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Bald Mountain Mining Risks: Hidden from the Public

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REPORT 80701/1

OPINION OF TECHNICAL
AND
ECONOMIC ASPECTS OF WASTE MANAGEMENT
BALD MOUNTAIN PROJECT

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OPINION OF TECHNICAL AND ECONOMIC ASPECTS OF WASTE MANAGEMENT BALD MOUNTAIN PROJECT

EXECUTIVE SUMMARY

Introduction and Objective of Review

The Bald Mountain Project, located in north-central Aroostook County, Maine, is being evaluated by Boliden Resources Inc. The deposit consists of gold bearing gossan overlying copper and zinc bearing massive sulfide zones.

Recovery of the resource is proposed by open pit mining to produce about 0.6 million tons per year of gossan ore for two years followed by up to 1.75 million tons per year of massive sulfide ore for about 13 years. Cyanidation would be used in the gold extraction process and cyanide may be used to enhance selectivity in the copper and zinc flotation process. A total of about 1.2 million tons of gossan tailings, 22 million tons of massive sulfide tailings and 39 million tons of mine rock would be produced.

The project is located in an area with significant timber harvesting and high quality groundwater and surface waters. It is proposed to locate the tailings and mine rock facilities over about 20 to 30 acres of wetlands. Bald Mountain Brook has its headwaters in the proposed tailings impoundment and mine rock storage pile area. Bald Mountain Brook drains into Clayton Stream about 1.5 miles from the impoundment. Both streams are Class A streams with a low dissolved solids content, particularly in the spring freshet period when most of the flow is from melting snow.

The review includes a preliminary assessment of the acid generation characteristics of the tailings, mine rock and pit walls, development of conceptual waste management and reclamation plans, evaluation of the water balance, effects on wetlands, groundwater and surface waters, and an evaluation of the potential to achieve environmental standards.

Acid Generation Characteristics of the Tailings and Mine Rocks

The tailings are massive sulfides and clearly potentially acid generating if exposed to both air and water. The ore deposit contains up to 50% sulfides, occurring principally as pyrite and pyrrhotite. Core samples of the ore are stored by Boliden Resources Inc. in freezers to prevent oxidation prior to metallurgical testing. This may be indicative of the reactivity of some of the massive sulfide rock. Material with a high pyrrhotite content can exhibit rapid oxidation characteristics. Acid-base accounting tests performed on the mine rocks as part of this study have demonstrated that the 13 million tons of foot wall mine rock and 12 million tons of massive sulfide mine rock would be potentially highly acid generating. The 6 million tons of hanging wall mine rock and the 8 million tons of glacial till are expected to be non-acid generating.

The status of current technology regarding the control of acid generation from sulfidic wastes is that the exclusion of oxygen through placement of reactive wastes under water is the most promising long-term means of limiting acid generation. The mine waste management plan for the Bald Mountain Project should be to place all acid generating tailings and mine waste under water, either during operation or on decommissioning. However, while the rate of acid generation is greatly reduced by placing the waste underwater, this does not halt the oxidation process entirely. The extent to which acid generation and metal leaching may occur and the resulting impact on the environment at the Bald Mountain Project site cannot be quantified at this stage. Minimizing the impact of acid generation during operation may be achieved by a combination of measures. These include measures to inhibit the acid generation process, for example addition of alkali material, measures to minimize infiltration and migration of the products, and allowance for collection and treatment of drainage.

For the purpose of this review it has been assumed that the tailings would not be classified as a hazardous waste, based on the results of previous laboratory leachate quality testing, and would therefore not be subjected to waste handling and storage criteria applicable to hazardous wastes. This would need to be confirmed prior to finalization of the mine waste management plan.

Proposed Waste Management and Reclamation Plan

A conceptual mine waste management and reclamation plan has been developed with the principal objective of providing the required environmental protection of natural water resources at the site in the most economical and practical fashion. The proposed waste management plan consists of:

Tailings

- Using separate, synthetically lined tailings impoundments for the storage of gossan and massive sulfide tailings. The gossan tailings would be expected to contain higher levels of cyanide and placement of these tailings in a separate impoundment upstream of the main embankment would provide added control of cyanide migration and reduces initial capital costs.

- Installing a drainage system under the liners to collect and discharge groundwater to a monitored seepage collection pond. This is required in order to prevent the build-up of water pressure beneath the liner during operation which may damage the synthetic geomembrane.

- Installing a drainage layer above the membrane liners to enhance drainage from the tailings and to provide a hydraulic 'high permeability' envelope around the tailings. The objective of this layer is to reduce the hydraulic gradient through the tailings mass and hence the potential for contaminated seepage through leaks in the synthetic liner in the long term.

Mine Rock

- Using non-acid generating till and hanging wall rock for embankment and cover construction purposes.

- Placing massive sulfide mine rock below water in the flotation tailings impoundment as it is mined.

- Stockpiling foot wall rock over a natural or compacted till liner. Acid generation in this material during operation would be limited by blending in a small percentage of finely crushed limestone and covering the dump as it is developed to reduce both oxygen entry and leaching.

- Backfilling all potentially acid generating mine rock from the temporary stockpile to the pit on completion of mining and flooding the pit. The quality of the pit water would be controlled during backfilling to achieve alkaline conditions with the objective of controlling dissolved contaminants.

Pit Walls

- Placing a till cover against all potentially acid generating pit walls (foot wall rock) located above the water level in the pit on completion of backfilling. Long term stability to the till cover would be provided by means of a rock buttress constructed from hanging wall waste.

Water Management

- Collecting, monitoring and treating the water from the pit, mill, tailings impoundment and mine rock piles prior to discharge to surface waters or land applied.

The reclamation plan would consist of:

- Covering the tailings with a till layer and flooding the impoundment to form marshland conditions in which a continuous zone of saturated till overlies the tailings.

- Covering the non-acid generating mine rock remaining in the surface rock piles with till and revegetating the covered piles. No acid generating mine rock would remain on the surface.

- Flooding the pit to submerge all backfilled potentially acid generating mine rock. Vegetation would be established on unflooded till surfaces.

Alternative Tailings Impoundment Sites

A number of alternative sites have been identified in previous studies. Apart from wetland considerations none of the sites offer any advantage over the selected site. These were reviewed, and evaluations made of their potential for the waste quantities currently proposed. All of these sites have considerable disadvantages with respect to groundwater seepage control and maintenance of a water cover on decommissioning and, in addition, would be considerably more costly to develop. They would result in environmental impacts over a much greater area and potentially impact additional watersheds. None of these sites are considered to be preferable to the selected site.

Water Balance

A water balance determination for the proposed mine development and waste management plan resulted in an average annual excess of 490 USgpm with 70% of the tailings water being recycled to the mill and 180 USgpm with 90% of the tailings water being recycled to the mill. These quantities were obtained assuming average precipitation conditions and assuming that drainage from the pit and foot wall rock dump is an inflow to the impoundment water balance. All evaluations allowed for staged diversions to minimize water capture. The importance of the recycle percentage is apparent as is the need to minimize the contributory area. These calculated excesses are considerably greater than those determined in the previous study by Barr Engineering. The difference is substantially accounted for in the assumption that recycle cannot be 100%.

Mine Water Treatment and Discharge Alternatives.

The mean annual dilution ratios of discharged treated mine waters into Bald Mountain Brook and Clayton Stream range between about 0.5 and 1.5 in Bald Mountain Brook and between 3 and 8 in Clayton Stream, when compared with the mean average annual mine water flows. To achieve 'no degradation' in Bald Mountain Brook requires treatment to water quality standards not achievable with present technology. The development of land application sites for such substantial flows will require large application areas. The fate of accumulated metals will be a concern. Further studies are required in order to identify alternative appropriate instream standards. Additional studies are also required to identify water management and treatment strategies to achieve such standards.

In our opinion, the only scenario under which permitting could be achieved would be to obtain variances which would allow treated water discharge which, with dilution in Clayton Stream, would still be protective of the local ecosystem. Based on our appreciation of current technology and site conditions, it will not be possible to achieve drinking water quality standards in Clayton Stream at the confluence with Bald Mountain Brook, under the proposed mine development plan. A site specific analysis could yield alternative in-stream criteria greater than background water quality.

Groundwater and Surface Water Quality

In addition to controlled discharges there will be non-point-source discharges resulting from drainage which escapes the perimeter ditching via either surface or groundwater routes. These losses will contribute to the degradation of water quality in Bald Mountain Brook.

To minimize such losses during operation a synthetic membrane liner is proposed for both tailings impoundments, installed directly onto compacted till to form composite liners, together with drainage layers above the liner to reduce water head on the liner. Seepage losses from the mine rock storage piles would be minimized by their placement on a till liner. No losses would occur from the pit during operation. These measures should be sufficient to control losses to very small values during operation and groundwater and surface water degradation should not represent a fatal flaw during this period, assuming seepage losses can be collected and treated effectively.

After closure the mine rock will be placed in the pit which will flood and discharge to Bald Mountain Brook through surface overflow and near-surface groundwater. The leaching of the backfilled rock waste and the contamination of highwall seepage with oxidation products are concerns and may represent a fatal flaw. Additional test and modelling work will be required to demonstrate the long term quality of this discharge. The tailings geosynthetic liner is expected to degenerate over the very long term (possibly 50 to 100 years). The till portion of the composite liner would remain over the very long term. The purpose of the high permeability 'hydraulic envelope' is to minimize contaminant migration from the low-permeability tailings mass. The effectiveness of this system in the long term cannot be quantified or demonstrated at this stage.

Waste and Water Management Costs

The total estimated gross capital cost for construction of the mines waste and water management facilities is $35.7 million ($1.56 per ton of ore mined) for the "base case". Taking account of staged construction and discounting costs at 12%, the present value of this cost is $25.2 million ($1.10 per ton of ore mined). Total estimated gross operating and closure costs are $26.4 million and $24.8 million, respectively.

Potential Technical and Economic Flaws

While an evaluation of the permitting requirements for the project development are excluded from the scope of work for this study, it is our opinion that, under the proposed mine development plan, the technical issues related to water quality may represent fatal flaws.

The maintenance of water quality in the downstream surface waters of Bald Mountain Brook and Clayton Stream is a possible fatal flaw. During operations the quantity and quality of treated water discharge is sufficiently large that it will be difficult, with the dilution flows available, to prevent degradation of these streams to levels where their ecosystems are not deleteriously effected. Following decommissioning the release of untreated seepage from the tailings and (particularly) the pit will also result in reduced water quality. While the impacts of these long term releases could not be established with confidence in a review of this nature, it is our opinion that it will be difficult to demonstrate low impacts. Further, based on our understanding of current technology and site conditions, it will not be possible to maintain drinking water quality standards in Clayton Stream at the confluence with Bald Mountain Brook, under the proposed mine development plan.

Conclusions and Recommendations

There are technical concerns with the proposed mine development and waste management plan as described in this review document. These concerns relate primarily to the maintenance of water quality in the downstream environment both during operations and post decommissioning. These concerns may prove to be fatal flaws unless it can be demonstrated that these issues can be addressed by technically and economically feasible means, incorporating appropriate contingencies and factors of safety against failure. This may be achieved through either:

- further evaluation of the existing plan, or
- modification of the current mining and waste management plan.

The following recommendations derive from this conclusion:

i) Perform additional testing and evaluations to confirm, by qualitative results, the validity of the technical concerns and obstacles to permitting.

ii) Identify the operating conditions and site conditions required at mine decommissioning to eliminate, or minimize, the concerns with regard to water quality in receiving waters.

iii) Evaluate alternative mine and mill development strategies that would meet these conditions or objectives, i.e., adopt a "design for closure" approach. Some of the alternative strategies that could be considered include:

   - reducing the size of the pit and hence waste and tailings areas,
   - underground mining,
   - backfilling tailings in underground workings,
   - placement of all potentially acid generating mine rock in the tailings impoundment in combination with revised pit configuration,
   - alternative mill processes to maximize recycle and minimize water balance excess.

REPORT 80701/1

OPINION OF TECHNICAL

AND

ECONOMIC ASPECTS OF WASTE MANAGEMENT

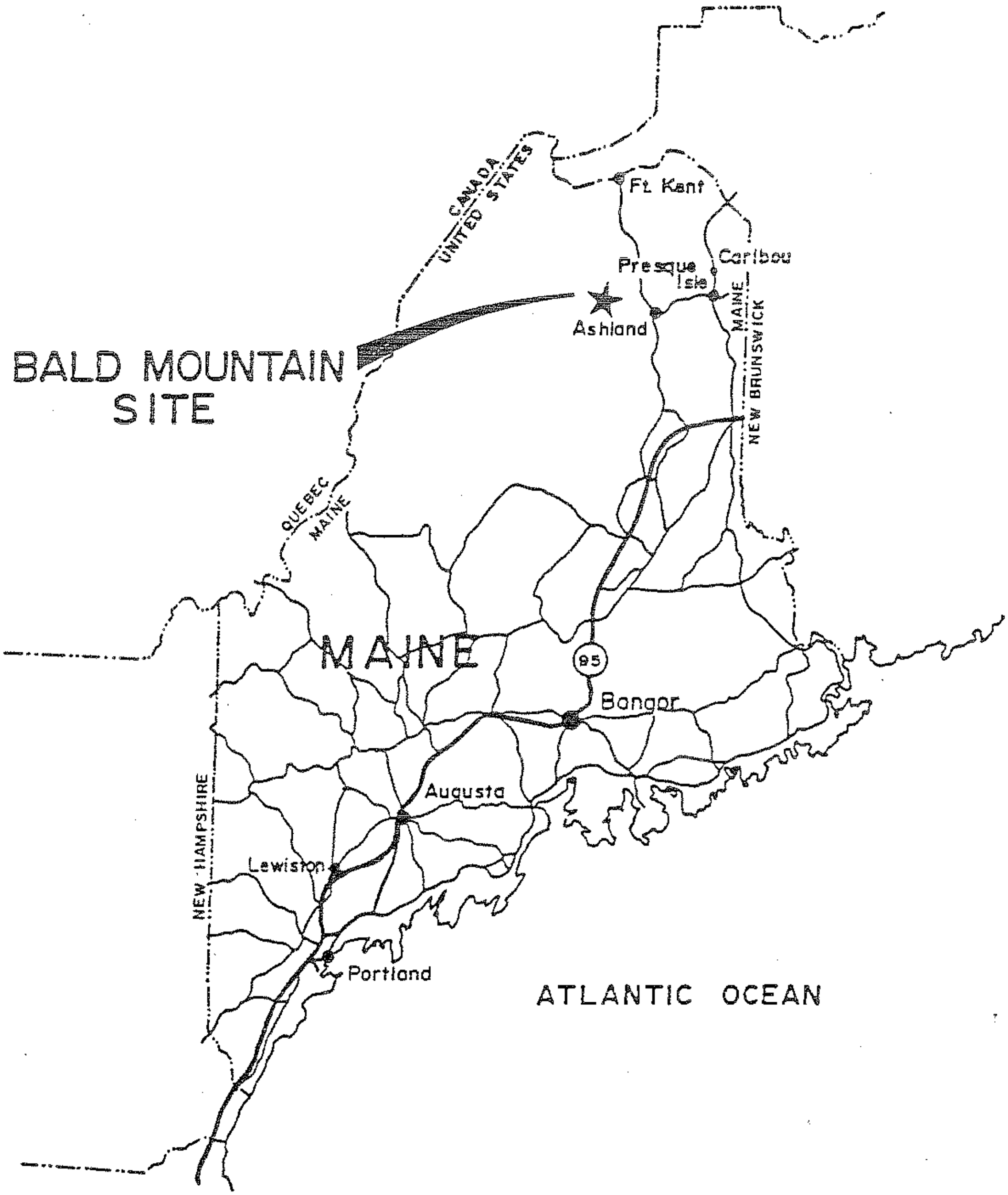
BALD MOUNTAIN PROJECT

1.0 INTRODUCTION

Boliden Resources Inc. (Boliden) is studying the feasibility of developing the Bald Mountain Project in north-central Aroostook County, Maine (Figure 1.1). Boliden has contracted Steffen Robertson and Kirsten (SRK) to conduct an initial review of the technical and economic aspects of waste management and permitting.

The workscope for this study is defined in proposal No E5342 from SRK dated April 6, 1990 and provided for the following tasks:

- Reassess the potential for acid rock drainage (ARD)
- Identify available ARD control techniques
- Carry out a preliminary tailings impoundment water balance
- Evaluate the feasibility of water treatment
- Perform a preliminary assessment of site hydrology, geohydrology, surface water quality and the potential environment impact
- Develop preliminary costs for all major waste management components
- Develop preliminary waste management and reclamation plans and prepare a report.



BOLIDEN RESOURCES INC. BALD MTN. PROJECT	DATE JUNE 1990
PROJECT SITE LOCATION	PROJ. NO. 80701
	APPROVED
	NO. 1.1
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers	

2.0 DESCRIPTION OF THE PROJECT

The Bald Mountain ore deposit is located approximately 14 miles (22 km) north-west of the town of Ashland in north-central Aroostook County, Maine. The deposit consists of two types of ore: a gold-bearing gossan zone overlying a copper and zinc bearing massive sulfide zone. Boliden Resources Inc. holds the mineral rights to the Bald Mountain deposit and plan to submit mining and other required permit applications. An open pit mine is proposed for the recovery of the gold, copper and zinc ores (Figure 2.1). Approximately 1.2 million tons of gold-bearing ore from the gossan zone would be processed during the first two years of operation at a rate of approximately 0.6 million tons per year. Following mining of the gossan zone, approximately 22 million tons of massive sulfide ore would be mined and processed at a rate of up to 1.75 million tons per year to recover copper and zinc for a period of about 13 years. Cyanidation would be used in the gold extraction process and cyanide may be used as a depressant in the copper and zinc flotation process. The overall waste to ore stripping ratio is approximately 1.7 to 1 resulting in approximately 39 million tons of mine rock. Acid generation, due to the natural oxidation of sulfide minerals contained in the tailings, open pit walls and some of the mine rock, would need to be controlled during both the operating and post decommissioning period to prevent adjacent surface and groundwaters from being adversely affected.

3.0 SITE CHARACTERIZATION

3.1 Topography

The topography of the project site is shown in Figure 2.1 and the surrounding area is shown on Figure 3.1. The ore-body occurs on the west side of No-Name Ridge, a peak that rises from the surrounding valleys at an elevation of about 900 ft. to a crest elevation of 1,500 ft. This peak is one of a chain that trends north-south through the project area. The chain is dissected by a series of valleys, the axes of which generally trend southwest on the west side of the chain and southeast or east on the other. Two valleys to the east of the mine peak have axes tending northwest to southeast. The orientation of the valleys along the chain of peaks reflects the underlying geology: a series of linear features, joints and faults or other geological discontinuities.

To the west of the chain, the ground slopes down along flatter valleys to a more level area where Clayton Lake and Big Machias Lake are found. To the northwest, the area drains along Clayton Stream to the Fish River and then into Fish River Lake. This lake fills a north-south depression, probably a part of the extensive series of linear features that dominate the surrounding topography.

To the southeast of the chain, the area flattens with only a few major peaks between the project site and Portage Lake. Just to the east, on the foothills of the chain, is Greenlaw Pond. This feeds into Greenlaw Stream, Sterling Brook and, ultimately, the Great Machias River.

The area to the northeast of the chain is dominated by Carr Pond Mountain and adjacent peaks. In amongst them nestles Bishop Pond. This drains into Bishop Pond Stream and then into Carr Pond. Carr Pond occupies an east-west depression formed by linear features.

3.2 Mine Development

The open pit would be situated on the west flank of No-Name Ridge. The limits of the ultimate pit would have maximum and minimum elevations of approximately 1,140 and 880 feet, respectively. The ultimate pit would have a floor elevation of approximately 180 feet.

The pit would be developed as a series of benches and material quantities by bench level, based on 1.0% copper and 1.83% zinc cutoffs, respectively, are summarized in Table 3.1. However, the specifics of the mine plan, particularly in the early years when the various waste storage facilities are being developed using mine rock, may depend to a significant degree on the construction scheduling requirements of the waste storage facilities.

TABLE 3.1

Open Pit Quantities by Bench Level

PIT 8 - ULTIMATE PIT - 1.0% CU & 1.83% ZN CUTOFFS

01-May-90

	TOTAL	ORE																WASTE					
		GOSSAN			ZINC MS			CU MS			CU MS +ZN			STRINGER			GOS WAST	MS WASTE			TILL	VOLCANIC
BENCH	TONS	TONS	AU	AG	TONS	CU	ZN	TONS	CU	ZN	TONS	CU	ZN	TONS	CU	ZN	TONS	TONS	CU	ZN	TONS	TONS
1125	25,316	0	0.000	0.0	0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0	0.00	0.0	25,316	0
1100	159,130	0	0.000	0.0	0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0	0.00	0.0	159,130	0
1075	348,014	0	0.000	0.0	0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0	0.00	0.0	348,014	0
1050	642,387	0	0.000	0.0	0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0	0.00	0.0	642,387	0
1025	1,025,108	0	0.000	0.0	0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0	0.00	0.0	978,092	47,016
1000	1,428,345	0	0.000	0.0	0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0	0.00	0.0	1,139,014	289,331
975	2,015,461	2,407	0.078	1.6	0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	2,407	0	0.00	0.0	1,249,709	760,938
950	2,590,455	60,168	0.073	0.9	0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	14,440	0	0.00	0.0	1,318,745	1,197,102
925	2,971,901	312,676	0.094	1.5	0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	0	0.00	0.0	50,642	0	0.00	0.0	1,242,888	1,365,595
900	3,320,151	435,620	0.128	2.9	71,429	0.16	2.2	5,102	1.23	0.3	56,122	1.22	1.3	0	0.00	0.0	31,288	142,857	0.34	1.4	822,757	1,754,978
875	3,521,861	274,368	0.148	3.6	163,265	0.20	3.2	102,041	2.23	0.2	153,265	1.49	1.3	25,316	1.23	0.1	24,067	418,367	0.40	1.2	122,538	2,228,634
850	3,578,758	120,337	0.141	3.1	193,878	0.16	3.6	387,755	2.66	0.2	193,878	1.63	1.1	36,165	1.21	0.1	7,220	588,853	0.45	1.3	0	2,050,671
825	3,598,028	0	0.000	0.0	239,796	0.18	3.5	744,898	2.66	0.2	127,551	1.38	1.2	39,783	1.22	0.1	0	678,571	0.47	1.3	0	1,767,429
800	3,454,762	0	0.000	0.0	311,224	0.23	3.3	790,816	2.43	0.2	137,755	1.31	2.0	50,633	1.32	0.0	0	704,082	0.48	1.3	0	1,460,252
775	3,264,117	0	0.000	0.0	352,041	0.20	3.4	836,735	2.21	0.2	107,143	1.27	1.7	36,166	1.42	0.3	0	647,959	0.47	1.4	0	1,284,073
750	3,104,915	0	0.000	0.0	377,551	0.24	3.7	841,837	2.19	0.2	61,224	1.12	0.8	39,783	1.65	0.4	0	683,673	0.48	1.3	0	1,100,847
725	2,963,094	0	0.000	0.0	392,857	0.22	3.5	831,633	2.27	0.2	86,735	1.33	0.7	32,550	1.79	0.4	0	760,204	0.46	1.3	0	859,115
700	2,816,166	0	0.000	0.0	372,449	0.18	3.3	795,918	2.45	0.2	127,551	1.56	0.8	39,783	1.75	0.1	0	846,939	0.48	1.4	0	633,526
675	2,642,490	0	0.000	0.0	408,163	0.16	3.1	744,898	2.54	0.2	102,041	1.52	0.8	50,633	1.64	0.1	0	882,653	0.56	1.2	0	454,102
650	2,468,123	0	0.000	0.0	408,163	0.13	3.0	647,959	2.13	0.2	127,551	2.73	0.8	72,333	1.61	0.1	0	841,837	0.57	1.1	0	370,280
625	2,302,126	0	0.000	0.0	377,551	0.16	3.0	663,265	1.89	0.2	107,143	3.02	0.7	57,866	2.21	0.1	0	846,939	0.57	1.0	0	249,362
600	2,092,030	0	0.000	0.0	295,918	0.16	3.1	678,571	1.91	0.2	66,327	1.30	0.7	65,099	2.17	0.1	0	790,816	0.57	1.0	0	195,299
575	1,887,949	0	0.000	0.0	275,510	0.22	3.2	724,490	1.80	0.2	45,918	1.77	0.9	57,866	1.58	0.1	0	581,633	0.60	1.0	0	202,532
550	1,697,688	0	0.000	0.0	188,776	0.26	3.0	704,082	1.87	0.3	45,918	1.86	0.9	72,333	2.00	0.1	0	494,898	0.64	1.0	0	191,681
525	1,498,063	0	0.000	0.0	71,429	0.25	2.9	642,857	1.72	0.3	96,939	1.93	1.3	68,716	1.87	0.0	0	433,673	0.66	0.9	0	184,449
500	1,334,991	0	0.000	0.0	56,122	0.28	3.3	596,939	1.67	0.3	132,653	1.99	0.8	79,566	1.88	0.0	0	321,429	0.68	0.7	0	148,282
475	1,148,734	0	0.000	0.0	45,918	0.24	3.6	540,816	1.77	0.3	127,551	1.95	0.7	54,250	1.99	0.0	0	250,000	0.72	0.7	0	130,199
450	970,356	0	0.000	0.0	0	0.00	0.0	489,796	1.82	0.3	96,939	1.92	0.7	43,400	2.40	0.0	0	224,490	0.74	0.8	0	115,731
425	817,489	0	0.000	0.0	0	0.00	0.0	403,061	1.79	0.3	56,122	1.84	0.7	28,933	3.19	0.0	0	224,490	0.83	0.8	0	104,883
400	702,919	0	0.000	0.0	0	0.00	0.0	336,735	1.65	0.3	51,020	1.65	0.8	54,250	1.81	0.0	0	163,265	0.85	0.7	0	97,649
375	548,760	0	0.000	0.0	0	0.00	0.0	311,224	1.76	0.3	66,327	1.40	0.8	39,783	1.73	0.0	0	66,327	0.86	0.8	0	65,099
350	437,807	0	0.000	0.0	0	0.00	0.0	229,592	1.92	0.2	66,327	2.05	0.8	57,866	1.63	0.0	0	15,306	0.93	1.1	0	68,716
325	318,522	0	0.000	0.0	0	0.00	0.0	168,367	2.05	0.2	45,918	2.58	0.7	39,783	1.67	0.0	0	10,204	0.98	0.9	0	54,250
300	240,700	0	0.000	0.0	0	0.00	0.0	153,061	2.02	0.2	10,204	1.67	0.6	32,550	1.55	0.0	0	5,102	0.68	0.7	0	39,783
275	154,353	0	0.000	0.0	0	0.00	0.0	127,551	2.11	0.2	5,102	1.51	0.8	18,083	1.46	0.0	0	0	0.00	0.0	0	3,617
250	98,230	0	0.000	0.0	0	0.00	0.0	76,531	1.90	0.1	0	0.00	0.0	14,467	1.18	0.0	0	0	0.00	0.0	0	7,232
225	20,408	0	0.000	0.0	0	0.00	0.0	20,408	1.87	0.1	0	0.00	0.0	0	0.00	0.0	0	0	0.00	0.0	0	0
200	5,102	0	0.000	0.0	0	0.00	0.0	5,102	4.38	0.0	0	0.00	0.0	0	0.00	0.0	0	0	0.00	0.0	0	0
Total:	62,214,810	1,205,776	0.122	2.6	4,602,041	0.19	3.3	13,602,040	2.09	0.2	2,311,224	1.74	1.0	1,207,957	1.77	0.1	129,964	11,624,567	0.55	1.1	8,048,590	19,482,651

1,205,776 = GOSSAN ORE   4,602,041 = ZINC ORE   17,121,221 = TOTALCU ORE   39,285,772 = TOTAL WASTE

Related to the mine development would be the production of gossan and sulfide tailings, glacial till, gossan mine rock, sulfide mine rock, hanging wall mine rock and foot wall mine rock. The expected tonnage of each of these materials and notes on whether they are expected to be acid generating are shown in Table 3.2. The tailings tonnages shown in Table 3.2 do not reflect final product (or concentrate) recovery which is expected to be approximately 6% of the total tonnage. The tonnage of tailings placed in the impoundment would therefore be approximately 94% of the values shown in Table 3.2. The acid generation potential of the mine wastes is discussed in detail in Section 5.0 of this report. It is the acid generation potential of these various materials that governs their management and reclamation. The conceptual waste management plan is briefly summarized here and described in more detail in Section 6.0. In particular, materials which have the capacity to generate acid would either be placed directly inside the tailings impoundment or temporarily on a till pad until the pit is completed and this waste can be backfilled to the pit. Mine rock which has a net neutralizing potential would be used in the construction of drains and embankments or would be placed downstream of the embankment used to confine tailings.

TABLE 3.2
Summary of Materials Produced as a Result of Mine Development
For 0.73% and 1.00% Copper Cut-off Grades

Material	Quantity (Tons) 0.73% Copper	1.0% Copper	Acid Generating Potential
Gossan tailings	1,210,000	1,210,000	yes (assumed)
Sulfide tailings	29,820,000	21,720,000	yes
Glacial till	8,050,000	8,050,000	no
Gossan mine rock	130,000	130,000	yes (assumed)
Massive Sulfide mine rock	5,890,000	11,620,000	yes
Hanging wall mine rock	8,240,000	6,300,000	no
Foot wall mine rock	17,340,000	13,200,000	yes

The gossan tailings are a product of a process which requires quantities of cyanide greater than the copper/zinc extraction process, and should be separated from the sulfide tailings in a lined impoundment. This impoundment would be located such that any leakage from the gossan tailings through the liner would be contained during operation. The location of the gossan impoundment is at the upstream end of the overall impoundment area, thus maximizing the length of possible seepage paths and taking advantage of the natural attenuation and degradation of cyanide. The embankment used to confine the gossan tailings would be constructed using glacial till and mine rock. Drains, placed beneath the liner, would consist of quarried, non-acid generating rockfill or hanging wall mine rock.

The sulfide tailings are believed to have a strong potential to generate acid. These tailings would be deposited in a lined impoundment. A confining embankment would be constructed using glacial till, and hanging wall mine rock.

The glacial till would be used to construct confining embankments for tailings impoundments, a temporary base pad, if needed, for storage of foot wall mine rock and a permanent pad to facilitate the early placement of massive sulfide mine rock inside the limits of the sulfide tailings pond. During operation, excess glacial till would be placed downstream of the sulfide tailings dam in a stockpile. A portion of this till would be used to cover the tailings surface in order to promote the development of marshland conditions. Till would also be used to develop fillets to cover those portions of the pit walls which are potentially acid-generating and for other reclamation purposes.

Gossan mine rock would be used in the construction of the embankment used to confine the gossan tailings.

Massive sulfide mine rock would be deposited in the tailings impoundment along with all the sulfide tailings.

Hanging wall mine rock would be used in the construction of drains beneath the two lined tailings impoundments and in the construction of embankments.

Foot wall mine rock is potentially acid generating and would therefore be placed temporarily on a glacial till pad so that drainage can be captured and, if contaminated, treated. At closure, the foot wall mine rock would be backfilled to the open pit below the final water elevation.

3.3 Alternative Tailings Disposal Sites

3.3.1 Initial Site Selection

In 1980 and 1981, Steffen Robertson and Kirsten (SRK) carried out a study to select, evaluate and rank alternative tailings disposal sites. The study resulted in the identification of 45 potential tailings disposal sites, the locations of which are shown on Figure 3.1.

An analysis was performed in which the potential sites were assessed in the context of potential fatal flaws. A fatal flaw is defined as a site characteristic which is sufficiently unfavorable or severe that, on its own, would eliminate the site as an alternative for tailings disposal. Typical fatal flaws established as part of this analysis comprised embankments with a volume of greater than 6.7 million cubic yards; access distances of greater than 9 miles; upstream catchments of greater than 5.4 square miles; access routes where two or more streams have to be crossed; and impoundments where more than three saddle dykes are required.

The analysis indicated that fatal or severe flaws affect most of the 45 sites. The sites which had no apparent fatal or severe flaws and, therefore, warranted further consideration, were Moose Site (Site 6), High Site (Site 7) and Logging Road Site (Sites 8 and 45). Conceptual designs were completed for each of these sites and preliminary costs of construction, operation and decommissioning were estimated. The sites were then ranked on the basis of visibility, land use, operation, environmental effects and cost, with the following result:

Ranked First	High Site
Ranked Second	Moose Site
Ranked Third	Logging Road Site

3.3.2 Site Selection Based on Wetlands Avoidance

In 1988 and 1989, International Engineering Company, Inc. (IECO) carried out another site selection study with a view to avoiding wetlands. Conceptual designs were prepared for the four impoundment alternatives (High Site 1, High Site 2, High Site 3 and Bull Hill Site) shown on Figure 3.2. The designs were based on storage of 7.5 million cubic yards of tailings, except for High Site 1 which was also assessed on the basis of 15 million cubic yards of storage. A description of each of these sites is included below and a summary of their characteristics based on the IECO analysis is included in Table 3.3.

• High Site 1

The site would be developed by constructing a single cross-valley embankment. To keep the embankment out of marshy areas as much as possible, the dam axis was located across a small knoll at the west end of the site. Studies by others indicate that this valley site supports a 20 to 30-acre wetland area.

