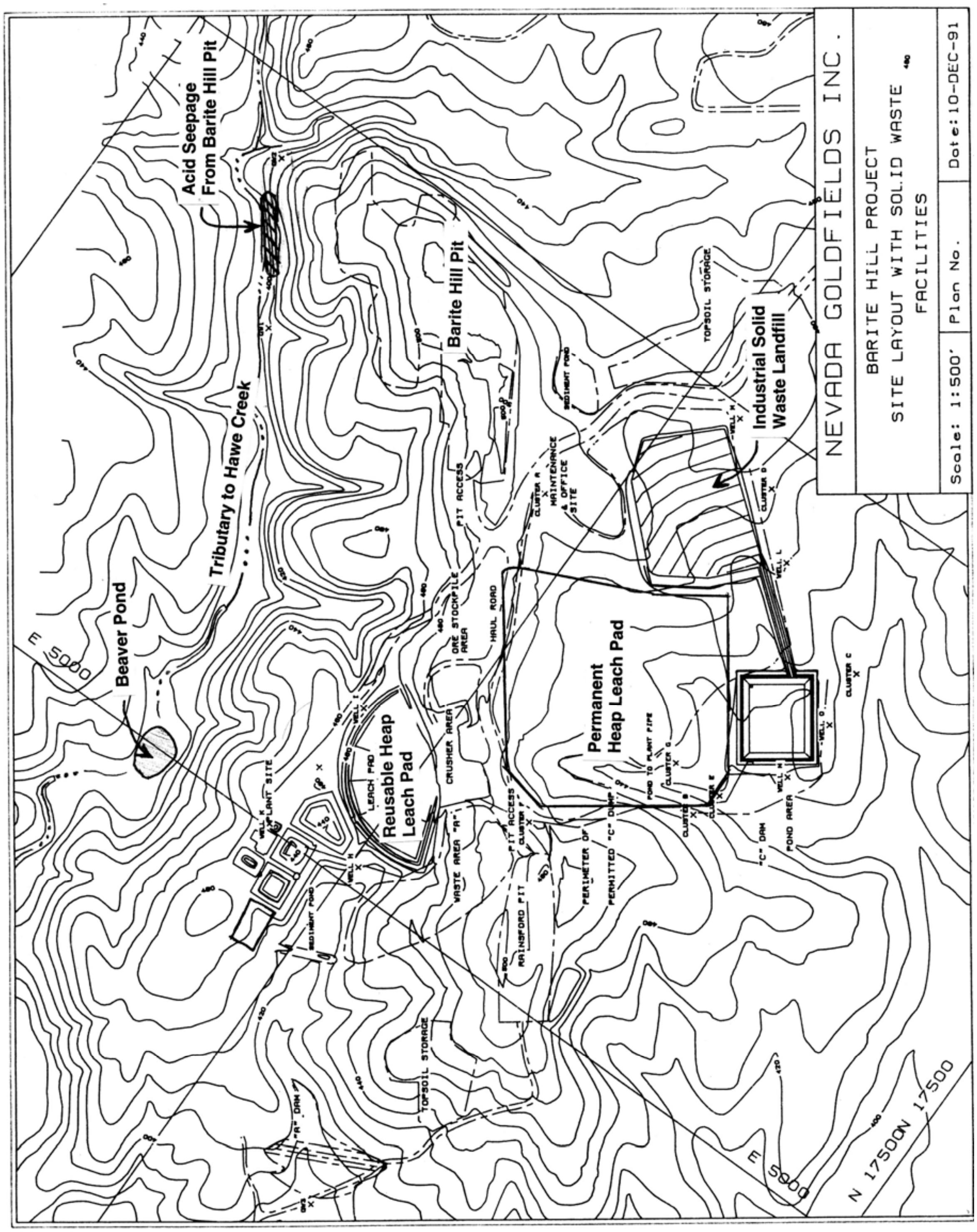

Figure 1. Major Site Features, Barite Hill Mine, South Carolina.

Land Ownership

The mine site is comprised of several, contiguous parcels of land which were acquired under various lease/purchase agreements. The company also owned and leased other lands in the region for exploration purposes. Files containing details of land ownership, royalty agreements, and payments were found in the mine office. These records were removed and given to Mr. Leo Francendese of the Environmental Protection Agency for safekeeping. Table 2 summarizes the various land parcels, area in acres and the mine features located in each parcel.

Table 2. Land Parcels Comprising the Barite Hill Mine

Name of Tract	Area in Acres	Mine Features Present
Rainsford & Sons	113.4	Waste Area A Rainsford Pit (Backfilled) Drainage Ditches
GP (Brunswick) GP (Brunswick) GP (Brunswick)	87.2 303.3 344.3	None None None
Nevada Goldfields, Inc. (USFS Exchange)	55.7	Process Plant Ponds Reusable Heap Permanent Heap Waste Area A
Nevada Goldfields, Inc.	148.1	Main Pit Permanent Heap Permanent Heap Ponds Industrial Waste Area Sediment Pond Clay Borrow Area
Dorn	311	None
Dorn	153.1	None

The permitted mine site totals 795.2 acres. Of this total, 659.7 acres are designated as buffer area (areas not disturbed beyond the pre-mine natural state); therefore the maximum disturbance area which was allowed under the mine permit was 135.5 acres. Most of the disturbance was reclaimed by the mining company. The current area of disturbance, not including the areas occupied by process ponds or the pit lake, is estimated to be in the range of between 20 to 25 acres. The disturbed areas are associated with the pit highwalls and benches, the clay borrow area, the former topsoil stockpile area, and the site roads.

Geology

Regional Geology

Barite Hill is the southernmost of four major surface gold mines which have been developed in the South Carolina Slate Belt. The other mines, located to the northwest, are Haile, Brewer, and Ridgeway.

The gold deposits at Barite Hill are hosted in igneous and metamorphic rocks which are locally called the "felsic pyroclastic sequence." The original sediments were altered and mineralized by igneous intrusions. All of the rocks were then altered by metamorphic action.

The mine area is one of moderate seismic activity. Slope stability analyses for the mine facilities utilized a seismic coefficient of 0.05 g (Water, Waste and Land, Inc., 1989).

Local Geology

Host rocks for the Barite Hill deposit are sericitically-altered, felsic metavolcanic and metasedimentary rocks of the Late Proterozoic Persimmon Fork Formation, which consists of the Lincolnton metadacite and metarhyolite and the overlying lower and upper pyroclastic units. The rock types found at the mine include Lincolnton metadacite and metarhyolite, a quartz crystal porphyry with a finer-grained quartz-feldspar matrix. The Felsic metavolcanics are quartz and feldspar crystal tuffs with a quartz-sericite matrix. Intermediate volcanics are feldspar crystal tuffs with a chloritic matrix. The pyroclastic units include metasedimentary rocks which are mostly coarse to fine grained wackes. Outside the deposit are fine-grained mica schists, quartzite, and other metasedimentary rocks. Structurally the rocks strike approximately north 55 degrees east and dip 80 degrees to the northwest. Local bedding planes preserved in the metasediments strike north 45 degrees east with varying dips from near vertical to northwest dips. Contacts are steeply dipping.

The Barite Hill deposit is interpreted by Clark (1999) to be the result of Kuroko-type submarine volcanogenic base-metal sulfide mineralization followed by precious metal deposition under epithermal conditions. The Barite Hill deposit lies stratigraphically below an overturned contact between the upper and lower pyroclastic units. Gold-silver-rich zones in the Main Pit are partly coincident with lenses of siliceous barite rock, but not confined to them, and occur more commonly in pyrite-quartz altered fragmental rock. The four ore zones in the Main Pit are overlain by a zone of barite and base-metal enrichment, which is, in turn, overlain by a talc-tremolite alteration zone. Siliceous barite zones are absent in the Rainsford Pit where gold and silver minerals are associated with silicified rocks and chert.

Mineralogy

The Barite Hill deposit was mined from 1990 to the end of 1994. Approximately 1,835,000 grams (58,996 troy ounces) of gold and 3,390,280 grams (109,000 troy ounces) of silver were produced (Clark, 1999). Three stages of mineralization are recognized as 1) local base-metal sulfide, 2) early, gold-poor mineralization having abundant pyrite and base-metal sulfides, and 3) late, gold-rich mineralization. The gold occurs in quartz-pyrite veins and in volcanic rock fragments. The host rocks have been sheared and altered by the mineralizing events. Non-metallic minerals found at the site include quartz, feldspar minerals, barite, muscovite (the fine-grained variety called sericite), talc, and tremolite. The metallic minerals are presented in Table 3:

Table 3. Metallic minerals occurring at the Barite Hill Mine (Back and Clark, 1992).

Name	Chemical Formula
Gold	Au
Sylvanite	$(Au,Ag)Te_4$
Electrum	(Au,Ag)
Silver	Ag
Argentite	AgS
Galena	PbS
Hessite	Ag_2Te
Chalcopyrite	$CuFeS_2$
Chalcocite	Cu_2S
Bornite	Cu_5FeS_4
Covellite	CuS
Goldfieldite	$Cu_{10}Te_4S_{13}$
Tennantite	$Cu_{12}As_4S_{13}$
Atacamite	$Cu_2Cl(OH)_3$
Sphalerite	ZnS
Molybdenite	MoS_2
Unidentified bismuth and copper selenides	Various minerals containing Bi, Cu, and Se

In addition to the minerals listed in Table 3, it should be noted that other metallic elements are likely to be present. Minerals such as pyrite and sphalerite are known to be scavengers of other elements. During crystallization, scavenger minerals commonly incorporate small amounts of other elements as impurities in their crystal structure. The ore and waste rock may contain a large number of different metallic elements as a result of the impure nature of the minerals. Examples of other elements which may be present are cadmium and arsenic.

SITE ACCESS

Access to the site is controlled by signage, fences and gates, and by natural barriers. The fencing is not complete. Although there are two locked gates along the site access road, during the field inventory work it was evident that the site was not completely closed to trespass. Local people have been using the site for recreation. Some rutting and erosion damage to the caps has resulted from the use of all-terrain vehicles by trespassers. The mine office has had the windows broken out, furniture turned over, papers dumped out of files, and empty beer cans were observed nearby. Evidence of trespass and vandalism was also observed around the Process Plant area.

Signage

Minimal signage was found at the property consisting of the mining company sign at the entrance and a speed limit sign. The need to post warning signs was recognized during the site visit and the State and EPA cooperatively developed appropriate warning signs to be added to key site areas and access points. More signage is needed around the site perimeter.

Figure 2. This sign adjacent to the site entrance gate identifies the mine and is visible from Road 30. The small sign at the left stating "check in at office before entering premises," is no longer valid and should be removed.

Figure 3. The main access road at the site has two of these speed limit signs.

Fencing

Site fencing consists of perimeter fences and road gates and internal fencing around the process ponds. The perimeter fencing is not continuous, but rather it appears to be placed at key locations such as adjacent to the entrance road and at other locations where needed to limit access to the site. Some avenues of access are open to foot traffic. Time did not allow for a complete assessment of the site perimeter fencing.

Figure 4. Photograph of the access gate near the mine office. A similar gate lies to the east at the site entrance.

Two access gates are located on the main entrance road. One is on the east side of the site near the mine entrance just off road 30. The other gate (see Figure 4) is near the center of the property just east of the principal mine disturbed areas and is adjacent to the mine office building. The gates each consist of two 10-foot swinging units providing an opening of approximately 20 feet at the mine entrance and a 19.5- foot-wide opening in the gate adjacent to the mine office building.

Figure 5. Close up view of fencing around the Process Plant Contingency Pond showing a smooth-wire grid and an upper single strand of barbed wire.

All of the process ponds are fenced. The pond fencing consists of a smooth wire grid with from one to three upper strands of barbed wire. When all three strands of barbed wire are present the fence forms a barrier which is approximately 6-feet tall. The Process Plant Contingency Pond fence is down in one segment on the south side and the entrance to the fenced area is open on the northwest side of the pond, thus access to all of the Process Plant area ponds is not properly controlled.

The fencing around the Permanent Heap Process Ponds is largely intact. This fencing varies from a 6-foot tall smooth wire grid topped by barbed wire to a simple three strand barbed wire fence on the east side of the ponds. A swing gate made from tubular steel controls the vehicle access point into the Permanent Heap Barren Pond.

Figure 6. Photograph showing a transition in the fencing at the Permanent Heap Rinse Pond. At left is a three strand barbed wire fence, at right is the taller fence with a smooth wire grid and upper strands of barbed wire.

Figure 7. Metal gate located at the southeast side of the Process Plant Barren Pond.

Existing Roads

Existing roads at the site include the site access road which trends from the east to west across the site, the pit access roads, the permanent heap access road, the permanent heap process ponds access road. Several other roads are present but are no longer passable.

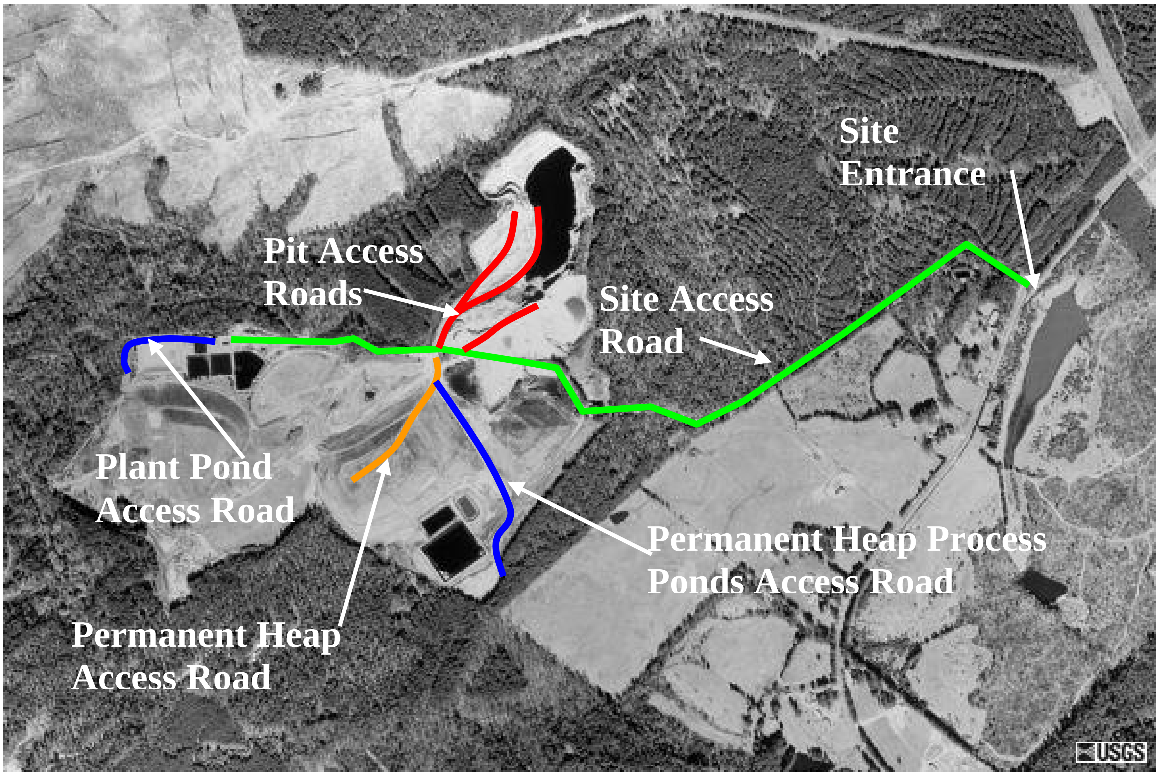

Figure 8. Aerial photograph of the Barite Hill Mine showing existing access roads.

The site access road is 20 feet wide over most of its length, but is about 30 feet wide adjacent to the mine pit. The other site roads are 10 to 12 feet wide and are being encroached by growth of the adjacent vegetation. The access road leading to the Permanent Heap Process Ponds requires trimming of the vegetation if it is to stay open to vehicle movement. Except for a very short segment of broken pavement in the site entrance where it connects to road 30, the site roads are not paved. The Permanent Heap Process Ponds Access Road is being encroached by vegetation and requires brush removal if it is to remain open. The Pit Access Roads are littered with large rocks and can not be traversed by passenger vehicles.

Mine Excavations

The site contains two mine excavations, the Barite Hill Pit (Main Pit) and the Rainsford Pit. The Rainsford Pit has been backfilled with waste rock and is described in a later chapter of this report. The Barite Hill Pit covers approximately 20 acres of land.

Barite Hill Pit (Main Pit)

Also called the "Main Pit" on drawings, this open pit mine excavation is bounded on three sides by steep rock highwalls and contains an approximately 80-foot-deep lake of metal-laden acid water. It was excavated from 1991 until mid-October 1994.

Figure 9. The most significant hazard remaining at the site is the Barite Hill Pit.

The pit occupies an area of approximately 20 acres. It consists of a 10-acre lake surrounded by 10-acres of disturbed uplands which drain towards the pit lake. The pit lake is continuing to grown in size. There are three access roads originating from the southwest side of the pit (Figure 8) which lead to 1) the upper northwest side of the pit, 2) down to the waters edge on the west side, and 3) along the top of the south highwall.

Although there are many rock types present, there appears to be two materials from a geochemical standpoint, oxidized soil and rock, and un-oxidized rock. The red-colored soil and rock is oxidized material (pyrite has been leached out over geologic time). The oxidized material is not likely to generate acid. This is evidenced by the fact that there is volunteer vegetation taking hold in the red soil and rock on the east side of the pit.

Figure 10. Photograph looking towards east side of the pit. The east highwall area shows signs of volunteer vegetation and it likely has a relatively low permeability. In the upper right part of the photograph, the excavation from the clay borrow area can bee seen which removed the top layer of red-colored clay soil.

Volunteer vegetation is not seen on the south side of the pit even though the soil and rock appears to be oxidized. A snow making machine was used along the south highwall to evaporate excess water from the pit (Figure 11). The mist fallback from the device would have contaminated the ground with acid salts which would inhibit vegetation establishment for a time; but now these salts should have been flushed from the soil. It is likely that the south highwall is too far away from existing vegetation for any seed to have been deposited in this area.

The un-oxidized material is the grey- to yellow-colored rock which is rich in pyrite and is highly acid generating. This material is evident in the northeast, north and west sides of the pit highwalls (see Figures 12 and 13). Additionally, pyrite-containing waste rock has been dumped onto the gently sloped bench areas on the west side of the pit (see Figures 14 and 15), and is a major acid source area draining into the pit.

Figure 11. Snow making machine on top of the south highwall was used to evaporate excess site water.

Figure 12. Photograph of the highwall on the northeast side of the pit. The grey to yellow rocks in the highwall are acid generating rock. The red colored rocks and overlying soil likely do not generate acid and show volunteer vegetation.

Figure 13. View of grey-colored rocks rich in pyrite on the west side of the pit.

Figure 14. Photograph showing the disturbed area on the southwest side of the Barite Hill Pit. This is a major source area for acid water draining into the pit.

Figure 15. Close-up view of some of the pyrite-containing waste rock piles dumped onto the upper benches on the west side of the Barite Hill Pit.

Prior to leaving the site in 1999, the mining company took two actions to control acid in the pit area. The pit lake was amended with lime to neutralize it, and the waste piles were coated with "gunite" to prevent acid runoff from forming. Neither of the actions were a success. The pit re-acidified because it was only partially full and it continued to receive acid input from the following four sources:

- Release of stored acid salts from rubble and fractured rock walls upon saturation by rising pit lake water levels.
- Inflow of acid stormwater runoff from exposed bedrock and waste piles in adjacent unsaturated upland areas as a result of precipitation and snowmelt events.
- Oxidation of pyrite rubble and fractured rock highwalls by interaction of the upper aerobic water layer with the pit shoreline and shallow submerged zone.
- Dissolution of pyrite in the anaerobic zone by Fe^{+3} ions to release acidity and Fe^{+2} ions into the pit lake (iron cycling)

Figure 16. Photograph of damaged "gunite" coating on pyrite-rich waste rock left exposed in the upper benches of the Barite Hill Pit. The coating is a failed attempt to mitigate the acid drainage originating from this waste rock.