• High Site 2

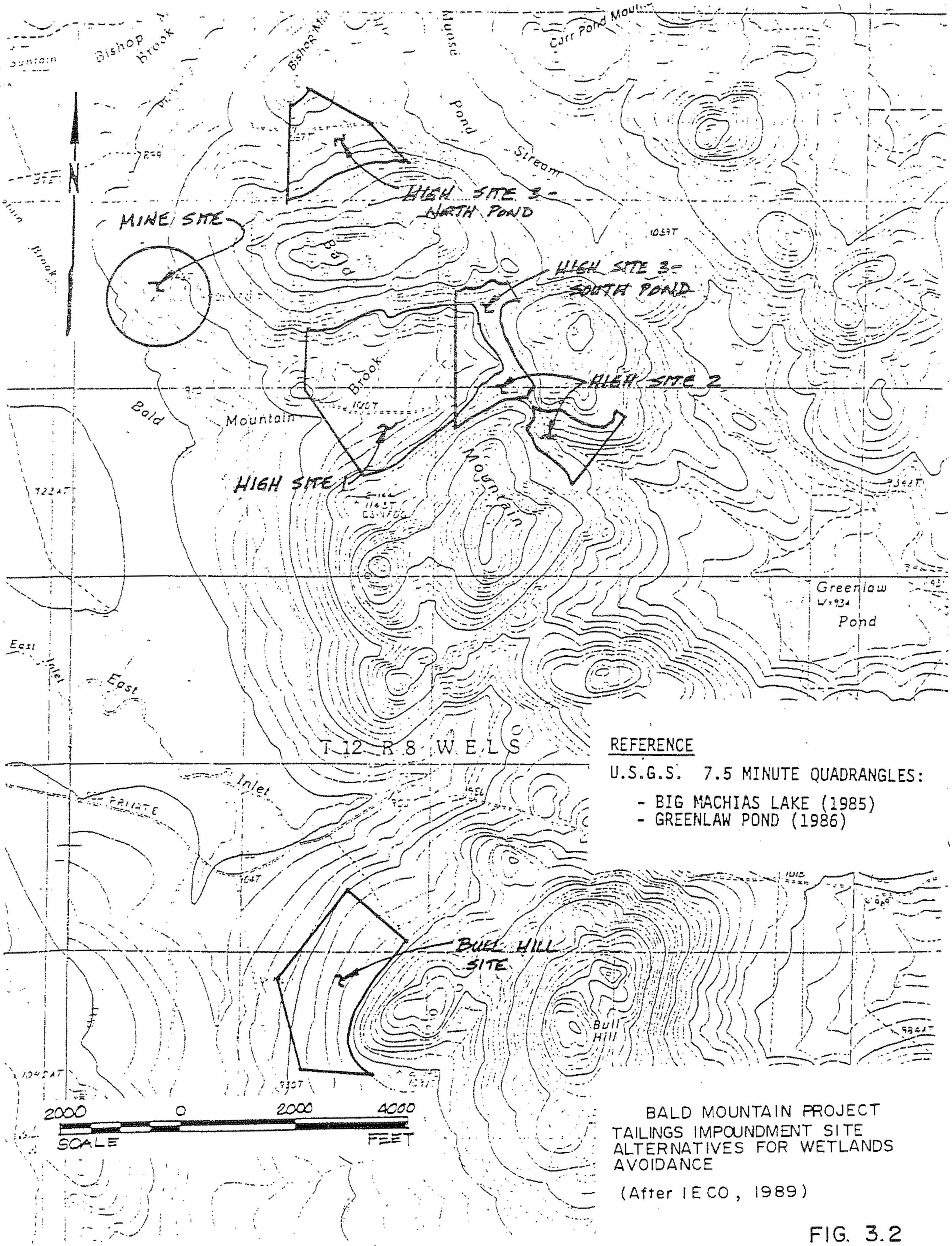
This site was located to avoid wetlands almost entirely. The west dam was located east (upstream) of the wetlands affected by High Site 1. To develop sufficient storage capacity, dams would be required in the northeast saddle and southeast of the southeast saddle.

• High Site 3

This alternative consists of two impoundments: a south impoundment in the High Site with a maximum tailings level at El. 1152 (the approximate elevation of the northeast saddle) and a north impoundment located north of No-Name Ridge.

• Bull Hill Site

This site is located on the west flank of Bull Hill, about 2.3 miles south of the mine site. The Bull Hill alternative is a side hill alternative and therefore consists of a three-sided impoundment.



BALD MOUNTAIN PROJECT
TAILINGS IMPOUNDMENT SITE ALTERNATIVES FOR WETLANDS AVOIDANCE

(After IECO, 1989)

FIG. 3.2

TABLE 3.3

Tailings Impoundments For Avoidance of Wetlands
Summary of Physical Characteristics (After IECO, 1989)

				HIGH SITE 3				
		HIGH SITE 1	HIGH SITE 2	SOUTH POND	NORTH POND	TOTAL	BULL HILL SITE	HIGH SITE 1
1)	Storage Capacity (million c.y.)	7.5	7.5	2.5	5	7.5	7.5	15
2)	Impoundment Area (acres)	118	92	44	58	102	91	165
3)	Maximum Tailings Elevation (ft.)	1,078	1,178	1,152	1,142	---	1,083	1,112
4)	Embankment Dam							
	A. Volume (c.y.)	1,085,000	4,080,000	1,385,000	2,380,000	3,765,000	5,158,000	2,357,000
	B. Length (ft.)	2,840	5,330	2,810	4,370	7,180	6,500	3,160
	C. Maximum Height (ft)	103	175	110	110	110	130	137
	D. Crest Elevation (ft.)	1,088	1,187	1,160	1,151	---	1,090	1,122
5)	Drainage Basin Area (acres)	367	185	107	135	242	134	367
6)	Drainage Basin Area/Impound. Area	3.1	2.0	2.4	2.3	2.4	1.5	2.2
7)	Storage Capacity/Embank. Volume	6.9	1.8	1.8	2.1	2.0	1.5	6.4
8)	Straight Line Distance to Mine (miles)	0.6	1.3 (avg.)	1.0	0.8	---	2.3	0.6

3.3.3 Review of Alternative Sites Based on Current Design Criteria

3.3.3.1 Design Parameters

The required storage capacity in the overall tailings impoundment was evaluated for two copper cut-off grade cases, namely 0.73% and 1.00%. A summary of material tonnages for these two cases is shown in Table 3.2. The storage requirement for 0.73% copper cut-off is for 1.2 million tons of gossan tailings, 29.8 million tons of sulfide tailings and 5.9 million tons of potentially acid generating sulfide mine rock. At estimated settled densities of 80, 130 and 177 pounds per cubic foot (pcf), respectively, these translate to 1.1 million, 17.0 million and 2.5 million cubic yards, respectively, or a total of 20.6 million cubic yards. Allowing for a 10% contingency, the total volume of material would be 23 million cubic yards. The required storage capacity for 1.00% copper cut-off grade is approximately 20 million cubic yards. A storage requirement of 23 million tons was assumed for the purpose of evaluating alternative sites. It was assumed in the current assessment that mine rock and till would be used to construct the embankments and that, based on the likelihood that a synthetic liner would be required, a 60 mil HDPE liner would be used to line the tailings impoundment.

The issue of gossan tailings and the potential need for a second impoundment has been ignored for purposes of this comparison of alternative sites.

3.3.3.2 Preliminary Design

The designs prepared by IECO (1989) have been used as the basis for evaluating and costing tailings disposal at the four sites. Impoundment capacity curves prepared previously by IECO have been extrapolated to determine the approximate embankment crest elevation required to store 23 million cubic yards of waste. A copy of the extrapolated curves is included in Appendix A. The embankment layouts prepared by IECO were modified to reflect these crest elevations (Appendix A) and the volumes of the respective embankments were computed. The results of these calculations are summarized below:

Site	Embankment Crest Elev (ft)	Embankment Volume (Cu. yd.)	Embankment Volume to Storage Ratio
High Site 1	1148	2,974,000	0.13:1
High Site 2	1274	16,692,000*	0.72:1
High Site 3	1237	17,065,000*	0.74:1
Bull Hill Site	1178	19,049,000	0.82:1

* Total of two embankments

Based on the ratios of embankment volume to storage, the High Site 1 has the most efficient storage.

3.3.3.3 Estimated Costs

The cost of constructing the impoundments at High Sites 1, 2, 3 and Bull Hill Site have been estimated. Cost estimates prepared by IECO, plus a 10% increment for inflation, form the basis of the current estimates. Other factors in the preparation of the current estimates are as follows:

- Assume the entire embankment is constructed prior to the start of mining.
- Assume the embankments are constructed entirely of mine rock and till from the open pit development. In fact, for all cases except High Site 1, approximately 12 million cubic yards of borrow will be required to construct the final embankments, possibly at lower costs than are noted in Appendix A, but with greater disturbance.
- Assume the cost of cutoff and foundation grouting will be eliminated from all cases.
- Assume that a 60 mil HDPE liner at 60¢/square foot will be required in all cases.

A summary of the cost estimates, prepared only for the purpose of comparing the alternative sites, is provided in Table 3.4.

TABLE 3.4
Summary of Estimated Costs for Embankment Construction at Alternative Tailings Impoundment Sites

Site	Total Estimated Cost*	Unit Cost of Disposal**
High Site 1	$24.3 million	$0.69/ton
High Site 2	$85.1 million	$2.43/ton
High Site 3	$79.7 million	$2.28/ton
Bull Hill Site	$112.2 million	$3.21/ton

* Prepared from the IECO estimates, for comparative purposes only
** For 35 million tons of tailings and potentially acid generating mine rock

3.3.3.4 Evaluation of Alternative Sites

The following is a discussion of the advantages and disadvantages of the alternative sites.

High Site 1

Advantages:

- close to mine and therefore has a likelihood of a smaller environmental impact in the event of

a rupture of the tailings pipeline.
- requires no additional borrow to construct the confining embankments
- drainage impact affects only one brook
- lowest capital cost, by a substantial margin
- operating cost would, by virtue of its location, be relatively low
- catchment area sufficient to ensure water cover can be maintained

Disadvantages:
- 20 to 30 acres of wetland affected
- Bald Mountain Brook impacted

High Site 2

Advantages:
- relatively close to mine and therefore has a likelihood of a smaller environmental impact in the event of a rupture of the tailings pipeline
- operating costs would be similar to that of High Site 1, with slightly higher waste haulage and tailings pumping costs

Disadvantages:
- drainage impact affects multiple brooks and groundwater systems
- a need to develop borrow areas to complete construction of the confining embankments
- high capital cost
- assured water cover may not be possible in dry years

High Site 3

Advantages:
- relatively close to mine and therefore has a likelihood of a smaller environmental impact in the event of a rupture of the tailings pipeline
- operating costs would be only slightly higher than that of High Sites 1 and 2

Disadvantages:
- two impoundments instead of one, which compounds potential operating and environmental problems
- drainage affects multiple brooks and groundwater systems
- high capital cost (only sightly less than High Site 2)
- need to develop borrow areas to complete construction of the confining embankments
- assured water cover may not be possible in dry years

Bull Hill Site

Advantages:

- no apparent advantages (early evaluations of the site indicated that there may be reduced impact on wetlands at the Bull Hill Site, however, recent studies have shown that this is not the case)

Disadvantages:

- distant from the mine resulting in likelihood of greater environmental impact in the event of a pipeline rupture
- highest capital cost, reflecting the high ratio of embankment volume to waste volume
- need to develop borrow areas to complete construction of the confining embankments
- additional haul road and pipeline construction, hence site disturbance
- additional operating costs for tailings pumping and mine rock haulage
- assured water cover may not be possible in dry years

In summary, High Site 1 stands out as the best site in terms of cost, suitability for controlling acid generation and minimizing the impact to one watershed. The Bull Hill Site has the potential to impact a large area in the event of a pipeline rupture. Furthermore, water cover in dry periods is not assured and it has by far the highest capital and operating costs with an incremental cost of at least $4.00 per ton over High Site 1. It is anticipated that such an incremental cost is likely to represent a fatal flaw for the development of this site. High Sites 2 and 3 are similar in that they both potentially impact multiple brooks and groundwater systems. This risk to more than one ground or surface water system may be a fatal flaw to permitting. Their capital and operating costs are at least $2.00 per ton higher than High Site 1 but lower than the Bull Hill Site. In conclusion, High Site 1 is the site most worthy of further consideration and is, therefore, the site used for the assessments discussed in this report.

3.4 Geology and Soils

The geology of the site is described, in detail, in the report "Bald Mountain Site, Surficial Geology of Proposed Tailings Impoundment Areas" by Jordan Gorrill Associates (JGA), dated January 1981. It is summarized below. Where possible, conclusions based on subsequent geological studies have been introduced.

3.4.1 Regional Geomorphology

The mildly metamorphosed volcanic province of Aroostook County is a maturely dissected plateau surface. The ridge and hill forming rocks are almost exclusively siliceous volcanic and volcaniclastic rocks, while slopes and valleys tend to be underlain by graphitic shales and micritic mudstones. Major topographic lineaments have been linked to structural control in a previous study. Subsequent identification of folding of volcanics on Bishop Mountain was made using aerial photography.

It would appear that the local bedrock topography is little changed from preglacial times. This contention is supported by the lack of major glacially scoured basins, the lack of deranged bedrock controlled drainage, the remnant natural topography and the lack of asymmetrical bedrock hills.

3.4.2 Regional Bedrock

The bedrock geology in the vicinity of the project is summarized on Figure 3.3, adapted from a figure prepared by Superior Mining Co. (SMC). It shows that the area is typically characterized by various volcanics (flow, fragmentals and tuffs) and, in the portion of Bald Mountain Brook which flows essentially northwards, a band of graphitic shale (Su). There is little structural data available in the area, primarily because of the extensive till cover. Faults which have been mapped are situated in the vicinity of the proposed open pit. Lineaments were mapped by JGA and are shown on Figure 3.3.

3.4.3 Regional Soils

The surficial geology is summarized on Figure 3.4 prepared by SMC. It shows that the soils in the area are typically comprised of tills, of which there are three types, and swamp deposits made up of peat, organic silt and clay and organic-free silt and clay. Although they are not shown on Figure 3.4, small, apparently inactive talus piles are common downslope of cliffs and steep outcrops.

Three tills were identified in the study area. Their presence and properties are important as they would serve as a "natural liner" when present. They can be re-worked to avoid permeable zones and used in combination with synthetic liners to form a much more secure "composite" liner. The lower till (Qtg), grey to brownish grey in color, displays fine fissility, has a pronounced clay fraction and is composed chiefly of slate clasts. Grain size distributions of this till indicate a characteristic curve with a distinctively high percentage of silt/clay. It appears to be relatively impervious, having an estimated field permeability of 10^{-6} cm/sec based on USGS field classifications. Owing to physical similarities and stratigraphic position, this till is correlated with the St. Francis till. This till is rarely found at depths shallower than 10 feet and it is presumed that the St. Francis till is present where the till is 15 feet or thicker. There are no data concerning the maximum thickness of this till or the presence of older units underlying it.

The upper till (Qtb) is brown, olive brown or chocolate brown in color. It is composed of clasts from many different rock units including cherts, graywackes, shales, volcanic rocks from basic to acidic, slates and a certain modest amount of phaneritic plutonic rocks. It is generally stoney with a moderate silt fraction and is somewhat pervious in places, owing to the distribution of lenticular bodies of immaturely washed sands and gravels. The till is correlated with the Mars Hill till and represents the latest Wisconsin glacial event in northern Maine. A comparison of the grain size distribution curves between the Mars Hill and St. Francis tills show a distinct increase in the fine fraction (minus #200 sieve) percentages. The color distinction between the St. Francis and the Mars Hill till seems to be a function of relative clast and matrix lithologies and bulk permeability. The greater permeability of the Mars Hill till has led to effective oxidation of iron-and-carbon-bearing shales, cherts and basalts. Oxidation may also be exacerbated by fluctuations in the seasonal high water table.

There is good evidence from texture, structure and compaction that both an ablation and a lodgement facies are represented in the Mars Hill till. Grain size distributions show that the ablation facies is somewhat better sorted than the lodgement facies. Although no stratification was observed in the field, the ablation till was definitely affected by limited selective action of meltwater during deposition. The ablation till lacks fissility and is consistently looser and more friable than the underlying lodgement till.

The third till unit, designated Qtw on Figure 3.4, is a relatively clean well sorted and permeable superglacial till. The precise mode of emplacement of this till is yet unclear. However, it is believed to be derived from the Mars Hill till.

Water contents of all three tills are low to moderately low (8 to 19 percent on a dry weight basis) with highest values generally associated with the more clay rich tills. This reflects the high porosities and low permeabilities associated with the clay fractions. Plasticity indices for all analyzed tills cluster closely in the low plasticity range.

Swamp deposits composed of muck, silt and some clay occur as a result of organic accumulation in bedrock depressions and other poorly drained areas. Although no section through the swamps has yet been obtained, they are believed to be relatively shallow deposits, probably less than 10 feet thick.

3.4.4 Bedrock Geology and Soils at Tailings Impoundment

The bedrock geology in the vicinity of the open pit and tailings impoundment is summarized on Figure 3.5. It indicates that, beneath most of the tailings impoundment, is a bedrock unit comprised of fragmental and massive volcanic rocks of andestic to basaltic composition; fragmental volcanics (dominantly lapilli and block fragmental) and massive volcanics which are locally pillowed. In the extreme east and west edges of the impoundment area are found fragmentals and tuffs of rhyolitic to calcitic composition intermixed with minor volcanic rocks.

Site specific investigations indicate the site of the tailings impoundment is underlain by thin to moderately thick (greater than 50 feet) glacial till. At the surface, the till is brown in colour, stoney with a moderate silt fraction, and somewhat pervious in places, due to the presence of lenticular bodies of sands and gravels. It is correlated with the Mars Hill till. For soil depths below about 15 ft, the St. Francis till is believed to occur. This is grey in color with a pronounced clay fraction, and is relatively impervious. It is composed mainly of slate clasts.

Linear east-west tending knobs on the north, south and east sides of the valley are bedrock controlled. The bedrock consists primarily of tuff overlying basaltic rocks of varying types and character.

The lineaments indicating geological contacts and faulting, defined by JGA are shown on Figure 3.3. It is apparent that there is a strong set of southwest northeast tending faults which may have a considerable influence on the groundwater flows in these directions.

3.5 Surface Water

The surface water characteristics of the project area and the regional stream systems were described by Woodward-Clyde Consultants (1982) and by the U.S. Geological Survey (USGS, 1989). The following description of the surface water system focuses specifically on the project drainages and the areas immediately downstream of the project.

The main surface water drainage in the project site is Bald Mountain Brook (Figure 3.3), over which the tailings impoundment will be situated. Bald Mountain Brook drains into Clayton Stream about 1.5 miles west and slightly north of the tailings impoundment area; Clayton Stream flows approximately 3.5 miles north of the project area before discharging into the Fish River. The project site is essentially at the headwaters of the Fish River drainage basin. Bald Mountain Brook and Clayton Stream are designated as Class A streams and Fish River is designated as a Class AA water of the State of Maine.

Precipitation at the project site is approximately 40 inches per year. Annual runoff is approximately one half of the precipitation, or 20 inches per year. The majority of the balance of the precipitation is removed by evaporation and evapotranspiration (Woodward-Clyde Consultants, 1982).

In late 1978, a surface water gauging station (WCC station 2) was installed on Bald Mountain Brook just downstream of the proposed impoundment. The gauge location is shown on Figure 3.3. As indicated, its catchment and that of the tailings pond are approximately equal. The gauging station catchment area is 358 acres; the impoundment catchment area will be approximately 417 acres. Data from this station indicate that for a three year period of record, the mean annual discharge of the stream was 0.74 cfs. Flow is perennial from this point on the stream to approximately 0.4 miles to the east (upstream). A large part of this segment and the remainder of the drainage consists of wetlands, and has a number of mapped springs and seeps.

Water quality at the project site is good. The USGS installed and subsequently monitored a gauging station on Bald Mountain Brook from 1979 through 1984 (Figure 3.3). The results indicate that the waters have a relatively high dissolved oxygen content, very low total dissolved solids (TDS), and have trace metals present in extremely low concentrations. Selected chemical data for Bald Mountain Brook is shown in Table 3.5. The USGS station indicated an average annual flow for the entire Bald Mountain Brook watershed (1.73 square miles) of 3.25 cfs for water years 1983 and 1984.

3.6 Groundwater

Much of the groundwater information developed to date was by Woodward-Clyde Consultants (1982). IECO (1989a) and Budo (1988a,b) performed additional specialized studies in the impoundment and pit areas, respectively. A summary of the groundwater characteristics of the site, based on the results of investigations through 1988, appears in Budo (1988c).

The major soil and rock units identified at the site include glacial till, a country rock (bedrock), the massive sulfide ore, a vuggy (porous) massive sulfide ore, and gossan. The gossan, massive sulfide

TABLE 3.5
Surface Water Quality For Bald Mountain Brook
(After USGS (1989))

Parameter	Number of analyses	Mean	Range
Temperature (°C)	53	7.7	0.0-20.0
Turbidity (NTU)	53	2.7	0.5-15.0
Color (Platinum cobalt units)	49	50	20-90
Specific conductance (micS/cm)	50	57	18-185
Dissolved oxygen (mg/L)	51	11.0	7.2-13.7
pH (standard units)	49	6.7*	6.0-7.8
Alkalinity (mg/L as $CaCO_3$)	54	16	2-40
Total solids, residue at 105°C (mg/L)	38	72	33-119
Total ammonia nitrogen (mg/L as N)	12	<0.01	<0.01-0.03
Total nitrogen NO_2+NO_3 (mg/L as N)	13	0.12	<0.01-0.42
Total phosphorus (mg/L as P)	39	0.01	<0.01-0.04
Total cadmium (mg/L as Cd)	8	0.002	0.002-0.002
Total chromium (mg/L as Cr)	10	0.007	<0.005-0.02
Total copper (mg/L as Cu)	53	0.003	<0.001-0.016
Total iron (mg/L as Fe)	50	0.256	<0.05 -0.92
Total lead (mg/L as Pb)	23	0.010	<0.001-0.03
Total zinc (mg/L as Zn)	50	0.008	<0.001-0.02
Total aluminum (mg/L as Al)	7	0.256	0.1 -0.36

* Mean of pH readings

ore, and vuggy massive sulfide ore are contained mostly within the limits of the pit area. The glacial till and bedrock are more extensive over the site area, and are the stratigraphic units of concern for dewatering and groundwater protection.

3.6.1 Glacial Till

Glacial till overlies the bedrock surface throughout much of the project area. However, groundwater aquifers associated with glacial till are not significant. In general the till is thin or missing in areas of bedrock highs and is as much as 130 feet thick in areas that represent erosional channels in the old bedrock surface. Although there are occasional sandy or gravelly zones, these are commonly discontinuous and are, for the most part, of little significance. Typically, there is a zone that will transmit some water into borings or pits at a depth of 3 to 16 feet, but it is too small and discontinuous to be considered a viable resource. Through the tailings impoundment valley the thickness of the till averages approximately 30 feet. The till there tends to be absent above elevations of approximately 1150 ft. In the valleys it serves as a confining unit to the fractured bedrock aquifer.

The till was tested at several locations in the tailings impoundment valley for engineering properties. Field tests for permeability show the till is relatively impermeable because of the large amount of silt and clay sized particles in the matrix. Field permeabilities indicate an average permeability on the order of $1x10^{-6}$ cm/sec. However, reworked samples of till can achieve permeabilities on the order of $1x10^{-8}$ cm/sec.

3.6.2 Bedrock

In the vicinity of the proposed mine and tailings impoundment, the significant aquifer appears to be that of the fractured surface of the bedrock. This aquifer ranges from confined to unconfined conditions through the general mine area, based largely on the thickness of the overlying glacial till. Field testing in the impoundment area for foundation assessments indicate that the fractured bedrock extends 50 to 80 feet below the contact with the till. Below this depth, fractures tend to infill and/or close, and permeability is reduced. The permeability within the fractured bedrock is in the order of $1x10^{-3}$ cm/sec, based on packer tests by IECO (1989a) and a pumping test by Budo (1988b). The pumping test indicated inter-connection of fractures within the bedrock to a depth of 50 to 80 feet; therefore, it would appear that this zone may form a potential seepage migration pathway away from the proposed impoundment.

There was no documentation reviewed which indicates that the bedrock has been hydraulically tested below a depth of approximately 80 feet below ground surface. Despite this, previous investigators conclude that this zone is essentially impermeable (Woodward-Clyde Consultants, 1982; Budo, 1988a). A bulk mass permeability in the order of $1x10^{-5}$ cm/sec is considered representative of this formation. The potential exists that there are additional southeast northwest tending faults such as are encountered in the pit area and shown on Figure 3.3. These may form preferential groundwater flow paths.

Previous estimates of pit dewatering flows have been based on the assumption that the bulk rock mass is intact below the ultimate pit bottom elevation (approximately 180 feet MSL). However, two major faults and at least two other faults are known to intersect the mine pit. These faults may extend into the small drainage valley west of the pit and could provide a means of underflow from the valley to the mine pit when the water table is lowered. Because the faults are potential pathways for groundwater movement, they have the potential to deliver greater volumes of water to the pit than has been previously estimated. This, in turn, would affect the water balance of the project. Although not a fatal flaw, the actual characteristics of the faults should be defined in subsequent evaluations. Additionally, the presence of faults should be investigated in the impoundment area, as they could be critical to any potential seepage movement.

Groundwater flows at the site are generally parallel to the surface topography. Recharge is estimated to be 3 inches per year. Based on this, the tailings impoundment area has a balanced recharge and outflow at the mouth of the valley of approximately 70 gpm (Budo, 1988). A potentiometric surface of the area was presented by Woodward-Clyde Consultants (1982), and others (IECO, 1989; Budo 1988).

Most of the groundwater quality data for the project site was recorded for the period 1973 to 1982. Four water quality stations (boreholes A, B, C, and D) were established early in the water quality monitoring program and were sampled beginning in October 1978. A number of other stations (piezometers 1002, 1006, 1007, 1013, 1014, and 1015) were sampled later in the program. The locations of the stations are shown in Figure 3.3. The groundwater quality summary is shown on Table 3.6.

The quality of groundwater in the project area is generally low in total dissolved solids (TDS). The total mineral content of the water is low; TDS, sodium, chloride, and sulfate are well below recommended levels. The groundwater could be classified as moderately hard to hard. Refer to Woodward-Clyde Consultants (1982) for a detailed description of water quality.

TABLE 3.6
Groundwater Quality Summary

Water Quality Parameters	A	B	C	D	1002	1006	1007	1014
General Constituents (mg/l unless otherwise noted)	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
pH (units)	6.7	6.9	6.5	6.3	7.7	8.3	7.6	7.8
Temperature (°C)	9.3	7.2	8.5	8.1	19.1	15.6	15.2	15.4
Redox Potential	-	-	-	-	-26	-153	-69	-76
Specific Conductance (micmhos/cm at 25°C)	183	231	164	129	274	150	164	250
Total Dissolved Solids	145	191	122	103	204	103	112	170
Total Suspended Solids	208	29.6	10.5	14.7	48	2	2	2
Turbidity (NTU)	38.7	8.1	4.1	3.2	3.7	0.6	1	1
Color (Apparent, APHA)	-	-	-	-	40-50	<5	5	5
Alkalinity	68	81.6	29.1	17.3	95.5	71.2	70	65
Hardness	104	137	83	50.6	122	56	80	83
Dissolved CO_2	1.7	6.4	8.4	6.6	1.8	0.1	1.8	0.9
Dissolved Oxygen	4.2	5.9	7.2	6.4	6.3	4.8	6.5	5.4
COD	-	-	-	-	980	25	25	25
Common Ions (mg/l)								
Calcium	33.4	30.7	16.5	7.3	38.8	20.2	24.4	26.2
Magnesium	7.5	41	7.2	4.8	6.0	1.8	2.8	3.6
Sodium	3.7	6.4	3.5	3.3	17.1	16.4	3.8	23.8
Potassium	0.51	0.72	0.57	0.6	1.06	0.56	0.58	0.8
Bicarbonate	35.8	42.3	13.4	8.4	54.7	42.1	39.2	37.6
Carbonate	N	0.9	N	N	0.2	0.5	0.1	0.1
Sulfate	32.2	43.2	49	39	40	4	12	22
Chloride	1.9	2.2	1.6	1.9	0.5	1.2	0.6	18.8
Silicon	-	-			18	8.9	10.4	9.6
Trace Metals (micg/l)								
Aluminum	-	-	-	-	203	286	364	256
Arsenic	121/0.8*	413/204	404/1.54	423/106	1	1	1	1
Cadmium	1.1/.59	1.1/.55	0.8/0.44	.9/.5	0.3	0.2	0.1	0.2
Chromium	5.8/2.8	4.6/2.2	1.72	8/2.5	1	1	1	1
Copper	45/15	29/4.7	7.8/3.2	56/5.3	1	1	1	2
Lead	3.8/2.1	2.4/2.0	2.6/1.9	3.2/1.7	1	4	1	2
Mercury	.6/.49	1.27/.73	.7/.5	1.7/.73	1	0.2	0.2	0.2
Nickel					7	4	1	1
Zinc	428/186	112/23	58/36	483/114	1	15	5	8

* Mean trace metal values indicate both total and dissolved concentrations (e.g., 121/.8).
N = not detected Source: Woodward-Clyde Consultants (1982)

4.0 PERMITTING REQUIREMENTS

4.1 Introduction

This section presents a list of permits and approvals which would be required to develop the Bald Mountain Project. Evaluation of the attainability and time period that will be required for permitting is specifically beyond the scope of this report, as is discussion of the environmental issues.

4.2 Significant Permits/Approvals

4.2.1 Environmental Impact Statement (EIS)

The Army Corps of Engineers (COE) and/or the U.S. Environmental Protection Agency (EPA) may require the preparation of an Environmental Impact Statement (EIS). An EIS for the Bald Mountain Project may take up to two years to complete.

4.2.2 National Pollutant Discharge Elimination System (NPDES) Permit

This permit deals with the discharge of water to natural water resources and is issued at both the state and federal level (review) by the Department of Environmental Protection (DEP) and reviewed by the EPA. NPDES permits are issued for 5-year periods.

4.2.3 Section 404 - Dredge and Fill/Wetlands

This permit is required where wetland disturbance may occur and is issued by the DEP and COE/EPA. It will be necessary to refer to the Federal Manual for Identifying and Delineating Jurisdictional Wetlands in defining the wetlands at the Bald Mountain Project site according to current standards.

4.2.4 Landfill/Solid Waste Management Permit

This permit would be required to obtain approval for sites to be used for the disposal and storage of tailings and mine rock. The permit is issued by the DEP, Bureau of Solid Waste Management.

4.2.5 Natural Resources Protection Act

This permit is required for any disturbance of soil within 100 feet of a water body or for any stream diversion and is issued by the DEP, Bureau of Land Quality Control.

4.2.6 Land Use Regulation (Rezoning) Law

This approval is required for rezoning current land use status to one which allows surface mining as a permitted use. This permit is controlled by the Land Use Regulation Commission (LURC), normally issued at the county level in most states. However, Maine regulates some of its larger rural areas at the state level.

4.2.7 Site Location of Development Law

For this permit the applicant must demonstrate that there will be no unreasonable effect on runoff/infiltration relationships, surface water and groundwater quality and quantity and adequate erosion and sedimentation control. The permit is issued by the DEP.

4.2.8 Prevention of Significant Deterioration (PSD)/Various State Air Quality Construction and Operation Permits

Permits relating to air quality emission may be required for stationary sources (such as crushers, etc.), mobile sources (haul roads, etc.) and toxic emissions. Emissions of 250 tons per year trigger the PSD level review. These permits are issued by the DEP and EPA.

5.0 ACID MINE DRAINAGE POTENTIAL

5.1 Introduction

This section discusses the acid generation potential of the different materials that would be produced during mining. Based on the available geological information and previous test work conducted on behalf of Superior Mining Company, acid generation may occur from the tailings, from some of the mine rock and from the pit walls.

For the purpose of this study, the tailings have been assumed to be acid generating in the long term and hence require measures to prevent an impact on receiving waters. The control of acid generation could be provided by maintaining the tailings under a water cover, i.e., in a saturated condition in the long term. There is still considerable uncertainty about the long term effectiveness of dry covers. While a proposed design incorporating a dry cover may not be a fatal flaw, it would be considerably more difficult to demonstrate low long-term environmental impacts. Since there appears to be little advantage in selecting a dry cover, this option is not considered further.

The results of toxicity tests on tailings samples are presented and discussed in Section 6.1.1. It has been assumed, for the purpose of this study, that the tailings would not be classified as a hazardous waste under the new mining regulations.

The objectives of this part of the study are to evaluate the acid generation potential of the mine rock and pits walls. The work carried out for this study, as described below, includes the following:

- an evaluation of the results from a laboratory test program carried out during 1980/81,
- a laboratory test program carried out for this study, and
- evaluation of feasible measures to minimize the environmental impact due to acid generation.

5.2 Results of Previous Acid Generation Prediction Testing

A study of the acid generation potential of tailings and mine rock from the Bald Mountain Project was carried out by the Colorado School of Mines Research Institute for the Superior Mining Company during 1980 and 1981 (Colorado School of Mines Research Institute, 1980 and 1981). The test program evaluated the acid generation potential by means of a series of column leach tests conducted on tailings samples and composite samples of core representing the mine rock. Two samples of flotation tailings were prepared for the tests, one containing a high pyrite content (35.1% S) and the other a high pyrrhotite content (42.6% S). Five composite rock samples were prepared from the borehole core. The samples were composited from sections of core of comparable sulfur content obtained from different boreholes. A description of the rock type of the samples was not recorded. However, an examination of the borehole logs indicates that the core samples used were all siliceous volcanics from the foot wall, except for one sample which was foot wall andesite. Acid-base account tests are not discussed in the reports and presumably these were not conducted. The behavior of the materials was studied under two conditions:

- samples subjected to wetting and drying over a 14-day cycle (submerged for 7 days, air-dried for 7 days), and
- samples fully submerged for the entire duration of the testing.

The samples were kept at approximately 68°F during the tests and 5 ml of acid mine drainage from an unspecified source (an existing tunnel) were added to each column with the intention of inoculating the samples with sulfide-oxidizing bacteria. This presumably also served to partially pre-acidify the samples although the pH and chemistry of the added water were not recorded.

Meaningful interpretation of the results from both the tailings and mine rock tests is difficult due to the lack of acid-base account data and the shortcomings in the test procedure. However, certain observations can be made from the test results.

5.2.1 Mine Rock Samples - Wetting and Drying Tests

A total of ten column tests were run, two columns for each composite rock sample, under wetting and drying conditions. The results show evidence of acid generation in these tests. The pH of the leachate, drawn from the columns 316 days after the start of the tests, ranged between 2.4 and 4.2 in eight of the ten tests performed. In the remaining two tests, conducted on the same composite sample, pH values of 8.0 and 8.4 were recorded after 316 days. The maximum concentrations of sulfate, copper and zinc in the leachate were as follows:

Parameter	Max. Concentration (mg/L)
SO_4^{2-}	4240
Cu	240
Zn	950

5.2.2 Mine Rock Samples - Submerged Tests

A total of five column tests were conducted, one column per composite sample, under submerged conditions. The pH of the leachate showed a definite increase, as the tests progressed, in three of the five tests conducted with pH values, after 7 days, of between 6.8 and 7.1 and between 8.9 and 9.4 after 316 days. In the remaining two tests the leachate exhibited relatively low initial pH values (4.5 and 4.2 after 7 days) with similar values after 316 days (4.4 and 4.8, respectively). The concentration of sulfate in leachate withdrawn from the columns after 312 days was a maximum of 792 mg/L and, on average, 29% of that in the columns undergoing wetting and drying tests, after the same period. Copper and zinc concentrations in the leachate after 368 days were below 0.01 mg/L and 0.02 mg/L, respectively, except in the two tests on samples exhibiting low initial pH values. The maximum copper and zinc concentrations in these tests after 368 days were 14 mg/L and 173 mg/L, respectively.