The gunite, a calcium-carbonate-rich spray-applied coating on the waste rock piles, was not successful in preventing acid generation. The gunite coating could not penetrate into the fine-grained portion of the pyrite-rich waste where most of the acid is generated (Acid formation is proportional to surface area of pyrite exposed to moisture and oxygen). Also, the gunite coating has very little tensile strength and is porous. It is easily fractured and loosened by temperature extremes and freeze-thaw action. In time the gunite was fractured, loosened, and removed by the weather.

Subsequent to the field inventory work, the State of South Carolina, Department of Health and Environmental Control, sampled the Barite Hill Pit on July 3, 2007 and found the pH values varied from 2.42 at the surface to negative 3.9 at a depth of 4 feet. Similar negative pH water was measured at depths of 25 and 30 feet. This is the most acidic water ever reported in a natural or manmade body of water anywhere in the world. Prior to this, a pH reading of -2.47 taken inside the Richmond Adit at the Iron Mountain Mine Superfund Site in California was considered to be the world's most acidic water (Nordstrom and Alpers, 1999).

This pit presents both physical safety hazards and environmental hazards. The physical safety issues include the potential for people to fall from unstable mine highwalls, potential for crushing by falling rocks, and the potential for drowning in the lake which has formed in the pit.

From an environmental perspective, the acid water is seeping out of the north side of the pit and making its way to a tributary of Hawes Creek. The acid seep has turned the creek flow brown and stained the rocks with iron hydroxide precipitates. It is thought to have killed a segment of the stream and the extent of the impact is the subject of an investigation being performed by others. The volume of seepage would be affected by the head differential between the pit lake and the creek. It is likely that the seepage rate has accelerated as the pit level continues to rise and that most of the downstream impacts have occurred in the past few years.

Pit Lake Overtopping

EPA has asked if the pit can fill to overtopping and what are the likely consequences. Some had argued that seepage outflows might offset the rise in the pit lake and result in a stable pit level that does not reach the rim of the pit. The following evaluation shows that unless there is a drought, the pit is expected to rise to overtopping levels within the next three to five years. If no action is taken, a catastrophic release of an estimated 20 million gallons of acid water is expected to occur.

Depending upon climatic and geologic conditions, a pit lake will either become a terminal lake (typical in a dry climate) or a flow through lake (typical in a wet climate). Pit lakes receive water input by three natural processes:

- Direct Precipitation
- Runoff from adjacent watersheds
- Groundwater inflow

Pit lakes loose water by two natural processes:

- Evaporation
- Groundwater outflow

The climate and water balance will determine if a pit becomes a terminal lake or a flow through lake. In the arid southwest states like Nevada and Arizona, pit lakes are typically terminal lakes. Evaporation rates exceed the rate of water inflow and as a result the water table does not fully recover after mining ends. Depression of the groundwater table is the long-term condition which results in a sustained groundwater inflow to the evaporating pit lake.

In wet climates such as in South Carolina, South Dakota, and Montana, pit lakes typically continue to fill until they become flow through lakes. The inflows from precipitation and runoff exceed the evaporative and seepage losses resulting in a mounding of the water table. These pits typically fill to the surface and have both groundwater and surface water discharge. In rare cases a flow through lake may loose all of its water to groundwater outflow if the upper walls of the pit are comprised of very pervious material.

The Barite Hill pit will become a flow through lake. Seepage from the pit to the unnamed tributary to Hawe Creek was recently estimated to be around 5 gpm. The upper pit walls, while allowing some acid seepage to flow to the adjacent creek, do not appear to be pervious enough to prevent the pit from filling completely. It is expected that the pit lake level will continue to rise until it begins to spill to surface flow pathways. This is consistent with the experiences at two other gold mines in South Carolina. At the Haile Mine (Champion and Snake Pits) and at the Ridgeway Mine (South Pit and North Pit), all of the pits have filled to the low side rim and are now flow through lakes.

At Barite Hill the water level in the pit is presumed to have been rising since the mining activity ceased in mid-October, 1994. It is presumed that the pit began filling as soon as mining ended. There would be no incentive to keep water out of the pit after all of the ore had been extracted. The aerial photograph shown in Figure 17, shows the pit lake as it appeared in the year 2000 which would have been 6 years after the end of mining. Also, water in the pit appears to have increased up to the present time. The approximate extent of the pit lake as it currently exists has been added to the aerial photograph shown in Figure 17.

A water balance model does not exist for the Barite Hill pit. Unlike the process ponds which are full and overflowing, the pit has a groundwater seepage component which complicates calculation of the water balance. When the seepage outflows and evaporative losses are greater than the inflows from seepage, precipitation, and runoff, the pit lake will decrease in volume. When the inflows from seepage, precipitation, and runoff are greater than the losses from seepage outflow and evaporation the pit lake will increase in volume. Accurate data regarding groundwater seepage do not exist. What is known is that the pit lake now covers about 10 acres of the 20-acre pit watershed. In other words there is about 10 acres of uplands draining into the 10-acre pit lake. This site is in a wet climate. The mining company's consultants (Water, Waste and Land, Inc., 1989) reported that there is on average 47 inches of precipitation and 46 inches of evaporation per year, that the 100-year, 24-hour storm event is a precipitation of 8 inches, and that the wettest year on record is 76.28 inches of precipitation. Using the average precipitation data and assumed values for runoff and groundwater seepage rates, a rough water balance calculation for an average year is shown in table 4.

Table 4. Estimated water balance for an average precipitation year, Barite Hill Pit.

Direct Precipitation (acre feet)	Runoff Into Pit (acre feet)	Evaporation Out of Pit (acre feet)	Groundwater Inflow (acre feet)	Groundwater Outflow (acre feet)	Annual Volume Change (acre feet)
47" over 10 acres = + 39.2	30% of 47" over 10 acres = + 11.8	46" over 10 acres = - 38.3	2.5 gpm for 1 year = + 4.0	5 gpm for 1 year = - 8.0	+ 8.8

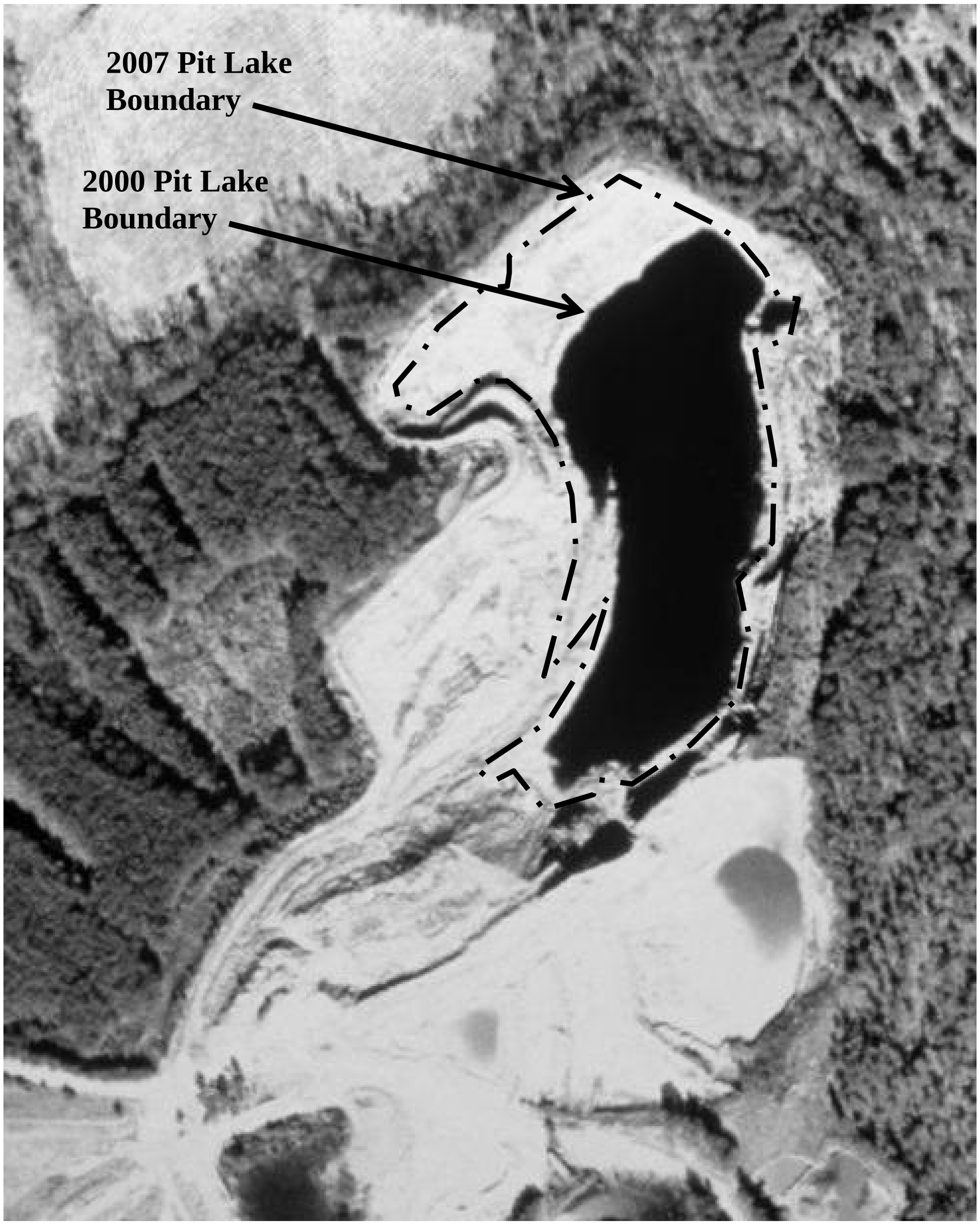

Figure 17. Aerial photograph of the Barite Hill Pit in the year 2000 showing the pit lake about 6 years after mining ended. The pit lake boundary in 2007 (about 12 years after mining ended) has been drawn onto the image.