5.2.3 Tailings Samples - Wetting and Drying Tests

A total of four tests were conducted on tailings samples subjected to wetting and drying conditions, two tests on each of the two tailings composite samples. The pH of tailings water extracted from the base of the columns after 276 days ranged between 8.0 and 8.1 for three of the tests, with a value of 3.8 for the fourth test. While the pH values remained relatively stable for the duration of the bulk of the tests, rust-brown discoloration of the tailings surface was reported, indicating sulfide oxidation having taken place on the surface during the tests. In the test that produced leachate with a pH 3.8 after 276 days, this rust-brown discoloration was observed in the column, between the glass wall and the sample, and in the glass wool packing in the base of the column. The sulfate concentration in the water extracted after 14 days was approximately 2,300 mg/L in all four tests, reducing to an average of approximately 200 mg/L after 117 days and remaining at this level until the end of the tests.

5.2.4 Tailings Samples - Submerged Tests

A total of four tests were carried out on submerged tailings samples, two tests on each of the two tailings composite samples. The pH of the test solution increased in all the submerged tailings tests, from an average initial pH of 8.5 to an average final pH of 9.4. The sulfate concentration in the water extracted during the early stages of the test was in excess of 3,000 mg/L in all four tests, reducing to approximately 200 mg/L in the later stages of the tests.

5.2.5 Conclusions Drawn from the Test Results

The following observations can be made from the results of the test program conducted by the Colorado School of Mines Research Institute:

- The samples of mine rock tested generated acid under the test conditions of alternate wetting and drying. Maximum copper and zinc concentrations in the leachate after 368 days were 240 mg/L and 950 mg/L, respectively in these tests.

- Column samples recovered from two of the five composite samples exhibited relatively low initial pH values (4.2 to 4.7 after 7 days) in both the wetting/drying and submerged tests. This is probably an indication of sulfide oxidation having occurred in the material prior to the tests.

- In the tests conducted on submerged rock samples, the values of pH generally increased as the tests progressed. This was probably due to a combination of reduced rate of acid generation and the presence of soluble alkali minerals. Sulfate concentrations of up to 792 mg/L (29% of wetting/drying test results, on average) were recorded in the leachate from these tests. These relatively high sulfate levels are considered to be due to either sulfate generated prior to the test and mobilized when the samples were submerged, or to oxidation under submerged conditions.

- Visual discoloration on the surface of the tailings samples indicates evidence of acid generation during the tests in which tailings samples were subjected to wetting and drying. The leachate was extracted from the base of the samples in all tests. The products of acid generation were not detected in the leachate from tests where acid generation was limited to the surface of the tailings sample. The products of acid generation would not be expected in leachate from these tests, considering the nature of the material and the period over which the tests were run. In one test, where visual evidence of acid generation (rust-brown discoloration) was observed down the side and at the base of the column, a pH value of 3.8 was recorded.

- Insufficient data are available from the tests carried out by the Colorado School of Mines Research Institute, concerning the test procedure and results, to enable quantification of the reduction in acid generation rates due to submergence of the tailings and rock samples.

5.3 Acid Generation Prediction Testing - 1990 Program

5.3.1 Acid-base Account Test Program

A laboratory test program was initiated for this study to obtain an initial evaluation of the acid-base account characteristics of the different types of mine rock that would be mined at the Bald Mountain Project. After discussions with the Boliden project geologist and scrutiny of the geological cross-sections, samples were selected from the existing borehole core for the purpose of conducting acid-base account tests. Samples, each approximately one to two kilograms in mass, were recovered from the various rock types as detailed in Table 5.1. A program consisting of 29 acid-base account tests was conducted on the samples.

The tests were conducted using a modification of the standard Environmental Protection Agency (EPA) acid-base account test procedure (U.S. Environmental Protection Agency, 1978). The procedure used in this study incorporates recent experience and is considered to have advantages over the EPA method which was documented in 1978. Extracts from the EPA test procedure and a technical paper describing the modified test procedure used in this study, and the reasons for these modifications, are included as an Appendix to this report.

5.3.2 Acid-base Account Test Results

The results of the acid-base account test program are presented in Table 5.2. The test data includes paste pH, sulfide-sulfur content of the samples (S%), acid generation potential (AP), neutralization potential (NP), net neutralization potential (NNP), and the ratio of neutralization potential to acid generation potential (NP/AP). AP, NP and NNP are expressed in kg $CaCO_3$ equivalent per tonne of material. The values of NNP and NP/AP are used in the interpretation of the acid-base account test results and characterization of materials as acid generating or non-acid generating. The next level of prediction testing in more detailed studies, namely kinetic laboratory tests, are generally considered for materials with NP/AP ratios less than 3. The information obtained from acid-base account tests is sufficient for the purpose of this preliminary study.

TABLE 5.1

Type and Number of Samples Selected for Acid-Base Account Testing

Material Category	Rock Type	No of Samples
Massive sulfide rock		5
Hanging wall rocks	Chert	3
	Tuff	2
	Andesite	3
Foot wall rocks	Siliceous Volcanics	9
	Stringer Sulfides	3
	Andesite	4
Total		29

5.4 Mine Waste Characterization

The character of the different mine rock types with respect to acid generation potential, based on the acid-base account and leach test results, are described below.

5.4.1 Massive Sulfide Rock

The tests conducted on massive sulfide rock samples indicate sulfur contents of between 26% and 47%, neutralizing potential (NP) of between -18 and 22 kg $CaCO_3$ equivalent per tonne and net neutralizing potential (NNP) of between -829 and -1476, with a mean of -1228 kg $CaCO_3$ equivalent per tonne. This material would clearly generate acid if exposed to the atmosphere and ambient temperatures unless control measures are implemented to inhibit the oxidation reactions. Rapid oxidation should be anticipated in material with a high pyrrhotite content. One of the samples tested exhibited a paste pH of 2.84 and a negative neutralizing capacity (-18 kg $CaCO_3$ per tonne). This probably indicates oxidation of sulfides in-situ, or in the core box, resulting in a material with low pH pore water and containing products of the oxidation reactions. If oxidation has occurred in-situ, this would provide oxidation products for immediate release. Secure short and long-term control measures to inhibit the acid generation process would be required for the tailings and massive sulfide mine rock. The amount of in-situ oxidation and rate of oxidation will have to be investigated during the detailed studies. Approximately 22 million tons of massive sulfide tailings and 12 million tons of massive sulfide mine rock would be produced, assuming a 1% cut-off grade for copper ore.

TABLE 5.2
ACID-BASE ACCOUNT TEST RESULTS

CATEGORY	ROCK TYPE	BOREHOLE	DEPTH (ft)	PASTE pH	S (%)	AP	NP	NNP	NP/AP
						kg CaCO3 per tonne			
Massive sulfide	pyrite	M-34	214-218	2.84	46.6	1458	-18	-1476	<0.1
		M-55	360-363	6.80	39.1	1221	22	-1199	<0.1
	pyrrhotite	M-54	468-475	6.08	26.6	833	3	-829	<0.1
	sphalerite	M-34	319-323	6.38	39.2	1225	5	-1219	<0.1
		M-94	215-220	5.84	46.8	1436	18	-1417	<0.1
Hanging wall	Chert	M-62	269-302	8.33	0.4	12	18	6	1.5
		M-86	148-158	8.30	0.1	4	68	64	16.5
		M-132	170-180	8.34	0.3	11	57	46	5.4
	Tuff	M-61	133-138	8.43	<0.1	<1	25	25	84.0
	(HW/FW contact)	M-31	310-320	7.77	0.7	22	22	1	1.0
	Andesite	M-41	169-174	8.76	<0.1	1	116	116	129.3
		M-93	116-126	8.77	0.1	3	55	53	19.8
		M-133	110-125	8.50	<0.1	<1	181	181	>181
Foot wall	Siliceous volcanics	M-13	347-357	7.91	0.2	6	4	-3	0.6
		M-41	264-268	7.92	3.3	104	17	-87	0.2
		M-31	338-343	8.05	2.8	88	390	301	4.4
		M-44	337-342	8.60	3.6	113	12	-101	0.1
		M-63	315-325	8.14	0.9	28	15	-14	0.5
		M-65	160-175	8.39	0.8	23	10	-14	0.4
		M-87	305-315	6.06	3.6	112	9	-103	0.1
		M-102	255-265	8.31	3.9	122	32	-90	0.3
		M-126	210-220	8.20	3.6	114	12	-101	0.1
	Stringer sulfides	M-36	236-240	8.20	4.5	142	24	-118	0.2
	(siliceous volcanics)	M-88	490-510	7.82	6.4	200	56	-144	0.3
		M-126	265-275	8.43	3.3	104	18	-86	0.2
	Andesite	M-30	97-103	6.37	7.4	231	5	-227	<0.1
		M-42	62-67	8.53	0.8	25	139	114	5.5
		M-63	383-397	8.37	0.8	26	16	-10	0.6
		M-102	145-155	5.65	12.8	400	3	-397	<0.1

NOTES: AP - Acid potential in kg CaCO3 equivalent per tonne
NP - Neutralization potential in kg CaCO3 equivalent per tonne
NNP - Net neutralization potential in kg CaCO3 equivalent per tonne
NP/AP - Ratio of neutralization potential to acid potential

5.4.2 Hanging Wall Rocks

Mine rock from the hanging wall would consist mainly of andesite with lesser amounts of chert and Tuff. The acid-base account test results indicate sulfur contents of up to 0.7% in these geological units. The test results show neutralizing potentials between 18 and 181 kg $CaCO_3$ per tonne with an average value of 68 kg $CaCO_3$ per tonne. The values of net neutralizing potential are all positive for the hanging wall rocks with an average of 62 kg $CaCO_3$ per tonne. The average NP/AP ratio for these materials is expected to be well in excess of 3. The hanging wall rocks are expected to be non-acid generating and should be suitable for use as construction materials. A total of approximately 6 million tons of mine rock would be produced from the hanging wall, assuming a 1% cut-off grade for the copper ore.

5.4.3 Foot Wall Rocks

Mine rock from the foot wall would consist mainly of siliceous volcanics with minor amounts of stringer sulfides and andesite. The acid-base account test results indicate sulfur contents between 0.2% and 12.8% for the foot wall rocks. The test results show neutralizing potentials of up to 390 kg $CaCO_3$ per tonne with an average value of 47 kg $CaCO_3$ per tonne. The net neutralizing potential of the foot wall rocks are all less than zero except for two samples that gave NNP values of 114 and 301 kg $CaCO_3$ per tonne. The average NNP from the test results is -68 kg $CaCO_3$ per tonne and the NP/AP ratios for these materials are generally less than 1. These test results indicate the presence of localized zones containing minerals with high neutralizing potential. The foot wall rocks are expected to generate acid unless measures are implemented to control the oxidation process. Assuming that the neutralizing potential reflected in the test results is available for reaction, it is anticipated that the onset of strong acid generation resulting from biological oxidation at low pH would be delayed. Nevertheless, control of acid generation and/or drainage would be required during mining and a secure long term control measure to inhibit acid generation would be required for mine rock and pits walls containing these rock types. A total of approximately 13 million tons of foot wall mine rock would be produced for the case of 1% copper cut-off grade.

5.5 Conceptual Measures to Control the Impact of Acid Generation

The results of the column leach and acid-base account testing as described in this report indicate that mine rock at the Bald Mountain Project would pose a serious threat to natural water resources unless effective control measures are implemented to limit the rate of sulfide oxidation and acid generation. The total acidity that could potentially be produced from the tailings, massive sulfide mine rock and foot wall mine rock, assuming these wastes were subjected to conditions favorable for acid generation, would consume the alkalinity produced by 43 million tons of $CaCO_3$ before being neutralized. The requirements to control the impact of acid generation from the tailings, mine rock and pit walls both during the operating period and in the long term have been evaluated. The conceptual control measures for each waste type are described below.

5.5.1 Flotation Tailings

The flotation tailings from the Bald Mountain Project would have a high sulfur content and large excess in acid generation potential. However, the tailings would be deposited at high pH (probably in the region of 10 to 11) which, together with the layering of fresh tailings, will prevent acid generation during the life of the operation. Measures would be required to control acid generation after tailings placement stops, and in the long term.

Available evidence indicates that water cover, in the form of either a water pond or a saturated soil/water cover, is an effective means to exclude oxygen entry to the tailings and to control acid generation. The tailings impoundment could be designed and reclaimed such that the entire tailings mass is maintained in a saturated condition in the long term. This could be achieved by establishing either a man-made lake or a saturated soil cover and marshland conditions on the tailings surface. The results of EPA toxicity tests conducted on bench scale tailings samples are presented and discussed in Section 6.1.1.

5.5.2 Hanging Wall Mine Rock

The hanging wall mine rock is non-acid generating, based on the results of the acid-base account tests, and may be used in the construction of the tailings impoundment facilities such as underdrains, embankments, etc.

5.5.3 Potentially Acid Generating Mine Rock

The potentially acid generating mine rock includes the massive sulfide rock and the foot wall rocks comprising siliceous volcanics and andesite.

5.5.3.1 Massive Sulfide Rock

The massive sulfide rock contains up to 50% sulfur and exhibits a very high net acid generation potential. It would be necessary to place this material below water soon after the rock has been mined. The tailings impoundment would provide the storage and the necessary water cover for this purpose. The alkalinity in the tailings water should be sufficient to neutralize any initiating acid generation and precipitate dissolved metals. Resulting water qualities would have to be monitored.

5.5.3.2 Foot Wall Mine Rock

The acid-base account test results show that the siliceous volcanics and andesite mine rock from the foot wall are potentially acid generating. If oxidation of the sulfide minerals is allowed to occur and the acid generation and metal leaching process become established, drainage from this mine rock would contain elements at concentrations exceeding receiving water quality, probably by many orders of magnitude. Data gathered from an operating metal mine in Canada (referred to as "Mine A") is presented as an example of the quality of drainage from an acid generating mine rock storage pile under similar climatic conditions. The average water quality of drainage samples collected from rock dumps at "Mine A" during 1986 and 1987 is shown in Table 5.3.

TABLE 5.3
Average Water Quality of Mine Rock Drainage Samples Collected From "Mine A" During 1986 and 1987

Parameter	Average Value
pH	2.61
Acidity	10,365 mg/L
SO_4	13,946 mg/L
Cu	207 mg/L
Fe	2,180 mg/L
Zn	99 mg/L

A summary of the acid-base account test results for the foot wall rocks at the Bald Mountain Project is shown in Table 5.4, together with results of tests on samples from an open pit at "Mine A", and from mine rock at another operating mine in Canada (referred to as "Mine B"). These results indicate similar acid generation characteristics for the samples tested at these projects. The water quality data from "Mine A" illustrates the need to control the acid generation process.

TABLE 5.4
Summary of Acid-Base Account Test Results from Bald Mountain Foot Wall Rocks, "Mine A" Pit and "Mine B" Mine Rock

Parameter	Bald Mountain (All values in kg CaCO	per tonne equivalent)	"Mine B"		"Mine B"
	Mean	Range	Mean	Range	Range
Neutralization potential (NP)	48	3 to 390	23	0.3 to 184	2 to 213
Acid potential (AP)	115	6 to 400	56	3 to 227	3 to 128
Net neutralization potential (NNP)	-67	-397 to +301	-33	-215 to +153	-38 to +200

It is envisaged that two different control measures would be implemented for this waste, for the following periods:

- during operation of the mine (short term), and
- following mine closure and decommissioning (long term).

During operation of the mine the mine rock would be stockpiled at a suitable location and the drainage from the stockpile collected and treated or disposed of in the tailings impoundment. A suitable stockpile site would be immediately downstream of the tailings impoundment embankment. Additional measures, such as mixing in crushed limestone with the mine rock to inhibit acid generation and a till and/or synthetic cover to minimize infiltration, should be considered to reduce treatment costs and improve drainage water quality. The proposed waste handling activities for the Bald Mountain Project are described in more detail in Section 6.0 of this report.

On closure of the mine, the waste should be placed and stored below water in the long term. This could be achieved by backfilling the mine rock into the open pit at the end of mining and flooding the pit.

5.5.4 Open Pit Walls

During mining, and at mine closure, the massive sulfides and acid-generating foot wall rock would be exposed in the pit walls. The results of seep surveys carried out in the open pits at "Mine A" and "Mine B" are summarized in Table 5.5. This data illustrates the type of water quality that may be expected from the Bald Mountain open pit during operation.

During mining, water entering the pit from groundwater seepage and precipitation would be collected and treated before discharge, or pumped to the tailings impoundment. The pit walls located in the potentially acid-generating foot wall rock would require measures to control acid generation in the long term. Control could be achieved by limiting oxygen entry by flooding of the pit for the rock faces located below the final groundwater elevation in the pit. Rock located above this level would require some other form of acid generation control. It is proposed that a till cover or "fillet" would be placed over these faces. This would require the pit to be backfilled with rock to form a foundation for the till fillet. Both measures achieve control by reducing oxygen to the potentially acid generating rocks. The required activities and quantities are presented in Section 6.0.

TABLE 5.5
Water Quality Results from Seep Surveys at "Mine A" and "Mine B" Open Pits

PARAMETER	MINE A			MINE B		
pH	2.79	to	8.02	6.02	to	8.36
Acidity	2	to	2,040 mg/L	-		
SO_4	270	to	3,670 mg/L	2	to	10,101 mg/L
Cu	0.01	to	17.00 mg/L	<0.002	to	13.8 mg/L
Fe	0.07	to	192.00 mg/L	<0.1	to	2,025 mg/L
Zn	0.01	to	35.60 mg/L	<0.01	to	240 mg/L

The acid generation potential of the gossan tailings and mine rock were not investigated during this study. Further geochemical testing would be required to determine the reaction kinetics and the relative rates of acid generation for the different materials under different test conditions. These kinetic tests may also be used to evaluate the effectiveness of different control techniques.

6.0 CONCEPTUAL MINE WASTE MANAGEMENT AND RECLAMATION PLAN

A conceptual mine waste management and reclamation plan has been developed with the principal objective of providing the required protection of natural water resources at the site in the most economical and practical fashion. The phenomenon of acid mine drainage and the potential for release of water from the tailings impoundment present threats to these water resources, during both the operating period and in the long term, following mine closure. Potential sources of contamination include:

- the mill site and tailings impoundment,
- mine rock storage piles, and
- the open pit.

The mine waste management and reclamation plan presented below has been developed at a conceptual level, in sufficient detail to conduct this fatal flaw evaluation, to determine what may be practically feasible, and to obtain an estimate of the costs involved. Detailed engineering of the structures and facilities has not been carried out. Reclamation of access roads, the mill site and other infra-structure facilities are not expected to represent fatal flaws to the project and are therefore not addressed here. A schematic of the conceptual mine waste management plan during operation and the reclamation plan for these specific areas is shown in Figure 6.1.

6.1 Mine Waste Management During Operation

The estimated total quantities of mine waste that would be produced during mining, for cut-off grades of 0.73% and 1.0% copper, are shown in Table 6.1. The estimated total tonnages of the different waste types that would be produced during mining and the location of placement, or "destination", of these wastes are shown in Table 6.2. The quantities shown in Table 6.2 and discussed below are for a 1.0% copper cut-off grade.

6.1.1 Tailings

The selected tailings impoundment is located at the "High Site" as described in Section 3.3 of this report. The tailings disposal facility would consist of separate impoundments for the gossan and the massive sulfide tailings (see Section 2.0, Figure 2.1). The purpose of two tailings impoundments are as follows:

- to place the cyanide-bearing tailings as far from the main embankment as possible for the purpose of protecting downstream water quality (to allow attenuation and seepage emergence), and

- to facilitate staged construction of the tailings impoundment.

TABLE 6.1
Estimated Total Mine Waste Quantities

Waste Type		Tonnage 0.73% Cu	(Million Tons) 1.00% Cu
Tailings	Gossan	1.2	1.2
	Massive Sulfide	29.8	21.7
Till		8.0	8.0
Gossan Mine Rock		0.1	0.1
Massive Sulfide Mine Rock		5.9	11.6
Hanging Wall Rock	Chert	1.0	1.2
	Tuff	0.3	0.4
	Andesite	6.9	4.7
Foot Wall Rock	Siliceous Volcanics	16.4	10.1
	Stringer Sulfides	0.5	2.8
	Andesite	0.5	0.4
Total Tailings		31.0	22.9
Total Till & Mine Rock		39.6	39.3
Total Waste		70.6	62.2

A study carried out on behalf of Chevron Resources Company during 1989 concluded that the tailings impoundment would need to be lined with a synthetic geomembrane to minimize seepage losses (International Engineering Company Inc., Report M.013, 1989). An evaluation of the impact on surface water quality downstream of the impoundment, carried out as part of this study, confirms the requirement for a composite till and synthetic liner.

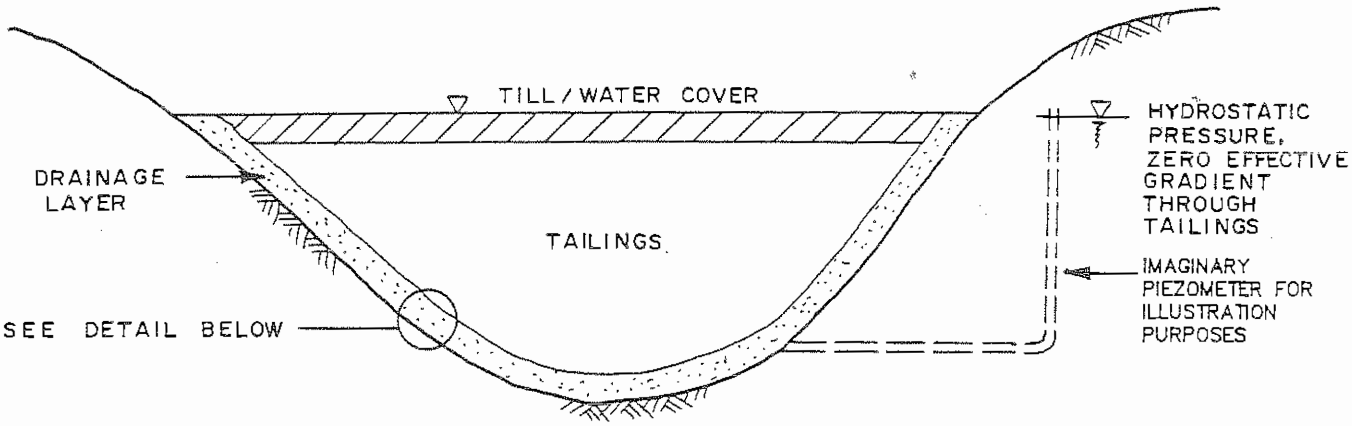
The composite liner would consist of in-situ till, a 60 mil thick synthetic geomembrane liner such as High Density Polyethylene (HDPE), and drainage layers. A schematic section through the proposed composite liner is shown in Figure 6.2. A system of finger drains would be required beneath the synthetic liner in order to prevent the development of excess pore water pressure due to seepage. A build-up of pore pressures beneath the liner could damage the liner during the early stages of the impoundment. The under-drain system would discharge downstream of the tailings embankment where the drainage quality would be monitored. Should the drainage quality deteriorate to the extent that it is not suitable for discharge, for example in the event of a leak in the liner, this flow could be intercepted and pumped to the impoundment.

TABLE 6.2
Waste Management During Mining

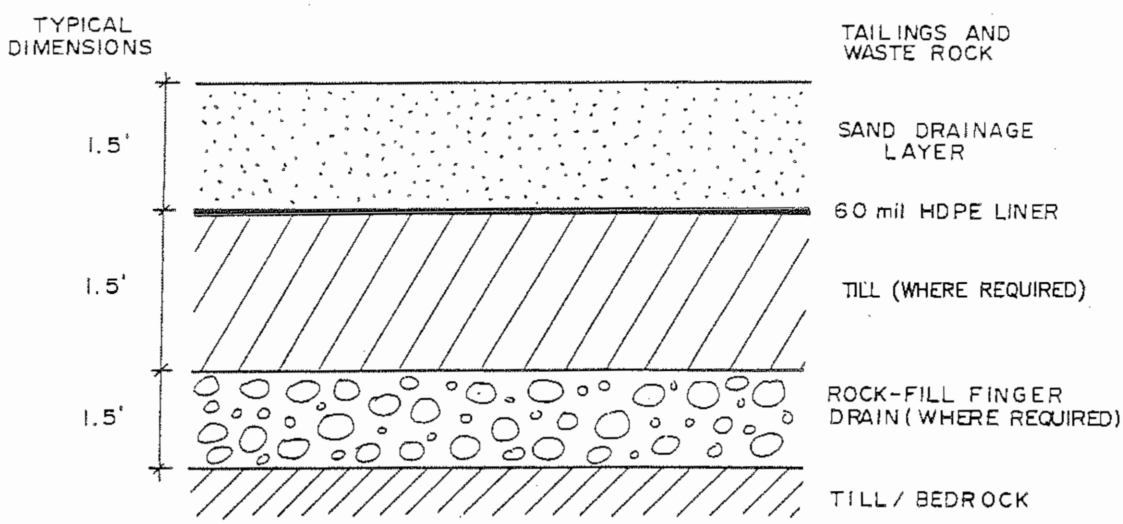
Tonnages (Million Tons) and Waste Destination
Assuming 1% Copper Cut-off Grade

Waste Type	Destination			Total Tonnage
	Stockpile	Construction Material	Tailings Impoundment	
Tailings				
- Gossan	-	-	1.21	1.21
- Massive Sulfide	-	-	21.72	21.72
Till	3.98	4.07	-	8.05
Gossan Mine Rock	-	0.13	-	0.13
Massive Sulfide Mine Rock	-	-	11.62	11.62
Hanging Wall Mine Rock	3.00	3.27	-	6.27
Foot Wall Mine Rock	13.20	-	-	13.20
Total	20.18	7.47	34.55	62.20

The objective of the sand drainage layer above the synthetic liner is to protect downstream water quality in the long term when the synthetic liner fails. The long-term performance of synthetic membranes is uncertain at present, however, gradual and progressive failure of the liner within a period of 50 to 100 years should be anticipated. The function of the drainage layer is to maintain a zone of relatively high permeability immediately above the liner and below the tailings. The drainage layer would extend to the tailings pond surface along the edges of the impoundment, maintaining hydrostatic conditions around the tailings mass. The aim is to minimize the hydraulic gradient through the tailings in the event of a leak in the liner. When leaks develop in the liner, water flow from the surface to the zone of the leak would occur predominantly within the higher permeability zone. Under these conditions, the quality of the water flowing through the leak would be expected to be better than tailings water. This concept has been designed and implemented at the lined tailings impoundment at Kennecott Ridgeway Mining Co.'s Ridgeway Mine in South Carolina (SRK, 1987). Water flow from the tailings mass into the sand drainage layer would occur principally due to excess pore water pressure in the tailings during consolidation. The need for a geomembrane (filter fabric) or careful sizing of the sand in order to prevent clogging of the drainage layer would need to be evaluated during final design.



SCHEMATIC SECTION THROUGH IMPOUNDMENT SHOWING DRAINAGE LAYER CONCEPT



DETAIL SHOWING COMPOSITE LINER

BOLIDEN RESOURCES INC.	BALD MTN. PROJECT	DATE JUNE 1990
		PROJ. NO. 80701
SCHEMATIC SECTION SHOWING THE PROPOSED COMPOSITE LINER		APPROVED
		NO. 6.2
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		

Construction of the composite liner is perceived as follows:

- strip vegetation and topsoil from the impoundment site to expose in-situ till,
- excavate and place rock-fill finger drains where required,
- place and compact till over rock drains and bedrock outcrops where these occur,
- place the synthetic liner, and
- place the sand drainage layer above the liner.

The impoundment configuration considered as the "base case" in this study may be summarized as follows:

- a double impoundment system (separate gossan and massive sulfide impoundment),
- a composite till/synthetic liner, and
- a drainage layer above the liner.

Alternatives and variations to the "base case" that were considered include:

- a single impoundment,
- an unlined impoundment,
- a double liner, and
- no drainage layer.

The volume and tonnage of materials required for the construction of the tailings impoundment are detailed in Table 6.3. Mine waste would be used for construction where possible, nevertheless, some natural material, specifically sand for drainage layers, may need to be imported to the site.

6.1.1.1 Gossan Tailings

Approximately $1.2x10^6$ tons of gossan ore would be milled and processed for gold recovery during the first two years of operation at a milling rate of approximately 1650 tons per day. The gossan tailings would be placed within the lined gossan impoundment as shown in plan in Figure 6.3.

TABLE 6.5
Results of TCLP and Water Analysis Tests on Copper Tailings
Conducted by Lakefield Research, 1988

Tailings Water Analysis		TCLP	
Element	Concentration (mg/L)	Element	Concentration (mg/L)
Iron	<0.05	Iron	7.35
Copper	1.63	Copper	23.3
Lead	<0.05	Lead	0.07
Zinc	<0.02	Zinc	3.14
Cadmium	<0.02	Cadmium	<0.01
Chromium	<0.01	Chromium	<0.02
Manganese	0.08	Manganese	3.86
Mercury	0.001	Mercury	<0.001
Cyanide	0.008	Cyanide	0.32
Arsenic	<0.05	Arsenic	2.23
Selenium	0.52	Selenium	<0.2
Chlorine	25.0	Chlorine	0.68
Sulfate	434.6	Sulfate	150.2
Nitrate	11.3	Nitrate	0.60
TDS	1080	TDS	6840
Barium	0.03	Barium	0.33
Sodium	62.0	Sodium	1839.8
Silver	<0.03	Silver	<0.03

The copper concentration shown in the test results is of concern. The form of the copper present and its mobility should be investigated. The elevated copper in the TCLP test result, combined with iron, zinc and arsenic may make the tailings marginal in terms of classification as a hazardous waste. As discussed in Section 6.1.1.1, the EPA limit for arsenic may be reduced and Maine may impose more stringent criteria than those of the EPA. If the limit for arsenic is reduced to 1mg/L, the tailings would be classified as a hazardous waste based on the test results in Table 6.5. This may also be the case if, for example, copper is designated a primary standard in Maine. The test results provided to SRK (Table No. 11: PP-10 Cu Tailing Water Analysis, and Table No. 12: PP-10 Cu Tailings TCLP Water Analysis) and presented in Table 6.5 show inconsistencies, as follows:

- The values reported for chlorine are probably values of chloride,

- The values reported for cyanide should be questioned. Based on experience, values of

1 to 2 ppm cyanide would be expected at the copper concentrations reported.

- The value of selenium in the tailings water analysis (0.52 mg/L) is greater than that in the TCLP test results. The opposite would normally be expected.

Further leach tests are required on samples that are representative of what would be produced in the field.

The massive sulfide tailings would be deposited at an elevated pH (pH>8) and would be maintained in a saturated condition in the long term, thereby limiting the rate of potential acid generation during operation and after mine closure.

6.1.2 Till

The quantity of till that would be obtained from stripping the pit area is approximately $8.0x10^6$ tons. This material would be suitable for use in the construction of the tailings impoundments. Till would be used in construction of both embankments (see Table 6.3) and till may be required to be placed over bedrock outcrops in certain areas of the impoundment. Till not used for initial construction would be stockpiled for use in later stages of embankment construction and for reclamation after mine closure. Till stockpiled during stripping of the pit area would be used in the reclamation of the site in the following areas:

- open pit reclamation, and
- reclamation of the tailings impoundment.

The estimated quantity of till required for embankment construction and reclamation exceeds that available from pit stripping. The additional quantity of till required, less than 1 million tons, could be obtained from borrow areas adjacent to the pit and other disturbed areas.

6.1.3 Gossan Mine Rock

Approximately $0.13x10^6$ tons of gossan mine rock is expected to be produced during the first two years of mining. This material would be placed within the embankment or in the gossan impoundment. This embankment would be covered by tailings and would be kept saturated in the long term and acid generation is not expected to be a concern for this waste under these conditions.

6.1.4 Massive Sulfide Mine Rock

The massive sulfide mine rock is expected to be potentially highly acid generating and will oxidize and release poor quality drainage within a period of months of mining if the oxidation process is allowed to proceed. The rate of acid generation would be minimized by placing the mine rock directly into the tailings impoundment so that it is submerged below water as soon as possible after it is mined. Careful preparation of a pad on the liner and controlled dump construction would be required to avoid instability and damage to the liner. It is considered that the liner could be suitably protected by constructing a pad on the liner, using till or similar material, followed by an initial low lift of waste material and then conventional end-dumped construction on the prepared base.

6.1.5 Hanging Wall Mine Rock

The results of the acid-base account tests (Section 5.0) indicate that the hanging wall mine rock is not likely to be acid generating and could be used in the construction of the impoundments and embankments. For the purpose of this study, it has been assumed that this material could be used in the following:

- rockfill in the tailings impoundment embankments,
- drainage layers beneath the composite liner,
- reclamation of the open pit to control acid generation from the exposed foot wall rock in the high walls (see Section 6.3.2), and
- possibly in making sand for the protection and drainage layer above the composite liner, as an alternative to importing sand.

A detailed mine plan is not available at this stage, however, it has been assumed that mining of the hanging wall rock could begin at an early stage in the mine plan in order to provide mine rock for construction. The quantity of material required and the sources are shown in Tables 6.3 and 6.2, respectively. Approximately $3x10^6$ tons of hanging wall mine rock would need to be stockpiled during mining to provide the required material for reclamation of the open pit at mine closure. This rock would be used for the construction of a buttress to the till cover that would need to be placed over the exposed potentially acid generating pit walls (Section 6.3.2). The location of the hanging wall mine rock stockpile is shown in Figure 6.5. Run-off from the hanging wall mine rock stockpile would need to be directed to a sedimentation pond for removal of sediments. This is discussed further in Section 6.2.4.