An increase of 8.8 acre-feet of water is indicated for an average year using conservative assumptions. Note that the value for runoff (30 % of rainfall) is an assumed number. It is difficult to determine without having either several years of actual monitoring data, or by running an evaporative model. While large storms will result in up to about 70 % to 80 % runoff, smaller precipitation events will have little runoff into the pit because the dry ground surface will absorb the initial rainfall, then as rain continues some component will fill small depressions on the surface, and some will infiltrate into the ground. The remaining water that does not pond or infiltrate will become surface runoff which will flow into the pit lake. For larger storm events, such as one inch of rain, the ground will quickly become saturated causing most of the precipitation to runoff into the pit. Also, the groundwater inflow and outflow values in the above water balance calculation are only a guess. The water balance calculation is rough, it is very sensitive to rates of runoff, evaporation, and groundwater flows and therefore should only be used to indicate that the pit is likely continuing to increase in size and is expected to overflow. The calculation should not be used to predict the rate of rise of the pit lake. Sensitivity analysis of the calculation shows that using less conservative values for the percentage of runoff and a lower value for groundwater inflow, the annual volume change could be as much as +35 to +40 acre-feet which would equate to a 3.5 to 4 foot annual rise in the water level.

Another method of evaluating the pit filling is to simply look at the water level change over time. The pit has been filling for 12 years and according to the State of South Carolina the water is now about 80 feet deep. Dividing the 80 feet of water depth by 12 years results in an average rise of 6.6 feet per year. It is expected that initial filling would result in a faster rise in the pit elevation than at present because the lake would have been smaller and the contributing runoff area would have been a little larger in the early years. This estimate suggests that the pit could currently be increasing in elevation by about 3 to 5 feet per year and would agree with the aerial photograph and site observations which show a pit lake that continues to increase in volume.

Figure 18. View of the north pit wall where outflow from the pit will eventually occur.

It is concluded that the pit will fill to overtopping. Considering that there is only about 15 to 20 feet of freeboard left (see Figure 18), and that the upper 6 to 10 feet of the pit rim are comprised of soil and weathered bedrock, the pit could fill to dangerous levels in as little as 3 to 5 years time. Once the pit reaches the soil layer there is a very high risk of failure. The soil and weathered bedrock are not likely to be capable of performing as a dam. Prolonged seepage induced erosion could cause this soil layer to fail even before the water reached the overtopping elevation. If a seepage type of failure did not occur, then it is certain that it would fail upon overtopping; the soil rim can not stand up to the concentrated overtopping flow of water and would rapidly erode. Either type of failure would erode fairly rapidly from down-cutting to a widening that would open a breach that would then discharge a flood of acid water in a catastrophic (uncontrolled) manner. It is estimated that at least 4 to 6 feet of the upper part of the pit lake would be released as a sudden outflow before the down-cutting reached a harder layer of rock. For the 10-acre lake, this would equate to a flood surge of between 40 to 60 acre-feet water (13 million to 19.6 million gallons) of acid water.

Action to prevent a catastrophic release should be taken as soon as possible. At the very least, the loose soil and rock should be removed and a spillway structure needs to be constructed. If a spillway is provided, the pit is still expected to release acid water with each significant rain event. To provide some perspective on this, the amount of water released by a 1-inch rain from a full pit can be calculated. Assuming the pit lake is at the spillway level (about to overflow) a 1-inch rain event would input 271,000 gallons of water as precipitation onto the pit lake water surface and another 230,000 gallons as runoff (assuming 85% runoff) from the adjacent 10-acre watershed. This means that a 1" soaking rain is likely to push 500,000 gallons of highly acidic water through the pit and into the creek in a single event. An action like neutralizing the pit should also be considered for implementation.

Waste Rock and Spent Ore Repositories

There are two waste-rock repositories and three spent ore repositories. The waste-rock repositories contain blasted rock which was too low in grade to be considered ore. The heap-leach pads and solid waste disposal area contain "spent" ore. Spent ore is blasted rock which was crushed, agglomerated, and leached with sodium cyanide to remove the gold, and then the ore was rinsed with water to remove most of the cyanide solution. The spent ore is also called "spent agglomerate" in some of the mine permit documents.

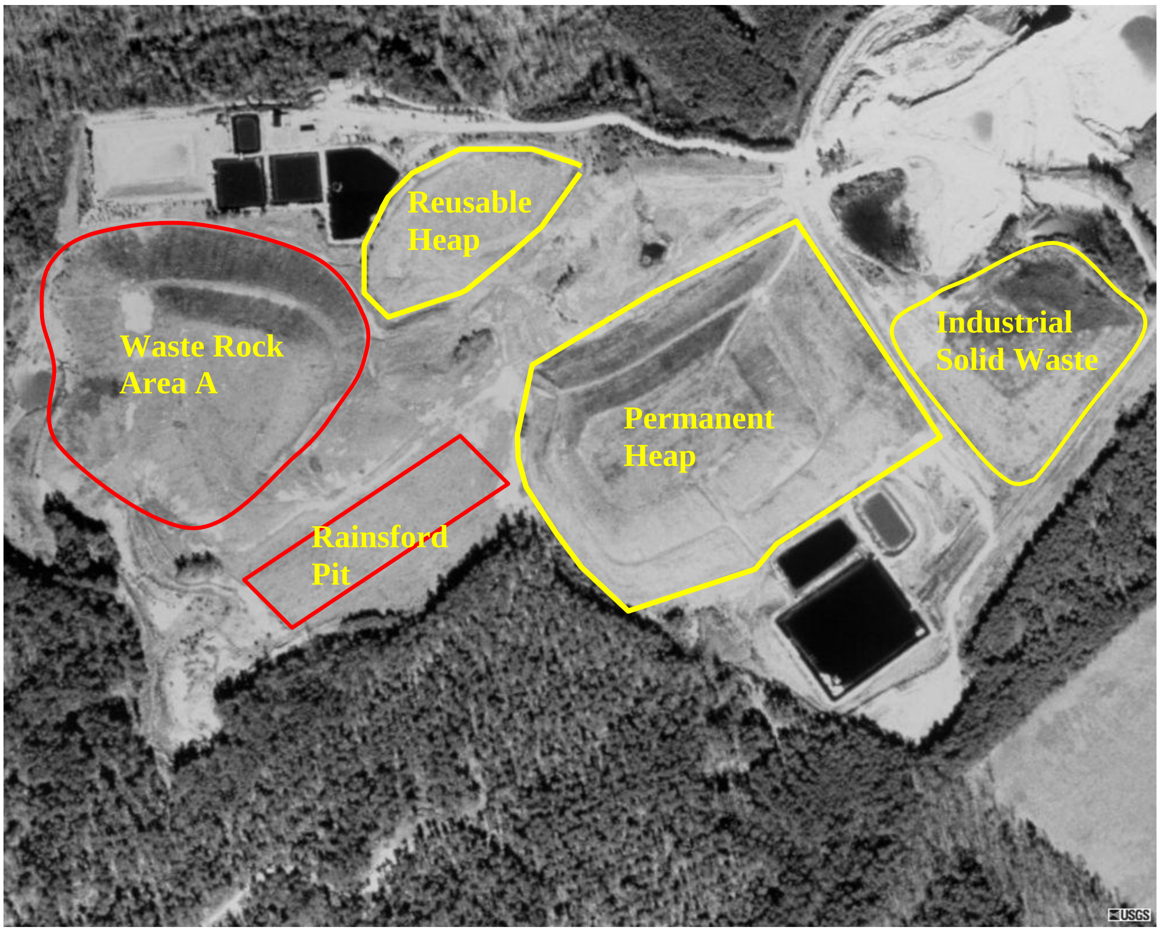

Figure 19. Aerial photograph of the Barite Hill Mine process areas showing waste rock and spent ore repositories.

Drainage from the waste-rock material would initially be near neutral and contain nitrates. The nitrates are a residual contaminant which is present due to the use of nitrogen-containing explosives to blast the rock so it could be excavated from the mine pit. Experience shows that it takes a period of years for the pyrite in the waste rock to "mature." Oxidation of pyrite bearing rock initially starts as a chemical reaction. As the pH drops to around 3.5, iron consuming bacteria accelerate the oxidation process (as much as one million times). Also, the extent of oxidized pyrite grains within the pile spreads out over time. Eventually, the rock will become fully mature, the pH will reach a constant low value and continue to generate acid for thousands of years. The supply of nitrate in the rock is much smaller, residual nitrate is likely to be leached out of the rock by the seepage within the first 50 to 100 years.

In summary, the repositories at Barite Hill contain acid forming rock which is still maturing. In addition, the vegetation-covered clay caps are showing signs of degradation. One can expect that the volume of acid seepage will increase and the water will become more acidic over time. The physical characteristics of the four repositories are described in detail in the following sections of this report.

Waste Rock Disposal Area A

Waste Disposal Area A covers 17 acres and has been capped with clay, cover soil and is vegetated. An area of dead vegetation was observed on the north side of the repository. The cause is believed to be acid and metals toxicity, but, no active acid seep was evident. It is likely that there is a small acid seep which is active during wet conditions. The perimeter diversion ditch on the north side of the repository has eroded its channel and further upstream on the northeast side the same ditch is actively headcutting. The banks

Figure 20. Photograph of the east slope of Waste Disposal Area A which is the high ridge line in the distance. View is from the Permanent Heap Leach Pad looking to the west.

are vertical and will soon begin to erode and gully. The gully action will eventually extend from the ditch banks up into the capped area and will degrade the cap. These ditch banks must be stabilized to protect the integrity of the cap. The top, west, and south sides of the repository were not inspected. It is understood that the former "Sediment Dam A" structure built on the west side of the repository has been removed and that a small sediment pond remains which is being allowed to silt in. Downstream from this facility is a beaver pond which is capturing sediment and water flowing from this portion of the site. It is concluded that this repository is turning acidic and may become a significant source of acid seepage in the future. Acid seepage is likely to be greatest on the west side where the bedrock forms a low point. Maintaining the integrity of the cap is essential to minimize the rate of acid discharge from this repository.