6.1.6 Foot Wall Mine Rock

The results of the acid-base account tests indicate that the foot wall rocks are potentially acid generating. Long term storage of this mine rock under water is essential in order to inhibit the acid generation process (see Section 5.4.2.2). The conceptual waste management plan incorporates stockpiling of this mine rock during mining and then backfilling this to the open pit at mine closure (Figure 6.1). The location of the foot wall rock stockpile is shown in plan in Figure 6.5. If no measures to control acid generation are implemented, it is anticipated that drainage emerging from the stockpile would develop high acidity and metal contents, based on the laboratory tests carried out to date and equivalent conditions at other mines (see "Mine A", Section 5.4). Temporary measures to inhibit the development of acid generation in the stockpile and/or to prevent or mitigate impact on receiving waters would be required during the period of mine operation. Available temporary measures include the following:

- addition of crushed limestone to control the pH within the stockpile, thereby inhibiting the acid generation process,

- placement of a low permeability cover over the stockpile, as construction proceeds, in order to minimize infiltration of precipitation, and

- collection of drainage emerging from the stockpile and either directing this water to the tailings impoundment, or treating the water and disposing of this through land application or discharge to surface waters.

Drainage from the stockpile has been included in the tailings impoundment water balance. It has been assumed that a low permeability cover would be placed over the stockpile during construction and that runoff from 50% of the stockpile area would meet discharge criteria following removal of suspended sediments. The need for limestone to be added to the mine rock would be evaluated following laboratory kinetic geochemical testing.

6.2 Water Management During Operation

6.2.1 Open Pit

Water management in and around the open pit would consist of two components:

- diversion of runoff from undisturbed areas, and
- collection of water within the pit.

Surface runoff from the undisturbed area up-slope of the pit should meet discharge criteria and would be diverted around the perimeter of the pit, or disturbed area, and discharged to Bald Mountain Brook via a settling pond for sediment control.

The water that collects in the pit due to inflowing groundwater seepage and precipitation would not meet discharge criteria (see example of pit water quality from operating mines, Section 5.4). There are two options for management of this water:

- pump to the tailings impoundment,
- pump directly to a treatment plant before disposing of the water through discharge to surface waters or land application.

The most appropriate option would depend on the water quality and the treatment technique adopted. The tailings impoundment water balance model has been set up to accommodate either of these options.

6.2.2 Tailings Impoundment

The tailings impoundment would be constructed in stages in order to minimize inflow to the impoundment and to stage construction capital costs. Runoff from the undisturbed area within the tailings impoundment catchment would be diverted around the impoundment and discharged to Bald Mountain Brook via a settling pond for sediment removal, if required. The staged construction of the impoundment is shown in Figures 6.3 to 6.5. The nominal elevation of diversion ditches and their catchment areas are as follows:

Stage	Nominal ditch elevation (ft)	Catchment area (acres)
I	1100	37
II	1100	136
III	1150	210

A rockfill finger-drain system would be constructed beneath the composite synthetic/till liner in order to collect groundwater seepage entering the impoundment beneath the liner. This system would drain beneath the embankment where water quality could be monitored and the flow directed to the seepage return dam in the event that water quality is unacceptable for discharge, for example, due to a leak in the liner.

6.2.3 Foot Wall Mine Rock Stockpile

Infiltration of precipitation into the foot wall mine rock stockpile would be minimized by placing a till and/or synthetic cover on the mine rock. Runoff from this cover would be directed to a sedimentation pond, the overflow from which should meet discharge water quality criteria. Infiltration into the dump would be collected above the prepared till base. This drainage is not expected to meet discharge criteria due to sulfide oxidation and metal leaching that is expected to occur within the dump. This drainage would be directed to the seepage return dam.. There are two options for management of this water, as for the pit water (Section 6.2.1), as follows:

- pump to the tailings impoundment,
- pump directly to a treatment plant before disposing of the water through discharge to surface waters or land application.

The most appropriate option would depend on the water quality of the drainage water and the treatment technique adopted. The tailings impoundment water balance model has been set up to accommodate either of these options.

6.2.4 Till and Hanging Wall Mine Rock Stockpiles

Approximately $7x10^6$ tons of till and hanging wall mine rock (non-acid generating) would be stockpiled during mining for use in reclamation activities at closure. Runoff from the till is expected to meet discharge criteria following sediment removal.

6.3 Mine Waste Reclamation

The conceptual mine waste reclamation plan for the open pit, tailings impoundment and mine rock storage piles is described in this Section and shown schematically in Figure 6.1. The estimated quantities of material that would require handling at mine closure are detailed in Table 6.6. Reclamation of access roads, the mill site and other infra-structure facilities are not expected to represent fatal flaws to the project and are therefore not addressed here.

TABLE 6.6
Waste Management Following Mine Closure

Tonnages (million tons) and destinations assuming 1% Copper cut-off grade

Waste Type	DESTINATION Tailings Impoundment Reclamation	Open Pit Backfill	Total
Till	1.0	4.0	5.0
Hanging Wall Mine Rock	-	3.0	3.0
Foot Wall Mine Rock	-	13.20	13.20
Total	1.0	20.20	21.20

6.3.1 Foot Wall Mine Rock Stockpile

The conceptual reclamation plan requires the foot wall mine rock to be backfilled to the open pit, below the final water elevation, at mine closure. The objective of this is to provide a water cover to the potentially acid generating mine rock and to the bulk of the potentially acid generating pit walls. The plan would involve rehandling approximately 13.2×10^6 tons of foot wall rock mine rock. A schematic showing the reclaimed pit is included as Figure 6.7.

The quality of the water draining from the flooded pit will depend on, among other criteria, the success of temporary acid generation control measures applied to the stockpile. It will be necessary to monitor and treat this discharge water for a period until acid products in the mine rock have been flushed out. The need to fill the pit with water during backfilling is discussed in Section 6.3.2.

6.3.2 Open Pit Walls

Till would be required to construct a low permeability cover to the potentially acid generating walls exposed above the final elevation of the backfilled foot wall mine rock as shown in Figure 6.7. In order to support the low permeability till cover and to provide long term stability to the exposed pit walls, a rock buttress over the till cover would be required. This rock would be exposed to wetting and drying conditions and would therefore need to be constructed using inert or non-acid generating rock. Hanging wall mine rock would be suitable for this purpose and approximately 3×10^6 tons of mine rock has been allocated for this purpose.

It would be necessary to fill the pit with water as quickly as possible following mine closure in order to submerge the mine rock and potentially acid generating pit walls. It may be feasible to drain the ponded surface water in the tailings impoundment to the pit at closure in order to facilitate tailings impoundment reclamation and to provide water to the pit. However, this may result in unacceptable quality of the pit water which would discharge to Bald Mountain Brook through groundwater flow and, ultimately, through surface water discharge from the pit. The tailings impoundment water quality and potential impact on surface waters would need to be evaluated in detail. Approximately 6×10^8 US gallons of water would be required to cover the foot wall mine rock backfilled in the pit. This volume would be provided by a pond of water with a depth of between 8 and 10 ft over the final tailings impoundment at closure. It would be feasible to direct runoff from the entire tailings impoundment to the pit after closure in order to fill the pit as quickly as possible. Under these conditions the pit would fill with water to the discharge elevation of approximately 900 ft within a period of 6 to 8 years following backfilling. Significant acid generation could occur on the exposed pit walls during this period and it would therefore be necessary to place the buttressed till cover over the potentially acid generating pit walls exposed above the top of backfilled rock (approximate elevation 690 ft). It may be necessary to use fresh water to fill the pit depending on water quality aspects and available volume of tailings water. An extraction permit may be required for this purpose. Lime will need to be added to the pit water during backfilling to prevent mobilization of metals contained within the mine rock and open pit. Nevertheless, water quality may still be a concern due to elevated total dissolved solids (TDS) and possibly other parameters.

6.3.3 Tailings Impoundment

It has been assumed that tailings impoundment reclamation would incorporate construction of a soil/water cover to create marshland conditions on the tailings surface. Till would be useful for this purpose in providing a growth medium and to provide an undulating surface, suitable for development of marshland conditions. Approximately 1×10^6 tons of till would be required for this purpose.

6.4 Water Management After Mine Closure

Water elevation would need to be controlled in the reclaimed tailings impoundment and backfilled pit after mine closure in order to maintain the reactive materials beneath the water surface.

6.4.1 Tailings Impoundment

The tailings surface would be reclaimed with the objective of establishing a marshland type cover on the impoundment surface (Section 6.3.2). The diversion ditches would be removed and the catchment contributing runoff to this area after reclamation would be 418 acres. The site experiences a net precipitation of approximately 20 inches a year and, under these conditions the reclaimed impoundment would have a net excess in the water balance which would need to be discharged to Bald Mountain Brook. A permanent spillway would be excavated in rock in the right abutment of the impoundment. The spillway could discharge to the reclaimed pit or to Bald Mountain Brook. During periods of low precipitation evaporation may exceed precipitation resulting in a deficit in the water balance. Under these conditions the water elevation may drop below the spillway crest elevation. However, the till cover on the tailings would be sufficient to maintain the tailings in a saturated state, even under extreme drought conditions applicable to this region.

6.4.2 Open Pit

The final water elevation in the flooded pit would be at approximate elevation 900 ft, controlled by the spillway located at the low point on the pit perimeter. The water elevation would be controlled by means of a spillway discharging to Bald Mountain Brook. The depth of water above the potentially acid generating mine rock within the pit would be of the order of 200 ft. This is considered to be more than adequate to ensure continuous water cover over the reactive mine rock.

7.0 TAILINGS IMPOUNDMENT WATER BALANCE

7.1 General Description

A water balance model for the Bald Mountain tailings impoundment has been developed to predict potential discharge and water treatment requirements and to evaluate short and long term storage requirements in the impoundment. Since the water balance is of critical significance to this study, it was evaluated at some depth. The model was developed using a Lotus 123 spreadsheet. Input data can be readily modified to evaluate changes in the overall water balance for changes in climatic data, mill processing circuit, tailings geotechnical characteristics, tailings impoundment location, configuration and size (including diversion ditches), discharge criteria and mine life.

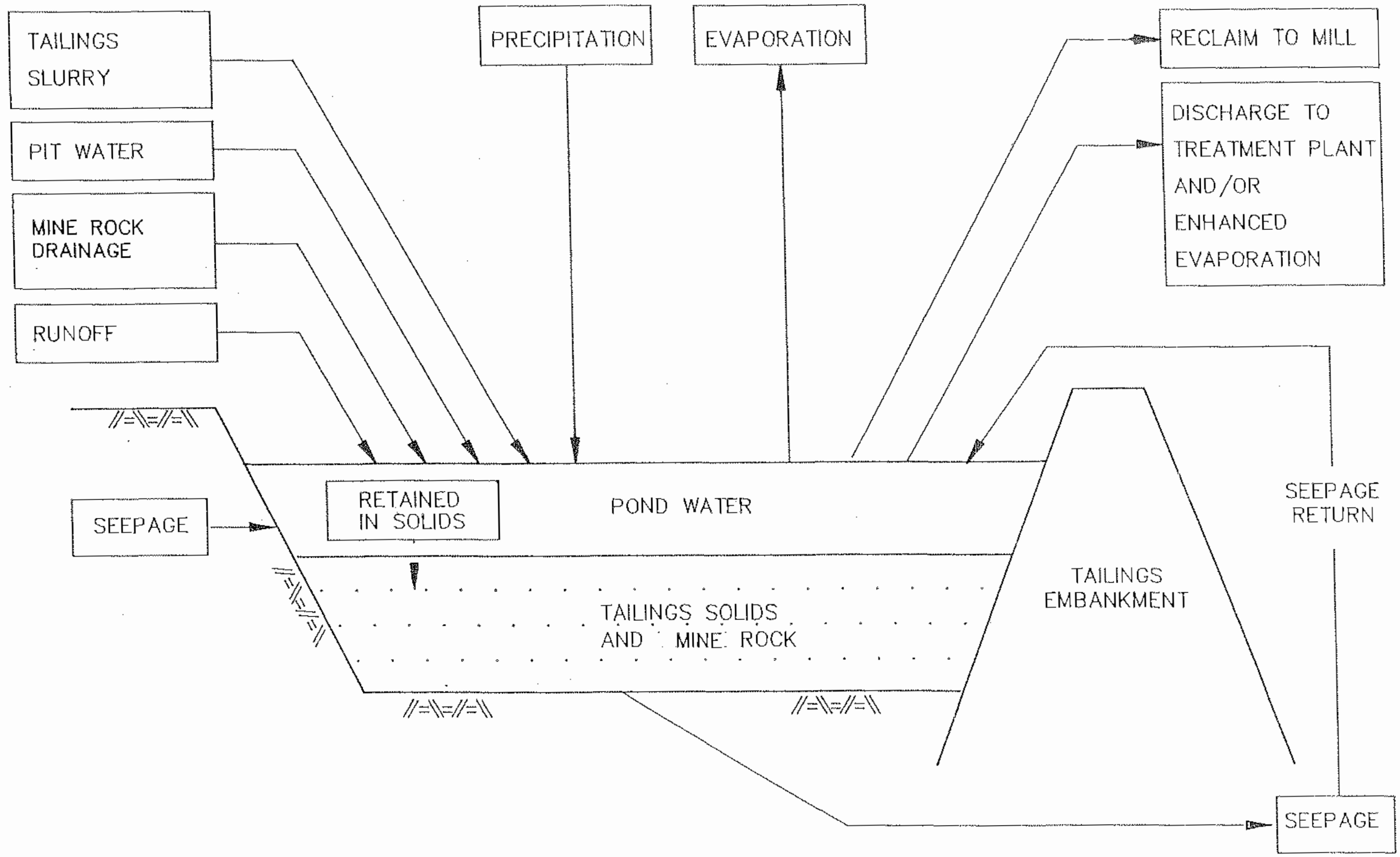
Tailings and waste rock would be deposited in the impoundment constructed at the "High Site 1" located as described in Section 3.3 and shown in Figure 2.1. The alternative tailings impoundment sites were evaluated with preliminary water balance calculations and reported previously by SRK (Report No. 02202/4 July, 1981; and 1982). A cut-off grade of 1% copper has been assumed in the water balance model. The overall impoundment would consist of separate gossan and massive sulfide impoundments as described in Section 6.0.

7.2 Model Description

A schematic diagram depicting the components of the water balance is provided in Figure 7.1. The tailings impoundment would receive water directly from precipitation on the pond surface, runoff from the catchment area, and, in the case of unlined impoundments, from groundwater seepage into the impoundment. The areas of the tailings impoundment subject to precipitation, evaporation and runoff are a function of the configuration of the basin used for disposal. The surface area of the pond over which precipitation and evaporation occur increases as tailings are placed, thereby decreasing the area over which runoff is calculated.

The water balance model was formulated to simulate the operation of the impoundment and the surrounding catchment for a given rainfall rate and tailings deposition rate. The catchment areas and pond surface area were determined from topographical maps and plan layouts of the impoundment, and the basin volume was calculated. Relationships were identified for the measured values of elevation and surface area, and elevation and volume. Thus it is possible to study the rate at which the level of the impoundment increases as tailings are placed, and determine the excess or shortfall of water in the impoundment.

Preliminary water balance calculations and previous studies have shown that the areal extent of the catchment basin is critical to determining the amount of excess water. A staged embankment construction consisting of a series of diversion ditches was assumed, as discussed in Section 6.0 and shown in Figures 6.2 to 6.4, in order to limit the catchment areas of the impoundment over the 15-year life. The total catchment area without diversion ditches is approximately 417 acres. This has been limited, with diversion ditches to:



BOLIDEN RESOURCES INC.

COMPONENTS OF THE TAILINGS IMPOUNDMENT WATER BALANCE

STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers

DATE JUNE, 1990
PROJ. NO. 80701
APPROVED
NO. FIG. 7.1

Stage	Period	Catchment area within ditches (acres)
I	Years 0-2	37
II	Years 3-7	136
III	Years 8-15	210

Drainage from the waste rock dump could be collected and discharged to the tailings impoundment if water quality is such that it is not suitable for discharge. The quality of drainage from the foot wall waste rock stockpile is likely to be such that it would not be suitable for discharge, as discussed in Sections 5.4.3.2 and 6.2. Similarly, precipitation and seepage collected in the open pit is not expected to be of discharge water quality and allowance has been made for these flows to be included in the tailings impoundment water balance model.

Water would be withdrawn from the pond primarily through reclaim water to the mill for reuse. The large surface area of the pond would result in loss of water through evaporation. Water would also be retained in the voids of the tailings solids; a permanent loss to the water circuit. Excess water in the tailings impoundment may be disposed of using various options including :

- enhanced evaporation through spraying or using tailings pond water as coolant in a power plant,
- water treatment and discharge to surface waters, and
- water treatment and land application.

These options are discussed in more detail in Section 8.0.

The water balance model calculates the change in storage based on inflows and outflows from the impoundment on a monthly basis, and the resultant volume and elevation of tailings solids and pond supernatant. Maximum and minimum depths of water in the tailings pond have been defined to limit the pond elevation and to provide sufficient water cover over the tailings solids. If the monthly net inflow results in the pond depths exceeding the criteria, discharge volumes are calculated. If insufficient water cover is predicted, mill reclaim volumes must be reduced.

The total mass inflow into the tailings impoundment consists of a number of possible components:

- volume of tailings solids (T_{solids})
- water associated with the tailings (T_{water})
- precipitation on the pond surface (P)
- runoff from the catchment area (R)
- drainage from the waste rock dump (WR)
- water from the open pit (OP)
- seepage into the impoundment (S_{in})

Thus the total volume flowing into the tailings impoundment at any time is given by the sum of the inflows:

$$\text{Inflows} = T_{solids} + T_{water} + P + R + WR + OP + S_{in} \qquad (1)$$

The amount of water that is lost or withdrawn from the tailings impoundment (outflow) could include:

- mill reclaim water (M_r)
- water retained in tailings and waste rock (R_s)
- natural evaporation (E_n)
- enhanced evaporation (cooling water) (E_e)
- planned discharge (D)
- seepage from the impoundment (S_{outh})

The amount of water withdrawn from the impoundment is thus the sum of the outflows at any given time:

$$\text{Outflows} = M_r + R_s + E_n + E_e + D + S \qquad (2)$$

The resulting change in storage within the pond over a given time interval is the difference between inflows and outflows, equation (1) - equation (2).

7.3 Description of Water Balance Components

7.3.1 Tailings (T_{solids}) (T_{water})

Total tailings discharged to the impoundment includes 1.2×10^6 tons of gossan tailings and 21.7×10^6 tons of massive sulfide tailings (1% copper cut-off grade). Processing rates of 1652 tons/day for years 0-2 and 4578 tons/day for years 3-15 were assumed. Results from the pilot plant tests on the gossan and sulfide ores indicated average dry density values of 80 and 130 pcf, respectively (SRK, Technical Engineering Report #6, 1982).

Tailings slurry densities of 45 % solids for the gossan material and 30 % solids for the sulfide material have been assumed (SRK Technical Engineering Report #6, 1982). These pulp density values correspond to water flow rates to the impoundment of 336 USgpm (1.3 m^3/min) and 1779 USgpm (6.7 m^3/min) for the gossan and massive sulfide tailings, respectively.

7.3.2 Precipitation (P)

There are no long-term precipitation records at the mine site itself, however a 30-year record of monthly precipitation is available from the Fort Kent Weather station, 40 miles north of the site. These data were used to calculate average monthly precipitation values for the water balance (SRK Report No. 02202/4, July 1981; 1982) as summarized in Table 7.1. Average annual precipitation was estimated to be 39 in. (1000 mm). The 100-year recurrence interval 24-hour storm was estimated to be 4.9 in. (125 mm).

A frequency analysis was conducted on the 30-year record using the Consolidated Frequency Analysis Package, based on a Generalized Extreme Value Distribution to identify precipitation values for wet and dry year events. Annual precipitation for a 1 in 20 wet year was estimated at 51.2 in. (1300 mm), and 30 in. (736 mm) for a 1 in 20 dry year. These precipitation figures were similar to recorded values in 1954 and 1965, respectively. To calculate the overall water balance accounting for the occurrence of an extreme precipitation event, recorded precipitation values for years representing wet and dry year values (1954 and 1965, respectively) were used in the water balance and are provided in Table 7.1. These were applied to the year with the maximum and minimum discharge requirements, respectively (Cases B and C - see Section 7.4).

TABLE 7.1
Climatic Data used in Water Balance Calculations

MONTH	AVERAGE MONTHLY VALUE (in.)				
	PRECIPITATION			RUNOFF	EVAPORATION
	ave.	1965	1954		
January	2.5	0.9	1.6	0.8	0.4
February	2.3	2.7	2.8	0.6	0.5
March	2.6	0.6	1.0	1.0	1.0
April	2.8	0.9	3.6	5.1	1.7
May	3.2	2.2	5.8	4.3	2.9
June	3.7	1.3	6.8	2.8	3.1
July	4.4	3.4	6.3	1.2	3.5
August	4.1	3.3	7.1	0.8	2.5
September	3.7	4.1	7.9	0.8	1.7
October	3.4	3.9	2.1	1.2	1.2
November	3.5	4.3	2.9	2.0	0.7
December	3.2	2.0	5.6	1.6	0.5
TOTAL	39.4	29.5	53.5	22.4	19.7

7.3.3 Runoff (R)

The average annual runoff for the area was estimated to be 22 in. (560 mm). An average annual runoff coefficient of 0.56 was obtained based on average annual precipitation of 39 in. The estimated average monthly runoff data was developed in previous reports and is summarized here in Table 7.1.

7.3.4 Evaporation (E_n, E_e)

The average annual lake evaporation for the site was estimated to be 19.7 in. (500 mm). Monthly evaporation values were developed from empirical relationships (SRK, 1982) and are presented in Table 7.1. Enhanced evaporation rates through cooling water losses were estimated to be 100 USgpm (provided by Boliden personnel).

7.3.5 Pit Water and Waste Rock Dump Drainage (OP, WR)

The volume of water from the open pit included both precipitation over the actual pit area and seepage into the pit. The pit area contributing to inflow from precipitation has been assumed constant at 40.3 acres and seepage inflow has been estimated to vary linearly over the 15-year life to a maximum of 50 USgpm. Drainage from the waste rock dump was estimated from runoff data (as infiltration and evaporation of precipitation would occur). The dump area was approximated as increasing linearly over years 3 to 15 to a final dump footprint of 50 acres. Within the first two years of operation the gossan waste rock would be utilized for embankment construction and thus there is no inflow to the water balance for these years.

7.3.6 Seepage (S_{in}, S_{out})

The water balance simulations have been conducted assuming the impoundment would be lined and thus there would be no net seepage into or out of the impoundment.

7.3.7 Water Retained in Tailings and Waste Rock (R_s)

The pore water retained within the solid waste in the impoundment is a component included in the water balance outflows. The volume of water retained within the tailings and waste rock was calculated based on assumed void ratios of 1.35, 1.02 and 0.3 for the gossan tailings, massive sulfide tailings and waste rock, respectively.

7.3.8 Mill Reclaim Water (M_r)

The water balance model has been set-up such that the model can be run for any ratio of mill reclaim to tailings water. The water balance has been computed for mill reclaim water ratios of 70% and 90%; a typical range for flotation milling circuits. The reclaim ratio refers to the percentage of the tailings water discharge which is returned to the mill as process water.

7.4 Water Balance Results

The water balance model was run for a variety of cases to evaluate the effect of changes in precipitation, mill reclaim ratio, enhanced evaporation, pit water input and waste rock dump drainage input. The variables for each of the cases are detailed below. The detailed results of Case A (described below) and summary results of all other cases are included as Appendix C. A summary of the mean annual discharge requirements from the water balance is shown in Table 7.2.

Case A
- average precipitation
- mill reclaim ratio 70 %
- enhanced evaporation excluded
- pit water and waste rock dump drainage included

Case B
- low precipitation event
- mill reclaim ratio 70 %
- enhanced evaporation excluded
- pit water and waste rock dump drainage included

Case C
- high precipitation event
- mill reclaim ratio 70 %
- enhanced evaporation excluded
- pit water and waste rock dump drainage included

Case D
- average precipitation
- mill reclaim ratio 90 %
- enhanced evaporation excluded
- pit water and waste rock dump drainage included

Case E
- average precipitation
- mill reclaim ratio 70 %
- enhanced evaporation included
- pit water and waste rock dump drainage included

Case F
- average precipitation
- mill reclaim ratio 70 %
- enhanced evaporation excluded
- pit water and waste rock dump drainage excluded

Case G
- average precipitation
- mill reclaim 70%
- enhanced evaporation; excluded for years 1 and 2, included for years 3 to 15
- pit water and waste rock dump drainage included

Case H
- average precipitation
- mill reclaim ratio; 70% for years 1 and 2, 90% for years 3 to 15
- enhanced evaporation excluded
- pit water and waste rock dump drainage included

TABLE 7.2

Water Balance Results
Summary of Average Annual Discharge (USGPM)

	Cases							
Year	A	B	C	D	E	F	G	H
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	189	189	189	0	89	89	89	0
4	522	522	522	3	422	415	422	3
5	517	517	517	156	416	401	416	156
6	294	294	294	92	209	200	209	92
7	308	308	308	0	199	161	199	0
8	677	677	677	139	576	541	576	139
9	621	621	621	223	493	469	493	223
10	690	690	690	333	590	540	590	333
11	695	695	695	338	595	538	595	338
12	701	701	701	344	601	537	601	344
13	707	707	707	350	607	536	607	350
14	714	714	714	357	613	535	613	357
15	720	720	875	363	620	534	620	363
Mean*	490	490	501	180	402	366	402	180
Mean**	598	598	610	225	495	451	495	229

* Mean of all years
** Mean of years 4-15

8.0 MINE WATER TREATMENT AND DISCHARGE ALTERNATIVES

8.1 Introduction

From the preliminary water balance calculations presented in a report by Barr Engineering Co., 1987, the average daily flow of mine water requiring treatment was estimated at 35 USgpm. The report indicated that the estimate could increase by an order of magnitude. A more recent study by Barr Engineering Co. concluded that, under "average" precipitation conditions, an excess of approximately 106 gallons per minute would occur in the tailings impoundment during operation (Barr Engineering Co., 1988). Due to the potential variability in the mine water flows, further flow estimates have been generated through development of a tailings impoundment water balance, as described in Section 7.0. The results obtained from the water balance calculations indicate a significant increase in the anticipated excess mine water flow. The recalculated excess mine water flows after year 3 of operation, under average precipitation conditions, range from 294 to 720 USgpm with an annual mean of 490 USgpm at 70% recycle of process water, to 92 to 363 USgpm with a mean of 180 USgpm at 90% recycle. The increase in mine water flows has a dramatic impact on the cost and viability of the proposed discharge and treatment options. It may be possible to achieve discharge requirements to between 0 and 260 USgpm at 90% recycle of mill water and enhanced evaporation of 100 USgpm. However, further analysis is necessary to validate these calculations.

With regards to discharge of treated mine water, two scenarios have been advanced. The first involves discharge of treated mine water into either Bald Mountain Brook or an upper reach of Clayton Stream. The second scenario involves land application of treated mine water through spray irrigation. Both the brook and stream are classified Class A according to the State of Maine water quality regulations. According to surveys conducted by Woodward-Clyde Consultants (1982) and Normandeau Associates (1990), both potential surface water receiving systems contain well established invertebrate and reproducing brook trout populations. The water quality of the local surface and groundwater are excellent, with very low levels of metals, hardness, dissolved solids, and nutrients noted in a study conducted by Woodward-Clyde Consultants (1982).

8.2 Surface Water Discharge

Due to the sensitivity of the fishery and the low background levels of hardness and metals, instream criteria associated with the surface waters are very stringent. The State of Maine recently promulgated numerical water quality criteria based on values presented in the USEPA Gold Book (USEPA, 1986) and a hardness of 20 mg/l as $CaCO_3$. The values presented in Table 8.1 are taken from an earlier report prepared by Normandeau Associates, 1990. The numerical criteria are very low, particularly in the case of silver, copper, cadmium, mercury, lead, and zinc.

TABLE 8.1
Selected EPA "Gold Book" Water Quality Criteria* Versus Detection Limits Reported By Woodward-Clyde Consultants(1982) and USGS(1989).
(After Normandeau Associates Inc., 1990)

PARAMETER	ACUTE TOXICITY LIMIT mg/l	CHRONIC TOXICITY LIMIT mg/l	REPORTED DETECTION LIMIT RANGES mg/l
Ag	0.00025	0.00012	0.001-0.10
Al	0.950	0.200	0.09-0.10
As	0.390	0.190	0.001-0.005
Cd	0.0006	0.0003	0.0001-0.005
CN	0.022	0.005	0.010-0.060
Cr VI	0.016	0.011	0.001-0.010
Cu	0.004	0.003	0.001-0.005
Hg	0.002	0.000012	0.0002-0.060
Ni	0.363	0.040	0.001-0.005
Pb	0.011	0.0004	0.001-0.005
Zn	0.030	0.027	0.001-0.010

*Assumes hardness of 20 mg/L

Assuming a mean flow in Bald Mountain Brook of about 335 USgpm, an annual mean low flow for upper Clayton Stream of about 1,800 USgpm, and mean average annual discharge flows ranging from 225 to 598 USgpm, depending upon the degree of recycle, the estimated dilution factors range between 0.5 and 1.5 in Bald Mountain Brook and between 3 and 8 in Clayton Stream. Through development of a more detailed site water balance and application of a controlled hydrograph release system, the dilution factor could increase significantly. In conjunction with dilution, completion of a site specific analysis could yield alternative instream criteria greater than the background water quality, but still protective of the local ecosystem.

The anticipated increase in mine water flows limits the available dilution significantly, and discharge to Bald Mountain Brook is not a viable option under present conditions. Discharge into upper Clayton Stream would require very high levels of treatment efficiency, even though there is increased dilution. It is not probable that the proposed treatment systems (as discussed in Section 8.4) would provide an effluent of acceptable quality to allow discharge into either the stream or the brook, unless reduced instream criteria can be obtained. Development and acceptance of site specific criteria may still not yield achievable end-of-pipe effluent limitations, due to the limited dilution.

The controlled hydrograph release approach involves discharge of treated mine water at such a rate as to maintain a specified minimum dilution based on continuously gauged stream flows. Precedence for the approach in the State of Maine is not known at this time. The approach is utilized in conjunction with industrial discharges in other states (i.e., South Carolina). The surface water discharge option into Clayton Stream is probable only if the above conditions of reduced instream standards can be satisfied and the approach is accepted by the State. The site specific approach will involve additional studies including further stream surveys and specific toxicity tests. At a minimum there would be a requirement for modification of existing instream criteria, development and acceptance of a controlled hydrography release system to maximize dilution, implementation of advanced or tertiary mine water treatment, and adherence to a stringent mine water balance. A detailed engineering and a scientific study would be necessary to verify the validity of these approaches.

8.3 The Land Application Option

The second discharge option involves land application of treated mine water through spray irrigation as discussed by Barr Engineering, 1987. Through a detailed study of the land application option it has been determined that suitable soils exist for percolation of the mine water (Woodard and Curran Inc., 1989). Treatment of the mine water prior to application would be required. The results of the geochemical evaluation included in the study indicates that the cation exchange capacity of the soil could supply the sorption necessary to remove the residual constituents and minimize the potential for groundwater contamination, the primary concern associated with land application. Of secondary concern is the accumulation of undesirable levels of constituents in the native vegetation.

There is precedent for land application of both industrial and municipal wastewaters in the State of Maine. However, the characteristics of the mine water are different from those of other wastewaters and more detailed evaluations of chemical and physical attenuation mechanisms are needed. With regards to land application of treated mine waters, there are permitted and operating systems existing in other states, such as Montana.

The success of the land application option is related to the effluent criteria established by the State of Maine and the volume of mine water requiring disposal. The Barr Engineering report suggested either drinking water standards or background water quality as possible effluent standards. From a review of the anticipated mine water characteristics, it is not probable that treatment to background levels is achievable. Treatment to drinking water standards is not acceptable since the aquatic life criteria are more stringent for several of the parameters of concern.

The preferred approach is to establish effluent limitations on the basis of probable soil attenuation and protection of groundwater. At this point in time, the acceptability of the approach and the probable selection of effluent limitations have not been addressed with the State of Maine.

If the land application approach proves viable based upon derivation of suitable effluent limitations, it would be necessary to provide storage for treated or untreated mine water for up to six or seven months. Storage of untreated mine water would dictate a significant increase in the capacity of the treatment system, since the total volume of mine water must be treated and discharged in about 50% of the time. Based upon the estimated range of daily mine water flows (i.e., 92 to 720 USgpm), the volume of storage required ranges from 20 to 190 million gallons. This approach would require storage capacity within the tailings impoundment or construction of a large lined mine water holding pond.

Another detailed assessment of required and available surface area for land application must be undertaken, since the required acreage would increase significantly due to the anticipated increase in mine water flows. However, unless a significant reduction in anticipated mine water flows is realized, land application is probably not a viable discharge option.

8.4 Selection of Preferred Mine Water Treatment Options

Based on anticipated effluent requirements employing either drinking water standards or background water quality, several treatment options have been postulated by Barr Engineering, 1987. The options included lime treatment, either alone or in combination with filtration, reverse osmosis, or ion exchange. Based on the original anticipated mine water flow of 35 USgpm, the capital costs of the system ranged from $1.8 to 3.1 million. The anticipated annual operating costs ranged from $240,000 to $410,000. These costs are very high compared with the anticipated untreated mine water flows.

However, the water balance calculations indicate that mine water flows requiring discharge could increase to between 200 and 720 USgpm. Conventional treatment including cyanide oxidation and metals precipitation using pH adjustment and flocculent addition would increase the anticipated capital costs to $5,000,000 or more. The annual operating costs could reach $1,000,000. A comparison of approximate costs and effectiveness of treatment for conventional and advanced treatment technologies is illustrated in Table 8.2. For example, this level of treatment using proven technology could achieve a copper effluent value of about 0.10 mg/L. Assuming an instream copper criteria of 0.003 mg/L taken from Table 8.1, a dilution factor of 33 is needed. At the anticipated discharge volumes, the required dilution is not available. A significant relaxation in stream standards or an alternative discharge point far downstream is needed.

Application of advanced technologies beyond the conventional treatment involving either filtration and reverse osmosis or filtration and ion exchange could produce an effluent copper of about 0.05 mg/L. At a minimum, the increased capital costs would be about $1,000,000 to $2,000,000. The annual operating costs would increase by an additional $200,000 to $400,000. The required dilution for copper to reach an instream concentration of 0.003 mg/L would still remain about 16, which is not achievable unless a discharge point far downstream is utilized. A downstream discharge point would require the installation of a pipeline which may need to be buried.