Figure 21. View to the west of the eroded diversion ditch on the north side of Waste Rock Disposal Area A. Significant amounts of pyrite rich waste rock are present in this eroded channel which is likely a source of acid drainage.

Rainsford Pit

The Rainsford Pit exposed some of the most reactive sulfide rock at the site. The mining company completely backfilled this pit with waste rock and constructed a clay cap over the backfill. The south and west sides of this facility were not inspected due to time limitations. The top, north, and east sides were found to be in good condition with a well vegetated cap. There are minimal concerns regarding this part of the site at this time; however; it is expected that portions of the fill above the water table will turn acid if they have not already done so.

Figure 22. Photograph taken from the top of the Permanent Pad looking to the southwest at the Rainsford Pit area (the flat area in the lower 2/3 of the photograph).

The cap was constructed in November, 1994 (Steffen Robertson and Kirsten, 1995). After the backfill was placed into the pit, the upper layer of the sulfide-containing, waste-rock backfill was covered with a four-inch-thick lift of organic material. The organic material was tilled into the upper surface of the fill. Next, a six-inch thick layer of clay was spread and compacted. A second six-inch thick layer of clay was applied and also compacted using a sheepsfoot roller. Density tests show the clay was compacted with moisture contents that are wet of optimum moisture content. Compaction levels vary from 95 to 99 percent of standard proctor density. Immediately following construction field permeability testing indicated that the in-place permeability of the cap is in the range of 2 x 10^{-7} cm/s to 3.9 x 10^{-8} cm/s. This indicates that a high-quality clay cap was built; however; recent EPA-sponsored research shows that such caps will degrade over time to a permeability range of between 1x 10^{-5} cm/s to 1x 10^{-6} cm/s. A geotextile and a 2-foot-thick layer of topsoil were placed over the clay cap prior to seeding.

It is expected that any potentially acid-forming backfill placed above the water table will eventually turn acidic. This material will form acid seepage that will migrate to the water table. The potential gradients and migration pathways for the seepage are not known. Topography would suggest that the south side of the backfilled pit is the most likely migration pathway. If the cap is maintained in good condition then infiltration and seepage will be minimized. The resulting acid seepage may not be an environmental problem if the seepage rates are low and the plume is diluted as it migrates. Such questions are only answered by a groundwater study which is beyond the scope of this report. It is concluded that as long as the vegetated cap remains in good condition, no actions other than monitoring need be taken with respect to this repository.

Industrial Solid Waste Landfill (Waste Rock Disposal Area C)

The Industrial Solid Waste Landfill is a 6.7 acre area which contains spent ore that was removed from the Reusable Heap Leach Pad after the gold was extracted and the ore was rinsed. Because the drainage from the spent ore did not meet State water quality standards, this spent ore repository was designed and permitted under industrial solid waste landfill regulations. The design includes an underliner for collection of leachate, and conveyance of this leachate through a buried pipeline to the Permanent Heap Barren Pond. During site operations, the company stored the leachate in the Permanent Heap Barren Pond. Later a water treatment plant was constructed and the water was pumped to the process plant area for treatment and release from the site.

Figure 23. View of incomplete reclamation on the west side of the Industrial Solid Waste Landfill. Note that organic matter (brown ring around white piles) and slaked lime (white piles) have been dumped but were not spread and incorporated into the mine waste. One deep erosion gully (see Fig. 24) cuts down through this un-reclaimed slope to the right and a shallow gully (see Fig. 24) is eroding the un-reclaimed area on the left side of the photograph.

The design of this facility includes a limestone rock drain. The thinking was that in the future the rock would turn slightly acid. Any infiltrating water would flow down to the liner, pass through the limestone drain and be neutralized prior to discharge to the pipeline leading to the pond. This would have been effective had the seepage been only mildly acidic. Unfortunately, the evaluation of acid-base accounting data for this mine was incorrectly performed and the actual leachate is much more acidic than anticipated. Experience has shown that the acidic seepage expected from this site will in time coat the limestone with a rind of iron and aluminum hydroxides which will render further water treatment ineffective. Depending upon the size of the limestone, it is even possible that the existing drain could clog.

Figure 24. Deeply incised erosion gully in un-reclaimed slope of the Industrial Solid Waste Landfill.

Figure 25. Shallow erosion gully formed in an un-reclaimed area on the gently sloping top of the Industrial Solid Waste Landfill.

Figure 26. Seepage discharging from near the bottom of the slope of the west side of the Industrial Solid Waste Landfill.

Uncontrolled seepage (Figure 26.) was observed lower on the southwest side of the Industrial Solid Waste Landfill. The seepage has killed the surrounding vegetation and is causing an erosion gulley to form. In a few years time this will trigger severe erosion damage to the west side of the cap. The seepage has not been tested for pH but is likely to be acidic. The flow discharges to a severely eroded diversion ditch lying between an access road and the southwest slope of the Industrial Solid Waste Landfill.

The occurrence of this seepage is potentially alarming and calls for closer monitoring. The seep should be surveyed and plotted on the facility as-built design drawings. Considering that the facility has an underdrain, seepage in this location would not be expected unless the drain is beginning to clog. The implication is that water levels in the pile could rise to such an extent that the slope stability of the facility could be jeopardized. Evaluation of the long-term stability of the southwest side of the Landfill might be necessary if continued monitoring indicated there are elevated groundwater levels in the fill. Such evidence would be formation of additional seeps or a significant increase in the rate of flow from the seep depicted in Figure 26.

It is also noted that a wetland and pond has formed to the north of the Landfill as a result of the placement of the access ramp and the Solid Waste Landfill cutting off the former surface drainage route. What relation the water in the wetlands has to the Landfill is not known but should be further considered. Again a survey of the water elevation in the wetlands and its new spill point is needed and should be compared to the Landfill drawings to see if it is possible for this water to enter the facility.

Permanent Heap Leach Pad

The Permanent Heap Leach Pad was constructed using a 40-mil-thick polyvinyl chloride geomembrane (PVC) placed at a 2% slope towards the south (Westec, 1992). A 12-inch-thick layer of compacted low-permeability soil was placed as a secondary containment below the primary geomembrane liner. The construction was phased with the Phase 1 liner (west side) having been constructed in September, 1992. Phase 4, shown on design drawings to be the eastern most portion of the pad, was not constructed. Fill slopes are approximately 3H:1V.

Figure 27. Photograph of the east slope of the Permanent Heap Leach Pad.

Seepage from the liner drains to the south and discharges through geomembrane-lined troughs into the Permanent Heap Pregnant Pond and the Permanent Heap Rinse Pond. The seepage is acidic and likely has clogged the lower flow pathways. New acid seeps have formed along the south toe of the pad as seen in Figures 27 and 28. Other problems with this facility are ruts on the cap due to trespass ATV use, and erosion of the south side down chute. The down chute is a steeply inclined ditch which takes clean storm water from the mid-slope berm down to the base of the slope for discharge to receiving waterways. The bedding under the riprap has eroded out and caused the riprap to be dislodged. Erosion is cutting into the cap. On the northwest side of the facility is a second down chute. This chute is less steep but is constructed from acid fill so it is partly barren of vegetation and is likely a source of acid runoff. The disturbed areas lead to increased infiltration and acid generation.

The acid seeps on the south side of the heap are a concern. They will expand and erode the cap. If water levels in the heap rise due to clogging of the lower layers of spent ore with iron hydroxide precipitates, then the stability of the slope could be jeopardized. Further evaluation of the problem is needed.

Figure 28. Acid seepage killing vegetation and causing piping like internal erosion at the south toe of the Permanent Heap Leach Pad.

Figure 29. Photograph of the largest of the acid seeps emerging from the southeast side of the Permanent Heap Leach Pad. Yellow staining is the result of precipitation of iron hydroxides. The white coatings on the adjacent bare soil are thought to be the iron sulfate mineral melanterite.

Figure 30. Rutting on the Permanent Heap caused by ATV use.

Figure 31. Erosion of drainage down chute can be seen as the disturbed area on the hill side above the men in the boat.

Reusable Heap Leach Pad

The Reusable Heap Leach Pad was constructed with an asphalt liner. It covers an area of approximately 6 acres. It appears that about 15 feet of spent ore was left on the pad. The area has been capped and the vegetation is in good condition except for one small seep on the northeast edge which has killed vegetation and caused a small amount of erosion. This problem is not significant enough to warrant any other action than monitoring.

Figure 32. Photograph of the reclaimed Reusable Heap Leach Pad. Disturbed areas at right are rock outcrops which are just outside the limits of the pad.

Figure 33. Photograph showing the Reusable Leach Pad (lower half of photograph) at the Barite Hill mine prior to ore placement in 1991 (From the Scotia International Website). Note how the pad is designed to discharge cyanide solution seepage to the Plant Pregnant Pond.

Figure 34. Photograph looking across the Plant Pregnant Pond showing the geomembrane-covered seepage outlet from the Reusable Heap Leach Pad.

Building Structures

Mine Office

The mine office is a modular trailer 12 feet by 56 feet long. There is an air conditioning unit on one end of the building. An ice chest, typical of that seen at grocery stores lies outside behind the building (potential for entrapment). The office building has broken windows and inside much of the furniture has been broken, turned upside down and papers scattered about. It appears that this is the work of trespassers. Despite the trespass damage and disarray, the project records were found inside the building. The land ownership files were found and given to Mr. Francendesce. Technical reports and relevant project maps were removed by the Bureau of Reclamation. The recovered reports are listed in the references section of this report, and key project maps have been copied and are included in Appendix A. Time did not allow for all project records and maps to be examined, about 3 hours were spent in the building. There may still be valuable records present that should be gone through.

Figure 35. The mine office is a modular building structure.

Water Treatment Plant

The Water Treatment Plant is a steel (column and beam) structure. It is insulated and sheathed with metal siding and has a metal roof. The garage door is damaged and inoperable. Inside the building were two wood pallets containing both opened and unopened bags of caustic soda. Liquid acid and caustic solutions were stored nearby in tanks outside of the building. These chemicals were disposed of during the initial Emergency Response by EPA.