TABLE 8.2
Comparison of Costs and Effectiveness of Different Treatment Technologies
For Illustrative Purposes Only

Level of Technology	Approximate Costs Capital	Operating	Effluent Copper (mg/L)	Required Dilution
Conventional	$5,000,000	$1,000,000	0.1	33
Advanced	$6,000,000	$1,400,000	0.05	16

The example using copper demonstrates the extreme difficulty and cost in achieving acceptable effluent quality for discharge, under the proposed mine plan. Similar or increased difficulties will be encountered for the metals silver, mercury, lead, cadmium, zinc, and nickel. These metals are of primary concern with regard to both treatment and toxicity. No significant advantage with regards to treatment efficiency is achieved through the use of advanced technologies.

For discharge of treated mine water to be a viable option, more reasonable effluent limitations must be obtained, in conjunction with a decrease in the anticipated mine water flows. In the case of the surface water discharge option, the effluent limitations would be derived from a site specific waste load allocation. In the case of land application, the effluent limitations would be based on considerations of potential groundwater impacts. For example, effluent limitations based on the BAT standards for the Ore Mining and Dressing Industry are achievable and acceptable. Effluent limitations based on either background water quality or the present aquatic life standards, in conjunction with required treatment of elevated mine water flows constitute a probable fatal flaw.

In the event that more reasonable effluent limitations are obtained along with a more favorable mine water balance, a treatment system based on conventional processes is possible. In this case, the treatment system would combine chemical oxidation and precipitation possibly followed by filtration. Reverse osmosis or ion exchange would not be necessary. These latter processes are not preferred due to expense, complexity, and the problems associated with brine or regeneration solutions. The side streams produced from these processes contain very high concentrations of dissolved constituents which can not be continuously disposed of in the tailings impoundment. A mine water treatment system based on the advanced processes is not practical or justifiable. Several operational problems could be encountered during the life of the mine.

In the case of conventional treatment, chemical precipitation would convert the metals to the insoluble hydroxides which could be disposed of in the impoundment along with the tailings. As long as the pH of the solids remains elevated, significant dissolution of the metals would not occur. The capital and operating costs for conventional treatment would be lower relative to the advanced or tertiary treatment options. In addition, conventional treatment processes, such as hydrogen peroxide oxidation for cyanide and lime precipitation for metals, are well known.

One additional area requiring discussion involves the need for increased design capacity for treatment of contaminated seepage in the event of failure of the liner. Based on preliminary hydrological calculations, the potential flow of groundwater which could be contaminated through failure of the liner is about 200 USgpm. Increasing the capacity of the treatment system would not only increase the cost of treatment, but further reduces the viability of both the surface water and land application discharge options.

In the case of the surface water discharge option, the degree of available dilution is reduced and a significant increase in treatment performance is required to meet the instream criteria. In the case of land application, the available storage capacity for untreated mine water is increased dramatically as is the area needed for irrigation. It is not probable that suitable land application area is available to accommodate a combined seepage and mine water flow in the range of 400 to 900 USgpm. Further analysis of this potential fatal flaw is necessary prior to making a final decision.

8.5 Conclusions

Based on a review of the available documents, there are several areas related to the mine water management and treatment systems which may result in a fatal flaw. It is not probable, based upon the current conditions, that either the surface water discharge or land application option are viable based upon the expected treatment cost and efficiency needed to achieve either background surface water quality or aquatic life criteria. In the case of a surface water discharge the available dilution is minimal, while in the case of land application the required surface area and storage volume are excessive. It is not probable that any available conventional or advanced treatment process can achieve background water quality.

In order to allow treatment and discharge of mine water to maintain the internal water balance, alternative site specific effluent criteria must be derived and accepted, along with a significant reduction in the expected mine water flows. The allowable mine water volumes and quality must be determined through further evaluations. Based upon a non-quantitative assessment, a reduction of 50% or greater in the anticipated mine water flow is needed.

The preferred approach would utilize either a controlled hydrograph release in conjunction with site specific criteria and conventional treatment, or land application using conventional treatment and effluent limitations base upon standards similar to the BAT regulations. In both cases significant reductions in the mine water volumes must be realized.

9.0 POTENTIAL IMPACT ON WATER QUALITY

9.1 Water Quality Criteria

9.1.1 Surface Water

The long-term surface water quality criteria for the project, by current regulations, is that Class A streams cannot be degraded in any way from baseline water quality (see Section 4.2.2 and Section 8.0). Without a variance to this regulation, the surface water quality criteria for Bald Mountain Brook would be the approximate baseline water quality presented in Section 3.5 and Table 3.5. The implication is that the discharge of any quantity of water of a quality substantially poorer than that shown in Table 3.5 would not be allowed. Since the water produced by the project would degrade the stream if discharged, untreated, it is necessary to either achieve a zero discharge condition or to treat to a suitable level prior to discharge. Section 8.0 presents a discussion of the feasibility of meeting water quality standards in Bald Mountain Brook and Clayton Stream.

9.1.2 Groundwater

Baseline groundwater quality at the site is discussed in Section 3.6 and summarized in Table 3.6. However, given the siting of the tailings impoundment in the Bald Mountain Brook drainage and the numerous springs and seeps in the impoundment valley which eventually feed the brook, groundwater quality criteria for the tailings impoundment will essentially default to those for surface water quality. For example, if, in the case of a lined impoundment, a leak were to develop in the liner there would be an impact on water quality in the underdrain which feeds Bald Mountain Brook. The primary means of control on groundwater quality should be to create effectively zero discharge facilities. With regard to the open pit, it would similarly be prudent to consider a subsurface release as having an immediate effect on surface water quality. For the purpose of this discussion, the potential impact on surface water quality has been assumed to be the critical issue.

9.2 Water Quality Objectives

The surface and groundwater quality criteria for the project, considered together with the expected tailings water quality and feasibility of treatment, indicate that the tailings impoundment system would essentially have to be a zero discharge facility in order to meet current regulations. The criteria of zero degradation cannot be met through treatment and discharge means (Section 8.0). The results of the tailings impoundment water balance (Section 7.0) indicate that zero discharge is unlikely to be achieved although the discharge may be reduced to less than the net accumulation resulting from the difference between precipitation and evaporation. An alternative approach is to establish in-stream water quality objectives less severe than background water quality but protective of local ecosystems (Section 8.2). Boliden should consider pursuing a variance on water quality criteria to establish appropriate water quality objectives for the project. The implications of proposing alternative water quality objectives on permit applications are discussed in Section 4.2.2 and the technical feasibility of achieving different water quality objectives is discussed in Section 8.0. It is unlikely that acceptable water quality objectives could be maintained in Bald Mountain Brook. It would therefore be necessary to locate the point of compliance for receiving water quality at, or downstream of, the confluence of Bald Mountain Brook and Clayton Stream.

9.3 Potential Impact During Operation

The water quality of surface water in the receiving environment would be impacted by water released from the following areas;

- the tailings impoundment,
- mine rock stockpiles,
- open pit, and
- the general mine site.

Water from the tailings impoundment would need to be treated and discharged as discussed in Sections 7.0 and 8.0. An additional release of water could potentially occur through subsurface and embankment seepage in the case of an unlined impoundment, and through leaks in the case of a lined impoundment. Seepage or leakage from the impoundment would be expected to emerge at the surface within a relatively short distance downstream of the impoundment. A large proportion of this water could be collected and returned to the tailings impoundment during operation, thereby maintaining the required protection of surface water quality during this period.

Runoff and drainage from the till and mine rock stockpiles, water collected in the open pit and runoff from the general mine site would need to be collected and treated before discharge to the environment, as described in Section 6.2. The water management plan during operation would need to be designed and implemented in order to prevent an unacceptable impact during mining. The technical feasibility of different treatment and discharge options is discussed in Section 8.0.

The impacts to the groundwater system which could result from mining include depletion of groundwater reserves in the project area by pit dewatering, and water quality deterioration in the shallow aquifer system via tailings pond seepage. As a number of investigators (Woodward-Clyde Consultants, 1982; Budo, 1988) have indicated that the groundwater volumes removed by mining will be minimal, it would appear that the only groundwater impact of potentially major significance will be that due to tailings pond seepage, as discussed above.

9.4 Potential Long-Term Impact on Water Quality

The long term impact on the surface water system, resulting from decommissioned mine facilities, could occur as a consequence of the following:

- surface runoff from the reclaimed pit,

- seepage of groundwater through the backfilled pit, with discharge to Bald Mountain Brook,

- seepage of groundwater beneath the tailings pond, with discharge to Bald Mountain Brook, and

- runoff from the proposed reclaimed tailing impoundment surface.

While it is expected that the engineered containment measures would minimize the impacts due to each of the above in the post-operational period, these measures may not result in acceptable water quality.

9.4.1 Runoff from the Reclaimed Pit

The plan for reclamation of the open pit is presented in Section 6.3.2. It could take up to 30 to 50 years for the pit to naturally fill with water to the final elevation of 880 ft, assuming the pit is flooded to the elevation of the top of the backfilled mine rock immediately following mine closure. This assumes that the sources of inflowing water to the pit after mine closure would be direct precipitation into the pit, runoff from the pit catchment as well as natural groundwater inflow from the up-gradient direction. This period could be reduced to between 6 and 8 years if the runoff from the tailings impoundment catchment is directed to the pit after closure. During the period of filling groundwater seepage from the pit would be negligible. In the long term the total inflow to the pit is likely to be greater than the outflow due to groundwater seepage and evaporation. This excess in the pit water balance would flow as surface water from the pit to Bald Mountain Brook. The mean annual flow of surface water from the pit is expected to be of the order of 70 to 120 gallons per minute. The quality of this water would depend on a number of factors, principally:

- the extent of sulfide oxidation within the mine rock stockpile prior to backfilling to the pit and the acid generation and metal leaching products contained within the mine rock,

- the extent of on-going acid generation on the pit walls and in the backfilled mine rock.

While measures to control acid generation would be implemented in the short term (i.e., during mining and stockpiling of the mine rock) some acid generation is expected to occur. The mine rock may contain products of the acid generation processes which could be released into the pit water on backfilling. The storage of reactive mine rock underwater reduces the rates of acid generation very significantly, however, the process is not halted entirely. It is possible that near-surface groundwater flow may convey oxygenated water through the upper, fractured zone of the pit walls, allowing acid generation to continue to some extent. While the conceptual waste management plan, as described in Section 6.0, incorporates what are considered to be the most promising, practically achievable measures to minimize the impacts from acid generation, no field data regarding the effectiveness of these measures from similar operations is available. This lack of field data and the uncertainties associated with the currently available modelling techniques make prediction of the quality of surface water flowing from the pit after mine closure extremely difficult. The long term impact of surface flow from the reclaimed pit on surface water quality is therefore a very significant issue of concern.

9.4.2 Seepage of Groundwater from the Backfilled Pit

When the water elevation within the pit has reached its final elevation of approximately 900 ft, the general groundwater gradient in the pit area will be restored to approximately pre-mining conditions. Seepage from the pit would occur through the overburden and upper zone of fractured bedrock. The quantity of flow has been estimated at 2 USgpm. The impact of this flow on surface water quality in Bald Mountain Brook and Clayton Streams is expected to be very small compared to that due to surface runoff from the pit.

9.4.3 Runoff from the Proposed Reclaimed Tailings Impoundment

The conceptual reclamation plan for the tailings impoundment area is described in Section 6.3.3. The source of water to the reclaimed tailings impoundment after mine closure would be direct precipitation and runoff from the catchment area which measures approximately 418 acres in total. The mean annual runoff from the tailings impoundment would be approximately 450 USgpm based on the available climatic and hydrological data. The runoff from this area could be directed to the pit which would take between 6 to 8 years to fill. Under these conditions, runoff from the tailings impoundment area would have no impact on surface water in the receiving environment during this period. The water quality of surface runoff from the till cover over the tailings impoundment would be expected to improve as marshland conditions become established.

9.4.4 Seepage from the Tailings Impoundment

Woodward-Clyde Consultants (1982) and IECO (1989) performed seepage analyses for the tailings impoundment under various containment scenarios. Although there were minor differences in the models used and in the selection of input parameters to the models, the analyses indicated roughly the same order of magnitudes for the unlined condition. SRK has reviewed the analyses, and believes the IECO estimates to be based on more representative parameter values. SRK presents the following evaluation of tailings impoundment seepage for the two containment scenarios: an unlined impoundment and a synthetically lined impoundment. The contingency measures which would have to be implemented should significant quantities of leachate develop are described below. The conceptual design of the drainage system to collect groundwater discharge beneath the tailings disposal area is described in Section 6.0.

9.4.4.1 Unlined Impoundment

After mining ceases, there would be saturated tailings to an approximate elevation of 1140 feet msl. Provided these tailings remain saturated, they will be a source of recharge to the groundwater system. The head created in the tailings will be the source of seepage water to the subsurface. The seepage water will first have to pass through the glacial till material, which underlies the impoundment area, before entering the upper bedrock aquifer. The primary mode of lateral transport of seepage fluid will then be through this bedrock aquifer.

The reclaimed tailings surface will comprise approximately 200 acres. Table 9.1 provides SRK's seepage estimates using Darcy's law for the unlined case, indicating that approximately 160 USgpm of seepage would enter the bedrock aquifer. This estimate was based on the assumption that all of the head loss thought the system is in vertical migration of fluid through the till (no head loss through the tailings), and a hydraulic gradient of 1 through the till. The till permeability was estimated as $1x10^{-6}$ cm/sec (Table 9.1).

TABLE 9.1

Tailings Impoundment Seepage Summary

	Unlined	Lined	
Governing Parameters		Permeation	Pinhole Leaks
Material Controlling Seepage	Glacial Till	Liner	Glacial Till
Permeability of Controlling Material (cm/sec)	$1X10^{-6}$	$1X10^{-12}$*	$1X10^{-6}$ ($1.47X10^{-5}$ gpm/ft^2)
Head/Gradient Through Controlling Material	Unit Gradient	50 ft. head per (80/1000) inch** = 7500	50 ft. head
Area Allowing Flow (Acres)	250	250	1 hole/acre = $1cm^2$/acre
Seepage per Unit Area (q = K.i) (gpm/ft^2)	$1.47X10^{-5}$	$1.1X10^{-7}$	$5.6X10^{-10}$
Seepage From Impoundment (gpm)	160	1.2	0.006

An unlined pond bears an additional risk that there are areas of the impoundment in which the till is absent or fractured, resulting in more direct seepage paths to the bedrock and significantly higher seepage quantities. Since the till is absent in some areas at elevations above approximately 1050 feet (Woodward-Clyde Consultants, 1982), seepage would probably be greater than 160 USgpm. IECO (1989), for example, estimates that 500 USgpm of seepage is possible. Final seepage rates will depend on the amount of till placement on exposed bedrock.

Current groundwater flow through the bedrock out of the mouth of the tailings impoundment valley is estimated to be on the order of 70 USgpm (Budo, 1988, a, b and c), based on an average annual groundwater recharge of 0.25 feet and a catchment area on the order of 460 acres. Thus, the potential seepage from an unlined impoundment is greater than the flow estimated to occur thought the valley. Unless seepage was of almost the same quality as natural surface waters in Bald Mountain Brook this seepage quantity would be considered unacceptable. This type of design would automatically have to provide for a seepage interception system, and would add uncertainty as to whether all of the seepage volume was contained.

9.4.4.2 Synthetically Lined Impoundment

In a synthetically lined impoundment, the equivalent permeability of the liner is so small that potential seepage flows from widespread permeation is negligible. IECO (1989) estimates that 0.9 USgpm of seepage flow would occur beneath the impoundment, using 80 mil HDPE liner. This is essentially a "no release" condition. The significant mode of seepage release could be through tears or punctures, commonly referred to as "pinhole" leaks.

The seepage from pinhole leaks is dependent upon the permeability of the underlying material,, the area of opening(s) in the liner, and the frequency of openings. A standard hole area of 1 sq. cm (diameter = 0.2 inch) and a frequency of holes of one per acre has been used for seepage estimation, following procedures recommended by EPA (1987). This selection in turn was based on interviews with quality assurance personnel which indicate that these are the maximum hole size and frequency which can be expected to exist after quality assurance inspection.

The potential seepage through a standard opening was estimated using formulas developed for estimating soil permeability using open-ended standpipes, because the permeability of the soil will control the rate of seepage flow through the opening. The potential seepage rate can be estimated by (Cedergren, 1977):

$$q = 2KDH$$

where: K = permeability of the soil
q = flow rate
D = diameter of intake area
H = head at the intake

Table 9.1 summarizes the estimated seepage through the impoundment resulting from liner leaks. As indicated, the resulting value of 0.006 USgpm is insignificant. From a water quality standpoint, a synthetically-lined system would therefore appear to be the best available technology for seepage control approaching zero discharge.

9.4.4.3 Collection System for Tailings Seepage Discharge

If tailings seepage were great enough to be detectable, down-gradient of the tailings facility, measures would have to be taken to prevent further migration and minimize degradation to the surface and groundwater quality. As a worst case, this seepage could amount to 160 USgpm (that is, the case of an unlined impoundment) if the liner was to completely deteriorate over time. Significant releases could also occur if there was a "catastrophic" liner failure. A potential control system which could be implemented would be a groundwater pump-back system, with water returned to the tailings pond or directly to the treatment system. Although it is possible that the quality of the seepage water would improve with successive displacements of tailings pore water, there are no data at present to support this conclusion.

Analyses indicate that such a system would consist of approximately twenty wells in a line downstream from, and parallel to, the main axis of the tailings impoundment. Costing for this contingency measure is indicated in Section 10.0.

The backup contingency measures are considered feasible because of the interconnected nature of the fracture system, as determined from pumping tests in the impoundment area (Budo, 1988, a, b or c). However, they could result in having to operate a treatment system indefinitely.

10.0 MINE WASTE MANAGEMENT AND RECLAMATION COSTS

10.1 General

Cost estimates have been prepared for the construction, operation and closure of mine waste and water management facilities at High Site 1. The cost estimates consider a base case, described in Section 6.1.1, as well as two alternatives related to the lining of the tailings impoundment.

These costs, a summary of which is included below in Tables 10.1 and 10.2 with more detailed backup included in Appendix D, are based on the conceptual waste management and reclamation plans. These estimated costs should therefore be regarded as approximate. Should further assessments of the feasibility of the project and/or the next phase of design be undertaken, these costs should be re-evaluated.

10.2 Construction Costs

The estimated construction costs for the base case and two alternatives are summarized in Table 10.1. As described previously, the base case consists of a double impoundment (one for gossan tailings and one massive sulfide tailings and massive sulfide mine rock), a single composite till/synthetic liner for both tailings impoundments, rock underdrains, diversion ditches, outlet structures, a reclaim barge, interception ditches, a seepage collection pond, a pump for a transfer of water which collects in the seepage collection pond to the tailings impoundment and a water treatment facility. The capital cost estimate allows for a very substantial water treatment facility at an estimated capital cost of $5,000,000. This estimate is considered appropriate given the level of treatment required and the present uncertainty in influent water quality. Also included in the capital cost estimate is an allowance for engineering and construction management (10 percent of the contractor's estimated fees). Not included in the capital cost estimates are the cost of mining and loading of the waste materials to be used for embankment construction, nor the tailings and water pipelines. The former is assumed to be included in the mining costs; the latter are assumed to be included in the capital cost of the mill.

The alternatives involve different liners for the tailings impoundments. Alternative 1 is the base case, with selective till placement, a HDPE liner and 18 inches of sand bedding over the synthetic liner. Alternative 2 is no liner at all. Alternative 3 is comprised of a double synthetic liner separated by a "sandwich" of sand.

To minimize the level of effort of the current study, unit costs prepared previously by IECO (1988) have been used to formulate many of the current costs. The IECO unit costs, where used, were increased by 15% to account for inflation.

The capital costs shown in Table 10.1 have been calculated based on total quantities. This is suitable for purpose of comparing the cost of different alternatives that would be similarly staged. The total capital cost for the "base case" could be staged as follows:

STAGE	YEAR	\$ (millions)
I	0	4.6
II	2	19.0
III	7	12.1
TOTAL CAPITAL COST		35.7

Assuming the above cost schedule, the present value of the total capital cost is \$25.2 million (\$1.10 per ton of ore mined), discounted at an interest rate of 12%.

10.3 Operating Costs

The estimated operating costs for the base case and its alternative are summarized in Table 10.2. With respect to the operating costs, the base case consists of discharge of tailings to the tailings impoundment, disposal of sulfide mine rock to the massive sulfide tailings impoundment, disposal of all other waste materials to the area immediately downstream of the confining embankment at the massive sulfide tailings impoundment, recycle of water from the tailings impoundments to the mill and treatment and discharge of excess water from the tailimgs impoundment. The operating cost estimate allows for water treatment at a cost of between 0.3 ¢/gal and 0.7 ¢/gal, depending on the quantity of water treated.

10.4 Closure Costs

The estimated closure costs for the base case and its alternative are summarized in Table 10.2. The base case consists of dumping the foot wall rock back into the open pit, placing a fillet constructed from till and hanging wall rock against the portions of the pit wall which are potentially acid generating, constructing a discharge structure at the open pit, backfilling the pit with water, covering the tailings with a till cap, shaping the waste areas downstream of the tailings impoundment and revegetation of all disturbed areas. The closure cost includes an estimated cost for lime addition to the pit during backfilling to control the pH of pit water. The cost estimate has been based on the quantity of lime required assuming acidity of 0.1% by mass is contained in the rock. This assumption is not based on test results and is made in order to make allowance for the cost of lime addition. The assumption is based on experience and takes into account limestone addition in the foot wall rock stockpile during operation.

10.5 Conclusion

While we have not built these waste disposal costs into an overall economic evaluation of the project it is apparent that the incremental costs should not of themselves be a fatal flaw with respect to project viability.

TABLE 10.1
Construction Cost Summary

	Alternative 1 (Base Case)	Alternative 2 (No Liner)	Alternative 3 (Double Synthetic)
GOSSAN IMPOUNDMENT			
- Materials and Contracting	$ 3,806,578	$ 1,590,748	$ 5,280,628
- Engineering and Construction Management	$ 380,658	$ 159,075	$ 528,063
- Total Cost	$ 4,187,236	$ 1,749,823	$ 5,808,691
- Cost per ton of gossan ore mined	$ 3.47	$ 1.45	$ 4.82
MASSIVE SULFIDE IMPOUNDMENT			
- Materials and Contracting	$28,656,514	$16,913,314	$40,759,584
- Engineering and Construction Management	$ 2,865,651	$ 1,691,331	$ 4,075,958
- Total Cost	$31,522,165	$18,604,645	$44,835,542
- Cost per ton of massive sulfide ore mined	$ 1.45	$ 0.86	$ 2.06
TOTAL COST	$35,709,401	$20,354,468	$50,644,233
COST PER TON OF ORE MINED	$ 1.56	$ 0.89	$ 2.21

TABLE 10.2
Operation and Closure Costs - Tailings Impoundment & Mine Rock Storage Piles

	TOTAL COST	COST/TON
OPERATING COSTS		
- yearly	$ 1,794,827	
- Total (over 15 years)	$26,430,100	$ 1.15*
CLOSURE COSTS	$24,806,180	$ 1.88*

* cost/ton of ore mined
** cost/ton of foot wall rock

11.0 POTENTIAL TECHNICAL AND ECONOMIC FATAL FLAWS

An evaluation of the permitting requirements and the attainability of the permits needed for development of the project are excluded from the scope of this study.

It is our opinion that, under the proposed mine development plan, there are two areas of substantial technical concern which may prove to be fatal flaws. These concerns relate to water quality in the receiving environment, both during operation and following mine closure.

11.1 Quality and Quantity of Water During Operations

The water balance indicates that excess water quantities in the range of 200 to 600 USgpm may be anticipated, depending largely on the percentage of recycle of tailings water that can be achieved. Recycling rates in excess of 90% will be required to achieve the lower figure. This recycling rate must be investigated further to determine if it is achievable.

With excess water values in the lower ranges there is still a considerably greater quantity than has been considered in previous evaluations. This increased water quantity compounds the difficulty of water discharge. With direct discharge the dilution potential in both Bald Mountain Brook and Clayton Stream is limited and would require high standards of water treatment. Even with site specific water quality standards in Clayton Stream, to limits to protect the stream ecosystem, the required water quality standards will be very onerous. Storage of contaminated waters to allow timed releases and the application of state-of-the-art treatment methods and operating skills would be required if adequate water qualities are to achieved. Given the state-of-the-art, there is considerable doubt as to the reliability with which such high standards could be consistently achieved.

The potential for land application reduces as the quantity of excess water increases. Large areas of land application are required and concerns exist regarding the potential for remobilization and migration of precipitated metals. There appears to be little merit in this form of discharge for the larger flows anticipated at the Bald Mountain Project.

11.2 Quality and Quantity of Water Following Closure

The long-term quality of surface water is likely to be influenced by discharge of water from the tailings cover and from seepage from the tailings impoundment, following deterioration of the geomembrane liner. While these may not represent fatal flaws, water quality has not been quantified in this study and remains a concern. The quality of surface discharges from the flooded pit is of considerably greater technical concern. The mine rock would contain the products of acid generation that would have occurred during the period of exposure on the surface. While the rate of acid generation in the submerged rock may be limited, this together with the potential for leaching of the acid products is not known. The solubility of sludges from lime treatment of acid mine drainage has been demonstrated to be of concern at values of pH below a threshold value which generally occurs between 6 and 7, depending on the nature of the sludge. The porous nature of mine rock and resultant potential for groundwater movement increases the likelihood of leaching. Groundwater entering the pit, through the pit walls under the till cover, may also contain products of acid generation occurring in the covered pit walls, albeit at reduced rates. There is insufficient data to reliably predict the quality of the pit waters. It is our opinion that these waters could be of such a quality that it would not be possible to achieve water quality criteria in Clayton Stream.

11.3 Economic Concerns

The costs determined for the tailings, water and waste rock management, while representing a substantial increment over more conventional plans, do not themselves appear to represent a fatal flaw.

12.0 CONCLUSIONS AND RECOMMENDATIONS

There are technical concerns with the proposed mine development and waste management plan as described in this review document. These concerns relate primarily to the maintenance of water quality in the downstream environment both during operations and post decommissioning. These concerns may prove to be fatal flaws unless it can be demonstrated that these issues can be addressed by technically and economically feasible means, incorporating appropriate contingencies and factors of safety against failure. This may be achieved through either:

- further evaluation of the existing plan, or
- modification of the current mining and waste management plan.

The following recommendations derive from this conclusion:

i) Perform additional testing and evaluations to confirm, by qualitative results, the validity of the technical concerns and obstacles to permitting.

ii) Identify the operating conditions and site conditions required at mine decommissioning to eliminate, or minimize, the concerns with regard to water quality in receiving waters.

iii) Evaluate alternative mine and mill development strategies that would meet these conditions, or objectives, i.e., adopt a "design for closure" approach.

A number of alternative strategies could be considered, including:

- Reducing the size of the pit, and in particular reducing the height of the exposed high wall, thereby also reducing the quantities and areas of the tailings and mine rock stockpile areas.
- Mining the gossan as an open pit and limiting acid generation in the final pit by means of a till cover. Mining the massive sulfide by underground methods which would result in a stable crown pillar with flooded workings. This would reduce the quantity of potentially acid generating mine rock as well as acid generation from the exposed pit slopes above the water table.
- Placing all potentially acid generating mine rock underwater in the tailings impoundment, in combination with a modified mine plan to reduce the area of potentially acid generating rock exposed on the highwall, or a modified pit slope to allow placement of a till cover directly on the pit wall above the flooded water level.
- Evaluating strategies to increase the percentage of recycled tailings water.

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S T A T E O F M A I N E

INTER-DEPARTMENTAL MEMORANDUM

DATE: September 13, 1990

TO: Mining Task Force & Work Group — DEPT: Environmental Protection

FROM: Mark Stebbins, QAO — DEPT: Environmental Protection

RE: Bald Mountain Tour and Presentation/August 30, 1990

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Provided below is a summary of the highlights of the Bald Mountain Tour & presentation. (See attachment for attendees.)

Boliden presentation:
J. Cesar - President Boliden
H. Lewis - Chief Environmental/Regulatory Affairs
M. Scully - Chief Geologist
P.M. Sandgren - Mill Manager
M. Robb - Mine Manager

Introduction: J. Cesar

Tentative schedule for the Bald Mountain Project (drafted 4/90).

	No EIS	EIS
Regulations adopted	2/91	2/91
Baseline Complete	6/91	6/91
Applications submitted	7/91	7/91
EIS determination	No	Yes
EIS complete	N/A	5/93
Applications approved	7/92	10/93
Begin construction	10/92	10/93
Begin production	6/93	7/94

Geology of Site: M. Scully

-Ore and Body size is 1200' x 900' x 800', stratabound deposits.
-Type - Massive sulfide ore deposit, submarine Volcanogenic.
-Stratigraphy: 40' - 60' of glacial till.

Hanging Wall: Tuff, Clert, Andesite.
Footwall: Tuff, Breccias, Basalts.
Massive sulfide: Zinc, copper & stringers
Structures: Faulting & folding
Mineralogy: Gossan cap (mine for gold) Goethite, Limonite, Quartz
Zinc - Pyrite, sphalerite, Quartz, Arsenopyrite
Copper - Pyrite, chalcopyrite, Pyrrotite, Quartz
Secondary copper - Pyrite, chalcocite, Arsenpyrite.

Drilling Info:

Past drilling by Superior & Cheveron (1977-1988). Total number of drill holes 508. Cost $8 million. Current drilling by Boliden, 12 holes at a cost of $150,000. Reclamation on all drill sites and other exposed areas by seeding, mulching, fertilizing and liming.

<u>Environmental Affairs:</u> H. Lewis

History: Superior Mining 1978-1983, large-scale study area that included air, land and water resources studies. Reports were never finalized and no permit applications were submitted.

-Cheveron 1987-1989, conducted supplementary baseline studies to fill in data gaps (ground-water, macroinvetebrates, vegetation). Limited agency interaction and no permit applications submitted.

-USGS - (United States Geological Survey) 1979-1984 studied surface water quality, hydrology and meteorology. Data contained in a 1989 USGS Publication.

-Boliden's baseline activities

<u>Air Quality</u> 1 year program that includes the following:
*Wind speed, direction and temperature. Data collection
*PM-10 Monitoring Program - Particulate monitoring less than 10 microns.
*Database for modeling for air emissions license
Cost: $160,000

<u>Surface Water Quality & Hydrology</u>

*Monthly sampling for 1 year for 40-50 parameters. Includes 6 stream sites and 2 lakes sites.
*Storm surveys, spring and fall (collecting water quality info.
*Sediment sampling
Cost: $250,000-$300,000

<u>Ground Water Quality and Hydrology</u>

*Consultant hired - R. Gerber, Inc.
*Quarterly for 1 year/40-50 parameters.
*Monitoring wells in both glacial till/bedrock aquifers.
*Pump tests for GW Modeling
Cost: $250,000-$300,000

<u>Aquatic Ecology</u>

*Aquatic insects
*Fish populations
*Stream habitat
*Fish tish analysis
Cost: $80,000-$120,000

<u>Terrestrial Ecology</u>

*Vegetation cover types
*Threatened plant studies
*HEP baseline assessment
*Deer wintering areas
Cost: $75,000-$100,000

Wetlands

*Field inspection by U.S. Army Corp. of Engineers
*Supplementary soil & vegetation sampling
*Inventory of wetlands around site
Cost: $15,000-$20,000

Other Baseline Studies

*Land-use within a 5 mile radius
*Social economics
*Visual analysis
*Traffic
*Cultural resources
*Noise
Cost: $100,000-$200,000

Potential Permitting Issues

-Wetlands
-Bald Mtn. Brock (Class A flows into a Double A stream)
-Water Management
-Acid mine drainage
-Reclamation on open pit & tailing ponds

Mining operation - Mike Rabb

-Run mine 2 shifts a day, 5 days a week
-Mine gold the first & second year of operation
-Mine copper/zinc in the 3rd year of operation
-Two options on size of mine (tons of ore mined).
    *2 million tons/year (entire deposit) for 13 years
    *750,000 tons/year
-Employ 80-130 people
-No housing units on site
-Mining operations are regulated by Mine Safety & Health Administration (stringent standards on dust control).
-No new roads, upgrade existing roads (Fish River Road)
Power - Need 5 - 13 m. watts
    Options: Powerline from Ashland
             Generation on site

Mining Processing - P.M. Sandgren

-Two different processes for the gold & copper
    Gold: Agitation leaching in vats (Cyanide)
    Copper: Froth Flotation
-Water treatment system & tailings
-Mill water requirements, total 1400-3600 gpm, recycle 1000-2500 gpm. Need additional 400-1000 gpm - of fresh water. Possible sources include runoff - R. GW wells.
Note: Potato processing plant uses 3500 gpm of water.

-Treatment of excess water by the following mechanisms:
*Lime treatment (most common & cheapest)
*Ion exchange
*Reverse Osmosis

-Disposal of excess water
*Steam evaporation
*Spray irrigation
*Disposal to surface waters

-Tailings Pond design: Composite liner
Synthetic liner
Till
Rock fill/finger drains
Till/bedrock

-Issues remaining for mill design
*Processing
*Water balance
*Reagent scheme
*Base for plant design and layout

Notes of Interest

D. Basley, Inland Fisheries, Carr Pond, 75-80 feet deep, cold water game species salmon, togue. Fed by Moose Pond stream which begins on the NE/E side of No Name Ridge. (Ore deposit located.) Moose Pond stream is the major source of smelts for Carr Pond. Eight camps on Carr Pond. Rich Hoppe, Wildlife Biologist, Concern about water fowl in tailings pond and bio-accumalation of metals by animals feeding on vegetation.

Special thanks to Nick Archer and Frank Wezner of the Presque Isle Regional Office for setting up the site visit.

Chronology of Key Events for Boliden Resources, Inc.

December 1989	Boliden Resources, Inc. met with the LURC director to discuss the permitting process for the development of an open pit sulfide mine.
June 1990	DEP accepted pre-application fee for submission of baseline monitoring plans.
July 1990	DEP staff reviewed preliminary Surface Water Monitoring Plan.
July 1990	LURC staff reviewed and offered guidance for proposed scope of Land Use Planning, Traffic, Visual Quality and Socioeconomic Data Collection Program.
July 1990	DEP staff commented on Biological Data Collection Program.
August 1990	MDIF&W staff reviewed and approved Terrestrial Ecology Program.
September 1990	The DEP staff reviewed the Air Quality/Meteorology Monitoring Program for the Bald Mountain Project and approved the monitoring site.
September 1990	Boliden Resources, Inc. presentation and tour of the Bald Mountain Project site in T12 R8 WELS.
October 1990	Boliden Resources, Inc. met with DEP and LURC staff to discuss the Hydrogeologic Work Plan.
November 1990	The DEP and LURC staff reviewed the Hydrogeologic Work Plan and requested the location and depth of monitoring wells be modified.
November 1990	MDIF&W and DEP staff reviewed and offered guidance for implementation of the Aquatic Ecology Work Plan.
December 1990	The MDIF&W commented on the Aquatic and Terrestrial Ecology Work Plan.
December 1990	DEP staff reviewed the Surface Water Baseline Monitoring Plan and rejected the PQL's submitted for the parameters.
January 1991	DEP staff met with Boliden Resources, Inc. to discuss the detection limits.
April 1991	The DEP staff conditionally accepted the revised Surface Water Baseline Monitoring Plan.

August 1991	Rules for Metallic Mineral Exploration, Advanced Exploration and Mining adopted.
September 1991	LURC and DEP staff met with Boliden Resources Inc. to discuss status of baseline plans . Boliden intends to use pre-existing data for surface water hydrology and archaeological studies.
October 1991	Boliden Resources, Inc. submitted to the DEP and LURC pre-existing data collected for soils, wastewater disposal and hydrology.
October 1991	Boliden Resources, Inc. submitted revisions to the Hydrogeologic Work Plan.
December 1991	Boliden submitted, and the DEP staff accepted, pre-existing data collected for surficial geology and soils at the Bald Mountain Project Site.
December 1991	DEP and LURC staff met with Boliden Resources, Inc. to discuss the revisions to the Hydrogeologic Work Plan.
January 1992	DEP and LURC staff approved the revisions to the Hydrogeologic Work Plan.
January 1992	Final air quality baseline results submitted to the DEP.
February 1992	Final surface water baseline monitoring results submitted to the DEP.

Although these work plans were approved in 1990, as of March 9, 1991, Boliden has not yet begun studies for: Aquatic and terrestrial ecology (except for macroinvertebrate data), groundwater monitoring, socioeconomic, traffic, land use, visual quality or noise studies. Some of these programs such as groundwater monitoring will take a year to complete once initiated.

Other Potential Permitting Issues:

- impacts to wetlands
- impact to Bald Mountain Brook (class A stream)
- water management
- acid mine drainage
- reclamation of open pit and tailings pond

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BHK

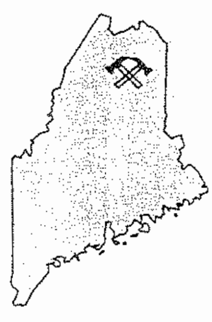
Black Hawk Mining Inc.

Volume 1

APPLICATION FOR MINING

Bald Mountain Project

T12R8
Aroostook County, Maine



NNM Resources, Inc.
wholly owned subsidiary of
Black Hawk Mining Inc.
Toronto, Ontario

APPLICATION FOR MINING

Bald Mountain Project
T12R8, Aroostook County, Maine

NNM Resources, Inc.
wholly owned subsidiary of
Black Hawk Mining, Inc.
Toronto, Ontario

prepared for:

Land Use Regulation Commission
Maine Department of Environmental Protection
Augusta, Maine

DECEMBER 1997

EXECUTIVE SUMMARY

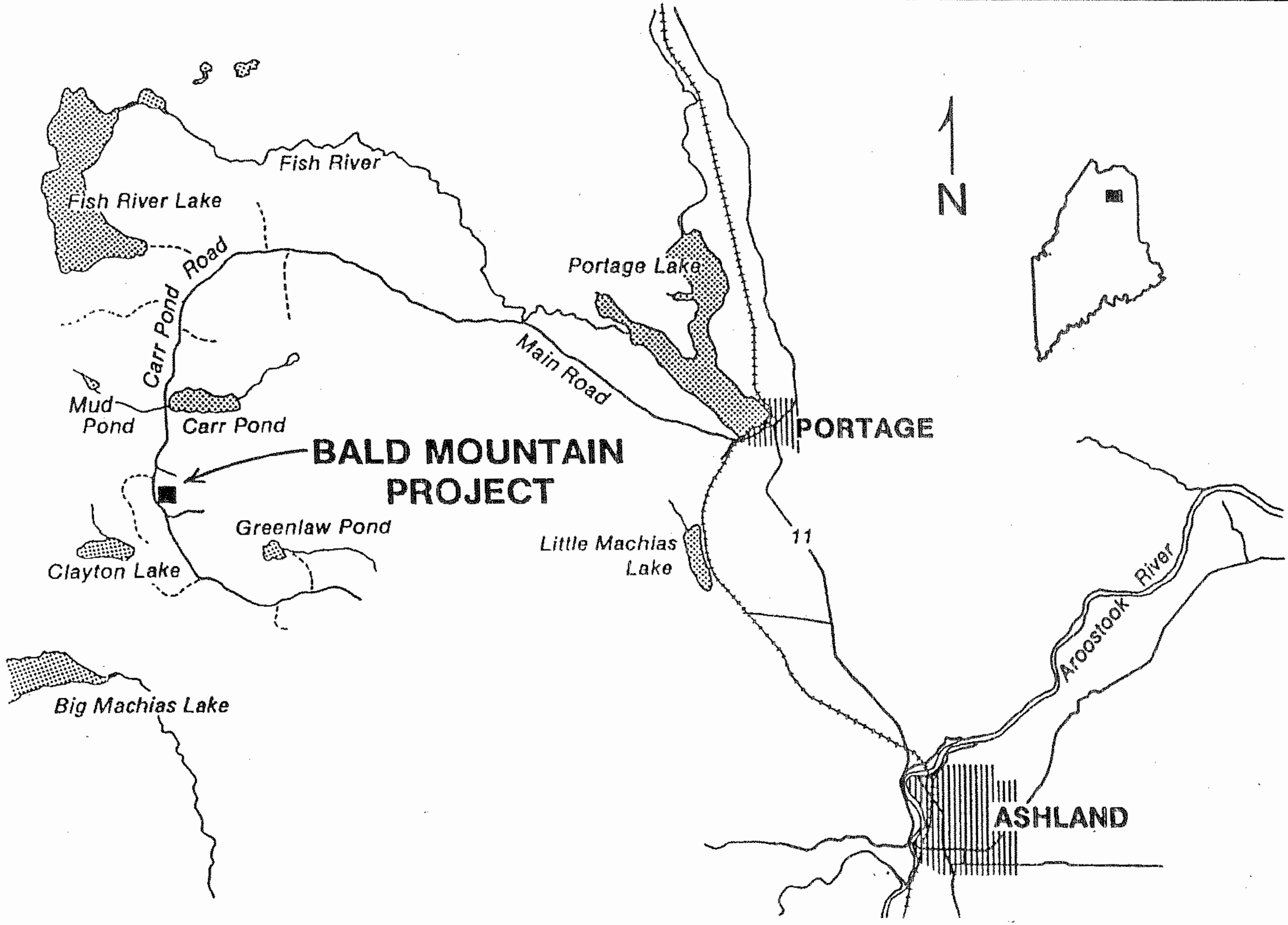
NNM Resources, Inc., a wholly owned subsidiary of Black Hawk Mining Inc. (Black Hawk), is proposing to develop a gold/silver mine in northern Maine known as the Bald Mountain Project. The ore body, discovered in 1977 through a regional exploration program based on geochemical sampling, is estimated to contain 35 million tons of massive sulfide (containing zinc, copper, gold, and silver). The gossan zone contains 1.2 million tons of 0.132 oz/ton gold and 2.94 oz/ton silver and has been naturally oxidized and leached of its zinc, copper and iron sulfides, leaving the gold and silver in a resultant sand-like gossan.

In 1995, Black Hawk purchased all the issued shares of Boliden Resources, Inc., the owner of the mining leases, and renamed the company to NNM Resources, Inc. Black Hawk is submitting this formal application for mining the gossan deposit. This application has been prepared in accordance with Chapter 13 of the Land Use Regulation Commission (LURC) regulations entitled, *Metallic Mineral Exploration, Advance Exploration, and Mining Rules (Rules)*. The application is a joint submittal to LURC and the Maine Department of Environmental Protection (MDEP). Black Hawk's development plans call for:

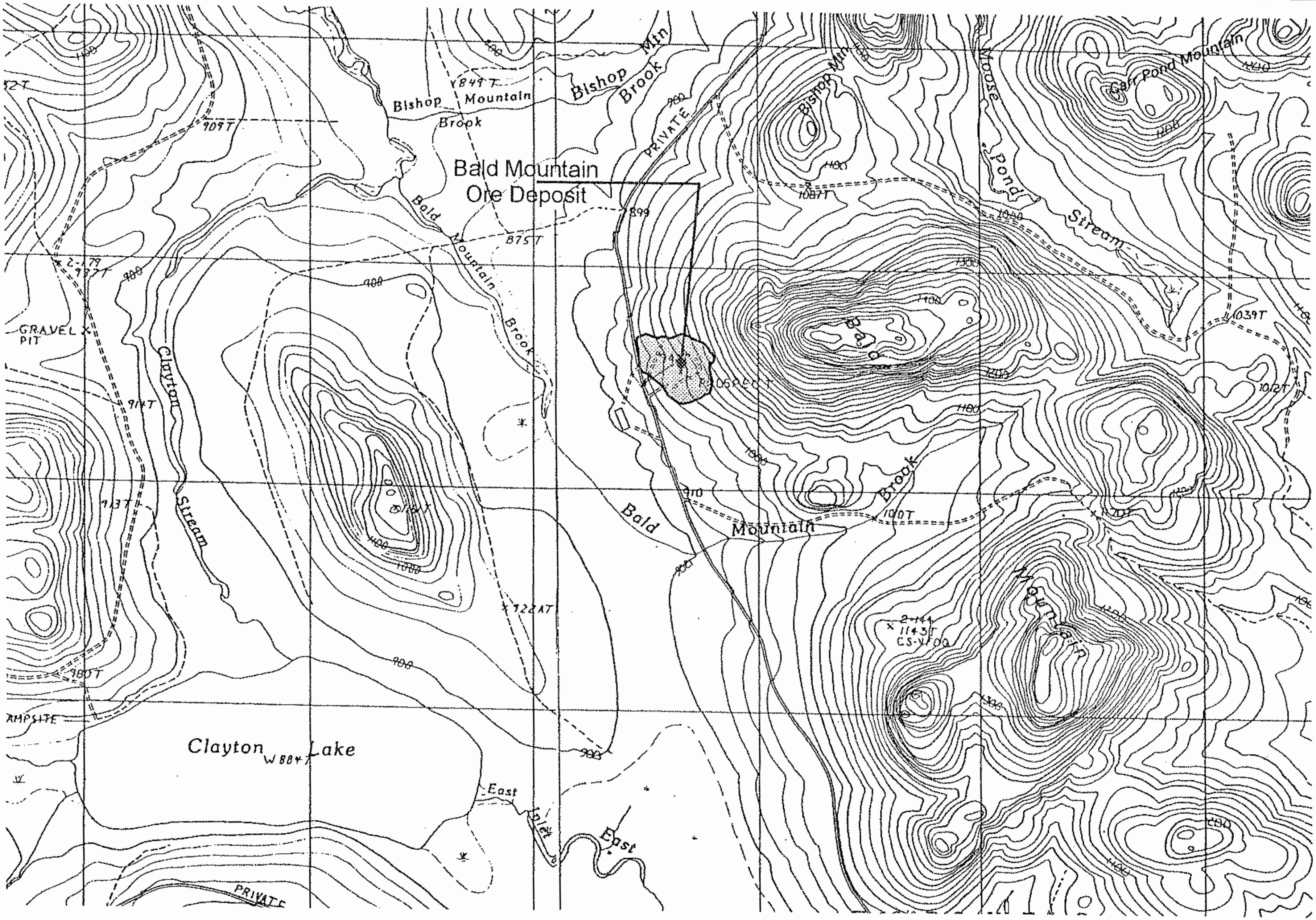
- removing topsoil and 40 feet of glacial till to expose the gossan zone
- mining of the gossan using standard gravel pit equipment and technology, with minimal drilling and blasting
- crushing and agglomerating the gossan at a production rate of 1,000 tons per day
- placing the agglomerated gossan in a walled (concrete basement) vat
- dissolving and recovering the gold and silver, recycling the leach solution, and washing and draining the agglomerate
- hauling the drained agglomerate to a soil lined landfill (with a leachate collection system) where it is piled, contoured, and covered

The studies performed for this application have identified and developed mitigation, in the most cost effective way, of all potential environmental impacts. This application includes:

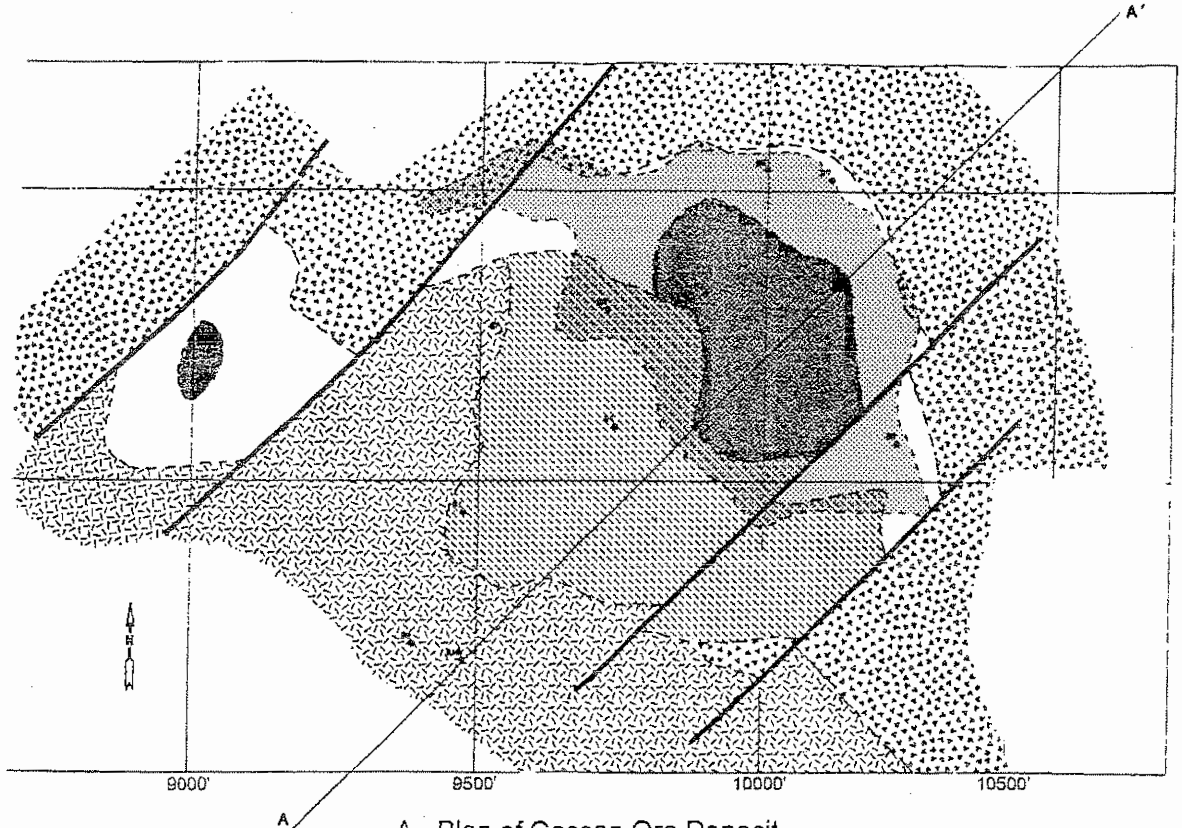
- summary of the extensive studies performed at the site by numerous companies since 1979



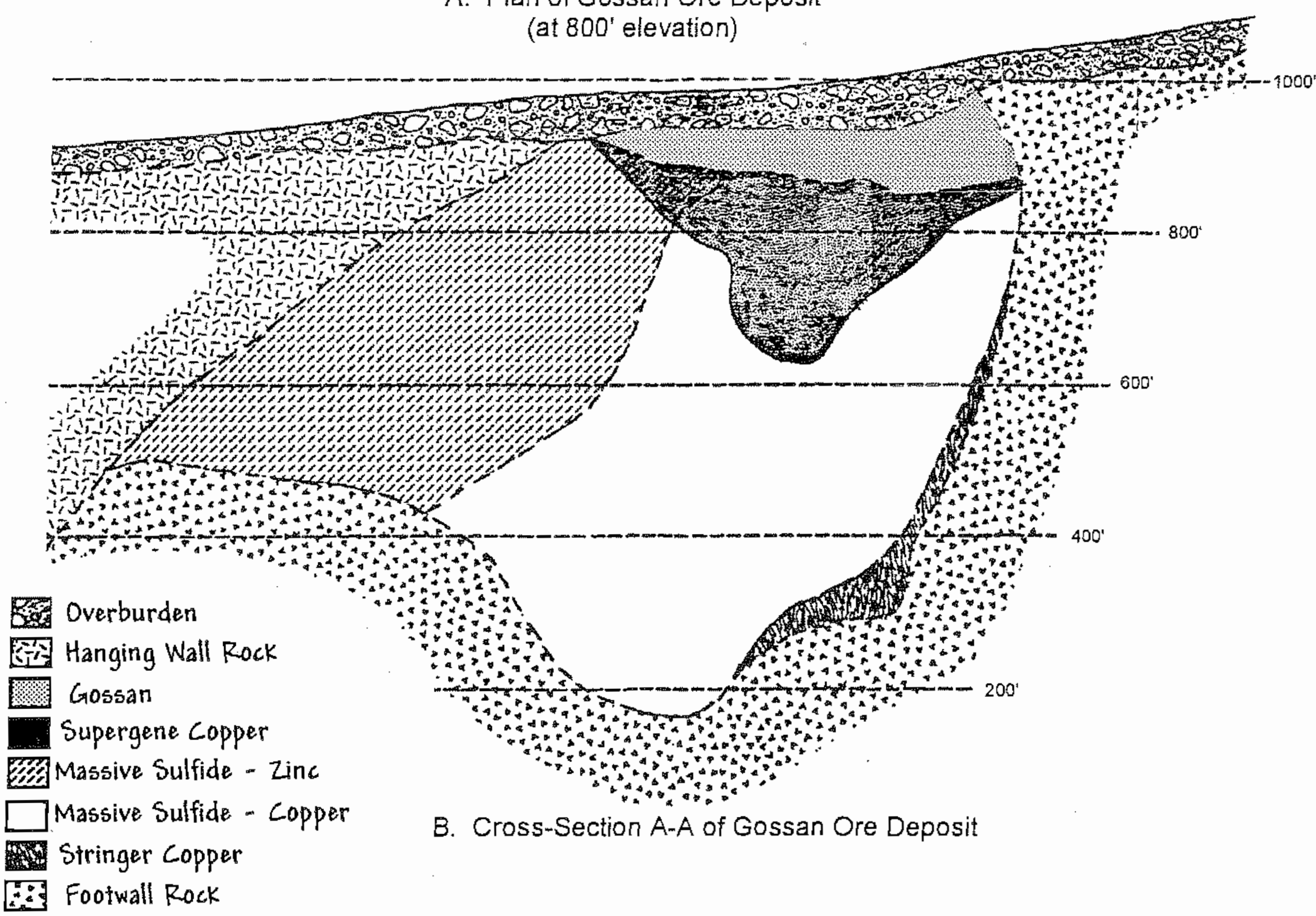
Scale: as shown Date: Dec. 1997		Figure 1.2 Site Location Bald Mountain Project	NNM Resources, Inc. a subsidiary of Black Hawk Mining, Inc.



Scale: as shown	Figure 1.3 Location of Ore Deposit Bald Mountain Project	**NNM Resources, Inc.** a subsidiary of **Black Hawk Mining, Inc.**
Date: Dec. 1997		



A. Plan of Gossan Ore Deposit
(at 800' elevation)



B. Cross-Section A-A of Gossan Ore Deposit

Scale: as shown		Figure 1.4 Gossan Ore Deposit Bald Mountain Project	**NNM Resources, Inc.** a subsidiary of **Black Hawk Mining, Inc.**
Date: Dec. 1997			

- results of the Baseline Monitoring Studies
- Environmental Impact Report (EIR)
- description of the extraction and beneficiation process
- mine waste treatment and management plan
- reclamation plan
- site monitoring plan
- description of other operating plans required by the Rules

This application, which includes the EIR, encompasses environmental, physical, cultural, land use, and socioeconomic impacts of the proposed project. It identifies measures for mitigating significant impacts, and proposes site and processing alternatives. The potential for unanticipated failures of the engineering controls at the site have been identified and alternatives for corrective measures presented.

The Mining Application is submitted in several volumes which include the Application for Mining, the Baseline Monitoring Studies, the Environmental Impact Report and companion reports prepared by Black Hawk and others. To support the Mining Application, other applications are submitted including:

- Petition for Rezoning
- Application for Air Emissions License
- Maine Waste Discharge License Application for Surface Waste Water Disposal System

7. MINE WASTE TREATMENT AND MANAGEMENT PLAN

Waste management at the Bald Mountain Project includes agglomerated tailings from the ore processing facility, overburden and waste rock from the mine pit, landfill leachate from the tailings landfill, and excess surface water and groundwater that has accumulated in the mine pit. This section describes the management plan for these wastes as described in Sections 31 through 35 of the Rules. Most of the discussion presented herein relates to the tailings landfill that has been designed in accordance with Sections 32 and 33 of the Rules. Management of other waste units are included at the end of each section in this chapter. Details of the mine waste treatment and management plan are presented in the *Civil Engineering Design Report* (Sevee & Maher, SM.030, 1997) included with in the Companion Reports. A plan view of the landfill is presented in Figure 7.1.

7.1 WASTE CHARACTERIZATION

In accordance with LURC's mining regulations (Section 31.C, Chapter13), a testing program was performed by Boliden (SRK: S.241, 1990; S.246, 1992) and Black Hawk (Wardwell: WA.031, 1997) to characterize the waste materials from the proposed mine and plant known as the Bald Mountain Project. As illustrated in Table 7.1, testing has been performed on all materials at the site including: footwall waste rock for both the gossan mine and massive sulfide mine; hangingwall waste rock materials including chert, tuff, and andesite and footwall rock along the full massive sulfide deposit. Also, ore material including gossan, supergene, and massive sulfide and agglomerated tailings associated with the extraction of gold and silver from the gossan deposit have been tested. Tests include both geochemical tests to evaluate the acid producing potential of the waste materials and geotechnical testing to support the engineering design of the disposal handling facility.

A summary of the test results is presented in the Waste Characterization Report (WA.031 1997) included in the Companion Reports. A summary of the test results is presented in this section.

7.1.1 Material Source

Core samples of the ore and waste rock were obtained from previous drilling programs performed by the various owners on the orebody. Residues from the gossan ore that was processed through a bench scale pilot plant were used for ABA and humidity cell testing.

Two types of gossan ore (goethite and limonite) have been identified based on their mineralogy. Samples of each were tested separately to determine the relative source of extracted mineral. While these minerals were tested separately, there are no plans to isolate the two minerals during the mining and ore processing. As will be demonstrated, there are no differences in the two types of tailings. Therefore, a composite of the two

Table 7.1
Geochemical Testing Details
Acid Generation Potential
Bald Mountain Project, Black Hawk Mining Inc.

Material	Sample	Boring Number	Boring Depth	Tests TCLP	Tests ABA	Tests Humidity Cell
1. Waste Materials - Gossan Mine						
Tailings[a]	Comp 2	(note 1)			x	
	Comp 3				x	
	Comp 4			x	x	x
Tailings w/ waste rock	10-90	(note 2)			x	x
(M21, M29, M87, M88,	15-85	(note 2)			x	x
M90, M97)[a]	20-80	(note 2)			x	x
Waste Rock						
Gossan Ore[b]	SRK-1A/B	B7	116-131'		x	
		B7	141-156'			
	SRK-2	B7	131-141'		x	
	SRK-3A/B	B6	76-85'		x	
		B6	90-94'			
footwall waste rock[a]	Comp 1	(note 2)			x	
	Comp 5	(note 3)			x	x
	Comp 6	(note 4)			x	x
2. Pit Water Quality						
Gossan Footwall[a]	Comp 5	(note 3)			x	x
	Comp 6	(note 4)			x	x
Gossan Ore[b]	SRK-1A/B	B7	116-131'		x	
		B7	141-156'			
	SRK-2	B7	131-141'		x	
	SRK-3A/B	B6	76-85'		x	
		B6	90-94'			
Gossan Waste Rock[b]	SRK-4	B7	101-116'	x	x	
(beneath gossan layer)	SRK-5	B7	166-176'		x	
	SRK-6	B7	156-166'		x	
	SRK-7	B5	163-173'		x	
Supergene[b]	SRK-8	B2	295-320'	x	x	
Massive Sulfide - Wall Rock[b]						
Zn	SRK-9	B6	104-149'		x	

Material	Sample	Boring Number	Boring Depth	Tests TCLP	Tests ABA	Tests Humidity Cell
3. Other Tests						
Massive Sulfide Footwall[b]	SRK-13A/C	B2	615-666'	x	x	x
		B7	358-395'			
		B8	127-167'			
	SRK-14A/D	B5	353-390'	x	x	x
		B7	323-390'			
		B8	43-127'			
		B8	167-229'			
Massive Sulfide - Wall Rock[b]						
Zn	SRK-10	B6	377-417'	x	x	x
Cu	SRK-11A/C	B5	205-271'	x	x	x
		B5	256-311'			
		B5	349-404'			
		B7	218-251'			
		C29	598-673'			
Massive Sulfide Waste Rock[c]		(Table 2, SRK 1990)				
pyrite	2 samples				x	
pyrrhotite	1 sample				x	
sphalerite	2 samples				x	
Hanging Wall Rocks[c]		(Table 2, SRK 1990)				
chert	3 samples				x	
tuff	2 samples				x	
andesite	3 samples				x	
Footwall Rocks[c]		(Table 2, SRK 1990)				
siliceaous volcanics	9 samples				x	
stringer sulfides	3 samples				x	
andesite	4 samples				x	

References

a. Lorax (1997), *Assessment of ARD and Metal Leaching Potential of Vat Leaching Residues and Waste Rock*, Bald Mountain Project, Black Hawk Mining, Inc.

b. SRK (1992), *Report on Mine Rock Acid Generation Potential*, Proposed Bald Mountain Project, Boliden Resources Inc.

c. SRK (1990), *Report on the Acid Generation Characteristics of Mine Wastes for the Proposed Bald Mountain Project*, Boliden Resources Inc., August.

Notes: Lorax (1997) samples-

1) tailings: Comp 2-goethite tailings; Comp 3-limonite tailings; Comp 4-composite from 55% goethite and 45% limonite tailings from bench scale tests
2) gossan waste rock composite: M21(32-218'), M29 (31-123'), M87 (32-355'), M88 (48-200'), M90 (28-189'), M97 (25-380')
3) Comp 5: M87 (57-110'), M88 (50-110'), M90 (75-105')
4) Comp 6: M87 (110-189'), M88 (110-190'), M90 (105-177')

samples from the bench test were combined and tested for geochemical and geotechnical characteristics.

7.1.2 Geochemical Testing Program

A program of ABA and humidity tests were performed on the waste rock core, and agglomerated tailings samples to determine their acid generation potential. A summary of the tests is presented in Table 7.1. These tests determine the leachate quality from each of the waste materials, as inferred by the rates of acid generation and metal release. In addition, the tests provide data on drainage water quality for preliminary water treatment estimation used in evaluating water handling procedures for the site (Wardwell: WA.040, 1997).

7.1.3 Summary of Results

ABA and humidity cell testing data are summarized in the Waste Characterization Report (WA.030). Details of the testing program and results are presented in the following reports included in the Waste Characterization Report:

- S.241 Report on the Acid Generation Characteristics of Mine Wastes for the Proposed Bald Mountain Project. Steffen Robinson and Kirsten. Report 80701/2. August 1990

- S.246 Proposed Bald Mountain Project, Report on Mine Rock Acid Generation Potential. Steffen Robinson and Kirsten. Report 80701/3. March 1992

- LX.010 Assessment of ARD and Metal Leaching Potential of Vat Leach Residues and Waste Rock. Lorax Environmental Services, Ltd., November 1997

Tests have already been performed on the gossan ore and waste rock waste (SRK 1992) to evaluate short term water quality in the pit during operations. As mentioned, additional tests were performed by Lorax for Black Hawk on a composite of the agglomerated tailings. Test results for the agglomerated gossan tailings and footwall waste rock were performed by Lorax on the following samples:

- Comp #1 - waste rock
- Comp #2 - goethite tailings from the vat leach process
- Comp #3 - limonite tailings from the vat leach process
- Comp #4 - composite of the goethite and limonite tailings
- Comp #5 - footwall rock sample
- Comp #6 - footwall rock sample

- mixtures of waste rock to tailings at the following ratios
    * 10-90
    * 15-85
    * 20-80

ABA testing on hangingwall samples (i.e. chert, tuff, and andesite) were performed by SRK for Boliden in 1990.

Based on the ABA testing, sulfide-S values are low in the tailings (Comp 2, 3, 4) and do not appear to contain enough reactive sulfur to be potentially acid generating. The lack of acid producing potential for the agglomerated tailings is confirmed by the revised net potential ratios (RNNP) of greater than 8 which are considered to be materials with sufficient buffering capacity (USEPA 1994).

Conversely, waste rock sample (Comp1) and remaining footwall rock (Comp 5&6) contain 0.6% to 2 % reactive sulfur and have RNNP ratios of -18 to -59, both indicating acid producing potential.

The five samples subjected to the ABA testing were examined petrographically and for total metal content. While the gossan tailings contains elevated levels of arsenic, there is a general absence of crystalline forms of iron arsenate (scorodite), suggesting that most of the arsenic is adsorbed to the surfaces of the iron oxyhydroxides.

A analysis of the ABA, petrographic and humidity cell test results for the Bald Mountain Project has produced the following conclusions:

- Vat leach residue samples of gossan ore (i.e. agglomerated tailings) do not appear to contain enough reactive sulphide to be potentially acid generating. These inherent properties, in concert with the added alkalinity from the agglomeration and cyanide leach process, demonstrates that leach residue material will not be a source of acid generation.

- Footwall rock samples contained significant quantities of reactive sulphide. Very little neutralization potential is available in footwall material and these rocks are predicted to be acid generating upon exposure.

- Vat leach tailings, when deposited in the landfill, are predicted to release elevated arsenic levels during periods of active infiltration and seepage. Similarly, elevated concentrations of cyanide, copper, mercury and silver are also expected during the initial flushing of residual metal-cyanide complexes in interstitial waters. Overtime, flushing and aeration through the pile is expected to result in reduced cyanide, copper, mercury and silver concentrations emanating in the seepage. Comparative reductions in arsenic concentrations overtime has not been observed.

While the gossan tailings leach arsenic and other metals, they will be contained in a landfill which includes provisions to collect the leachate which drains from this material. At closure, the landfill will be capped with an impervious composite barrier to prevent infiltration.

In addition to this testing, previous work was performed by Boliden to evaluate the acid producing potential of the hangingwall materials (i.e. chert, tuff, and andesite) that would be encountered during the deeper excavation of the massive sulfide (Table 2, SRK, S.241, 1990). The current mine plan does not anticipate excavation of these materials. Regardless, the initial ABA testing demonstrates that, if encountered, these materials would not be acid producing.

7.1.4 Waste Characterization Conclusions

Agglomerated gossan tailings do not appear to contain enough reactive sulfide to be potentially acid generating. These inherent properties, coupled with the added alkalinity from the agglomeration and cyanide leach process demonstrates that leach residue material will not be a source of acid generation. The sand-like material is drained but is still damp.

Footwall rocks and gossan waste rock contain fairly abundant sulfides mainly as pyrite, as these are the rocks through which the sulfuric ore forming fluids passed to produce the massive sulfide deposit. Sine they have very little neutralizing potential, they are acid producing.

Hangingwall rocks were deposited on top of the orebody after the main ore-forming process was completed. As such, they do not contain elevated levels of sulfides and are not acid-producing.

Based on the ABA and kinetic (humidity cell) testing, the agglomerated gossan tailings are classified as a Group B waste by the Rules. Hangingwall waste rock is classified as Group C mine waste. Footwall waste rock is classified as a Group A waste. The landfill is designed to contain only Group B and C wastes. Only material which passes through the ore processing facility and demolition debris at closure will be brought to the landfill.

7.2 HYDROGEOLOGIC ASSESSMENT

Hydrogeology for the Bald Mountain Project site has been studied in detail during previous years (JGA, 1981; WWL, 1982; W-C, 1982; Budo, 1988; RGGI 1990, 1991 and 1997). These studies were initiated by Superior Mining in 1980 through their consultant Woodward Clyde Consultants. Their work focused on developing the full massive sulfide deposit. A summary of the geologic conditions at the site was prepared by Gerber (G.010, 1990) and submitted by Boliden in 1991.

Three dimensional groundwater modeling for this site, including the present tailings landfill area, was performed for Boliden by R.G. Gerber Inc. in the early 1990's (G.011, 1991). This model was recently updated for Black Hawk by Gerber-Jacques Whitford (G.020 July 1997). This section summarizes the previous studies and the results of the recent modeling performed to evaluate the hydrogeologic conditions at the site. The Gerber reports are included in the Companion Reports for a full discussion of the assumptions and procedures used to evaluate the hydrogeologic conditions at the site. Their work has been incorporated into the landfill design presented in detail in the *Civil Engineering Design Report* (SM.030, 1997).

7.2.1 Hydrogeologic Conditions

The landfill site is underlain by a layer of overburden soil over bedrock. Overburden soil in the landfill area consists of a thin layer of forest duff/root mat underlain by dense glacial till. Based on the explorations made in the landfill area, the glacial till ranges in thickness from not present (bedrock outcrops) to more than 20 feet. The design report presents an overburden thickness map for the landfill area. In-situ penetration testing indicates that the glacial till is dense to very dense. The testing results are consistent with other laboratory tests performed by previous companies investigating the site (S.111, 1982; M.012, 1989). The water table in the till, where present, appears to be an unconfined perched condition caused by localized variations in hydraulic conditions. The majority of available groundwater generally lies in a thin veneer of fractured bedrock.

Based on the site topography and the vertical position of the bedrock encountered in the 1997 borings, the bedrock surface in the landfill area appears to downslope in a generally east to west direction. In the vicinity of the tailings landfill, there appears to be only one significant aquifer, that of the fractured surface of the bedrock. This aquifer ranges from confined to unconfined conditions through the general mine area, based largely on the thickness of glacial till. Local variations in the potentiometric surface appear to have other causes.