Figure 36. Water Treatment Plant structure contained a 25 gpm treatment system for treating process waters and landfill leachate to meet discharge standards.

The building housed a water treatment system designed by Siemens Corporation. It was put into operation in December, 1994 to treat contaminated process water and leachate from the Industrial Solid Waste Repository at a rate of 25 gpm. Operation of the plant allowed the mine operations to discharge excess process water to offsite surface water drainage systems. The plant employed multimedia filters to remove metals and solids, carbon adsorption filters to remove organic contaminants, and reverse osmosis and ion exchange units to remove salts and metals to the ppb range. The brine from operation of the plant was re-circulated back into the process water ponds at the site. Therefore the salinity of the water in the Process Plant ponds would have increased over time.

Figure 37. View of tankage and motors remaining inside the partially dismantled Water Treatment Plant.

Figure 38. Workers removing sacks of sodium hydroxide from the Water Treatment Plant as part of the Emergency Response.

Gold Assay and Melting Furnace Building

This building served as the assay laboratory and also housed the final stages of gold production. Melting of gold alloyed with silver and pouring bars would typically be performed in this building. A vault was located in an interior room of the building for storing gold and silver bullion.

Figure 39. The gold assay and melting furnace building. Note fume ventilation system components on the roof.

Fire assaying was performed to distinguish ore from lower grade rock which is considered waste. The fire assay method utilizes litharge (lead oxide) to gather gold and silver from pulverized ore and form a metallic bead. Fumes from the assaying process contain heavy metals. Lead, and metals in the ore such as bismuth and selenium volatize during the melting process and are gathered by the fume capture systems and are vented. Over time these ventilation systems become contaminated with a build up of heavy metal oxide dusts. These ventilation systems are considered to be hazardous material because of the potential for acute heavy metals poisoning.

Figure 40. Two fume ventilation systems used for the fire assay process. At left is a portion of the fume ventilation system for the small melting/assay furnace, at right is the fire assay acid fume hood and ventilation duct leading to the roof.

Three separate ventilating systems were found in the building. Two appear to be a part of the assaying operation (Figure 40), the third system was associated with the gold and silver production (Figure 41). All of the ventilation systems have the potential to contain heavy metal oxide flue dust. Contamination was evident in the assay systems, no attempt was made to open the larger production ventilation system. A small assay/melting furnace was on the ground just outside the building. The vent opening at the top of the small furnace also appeared to be coated with metal oxides.

Figure 41. Ducting for large fume ventilation system used during gold production.

Figure 42. Demolition of the Gold Assay and Melting Furnace Building on March 30, 2007 as part of the Emergency Response.

Process Plant Foundations

The plant has been removed from the site and only the concrete foundations remain. The following photograph shows how the Process Plant appeared during mine operations. The Process Plant was used to extract gold from the cyanide solution which was collected in the pregnant ponds.

Figure 43. Photograph of the Process Plant at Barite Hill Mine designed by Scotia International of Nevada, Inc. as it appeared in 1991 (From the Scotia International Website).

According to the Scotia International website (http://www.scotiacorp.com/gwalia.htm): *"Scotia provided the engineering, procurement, and construction management for the 5,000 t.p.d. gold heap leach facility. The project consisted of the design, engineering, fabrication, and installation for the skid-mounted, gold recovery process plant. Systems included: adsorption columns, carbon stepping systems, acid wash system carbon conditioning, (including regeneration kiln), carbon storage solution, electrowinning/replating equipment, melting furnace, concrete containment and all architectural design. Scotia also furnished construction management for construction of the reusable asphalt pad and the required ponding."*

At present, only the foundations for the Process Plant remain. As can be seen in the accompanying photograph, the foundation included a concrete slab with bermed edges for spill containment. This containment would have overflowed to the adjacent process ponds in the event of a large spill. No significant issues are associated with these foundations.

Figure 44. Photograph of the foundations remaining at the Process Plant area.

Pole Barn Storage Shed

This structure was used to store materials during site operations. At present there is a variety of inert debris including a 55-gallon drum filled with steel wool, broken glass, plastic, and cardboard. Several sacks of cement are present, but exposure to the elements has hydrated them. A 55-gallon drum labeled "Methyl-ethyl Keytone" was sampled by others for analysis.

Figure 45. The Pole Barn storage shed facility.

There are many boards with protruding nails on the ground in and adjacent to the Pole Barn. The wood, glass, and other inert debris should be disposed of.

Process Tanks

Four polyethylene tanks associated with the gold processing system were found at the site. Three of these tanks were outside in the process area. One containing a caustic solution and one containing acid were identified. Both of these tanks were taken to the mine pit, cut open and their contents emptied into the contaminated water in the pit for disposal. Liquid in a 1,500 gallon polyethylene tank next to the Permanent Heap Barren Pond was sampled by others and is pending analysis. This tank would have contained cyanide solution used to recharge the barren fluid for additional leaching.

Figure 46. Removing foam insulation from the 3,000 gallon tank containing caustic prior to taking it to the pit. Another tank is seen to the left.

Figure 47. Tank next to the Permanent Heap Barren Pond was used for make up cyanide solution. The fluid was sampled for analysis by others.

Crusher Area

The mine had a crushing and agglomeration system. The ore was crushed to 1" minus size and then cement, cyanide powder, and lime were added to the conveyor belt and mixed with the ore in an agglomerator (Figure 48). Nothing remains of the crusher area except some blue stains on some rocks (Figure 49). The blue stains are believed to be ferrocyanide which is more commonly known as "Prussian Blue" which has been used as a dye. This coating is believed to have formed as a result of cyanide spilling on the ground and reacting with iron in the soils. It is a very stable compound. It is unlikely that significant amounts of free cyanide are in the soils and rocks in this area of the site.

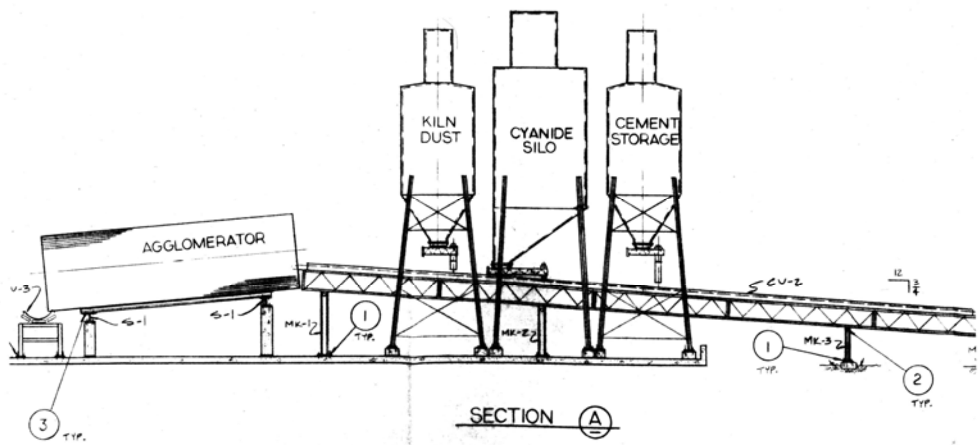

Figure 48. Silos and Agglomerator designed by Scotia Engineering.

Figure 49. Prussian blue stains on bedrock in the crusher area.

Process Ponds and Related Facilities

Eight process ponds are present at the site. Five ponds are located in the northwest part of the site adjacent to the Process Plant Area. These ponds are described as “Process Plant Ponds” and were operated in conjunction with the Reusable Heap Leach Pad. An additional three ponds are located to the southeast adjacent to the Permanent Heap Leach Pad and are described as “Permanent Heap Ponds.” Table 5 summarizes the process ponds pH and storage capacity data.

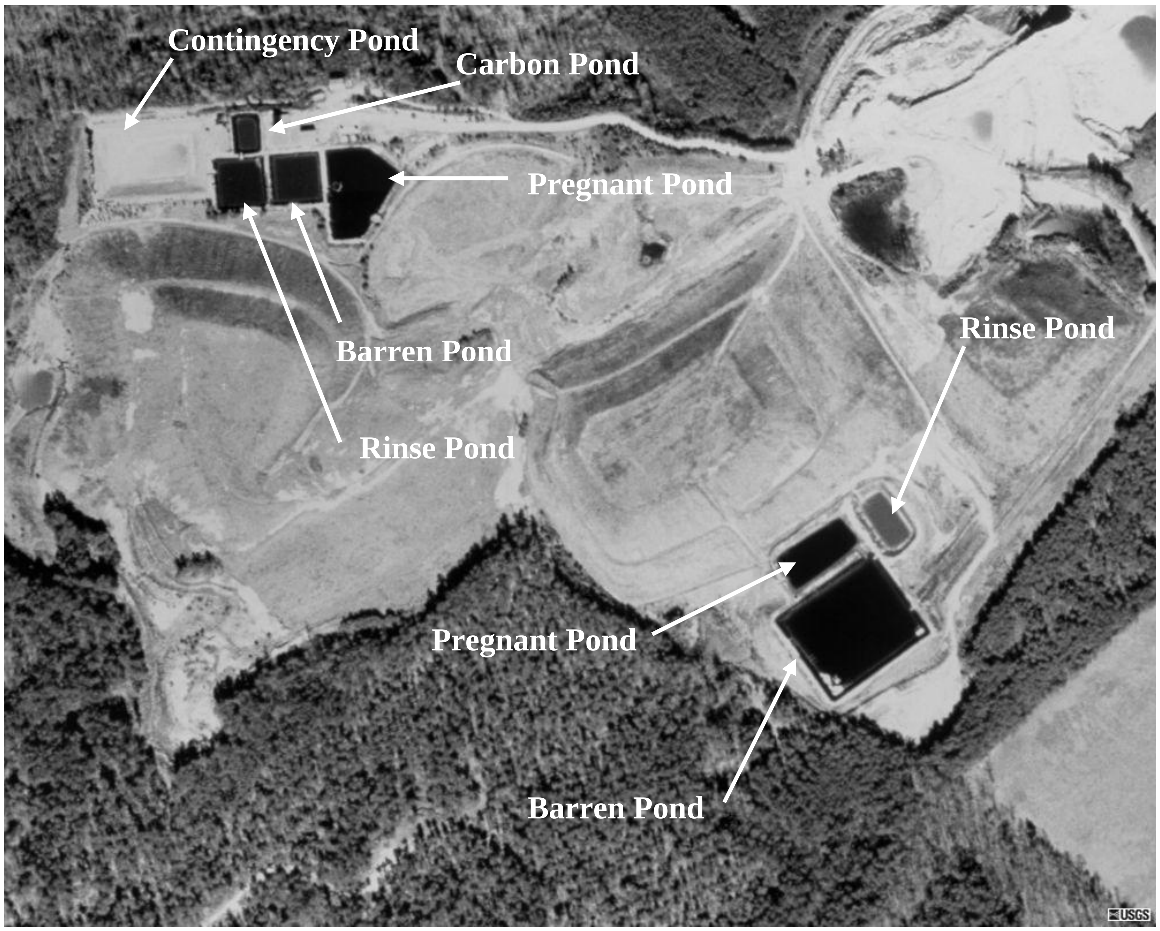

Figure 50. Aerial photograph of the process ponds at Barite Hill. The five Process Plant area ponds are at the upper left, the three Permanent Heap ponds can be seen in the lower right side of the photograph.

The network of ponds includes access ports leading to leak detection sumps, solution intake suction lines, solution pumps, and solution conveyance pipelines. The ponds are linked together by geomembrane-lined overflow channels so that in the event of a large flood all available storage capacity can be utilized to prevent loss of cyanide from the facility. During normal mine operations, each pond would have been only part full and solutions would be transferred in and out of the ponds using dedicated pipelines and pumps. The cyanide in the pond waters was neutralized by the mining company prior to their departure from the site. Samples of the water and sediments were taken by others to determine the nature of the presently stored water and pond sediments. This sampling showed unacceptable cyanide levels in the leak detection sump of the Permanent Heap Pregnant Pond. Typically the neutralized water in the ponds will contain nitrates and have a high pH. Acid water is now seeping into the ponds and they are expected to become acidic in future years once all available alkalinity is consumed by reaction with the acid seeps. The largest acid seep was seen flowing into the Permanent Heap Rinse Pond which understandably has the lowest pH of all of the ponds.

Table 5. Process Ponds at the Barite Hill Mine

Pond Designation	pH measured on March 29, 2007	Storage Capacity in Gallons	Comments
Process Plant Pregnant Pond	9.30	1,370,000	60-mil HDPE liner with 20 mil PVC leak detection sump liner
Process Plant Barren Pond	9.10	690,000	60-mil HDPE liner
Process Plant Rinse Pond	9.08	690,000	60-mil HDPE liner
Process Plant Carbon Pond	9.20	Estimated 50,000	60-mil HDPE liner
Process Plant Contingency Pond	8.48	Estimated 4,400,000	Liner has been removed. Water seeps to diversion ditch.
Permanent Heap Pregnant Pond	7.20	1,500,000	30 mil PVC liner. Receives acid seepage from the Permanent Heap. Sump contains cyanide.
Permanent Heap Barren Pond	8.10	5,500,000	It receives seepage flow from the Industrial Solid Waste Landfill.
Permanent Heap Rinse Pond	6.85	1,000,000	30 mil PVC liner. Largest acid seeps from Permanent Heap are flowing into this pond. It will soon turn acidic.

The ponds were sized and operated to contain the water from the process operations, water fluctuations from precipitation and evaporation, and water from a 100-year, 24-hour storm event of 8 inches (Water, Waste and Land, Inc., 1989). Except for the Process Plant Contingency Pond, the ponds are full up to their overflow points (no available storage capacity). With each precipitation event, the ponds discharge water to the environment. Although it appears that the Process Plant Contingency Pond is capturing overflow from the adjacent ponds, this is not the case. The liners and geonet have been removed from the Process Plant Contingency Pond. Water that enters this pond seeps out through a fill embankment to the receiving diversion ditch and flows off site. Each pond had a secondary geomembrane liner, a geonet drain for collecting leaks, a leak detection sump with a plastic pipe riser, an electric pump, and piping for solution transfer. Each pond is individually described in the following sections of this report.

Process Plant Pregnant Pond

This pond was designed to capture and store seepage discharge (pregnant cyanide solution) from the reusable heap-leach pad. The pregnant solution contained dissolved gold, silver, copper, and other metals. The solution in the pond has a pH of 9.3 standard units. The pond is sized to contain a volume of 1.37 million gallons

Figure 51. Photograph of the Process Plant Pregnant Pond. The view across the pond shows the seepage inflow area from the Reusable Heap-Leach Pad. An electric pump can be seen at lower right.

Process Plant Barren Pond

The Process Plant Barren Pond was used to contain cyanide solution discharged from the Process Plant carbon columns after it passes through the Process Plant Carbon Pond. The carbon columns remove the gold from the pregnant cyanide solution thus rendering the solution "barren." The pond is 140 ft. wide by 140 ft. long. This pond is full and precipitation results in overflow to the Process Plant Rinse Pond.

Figure 52. Photograph showing the Process Plant Barren Pond and leak detection sump riser pipe.

Process Plant Rinse Pond

Also called a "wash" pond, this pond would be used to capture rinse water circulated through a cell in a heap-leach pad that has been leached and is being rinsed to remove cyanide solution from the spent ore. The rinse pond is 140 ft. wide by 140 ft. long.

Figure 53. Discharge channel and the west portion of the Process Plant Rinse Pond. This pond, like those upstream of it, is full, all additional precipitation results in discharge to the unlined Process Plant Contingency Pond.

Process Plant Carbon Pond

The Process Plant Carbon Pond was used to receive fluids discharged from the carbon column processing unit. The pond was used to settle out fine-grained particles of carbon which escape from the process units. The pond is approximately 80 feet wide by 100 feet long and is constructed with an HDPE liner and a leak detection sump.

Figure 54. Photograph of the Process Plant Carbon Pond. The electric pump has been removed from its concrete base.

Process Plant Contingency Pond

The process plant area ponds are overflowing into the contingency pond which contains some standing water. This pond is approximately 200 feet wide by 300 feet long and was sized to contain runoff from the all of the Process Plant area ponds in the event of a 100-year storm event. The pond liner has been removed and water is seeping to a nearby drainage ditch which is evident by a line of copper and iron sulfate salt forming at the seep line. One corner of the pond is supported by an embankment which acts as a dam which appears to be between 20 to 30 feet high. If this pond were to fill in response to a large flood the pond might fail and release its contents. There are two ways the pond might fail, by overtopping and erosion, or by internal erosion of the fill embankment due to seepage forces removing the fine-grained soil. Either way the pond would release its contents in an uncontrolled manner. Fortunately, the downstream area is not developed; however there could be significant environmental consequences.

Figure 55. View of the Plant Contingency Pond (view looking towards the west). Note that the liner has been cut and removed. The slope in the right side of the photograph is weathered bedrock. The slope in the left side of the photograph is a fill embankment through which water is seeping.

Figure 56. Signs of erosion and piping of the outslope of the fill embankment supporting the contingency pond.

Figure 57. Damp soil at the seepage line along the toe of the fill embankment supporting the Process Plant Contingency Pond. Note the prussian blue coating the rocks below the damp soil.

Permanent Heap Pregnant Pond

Labeled as a Pregnant / Rinse Pond on design drawings, the Permanent Heap Pregnant Pond was constructed in the fall of 1992 (Westec, 1992). The pond has a 30-mil-thick PVC bottom liner and a 40-mil-thick UV resistant PVC upper liner. Between these two liners is a geonet drain leading to a gravel-filled leak detection sump. An 8-inch diameter PVC perforated drain pipe is placed in the sump and it is accessed by connection to a solid PVC pipe riser which penetrates the liners and is attached to them using boots. The fill around this pond appears to be acidic spent ore. Sampling by others indicates that the leak detection sump contains water with 30,000 ppb (30 ppm) cyanide and it needs to be neutralized.

Figure 58. Photograph of the Permanent Heap Pregnant Pond looking towards the west. The southwest portion of the capped and reclaimed Permanent Heap forms the hillside in the background of the photograph. Note the small pile of acidic material adjacent to the pump station on the left side of the photograph.

Permanent Heap Rinse Pond

Labeled as a Rinse / Pregnant Pond on design drawings, the Permanent Heap Rinse Pond was also constructed in the fall of 1992 (Westec, 1992). The pond has a 30-mil-thick PVC bottom liner and a 40-mil-thick UV resistant PVC upper liner. Between these two liners is a geonet drain leading to a gravel-filled leak detection sump. An 8-inch diameter PVC perforated drain pipe is placed in the sump and it is accessed by connection to a solid PVC pipe riser which penetrates the liners and is attached to them using boots. This pond is being affected by acid seepage from the Permanent Heap Leach Pad.

Figure 59. View of the Permanent Heap Rinse Pond. The disturbed area just above the pond is the location of a major acid seep from the Permanent Heap Leach Pad which is lowering the pH of this pond.

Permanent Pad Barren Pond

Constructed in January 1992, this pond covers nearly 2.5 acres. It has a capacity of 5,500,000 gallons. Originally used to contain barren solution, this pond receives seepage flows from the Landfill Repository via a buried drainage pipeline. The pond is full and it will likely turn acid in the future.

Figure 60. Permanent Pad Barren Pond is the largest of the lined impoundments. The Canadian Geese had a nest on the side of the pond which contained two eggs.

Stockpiles and Borrow Pits

Soil materials were removed from the site for use in reclamation. Associated areas include a Topsoil Stockpile Area, and a Clay Soil Borrow Pit.

Topsoil Stockpile Area

During site operations there were two areas used for topsoil storage. The western most area was reclaimed. The remaining Topsoil Stockpile Area is located just south of the Barite Hill Pit. There is a very small amount of topsoil remaining in this area (about 20 cubic yards). A much larger stockpile (several thousand cubic yards) of slaked lime remains on hand in this area. The slaked lime was used as a soil amendment and to neutralize the water in the mine pit. This is a valuable resource which can be used for further site remediation.