Based on the previous hydrogeologic evaluations(J.0050, 1981; WWL.010, 1982; W.170, 1982; SB.013, 1988; G.010 to 011, 1990, 1991, 1997) and on-site piezometric measurements, the landfill area spans the region of groundwater recharge (to the east, upslope side of landfill) and groundwater discharge (to the west, downhill side of landfill). Groundwater phreatic surface map and profile for the landfill are presented in the companion reports (G.020, 1997, SM.030, 1997).

7.2.2 Initial Modeling

Gerber - Jacques Whitford (GJW) previously performed work for the proposed Bald Mountain mine during 1990 and 1991. This work was done under contract with Boliden Resources, Inc. The project was to characterize the hydrology of the mine and waste disposal areas and to predict the impacts of operation and closure of the mine. The project was divided into three components: Hydrogeological Work Plan, Phase I Analysis and Report, and Phase II Analysis and Report. The Hydrogeological Work Plan and Phase I Analysis were completed and reports were submitted to Boliden (G.010, 1990; G.011, 1991).

The Phase I Report was submitted to Boliden on August 22, 1991. The report documented the field work and analysis performed by GJW. The field work included test pits, monitoring well installation, and a photolinear interpretation. The analysis consisted of developing a three-dimensional ground water flow model for the mine region, and simulating the ground water inflow to the active mine. The Phase II analysis, never initiated, would have analyzed the mining related impacts. The details of the initial groundwater model are documented in the Phase I Report (G.011).

7.2.3 Revised Boliden Model

The mine as proposed by Black Hawk is substantially smaller and much shallower than the Boliden proposal. In applying the existing model, it was decided to reduce the regional extent (grid size) of the model and refining the grid resolution in the mine and landfill areas. Other than these changes, and the manner in which the mine is simulated, the new Black Hawk model and older Boliden model are essentially identical (e.g., model layering, hydraulic conductivities, storage coefficients, and recharge).

Several scenarios were simulated using the revised model:

- pre-mine calibration to August, 1982, and 1990 water levels
- mine dewatering, inflow, and adjacent drawdown using the calibrated model
- sensitivity analysis of mine inflow
- particle tracking from the landfill for assumed failure conditions

7.2.4 Hydrogeologic Results and Conclusions

Based on the previous referenced studies, the landfill area is generally situated in a region of both groundwater recharge (east side of site) and groundwater discharge (west side of site). Groundwater phreatic surface map for the landfill, based on the results of MODFLOW simulations and existing site data, and hydrogeologic cross-sections are presented in the modeling report (G.012, 1997).

7.3 ENGINEERING DESIGN

Details of the stockpile and landfill design are presented in the *Civil Engineering Design Report* (SME, SM.030) presented in the companion reports. The Design Report includes a detail discussion of the siting criteria. This section summarizes the design of the tailings landfill, footwall waste rock storage, and handling procedures for excess water at the site.

7.3.1 Tailings Landfill

Landfill Configuration - The tailings landfill (landfill) will occupy approximately 20 acres of the project site as shown on Figure 7.1. The landfill is designed to be constructed and operated as a series of contiguous waste cells which have a combined waste capacity of 1.2-million cubic yards. The footprint will be underlain with a soil liner and leachate collection system to handle infiltration and internal drainage from the landfill.

To minimize leachate generation, the active landfill area will be restricted to a maximum of 4 acres during operations. In addition, portions of the landfill at final grade will be covered with a synthetic interim cover material (SICM) until the permanent landfill cover can be installed. SICM will act to shed essentially all precipitation from the covered portions of the landfill, thereby greatly reducing the quantity of leachate generated in those areas.

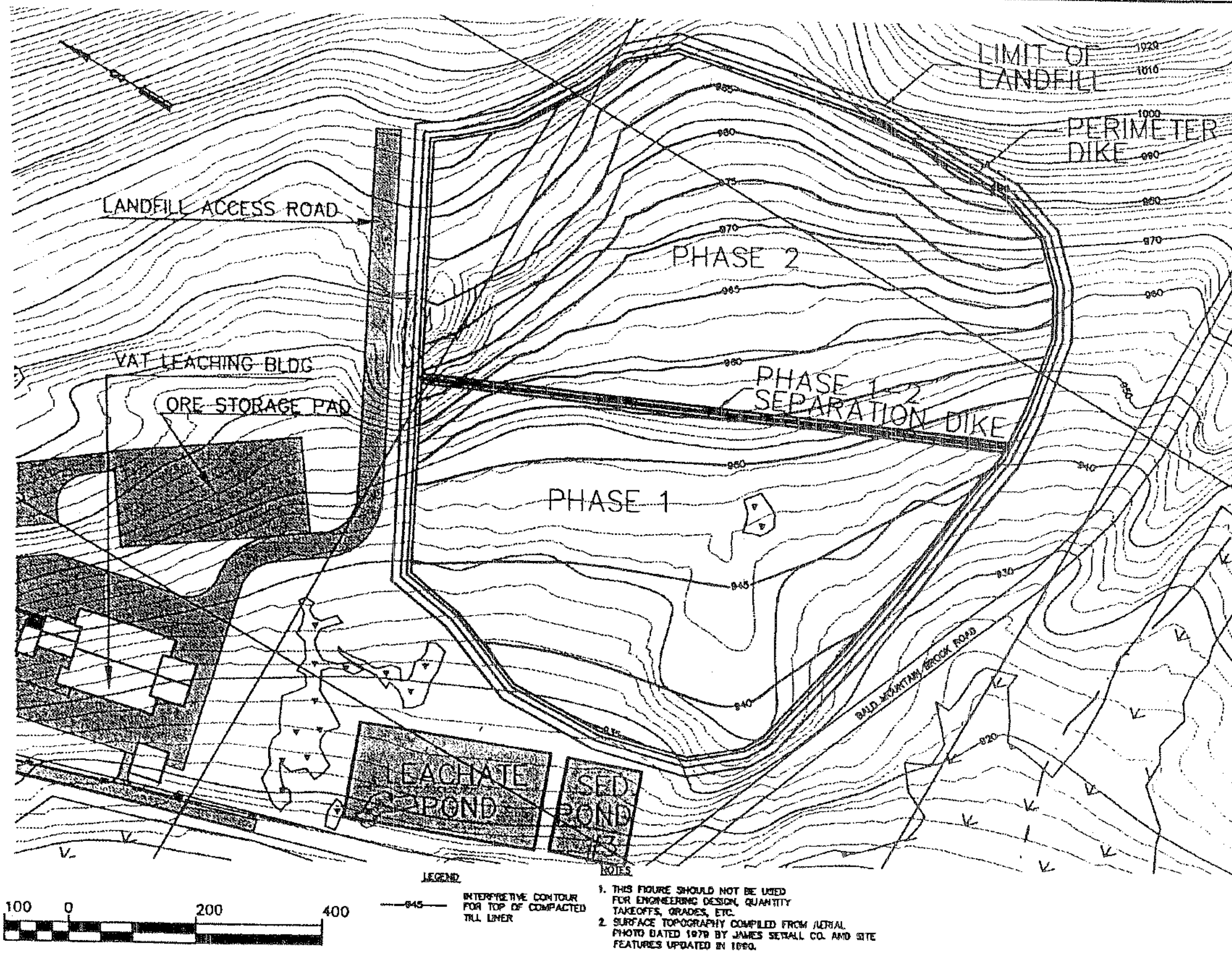
The landfill will be constructed in two adjoining phases as shown on Figure 7.1. The base grading plan for the top of the till liner is also shown on this figure. Together, the two landfill phases will have an approximate waste disposal volume of 1.2-million cubic yards, which is expected to be sufficient to hold the agglomerated tailings and site reclamation debris. Phase 1 of the landfill will be built during the first construction season, and Phase 2 will be built the next year. Figure 7.2 shows the final grading plan for the landfill.

Agglomerated tailings will be hauled from the processing plant to the tailings disposal area using normal earthmoving equipment. Access roads will be built on the tailings to provide mobility. These roads will be cleared of deep snow in winter. All snow on the active cell will remain within the cell footprint. In this way, snowmelt will be contained and collected in the leachate collection system. No tailings or meltwater will leave the active cell area.

Permanent landfill sideslopes will be inclined at angles not exceeding 3H to 1V in order to maintain slope stability. Horizontal benches will be located along the final landfill slopes at 30-foot vertical intervals to form breaks in the overall slope length. The benches will be approximately 30 feet wide and will serve to provide anchorage opportunity of the VLDPE cover and geocomposite drainage net. Drainage ditches will also be installed on the benches to intercept surface runoff and to collect drainage from the geocomposite drainage net. Riprapped sideslope drainage channels located transverse to the landfill final grades will be used to convey runoff collected in the bench ditches to the landfill perimeter. Final sizing of the bench ditches, drainage channels, and geocomposite drainage net will be completed as part of final design.

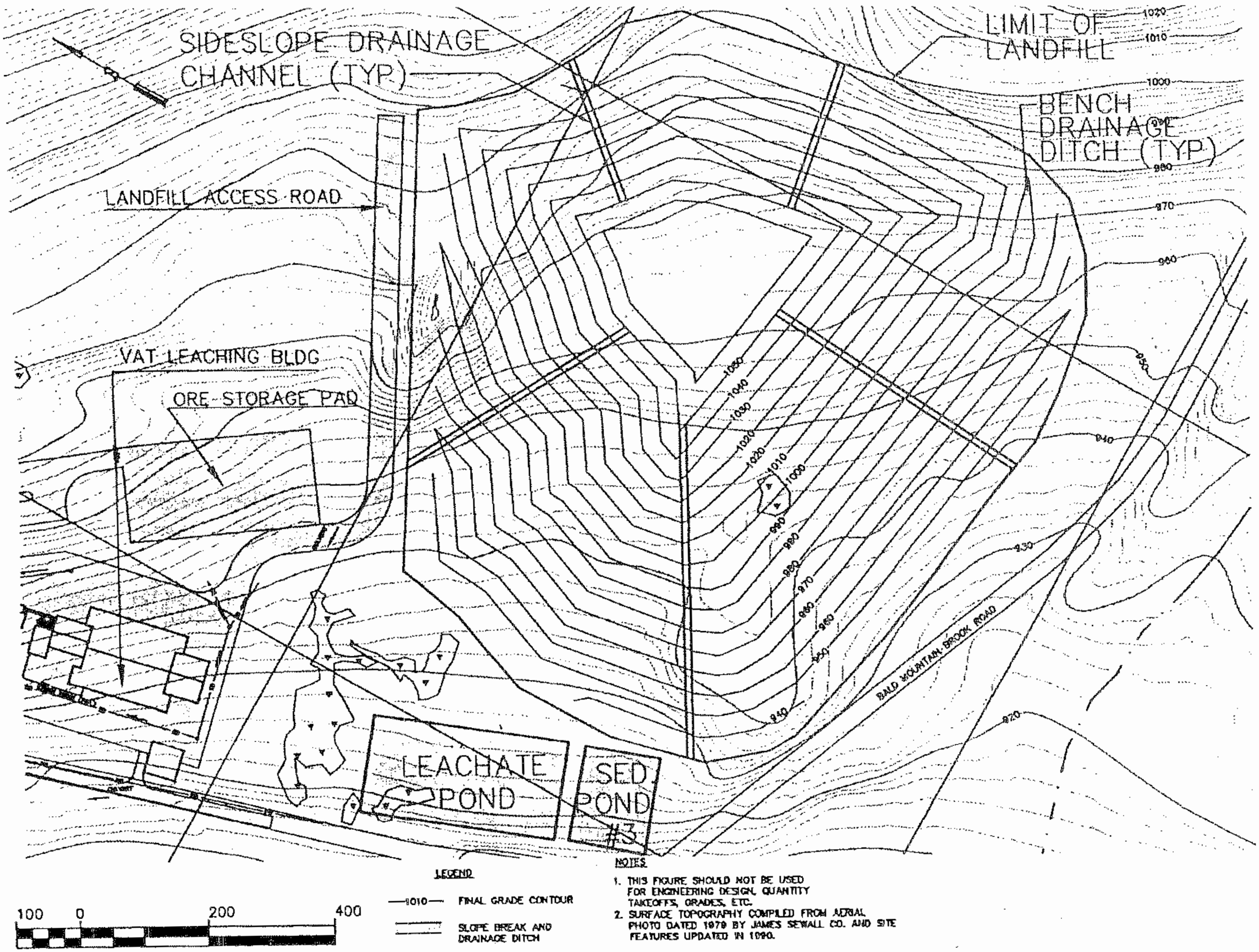
Landfill Liner - The landfill liner will consist of a 3-foot thick layer of compacted glacial till which exhibits a permeability of $1x10^{-7}$ cm/sec or less. The soil liner will present a barrier to leachate vertical movement equivalent to a 7-year travel time (based on a permeability of $\leq 1x10^{-7}$ cm/sec, hydraulic gradient = 1.0 and effective porosity = 0.25). Because Black Hawk plans to complete the ore processing/landfilling in less than 4 years, the landfill cover will be in-place before hydraulic breakthrough of the liner occurs.

Leachate Collection - The leachate collection system will consist of a network of finger drains comprised of perforated piping surrounded by drainage stone and filter sand. This system is described in detail in Section 8.1.2 of the *Civil Engineering Design Report*



(Ref: Figure 6.1, Sevee & Maher, SM.030)

Scale: as shown	Figure 7.1 Tailings Landfill Site Plan Bald Mountain Project	NNM Resources, Inc. a subsidiary of Black Hawk Mining, Inc.
Date: Dec. 1997		



(Ref: Figure 6.2, Sevee & Maher, SM.030)

Scale: as shown		Figure 7.2 Final Grading Plan, Tailings Landfill Bald Mountain Project	NNM Resources, Inc. a subsidiary of Black Hawk Mining, Inc.
Date: Dec. 1997			

(SM.030, 1997). The finger drains will be augmented by collection header pipes, inlet structures, and vertical drains. Post-closure leachate management will be use gravity drainage since permanent electricity, necessary for pumping, to the site is not planned. All leachate piping, inlet structures, and manholes will be constructed of HDPE. Leachate collected in the leachate pond will be pumped to the ore processing facility to be reused as process water. Procedures for handling leachate in the event of plant shut-down are presented in the design report. At the end of ore processing, leachate remaining in the leachate pond will be treated by destroying the cyanide. If CN contents are reduced to 0.2 mg/L or less, the water will be discharged through the land application area. If CN concentrations are higher, the water will be stored and shipped off-site for disposal at an approved facility.

7.3.2 Waste Rock

Acid producing waste rock from the footwall will remain in the mined out pit area. Non-acid producing waste rock from the hangingwall will be stored in the area of the till stockpile for use during reclamation.

Mine waste rock will be separated and handled according to its acid-producing potential. As shown on Figure 5.7, the spatial distribution of the hangingwall and footwall types is well defined from drilling information. All four types of waste materials (i.e. till, footwall rock, hangingwall rock, and gossan) will be easily distinguished based on visual inspections of their lithologies along the active excavation face. Consequently, management of excavation and haulage operations (in order to direct material to their appropriate storage piles) will be relatively straight forward based on the visual discrimination between these rock types in the mine pit. The excavation activities will be planned by the on-site engineering and geology staff. They will communicate their plan to the operations supervisor on a daily basis to control the transportation and storage of materials.

The northeast corner of the mine pit, where footwall and hangingwall rock are in contact as illustrated in Figure 5.7, will require more careful material assessment. Exposed pit wall rock will be visually inspected for sulfide content and will be handled accordingly. Due to the low levels of sulfide necessary for acid generation, a program of ABA testing will be performed on the blast hole chips to help determine the acid producing potential. Any acid producing rock will be identified based on the detail geologic inspection and ABA test results and remain in the pit for future burial and submergence.

7.3.3 Process Water and Landfill Leachate

All the vat leach solution will be recovered, stripped of its gold and silver content, and returned to the vat leach circuit.

All the water draining from the tailings landfill, as well as site runoff and pit inflow, will be collected and reclaimed to the process-water balance. If there is an excess water balance, the water will be treated on-site to meet environmental quality guidelines and then discharged.

7.3.4 Excess Water Collection and Treatment

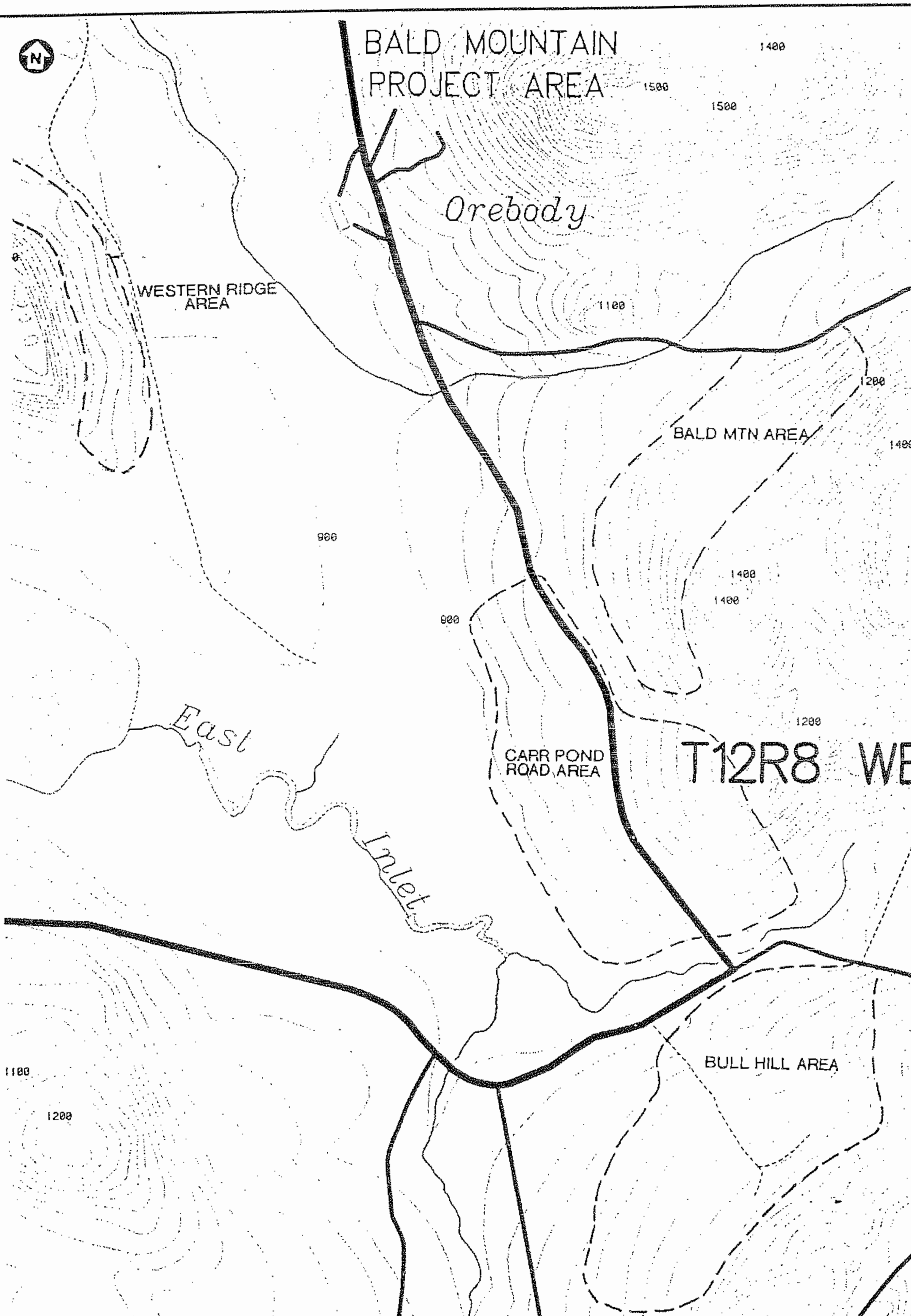
Excess water is limited to groundwater and surface water collected in the mine pit and runoff from the process area. The water quality is expected to be reflective of existing groundwater conditions (WA.040, 1997). The water is expected to be acidic and contain elevated metals. To mitigate this, excess water will be detained in storage ponds located to the south of the facility on the opposite side of Bald Mountain Brook. As a contingency, the ability to raise the pH of the excess water will be built into the collection system prior to pumping the water to the storage ponds (EE.010, 1997). Potential land application areas are shown on Figure 7.3. During the growing season, water will be applied to a land application area located along Carr Pond Road with the use of the Bull Hill site as a backup.

Water applied to the land application area should have no impact on water quality or aquatic resources in nearby receiving waters. The design report specifies the application rate, land area, and operation and monitoring requirements (TA.012 1997). These operational parameters have been based on detailed field studies in accordance with the detailed work plan, presented in Appendix C of the EIR Scoping Document (BH.010 1997). These conditions are designed to prohibit direct runoff into nearby water bodies.

Once operational, attempts to control groundwater into the mine pit will be considered. If dominant seeps are encountered in isolated defined fractured areas or fault zones during operations, investigations will be made to evaluate the potential of intercepting this water prior to encountering the exposed footwall rock. Water collected upgradient of the pit will be discharged into the perimeter ditches as clean water and routed to the detention basins located downgradient of the mine.

7.4 ENGINEERING REPORT

The engineering report is presented in the Companion Reports. In accordance with the guidance document submitted for LURC and MDEP review and comment (REW 1/31/97), details on some of the plans will be finalized as part of final design to be performed after license approval. A narrative discussing the contents of these plans and Black Hawk's commitment to the conceptual obligations associated with each plan is discussed in Section 15.



Ref: *Land Application Design Evaluation Report*, Tewhey Associates (T.012, 1997)

Scale: as shown Date: Dec. 1997		Figure 7.3 Location of Land Application Areas Bald Mountain Project	**NNM Resources, Inc.** a subsidiary of **Black Hawk Mining, Inc.**

BHK

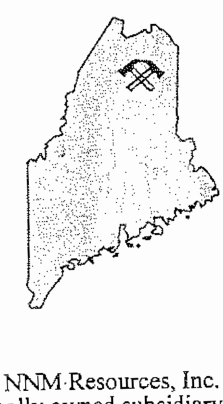
Black Hawk Mining Inc.

Volume 3

ENVIRONMENTAL IMPACT REPORT

Bald Mountain Project

T12R8
Aroostook County, Maine



NNM Resources, Inc.
wholly owned subsidiary of
Black Hawk Mining Inc.
Toronto, Ontario

ENVIRONMENTAL IMPACT REPORT

Bald Mountain Project
T12R8, Aroostook County, Maine

NNM Resources, Inc.
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Toronto, Ontario
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prepared for:

Land Use Regulation Commission
(coordinating agency)
and
Maine Department of Environmental Protection
Augusta, Maine

coordinated by:
Richard E. Wardwell, P.E., Ph.D.
Orono, Maine

DECEMBER 1997

EXECUTIVE SUMMARY

NNM Resources, Inc., a wholly owned subsidiary of Black Hawk Mining, Inc. (Black Hawk) is proposing to develop a gold/silver deposit in northern Maine known as the Bald Mountain Project. In 1995, Knox Nickel Corporation, a wholly owned subsidiary of Black Hawk, purchased all the issued shares of Boliden Resources, Inc. (the owner of the mining leases) and changed the name of the company to NNM Resources, Inc. Black Hawk's plans are to permit, develop, and process only the gold/silver gossan zone which overlays the sulfide zone of the large deposit. The gossan zone contains 1.2 million tons of 0.132 oz/ton gold and 2.94 oz/ton silver. This zone has been naturally oxidized and leached of its zinc, copper, and iron sulfides leaving the gold and silver in a resultant sand-like gossan. Laboratory testwork confirmed that the gold and silver in the gossan can be leached and recovered by an environmentally friendly vat leach process.

Black Hawk is submitting a formal application for mining the gossan deposit. Development plans call for:

- identification and mitigation, in the most cost effective way, of potential environmental impacts
- removal of top soil and 40 feet of glacial till to expose the gossan zone
- mining of the gossan by standard gravel pit equipment and technology with minimal drilling and blasting,
- crushing and agglomerating the gossan at a production rate of 1000 tons per day
- placing of the agglomerated gossan in a walled (concrete basement) vat
- extraction and beneficiation of the ore by dissolving and recovering of the gold and silver, recycling the leach solution, and washing and draining the agglomerate
- hauling the drained agglomerate to a lined landfill where it is piled, contoured, and covered.

A mining application is being prepared in accordance with Chapter 13 of the Land Use Regulation Commission (LURC) regulations entitled, *Metallic Mineral Exploration, Advance Exploration, and Mining Rules* (Rules). The application is a joint submittal to LURC and the Maine Department of Environmental Protection (MDEP).

As part of the environmental review process, the Environmental Impact Report (EIR) has been prepared to be submitted with the Application. The EIR was prepared in accordance with the EIR Scoping Document (Black Hawk, March 1997). The EIR identifies environmental issues relevant to the proposed project, encompassing environmental, physical, cultural, land use, and socioeconomic impacts of the proposed project. It identifies measures for mitigating significant impacts, and proposes site and processing alternatives.

The major findings indicate that potential site impacts, relating to surface water and groundwater quality downgradient of the mine pit and tailings landfill have been minimized with the current mine plan. Attributes of the plan that help to minimize environmental impacts include the following:

- Location and weathered nature of the gossan layer almost eliminates the acid producing characteristics of the gossan and waste rock.

- Limited depth and granular nature of the deposit allows for routine excavation processes.

- Attributes of the vat leach process (to be used for ore beneficiation) helps minimizes environmental impacts and include the following:

    * small, isolated batch process

    * net consumer of process water

    * in a covered building

    * wet process therefore no dust

    * very quiet operation

    * leach solution recycled

    * no free water in the final agglomerated tailings

    * the final agglomerated tailings have an acid neutralizing potential because of the cement and lime used in the agglomerating step of the process

    * agglomerated tailings will be drained and trucked to the landfill in a dry stable condition.

- Overall land disturbance is small; no streams are altered and less than 1 acre of wetlands are disturbed.

- Abandonment of the site, including the tailings landfill, will result in a revegetated site contoured to blend with natural conditions.

- Mine site is an isolated area away from towns and lakefront cottages.

The EIR demonstrates that potential impacts from the proposed mining activity have been controlled and mitigated. The potential for unanticipated failures of the engineering controls at the site have been identified and alternatives for corrective measures presented.

6. SOCIOECONOMIC IMPACT ASSESSMENT

Black Hawk retained Dames & Moore (D&M) to perform an updated socioeconomic study for the reduced mining plan and using updated information. The current study was performed in accordance with a work plan approved by LURC and DEP (October 23, 1991) to fulfill requirements of the state's Rules. It builds on the previous study performed by Superior Mining (E.043, 1982). Following completion of supplemental field-related work and data collection, a report was prepared to document results of the socioeconomics study (DM.010, 1997). As presented in the companion reports, data was summarized in table and figure format with supporting appendices. Local and regional literature sources that corroborate results of the investigation were cited.

Socioeconomic analyses typically have a three part sequence leading to the actual impacts. The typical stages are: new employment, in-migration, and population changes which then cause the majority of the social and economic impacts. The proposed Bald Mountain Project is significantly smaller than previous proposals considered by Superior Mining, Chevron, and Boliden Resources. The smaller direct employment leads to significantly smaller effects through the chain of in-migration, change in population, and resulting impacts.

The following sections summarize the potential impact of the mine on the socioeconomic conditions in the region (DM.010, 1997). Baseline socioeconomic conditions are discussed in detail in the report and summarized in the *Baseline Monitoring Studies* being submitted as part of the application.

6.1 SUMMARY OF SOCIOECONOMIC STUDY

The construction and operation of the Bald Mountain mine will provide benefits and impose relatively minor demands on the surrounding communities. The magnitude of the impacts from the current proposal are very different from earlier studies for other possibilities at this mine site. Land use, employment, duration, and indirect impacts are all a fraction of the size of earlier estimated impacts. Nonetheless, the Bald Mountain Project would have been listed in the top 10 additions of new employers for the State of Maine in 1996, so that the job impacts are still meaningful.

The potential socioeconomic impacts associated with the Bald Mountain mine site have changed in important ways since a 1982 socioeconomic study (E.086, 1982). The change is primarily due to a significantly smaller scale of operation with about 75 employees during the operation phase of the proposed project instead of about 200 employees in the previous study. The construction phase is even more dramatically shortened from 2.5 years to 6 months with the current project and a corresponding reduction from 385 to about 60 construction workers.

The Bald Mountain project is not likely to create the kind of problems associated with intense activity associated with construction and the reduced impact of operations at closure. The construction period is relatively short, 6 months, the construction crew relatively small, and the construction work force is the approximate size of the operations work force. All these factors suggest that there will not be large new demands for local services nor will there be a large decline with the transition to the operations phase.

At the time of the mine closure, if the mine operates and closes as scheduled, there will be additional expenditures to remove buildings and close the site. At closure, workers would lose their jobs although the potential exists for the Black Hawk to demonstrate the profitability and local desirability of other development in the region. As the initial positive impacts from the mine opening were not believed to create large demands on public services, nor would the closure be expected to significantly change demands for public services. The employment and income impacts associated with closing the mine will be greatly alleviated if the mining industry locates and develops additional developments. The nature of this project allows community leaders to anticipate these changes much better than with the closing of other area businesses. The operating life of the mine also allows time for other economic opportunities to expand in the region.

It is estimated that up to 70 employees will be hired locally out of the total number of 75 direct employees. The potential employment at the mine site is less than five percent of those unemployed in the study area. While the match between jobs and workers is uncertain, it is likely that heavy machinery operation and other tasks could be filled by some of the unemployed. Alternatively, some lower paid or part-time employed individuals may move up the job ladder and open the way for those currently unemployed. This study assumed that no in-migration would result from the secondary jobs as a result of scattered job openings in an area of relatively high unemployment or the addition of new workers as part of the newly in-migrant households.

The result of the smaller initial size of the current project and the resulting smaller in-migrate worker population is that the total population impact of the current proposal, estimated to be about 30 people and less than 10 children (DM.010, 1997). Population related social and economic impacts of the current proposal are much smaller than previous conceptions of the project and compares in size to the maintenance only option studied for Loring AFB. Consistent with the analysis performed for the maintenance option at Loring Air Force Base (USA1994), no impact from the Bald Mountain Project is expected for the following:

- Population
- Housing
- Public Services
- General government
- Police and fire
- Education
- Health Care

- Transportation
- Utilities

Evidence about the size of impacts from operation can secondly be assessed by looking more closely at a multiplier impact on public services and variations in population in the less populous central part of the County. The multiplier analysis relates a percentage change in population into an equivalent percentage change in public service, housing and other similar demands. If population changes by 5 percent, then all public service and housing demands change by 5 percent.

The range of a 0 to 30 person change in population estimated to result from the mine is a small percent of the study area and of the county in general. The individuals may be a larger percentage of an individual town if they all chose to locate in one town. This is highly unlikely because the existing facilities and personal preferences would discourage this potential. The long term gradual decline in population of the area and the closing of Loring AFB lead to a decline in county population of over 11 percent. In that context, the estimated in-migration appears to be small percentage of recent population changes in the study area and within the normal variation expected in an area over any given period.

6.2 PUBLIC HEALTH AND SAFETY

As discussed in the summary above, the small population impact will result in no impact to public health and safety.

6.3 SCHOOLS

Increased costs may be incurred by the state for education subsidies for the limited increased school enrollment. However, the limited population growth is within the normal variation expected in a given year, assuming that all the new workers located in several of the communities in the region.

6.4 ROADS AND TRAFFIC ENGINEERING

A separate report on the transportation impacts of the project has been prepared for this project. This analysis was performed by Eaton Traffic Engineering (ETE) of Brunswick, Maine in accordance with requirements of the traffic-movement rules pursuant to the Maine Site Location of Development Act (06-096 CMR 374). A copy of the ETE report (ET.010, 1997) is included in the *Baseline Monitoring Studies*. As part of this, a traffic study for the Bald Mountain Project was conducted to evaluate the impact of new traffic generated by the proposed facility on roadway in the vicinity of the site. Based on the reduced mining plan and limited additional traffic, Black Hawk currently proposes to upgrade the existing Fish River Road/Carr Pond Road system and use it as access to the project site.

7. MITIGATION MEASURES

Various mitigation measures have been incorporated into the mine plan to minimize environmental impacts. The mine plan has been reduced in scope with limiting extraction to only the shallow gossan ore. With the reduced mining plan, the socioeconomic impacts are negligible (DM.010, 1997). These impacts and mitigation alternatives are discussed in detail in the following sections.

7.1 ENVIRONMENTAL IMPACTS

Several mitigative measures have been incorporated into the project design to reduce the environmental impacts associated with mining and processing the ore deposit at the Bald Mountain Project. These measures are discussed in the following sections.

7.1.1 Reduced Excavation Depth

The current mine plan limits mining to only the upper gossan layer which overlies the massive sulfide deposit. The decision to limit mining to the gossan layer was based on economic factors. The cost to mitigate the environmental impacts associated with the deeper excavation was a contributing component in the selection of the final mine plan.

Limiting mining to the gossan layer reduces the depth of excavation from over 700 feet to an average depth of 150 feet below bedrock surface. This shallower depth helps to mitigate environmental impacts at the site by:

- reducing the total amount of land disturbance
- eliminating the need to alter streams
- limiting the development to one watershed
- minimizing excess water during operation
- reducing operational life which limits potential impacts prior to closure
- reducing wetland impacts to less than one acre
- reducing the total amount of waste rock
- improving water quality in the pit by limiting the area of exposed footwall rock subject to acid generation

The shallow mine pit reduces the total amount of acid producing waste rock from the eastern slope of the excavation. The smaller pit also reduces the amount and severity of acid producing footwall rock left exposed on the eastern pit slope against Bald Mountain. Based on the ABA and humidity cell testing, the footwall rock next to the gossan has less acid producing potential than the same rock abutting the massive sulfide deposit (S.241, 1990; S.246, 1992; LX.010, 1997). Only the footwall rock next to the gossan will be exposed during operations with the current plan.

The shallow excavation also reduces the amount of excess water which will need to be handled at the site. The smaller footprint of the mine pit will reduce the total excess water from 124 gpm to about 76 gpm with the gossan excavation at an average elevation of 850' msl. This reduced depth is instrumental in reducing the flow of excess water to manageable rates which can be handled.

7.1.2 Mitigate Acid Generation

Exposure of materials at the site (e.g. agglomerated tailings, waste rock, footwall rock) containing sulfide minerals can result in the oxidation of the sulfides and the production of acidity, resulting in elevated concentrations of sulfate and metals in the groundwater. The essential components for sulfide oxidation are 1) the presence of reactive sulfide minerals and their exposed surface area, 2) water and/or atmospheric humidity, and 3) the presence of oxygen.