Figure 61. Small pile of topsoil remaining in the Topsoil Stockpile Area.

Figure 62. Slaked lime stockpile is a valuable resource.

Clay Soil Borrow Pit

The Clay Soil Borrow Pit is an area of the site from which clay was removed for use in constructing the clay caps over the waste rock and spent ore repositories. This pit does not have any drainage outlet, so water ponds in the area and slowly seeps into the ground. It is possible that this seepage is flowing into the adjacent Barite Hill Pit. This area needs to be reclaimed. No drawings were found for this area. The disturbance is roughly estimated to be 4 acres in size.

Figure 63. Photograph of the Clay Soil Borrow Pit.

Surface Water Drainage and Control Facilities

The site storm water conveyance and control system consists of diversion ditches and a sediment pond. A former Sediment Pond known as "Sediment Dam A" has been removed from the site. The two principal diversion ditches are badly eroded and actively head cutting. The remaining Sediment Pond serves little function other than to store clean water.

Surface Drainage Ditches

Two major diversion ditches were constructed. One ditch begins near the Rainsford Pit, flows north then west between Waste Rock Disposal Area A and the Process Plant Ponds. It then flows through a failed sediment control structure and then turns south and discharges into a small sediment basin near the former Sediment Dam A. Downstream from this is a Beaver Pond which captures any additional sediment escaping from the system. This ditch is severely eroded and needs to be stabilized. Pyrite containing waste rock was observed in the bed of the ditch.

The second diversion ditch is located between the Industrial Solid Waste Landfill and the Permanent Heap Process Ponds. It flows southeast then turns west and enters a natural channel. This ditch is severely eroded adjacent to the Industrial Solid Waste Landfill. It needs to be stabilized before it causes damage to the Landfill cap.

Figure 64. Failed sediment control structure on eroded diversion ditch near the Process Plant Contingency Pond.

Figure 65. Erosion of diversion ditch adjacent to the Industrial Solid Waste Landfill.

Sediment Pond

The sediment pond is located in a area of 1.9 acres of disturbance. It includes a fill embankment which retains the reservoir. The embankment has no spillway. What appears to be good quality water is impounded behind the embankment. This pond is of more value for the water it captures and stores than its function as a sediment control feature. The water can be used for dust control and washing down equipment used in site reclamation work.

Figure 66. Sediment Pond located south of the Barite Hill Pit.

Wetland Areas

Two wetlands/pond areas have formed on the site. One area which appears to be a pond with wetland vegetation is northeast of the former crusher area. The other area is more of a pond which formed as a result of the access ramp being constructed to the Industrial Solid Waste Landfill. This area is on the northwest side of the landfill. It is not known if the water from this ponding is affecting the landfill and it needs further evaluation.

Figure 67. Ponding area adjacent to the Industrial Solid Waste Landfill.

Ground Water Wells

Groundwater is present at the site in shallow and deep aquifers. The shallow aquifer is associated with the soil - bedrock contact and includes the soil horizon and the upper layer of weathered bedrock. The deep aquifer is found in the bedrock where groundwater is structurally controlled by features in the rock fabric. Most of the unbroken rock has a low permeability, therefore the structural features, such as joints, fractures, and contact zones, exhibit a major influence upon the deep aquifer.

Landfill Area Wells

Many wells were installed during mine development. Seven clusters of monitoring wells labeled A through F were installed prior to mining. Clusters A and F were placed upgradient of the mine facilities to monitor background conditions. Details of the well depths are presented in Table 5.

In January 1992, four additional groundwater wells were installed in bedrock material to the south and southwest of the Industrial Solid Waste Repository at the request of the State of South Carolina (Steffen Robertson and Kirsten, 1992). The wells were designated L, M, N, and O and consist of two-inch- diameter PVC pipe (schedule 40) inserted into an eight-inch-diameter auger borehole. A well screen with 0.010-inch slots was installed in the lower 10 feet of each well. Clean sand was placed around the well screen. Bentonite clay to a height of 15 inches was placed above the sand to seal the monitoring interval. The remainder of the borehole was grouted with a cement-bentonite mixture. A steel riser and locking cap were provided.

Table 6. Barite Hill Mine Groundwater Monitoring Wells.

Well Name	Depth in Feet	Notes
GW-1		Located north of the Barite Hill pit.
GW-2		Located Northeast of the Barite Hill pit.
GW-3		Located east of the A Sediment Dam and Waste Rock Disposal Area A
A1	193	Located in an upgradient area north of the Industrial Solid Waste Landfill. A wetlands has formed to the west of this cluster due to a depression being cutoff by fill placed for the Landfill access ramp.
A2	143	Located in an upgradient area north of the Industrial Solid Waste Landfill. A wetlands has formed to the west of this cluster due to a depression being cutoff by fill placed for the Landfill access ramp.
A3	70	Located in an upgradient area north of the Industrial Solid Waste Landfill. A wetlands has formed to the west of this cluster due to a depression being cutoff by fill placed for the Landfill access ramp.
B1	171	Located on the southwest corner of the Permanent Heap.
B2	121	Located on the southwest corner of the Permanent Heap.
C1	182	Located 150 feet southeast of the east corner of the Permanent Heap Barren Pond.

C2	75	Located 150 feet southeast of the east corner of the Permanent Heap Barren Pond.
GW-5	37.8	Located with the C cluster to monitor the shallow aquifer.
D1	130	Located about 100 feet east of the Industrial Solid Waste Landfill.
D2	160	Located about 100 feet east of the Industrial Solid Waste Landfill.
D3	79	Located about 100 feet east of the Industrial Solid Waste Landfill.
E1	60	Located in a drainage channel located south of the Permanent Heap and west of the Permanent Heap Pregnant Pond.
E2	300	Located in a drainage channel located south of the Permanent Heap and west of the Permanent Heap Pregnant Pond.
E3	106	Located in a drainage channel located south of the Permanent Heap and west of the Permanent Heap Pregnant Pond.
GW-6	28.4	Part of the E cluster to monitor the shallow aquifer.
F1	205	Located in an upgradient area east of the Rainsford Pit and no the northwest edge of the Permanent Heap.
F2	140	Located in an upgradient area east of the Rainsford Pit and no the northwest edge of the Permanent Heap.
F3	75	Located in an upgradient area east of the Rainsford Pit and no the northwest edge of the Permanent Heap.
G1	38	Located about 1,000 feet south of the Reusable Heap. It would have been eliminated by construction of the Permanent Heap.
G2	200	Located about 1,000 feet south of the Reusable Heap. It would have been eliminated by construction of the Permanent Heap.
G3	125	Located about 1,000 feet south of the Reusable Heap. It would have been eliminated by construction of the Permanent Heap.
H		Located west of the Reusable Heap and south of the Process Plant Pregnant Pond.
I		Located north of the Reusable Heap.
K		Located northeast of the Process Plant.
L	27	Located 50 feet east of the east corner of the Industrial Solid Waste Landfill. Sericite schist, no water observed when drilled.
M	26	Located 50 feet east of the east corner of the Industrial Solid Waste Landfill. Sericite schist, no water observed when drilled.
N	24.7	Sericite schist, water encountered
O	26	Sericite schist, no water

Equipment and Debris

Only small amounts of equipment and debris remain on the site. Most of the equipment is in the form of Goreman-Rupp pumps with electric motors which are mounted on concrete pads next to most of the process ponds. Electric switch boxes are present near most of the pumps. None of these facilities are operational. It appears that the power lines which brought in power from off site have been removed and there is no sign of the onsite generators. The pumps have not been tested, it is not known if they are still functional. Solution piping leads from nearly every process pond. This piping is a valuable resource for future operations.

Near the mine office is an McElroy Fusion Machine which is used for welding HDPE pipe. Although this unit has been exposed to the elements and appears to be missing its heating element, it likely could be refurbished at reasonable cost. Should water treatment be required at the site, such a pipe welding machine is an essential component for maintaining and modifying pipelines for solution transfers. This unit should be retained for further evaluation.

A few debris piles were found at the site. Next to the contingency pond is a pile of geonet drain. The debris in the Pole Barn has already been described. There are two piles of debris outside this structure containing wood, metal pipe, plastic pipe, sheet metal and rubber. Near the mine office is a pile of rusted metal and several piles of pipe segments. HDPE pipe segments are present in one of the piles. The HDPE pipe should be retained for future use. Other types of plastic pipe have deteriorated from exposure to sunlight and should be disposed.

Figure 68. Discarded geonet drain material lies next to the Contingency Pond.

Figure 69. Debris pile near the Pole Barn.

Figure 70. Piles of pile located near the Mine Office. The HDPE pipe in the foreground should be retained. Pipe in the background is of no value.

Acid Rock Drainage

The gold ore and much of the waste rock at the mine contain the mineral pyrite (FeS_2) which oxidizes to form acid rock drainage. Although there are complex interactions between sulfur and iron, the overall effect of the action of water and oxygen upon pyrite can be described by the following equations:

$$FeS_2 + (7/2)O_2 + H_2O \rightarrow Fe^{2+} + 2SO_4^{\ 2-} + 2H^+ \quad (1)$$

$$FeS_2 + 14Fe^{3+} + 8H_2O \rightarrow 15Fe^{2+} + 2\ SO_4^{\ 2-} + 16H^+ \quad (2)$$

Both reactions are greatly accelerated at low pH by the action of bacteria. The first reaction requires the presence of oxygen and water to initiate and sustain the process in an aerobic environment. In the second equation, ferric iron Fe^{+3} is the oxidizing agent which results in the formation of acid in anaerobic conditions.

Once the pyrite has reacted to form acid, the acid attacks other minerals in the rock to release other metals. The mixture of metals that will be released into the acid water is dependant upon the site mineralogy. As previously discussed under the Geology section of this report, the ore and waste rock at the mine contains sulfide, selenide and telluride minerals which would be sources of a large number of heavy metals including bismuth, copper, lead, selenium, tellurium, and zinc. Other heavy metals are likely to be present in the mine drainage.

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APPENDIX A - SITE MAPS