The amount of oxygen available to react with the sulfides is often the limiting factor in these reactions. Since these kinetics are relatively rapid, exposure of sulfide minerals to the atmosphere, even for a matter of days or months, can result in oxidation of sulfide minerals. The extent of acid generation and metal dissolution will depend on the surface area of the rock fragments and the nature and distribution of iron/sulfide minerals in the exposed wall rock. If acidity is generated as the result of oxidation of the sulfide minerals, it can either be flushed by precipitation or fluctuating groundwater moving through the rock, or it can accumulate in the rock and remain available for flushing in the future. The formation of low pH groundwater enhances the solubility of many metallic minerals in the rock (SM.040, 1997).

Several steps have been taken with the proposed design and operation of the Bald Mountain Project to mitigate acid generation from the mill tailings, waste rock, and exposed footwall. As the first step, waste characterization testing has been performed to help quantify the potential for acid generation of materials at the site. Acid Base Accounting (ABA) and kinetic humidity cell testing were used to evaluate the potential for acid drainage and metals dissolution resulting from metallic mining activities at the Bald Mountain projects. These tests were run on gossan ore, residual gossan ore tailings, massive sulfide, footwall rocks, and hangingwall rocks as summarize in Table 7-1.

ABA tests are used to determine if a rock has the potential to be acid generating by evaluating the presence of reactive sulfur and the potential neutralization capacity of the rock. Laboratory humidity cell tests attempt to simulate the accelerated natural weathering and oxidation of rocks and the subsequent release of metals and acidity.

Table 7.1
Geochemical Testing Summary
Acid Generation Potential
Bald Mountain Project, Black Hawk Mining Inc.

Material	Sample	Boring Number	Boring Depth	Tests TCLP	Tests ABA	Tests Humidity Cell
1. Waste Materials - Gossan Mine						
Tailings[a]	Comp 2	(note 1)			x	
	Comp 3				x	
	Comp 4			x	x	x
Tailings w/ waste rock	10-90	(note 2)			x	x
(M21, M29, M87, M88,	15-85	(note 2)			x	x
M90, M97)[a]	20-80	(note 2)			x	x
Waste Rock						
Gossan Ore[b]	SRK-1A/B	B7	116-131'		x	
		B7	141-156'			
	SRK-2	B7	131-141'		x	
	SRK-3A/B	B6	76-85'		x	
		B6	90-94'			
footwall waste rock[a]	Comp 1	(note 2)			x	
	Comp 5	(note 3)			x	x
	Comp 6	(note 4)			x	x
2. Pit Water Quality						
Gossan Footwall[a]	Comp 5	(note 3)			x	x
	Comp 6	(note 4)			x	x
Gossan Ore[b]	SRK-1A/B	B7	116-131'		x	
		B7	141-156'			
	SRK-2	B7	131-141'		x	
	SRK-3A/B	B6	76-85'		x	
		B6	90-94'			
Gossan Waste Rock[b]	SRK-4	B7	101-116'	x	x	
(beneath gossan layer)	SRK-5	B7	166-176'		x	
	SRK-6	B7	156-166'		x	
	SRK-7	B5	163-173'		x	
Supergene[b]	SRK-8	B2	295-320'	x	x	
Massive Sulfide - Wall Rock[b]						
Zn	SRK-9	B6	104-149'		x	

Material	Sample	Boring		Tests		
		Number	Depth	TCLP	ABA	Humidity Cell
3. Other Tests						
Massive Sulfide Footwall[b]	SRK-13A/C	B2	615-666'	x	x	x
		B7	358-395'			
		B8	127-167'			
	SRK-14A/D	B5	353-390'	x	x	x
		B7	323-390'			
		B8	43-127'			
		B8	167-229'			
Massive Sulfide - Wall Rock[b]						
Zn	SRK-10	B6	377-417'	x	x	x
Cu	SRK-11A/C	B5	205-271'	x	x	x
		B5	256-311'			
		B5	349-404'			
		B7	218-251'			
		C29	598-673'			
Massive Sulfide Waste Rock[c]		(Table 2, SRK 1990)				
pyrite	2 samples				x	
pyrrhotite	1 sample				x	
sphalerite	2 samples				x	
Hanging Wall Rocks[c]		(Table 2, SRK 1990)				
chert	3 samples				x	
tuff	2 samples				x	
andesite	3 samples				x	
Footwall Rocks[c]		(Table 2, SRK 1990)				
siliceaous volcanics	9 samples				x	
stringer sulfides	3 samples				x	
andesite	4 samples				x	

References

a. Lorax (1997), *Assessment of ARD and Metal Leaching Potential of Vat Leaching Residues and Waste Rock*, Bald Mountain Project, Black Hawk Mining, Inc.

b. SRK (1992), *Report on Mine Rock Acid Generation Potential*, Proposed Bald Mountain Project, Boliden Resources Inc.

c. SRK (1990), *Report on the Acid Generation Characteristics of Mine Wastes for the Proposed Bald Mountain Project*, Boliden Resources Inc., August.

Notes: Lorax (1997) samples-

1) tailings: Comp 2-goethite tailings; Comp 3-limonite tailings; Comp 4-composite from 55% goethite and 45% limonite tailings from bench scale tests
2) gossan waste rock composite: M21(32-218'), M29 (31-123'), M87 (32-355'), M88 (48-200'), M90 (28-189'), M97 (25-380')
3) Comp 5: M87 (57-110'), M88 (50-110'), M90 (75-105')
4) Comp 6: M87 (110-189'), M88 (110-190'), M90 (105-177')

These tests are designed to provide a measure of the rate of oxidation, metal dissolution, and acid generation, as might occur in mine wall rock. The results of these tests are summarized in other reports (S.241, 1990; S.246, 1992; LX.010, 1997; WA.031, 1997)

Agglomerated Gossan Tailings - As part of the vat leach process, the crushed ore is agglomerated with cement to form uniform sand-like balls (< ¾" diameter). The agglomerated ore is then leached, washed, and drained for several days to remove the precious metal. The addition of cement helps to neutralize the potential low pH of the agglomerated tailings. The leaching process appears to remove much of the reactive sulfur from the samples. The agglomeration process greatly reduces the surface area of the waste material.

Based on ABA testing, samples of the agglomerated tailings do not have acid producing potential (LX.010, 1997). As a result, gossan tailings are classified as Group B wastes. The agglomeration process reduces the environmental impact of the residual tailings by eliminating the acid generation potential of the material.

Waste Rock - During mining, overburden will be removed and groundwater levels surrounding the mine will be lowered, exposing previously saturated rock to the atmosphere. Testing indicates that the footwall rock abutting the gossan deposit to the east is acid producing (LX.010, 1997) and classified as a Group A waste (WA.031, 1997).

To mitigate this situation, waste rock during excavation of the footwall will be kept in the mined out pit area at all times during operations. As a result, any runoff will be collected with the other precipitation and groundwater flow into the pit, and become part of the excess water to be controlled at the site. This process provides for direct control of acid runoff from the waste rock during operations. Likewise, rain water and groundwater which contacts the footwall rock will be directed into the excavation by the inward gradients provided by dewatering the pit. These processes will prevent any direct discharge of acid water to the surrounding environment during operations.

It is difficult to predict the water quality of the collected water due to the complex interactions and mixing of various water sources (SM.040, 1997; WA.040, 1997). The best prediction indicates that the water will not be significantly different than the existing groundwater quality in the deposit, except for a lowered pH. To mitigate any impacts to adjacent water resources, all excess site water will be collected and buffered if needed. The water quality will be detained and land applied (EE.010, 1997; T.012, 1997).

Operational Pit Water Quality - The current mining plan proposes to excavate from the northwestern portion of the mine in an easterly direction where the footwall rocks will be exposed as shown on Figure 7.1. This proposed mining plan will help minimize the exposure of the majority of the footwall rocks until the last phase of mining. This plan will help to limit the exposure of the footwall rocks to atmospheric oxygen and help to minimize oxidation of the sulfide minerals in the footwall rocks during mining operations.

Closure Pit Water Quality - The oxidation of reactive rocks exposed as the result of mine dewatering will influence the quality of the pit water upon mine closure. When mining operations cease and groundwater levels are allowed to return to static conditions, water moving through the oxidized rock surfaces will transport metals and acidity into the water that flows into the pit lake. The changes in the groundwater geochemistry as the result of mining operations will depend on the ambient groundwater geochemistry, the surface area of reactive wall rock that is oxidized and the groundwater flux into the pit.

Based on the test data to date, it is doubtful that the water quality will be much different than the existing groundwater quality in the gossan. Additional models and analyses could be run to provide other estimates of the pit water quality (SM.040, 1997). Due to the noted environmental complexities, the accuracy of the results will not be known until actual field measurements are made at closure.

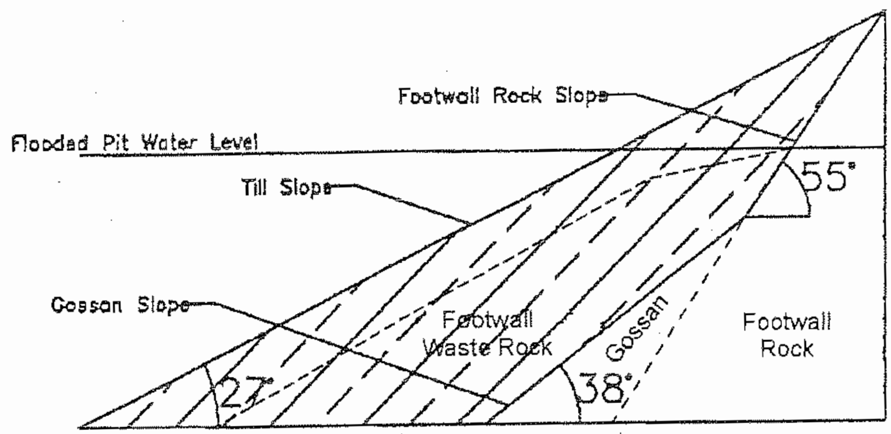
Rather than conducting additional analyses within unknown assurances to their accuracy, Black Hawk has elected to incorporate measures into the mine plan to mitigate adverse water quality in the mine pit at closure. These measures will be implemented to reduce the levels of oxygen needed for the generation of acid from sulfide materials.

To limit the exposure of the footwall to oxygen, till and waste rock will be placed against the footwall as illustrated in Figure 7.2 and buried in the pit. The reclamation cross-sections are shown in Figure 5.2. Column testing conducted by SRK suggests that submerging the waste rocks will help to limit the oxidation of the sulfide minerals. The flattened footwall slope and the bottom of the mine pit will be covered with 5-feet of till. This veneer of material will limit the amount of oxygen available for acid generation.

Once this is completed, the pumps in the pit will be shut off and the pit allowed to fill with groundwater. It is estimated that it will take approximately six to eight years for the water level to reach steady state conditions (G.020, 1997). To accelerate this process and further eliminate the potential for acid production, water will be pumped into the pit from nearby surface water bodies, reducing the filling time to less than 12 months. It is estimated that the steady state water level in the pit will be close to the till/gossan contact elevation of approximately 910 to 925 feet MSL.(GJW 1997). This will effectively submerge the footwall and acid producing waste rock and eliminating future acid production.

7.1.3 Leachate Generation from Tailings Landfill

Agglomerated tailings emanating from the ore processing area are classified as a Group B waste. Only material passing through the ore processing facility and inert demolition debris at closure will be allowed in the landfill. By doing this, only Group B wastes will be placed in the landfill.



Backfill Volume = 300,000 cu.yds.
Exposed Backfill Volume = 36,000 cu.yds.
(Post Flooding)

Scale: as shown Date: Dec. 1997		Figure 7.2 Pit Wall Backfill Detail Bald Mountain Project	**NNM Resources, Inc.** a subsidiary of **Black Hawk Mining, Inc.**

While acid production will be minimal, the agglomerated tailings still leach elevated concentrations of metals and inorganic elements. To minimize environmental impacts, the tailings landfill has been design with a leachate collection system to collect drainage, infiltration, and runoff from the active landfill cell. All of the leachate will be returned to the mill for use as make up water in the agglomeration process. In this manner, all of the cyanide containing water will remain within the ore processing system. Excess water at the site will be limited to groundwater and surface water collected in the mine pit and runoff from the process area.

The leachate collection system reduces the potential for groundwater impacts compared to traditional tailings impoundment where the tailings are kept water submerged to prevent oxidation. To further limit the impact and assure that all leachate can be used as makeup water, the open landfill area will be kept to 4 acres or less, limiting the flows to an average of about 4 gpm.

Clean runoff will be diverted around the active cell. Runoff and infiltration on the open cells will be collected and returned to the processing facility. Total impacts from the landfill are further reduced by the limited operating period. The gossan will be removed in less than 4 years. At closure, the landfill will be capped with a composite barrier, drainage layer, and topsoil. The barrier exceeds the requirements of the Rules, but has been selected to assure that virtually no infiltration occurs through the landfill during the post-closure period.

7.1.4 Excess Water Control

As discussed in Section 5, excess water will occur at the site due to groundwater and surface water flow into the mine pit and from site runoff from the ore processing facility. Various mitigation measures have been incorporated in the design to minimize the excess water at the site.

Surface water runoff from the processing plant, haul roads, and ancillary facilities will be minimized by constructing separation berms as close to the facilities as possible. These berms will be used to intercept clean runoff before it encounters the mine area. In this manner, water collected within the mine area will be kept to a minimum. The mine pit will be built in two phases which limits the exposed area during the early phases of ore excavation.

For the tailings landfill, volume reduction methods include the following:

- constructing and operating small cell areas of 4 acres to reduce the open area exposed to infiltration

- separating unused portions of the landfill footprint to further divert clean runoff

- developing the landfill in a manner that attempts to reach final grade as soon as possible and then capping those portions of the landfill at final grade

- placing an interim cover on cell areas that will be inactive for more than six months to further limit infiltration through these intermediate grades

- limiting open landfill cell development to small cells of 4 acres or less

The vat leach process needs make up water for the hydration of the cement to agglomerate the ore. Flow from the landfill leachate collection system will be the primary source of make up water. At all times, the plant can use all the flow from the landfill as currently design. However, the less flow from the landfill will allow the plant to use more of the water from the other sources. Therefore, one of the first mitigation measures is to reduce the open area of the operating cell at the landfill. The other mitigative measures diverts clean water around the site and limits the open area of the pit for the longest possible time.

7.1.5 Excess Water Collection and Treatment

Excess water is limited to groundwater and surface water collected in the mine pit and runoff from the process area. The water quality is expected to reflect existing groundwater conditions with a slightly lowered pH (WA.040, 1997). To mitigate this, excess water will be detained in storage ponds located to the south of the facility on the opposite side of Bald Mountain Brook as shown in Figure 3.2. Facilities to raise the pH of the excess water before it is pumped to the storage ponds will be built into the pump station located adjacent to the ore processing facility (EE.010, 1997). From the storage ponds, water will be applied to a land application area located along Carr Pond Road (T.012, 1997). The design of the collection and treatment facility is discussed in more detail in the application and referenced reports. These reports specify the application rate, land area, and operation and monitoring requirements to assure that this system does not have an impact on water quality or aquatic resources in nearby receiving waters (T.012, 1997).

Extreme flows due to unanticipated weather events, exceeding the design capacity of the storage ponds and land application area, can still be handled at the site. On a temporary basis, alternatives for handling the excess water include:

- storing in the freeboard capacity of the leachate pond and storage ponds

- routing to the pit for temporary storage

- trucking to an off-site treatment plant

Water will continue to be collected and treated for an indefinite period following reclamation of the open pit, tailings landfill, and plant site. After water has drained from the tailings landfill and water quality in the pit has stabilized, treatment will be curtailed. The small trickle of flow from the capped tailings landfill will flow passively into a small wetland that will be developed in the reclaimed leachate pond.

Collection and treatment is disused in more detail below.

Water Storage - Excess water will be stored in storage ponds for detention and to store during the dormant season for land application during the growing season. These ponds will be built south of Bald Mountain Stream and the tailings landfill as shown in Figure 3.2. For planning purposes, excess water will be stored from the beginning of October until the end of May. A maximum of 85 acre feet of storage will be required during the last year of operation.

To enhance operational flexibility and provide emergency storage, the pond will be divided into two cells, separated by the berm of compacted till. During normal operations, one cell will be lowered to provide emergency storage capacity in the event of extended plant shut-downs. Excess water will be pumped from one cell to the land application area while the other cell is being filled. This will maximize the retention time for excess water prior to land application. During the winter months, both cells will be used to store excess water. The pond level will drop during the early summer as water is pumped to the land application area. The pond will be emptied at the end of the summer to provide storage capacity for the following fall, winter, and spring seasons.

The combined capacity of the water storage ponds is approximately 115 acre-feet, not including 2 feet of freeboard. The water storage ponds are designed to store the following:

- an average of approximately 60-gpm continuous flow of surface runoff and collected groundwater from the ore processing area and mine pit over an 8-month period
- winter precipitation of 23-inches falling directly on the pond surface
- the 24-hour/100-year storm event

The water storage ponds will be temporary structures. At the end of mining, the water storage ponds will be closed by pumping the remaining water to the land application area. Sediments collected in the pond bottoms will be removed, characterized, and placed in an appropriate disposal facility. The dikes forming the ponds will be regraded to preclude any future impoundment of surface water. The interior pond slopes and any recently disturbed earth will be seeded to establish a perennial grass cover resistant to erosion and assist in the establishment of native vegetation.

Land Application - A land application system is proposed to dispose of excess water generated during operations at the Bald Mountain Project (T.012, 1997). This system was designed to match the hydrologic capacity of the shallow soils.

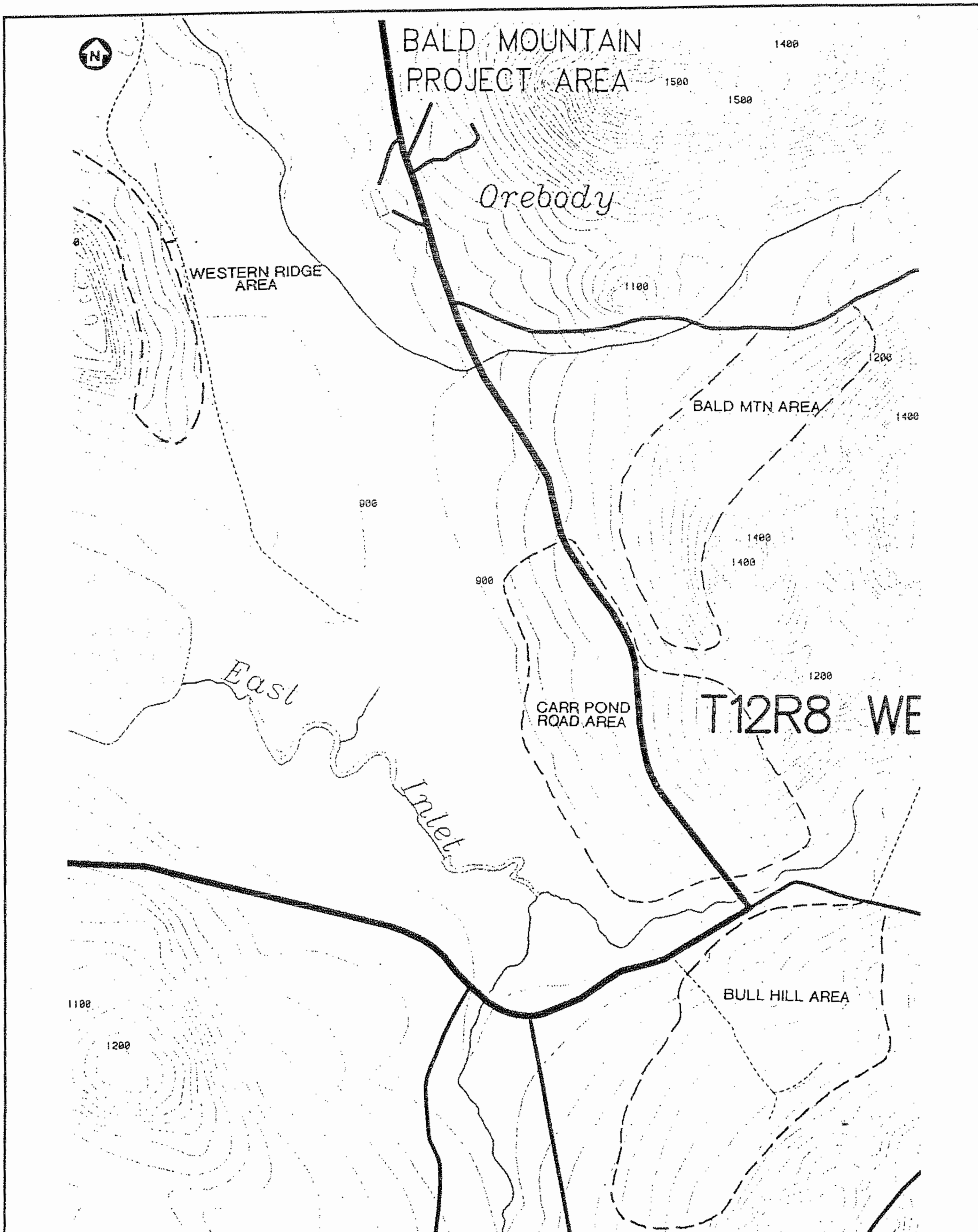
The project quality of excess water is similar and, in many aspects, generally superior to the quality of water applied at other land application systems in Maine (T.012, 1997). Two areas, consisting predominantly of Chesuncook silt loam, were identified near the mine site. Of the four areas shown in Figure 7.3, the primary area for land application is south of the mine site, straddling Carr Pond Road. The secondary, backup area, is located further to the south on the northern slope of Bull Hill.

Design of a spray irrigation system for the Bald Mountain Project is based primarily on the ability of the land application areas to accommodate the conservative estimate of 100 gpm of additional water, through a combination of evapotranspiration and interflow through the shallow soil matrix. Water will be land applied through a spray irrigation system at a rate of 1.0 to 2.0 in/ac/wk during a 130 day period. The rate of irrigation will be kept low, so that water remains in the shallow soil, above the dense basal till, with limited infiltration to the deeper water table. During the winter months, water will be stored in a pond for land application the next growing season.

Irrigation will occur on 5 to 6 acre plots on a 7-day rotation schedule. One plot will be irrigated each day during the growing period. As with other land application sites in Maine, irrigation will be postponed following 8-hour periods of more the ½ inch of rainfall. As described in detail in the waste discharge license application, the water storage ponds will be used to permit smooth operation during rainy periods in the irrigation season. Each irrigation plot will be inspected weekly to ensure that water is not flowing across the land surface in a channeled manner. Channels and small rivulets will be repaired to disperse flow.

The suitability of land application for excess water at Bald Mountain was based on a comparison with existing systems in the State of Maine and geochemical characteristics of site specific soils (T.012, 1997). The estimated water quality of the collected groundwater and surface water runoff is sufficiently clean so that land application of this excess water will not represent an excessive loading. As discussed, excess water from the mining operation will be neutralized, if necessary. Water chemistry is expected to be consistent with or better than the quality from other land application systems before discharge in the spray irrigation areas.

Potential for the spray irrigation system to influence surface water and groundwater quality is expected to be minimal because of the design of the irrigation system, the short duration of application (i.e. less than five years), and geologic conditions in the irrigation areas. Actual performance of the land application areas will be monitored by the following: measurements of soil moisture, inspections for vegetative stress, groundwater



Ref: *Land Application Design Evaluation Report*, Tewhey Associates (T.012, 1997)

Scale: as shown	Figure 7.3 Location of Land Application Areas Bald Mountain Project	**NNM Resources, Inc.** a subsidiary of **Black Hawk Mining, Inc.**
Date: Dec. 1997		

quality, and surface water quality in the East Inlet to Clayton Lake and Bald Mountain Brook.

7.2 SOCIOECONOMIC IMPACTS

As demonstrated in the recent socioeconomic study performed by Dames and Moore (DM.010, 1997), the proposed mine will have only a small impact on the population of the area and virtually no impact on the social services of the region. In part, the proposed mine will barely compensate for the gradual population reduction in the area and the recent closure of Loring AFB. The project expects that over 90% of the work force will come from the local region, which will help to reduce the current unemployment and add a large ratio of multiplied expenditures compared to the minimal additional demands on the current services required of the local communities. For these reasons, no other mitigation efforts were required to compensate for the minimal socioeconomic impacts.

8. ASSESSMENT OF ALTERNATIVES

Several design and process alternatives were evaluated in the selection of the final mine proposal. In each case, the environmental benefits for each alternative was considered along with the economic impacts to developed the plan described in the previous sections. This section discusses some of the alternative evaluated during conceptual design.

8.1 DESIGN ALTERNATIVES

Design alternatives were considered for the ore processing unit and mine waste units as described in the following sections.

8.1.1 Ore Processing Unit

In the gossan ore at the Bald Mountain site, the gold (principle value mineral) occurs as free and minute particles in a naturally oxidized rock. The gold particles are readily soluble in a dilute sodium cyanide solution.

The alternative processes consider are as follows:

1. Do not develop the resource: This alternative was rejected because there are proven methods of recovering the gold which are environmentally sound. The project economics are positive so the resource is available for investor interest and for job creation in the region.

2. Conventional Milling: The gold in the gossan can be readily extracted so a simple, conventional gold mill would be a practical ore processing method. However, if the gossan ore was conventionally processed (grinding, leaching, and gold recovery), then a conventional mill tailings pond would be required. The tailings pond will have to retain a water cover to prevent acid formation of the impounded tailings. The use of a fluid retention pond would increase the environmental risks associated with operations and post closure reclamation. The economics for such a small deposit would not be positive so the project would not have materialized. For these reasons, conventional grinding and leaching process was rejected.

3. Heap Leaching: The gold in the gossan ore is readily extractable even with limited crushing to -½ inch particles, agglomerated and heap leached. This alternative was also rejected. Although a heap leach processing approach could be done successfully, there are several negative affects to be considered. The operation would only be seasonal (i.e. spring, summer, and fall) thereby affecting job creation. The amount of excess water to be handled at the site would increase significantly. Likewise, process water would be included in the water that would need to be handled at the site. Limiting excess water at the site would be more difficult because the entire heap leach pile would be exposed to the weather until

the gossan ore reserve has been leached and cover placed at closure. There would be the necessity for a more intense and expensive water treatment plant. The economics would be less favorable and environmental approval more difficult.

4. The gold in the gossan ore could be recovered in a custom smelter operation. This alternative was rejected because the economics would not be positive and the environmental risks increased. The value of the gold content of the gossan would not cover the cost of mining, transportation, and processing at a custom smelter. Regional job creation would be very limited.

Based on this analysis, the vat leach process was chosen as the alternative with the less potential risk to the environmental and still be economically feasible. This process produces a dry stable agglomerated tailings that can be disposed of in a tradition waste landfill. All leachate encountering the waste pile can be used as make up water in the agglomeration the crushed ore. Therefore, no process water will be included in the excess water to be handled at the site.

8.1.2 Mine Waste Unit

Various options were considered for the design of the landfill for the site. Initially, footwall waste rock was to be placed in the landfill. As demonstrated in the Waste Characterization Report (W.031, 1997), footwall waste rock is acid producing. The landfill had to be designed to handle Group A wastes and included a composite liner consisting of a geomembrane and soil layer.

Vat leached agglomerated tailings are not acid producing due to the buffering provided by the cement and lime used in the agglomeration process. The placement of some waste rock in the landfill increased the overall potential environmental impacts associated with the tailings landfill by:

- making all the waste a sensitive Group A waste
- increasing the landfill footprint by almost double

To reduce the amount of wastes in the landfill, the footwall waste rock will remain in the mine pit. By doing so, the landfill was redesigned to accept only Group B waste associated with the sand-like agglomerated tailings from the vat leaching process. This redesign also uses more of the excess till at the site. This, in turn, reduces the size of the final till stockpile at closure. Likewise, keeping the acid producing waste in the pit eliminates the potential impacts from acid production.

As noted above, the initial design included a layer to increase the travel time to bedrock beneath the liner system. With the new design, it is estimated that it will take more than 5 years for the wetting front to pass through the till liner. Prior to this, the landfill will be closed and capped to virtually eliminate additional infiltration. Therefore, the travel time layer at this site is not necessary. It would be useful to retard unanticipated breaches in the till barrier. The potential for this is very remote considering the thickness of the layer and the stability of the till foundation material. Likewise, it could be argued that it would be better to observe any unanticipated seepage during the operation of the landfill when remedial steps can be taken to isolate the problem and mitigate the problem. In accordance with the Rules, the travel time layer was eliminated on the basis of the additional protection provide by the site and landfill design by the following:

- limited time of landfill operations (3.5 years)
- reduced hydraulic heads within landfill created by the installation of a leachate collection layer
- enhanced closure with installation of composite cap
- underlying fractured bedrock is not a significant receptor since the existing groundwater is already impacted by the ore body and the groundwater is not used as a water resources nor will it in the future

8.2 WASTE MINIMIZATION ALTERNATIVES

In development of the proposed mining plan presented in the application, procedures and techniques to minimize waste were evaluated in detail to reduce the potential environmental impacts of the project and to reduce the overall development and closure costs. This section described the options considered and incorporated to minimize waste.

8.2.1 Alternative Extraction Techniques

The biggest reduction in waste volume, compared to other mining plans discussed for the Bald Mountain Project, relates to limiting extraction to gossan layer. This greatly reduces the waste rock generation, thereby vastly reducing the overall environmental impact of the project. The shallow depth does not warrant the expense of underground mining techniques. In-situ mining is not feasible for hard rock applications and would have a high risk of impacting regional groundwater resources. As such, the proposed shallow open pit mine to extract the gossan ore has the least environmental impact.

8.2.2 Alternative Beneficiation Techniques

As mentioned above, other options were considered for beneficiation of the ore. Conventional milling would require a large water impoundment for tailings disposal. Heap leach process would produce more wastes, increase the volume of excess water, include cyanide containing fluids within the excess water, and create a larger waste area at closure. For these reasons, vat leaching process was selected, in part, for having minimal
environmental impacts.

Cyanide will be destroyed at the end of the mining operations using an SO_2 oxidation process as discussed in detail in the application. Other cyanide destruction processes were considered including natural degradation, alkaline chlorination, and hydrogen peroxide oxidation. Other processes not considered in detail include biological, acidification/regeneration, UV/ozone, and ion exchange. Natural degradation was eliminated from consideration due to the uncontrolled nature and unknown timing for this process. The other processes were much more involved, too complicated, and/or economically less favorable than the selected method for the Bald Mountain Project.

The vat leach process for the agglomerated ore is a net water user. Therefore, all cyanide process water can be recycled during operations. There is only a need to destroy cyanide at closure and only for the small volume of process water that remains at that time. The INCO process was selected based on its simplicity, ease of operation and construction, and economics.

8.2.3 Opportunities

Options for reusing waste materials at the site were evaluated in detail. The opportunities for this were limited due to the sulfur content of many of the materials. The following has been done to reduce the amount of waste material at the site:

- to reduce the size of the till/hangingwall waste rock pile
    * tailings landfill liner design has incorporated a thick layer of till
    * till will be used as a cover for the footwall and pit floor to reduce exposure of acid generating surfaces
    * inert waste rock from the hangingwall will be used to armor drainage ditches and further protect surfaces at closure
- to reduce the amount of exposed footwall rock
    * expending the operational effort to keep the footwall waste rock within the pit
    * placing the footwall waste rock against the exposed footwall and covering will till
    * flooding the pit at closure

Aside for these considerations, there were no other opportunities for reuse, in-mine disposal, sale, recovery, treatment/processing of mine wastes considering the small size of the mining operation and the types of waste materials produced by the mining operations.

8.3 WASTE HANDLING AND TREATMENT ALTERNATIVES

Various waste handling and treatment alternatives were evaluated as discussed in this section.

8.3.1 Tailings Deposition

The vat leaching process produces a dry, sand-like agglomerated tailings that will be trucked to the landfill, deposited, and spread in lifts. The most common disposal technique is the use of hydraulically placed slurried tailings. While the operational costs are less with this technique than with trucking the dry agglomerated tailings, the environmental impacts are significantly higher for several reasons. The volume of waste material (i.e. solids and fluid) is much larger. The space occupied by the agglomerated tailings is further increased due to the flat surface of the hydraulically placed material. The hydraulic tailings would require at least two to three times the footprint than proposed design. Likewise, there is very little opportunity to manage the size of the exposed tailings to reduce excess water balance and to closed portions while the processing plant is still in operation.

Seepage from the slurried tailings impoundment would be much higher that the dry agglomerated tailings due to the large hydraulic head on the liner system. The potential environmental risks are much higher due to the impoundment of fluid. Post closure maintenance would be more involved due to need to keep the impoundment flooded to help assure no acid generation of the reconstituted tailings. Future environmental risks would also be higher with the impoundment of a slurried, compressible tailings.

Based on the environmental benefits, the agglomerated tailings from the ore processing plant will be truck to the landfill and placed in individual cells of 4 acres or less and capping. The higher operational costs are compensated by the improvement in environmental protection provided by this alternative.

8.3.2 Waste Rock

The amount of waste rock generated during the mining operation is kept to a minimum by limiting excavation depth to the bottom of the gossan and by maximizing the pit wall slopes as allowed by the slope stability considerations. In addition, the access road has been relocated to the hangingwall on west side of the pit. This minimizes the amount of exposed footwall during the first two years of pit development.

For ease of pit operations, the waste rock was going to be removed and placed in either the till stockpile if it is hangingwall rock or the tailings landfill if it is footwall rock. This would required handling the rock only once. It would also assure that the rock is not in the way of the mining operations. With the proposed mining plan, the hangingwall rock will still be removed to the till stockpile, but the footwall rock will be stockpiled within the pit footprint. This requires that the footwall rock be re-handled several times during mining operations. However, this procedure will assure that any acid producing runoff during operations will be collected and handled with the other pit water. At closure, the rock will then be flooded to reduce post closure exposure. This procedure greatly reduces the exposure of footwall waste rock that creates the potential for acid generation.

8.3.3 Potential for Acid Generation

The current mining plan proposes to excavate from the northwestern portion of the mine in an easterly direction where the footwall rocks will be exposed. This proposed mining plan will help minimize the exposure of the majority of the footwall rocks until the last phase of mining. This plan will help to limit the exposure of the footwall rocks to atmospheric oxygen and help to minimize oxidation of the sulfide minerals in the footwall rocks.

During operations, acid generating footwall waste rock will be left in the mine pit area. At closure, this material will be placed against the footwall and covered with a layer of till to reduce oxygen exchange and the pit flooded.

8.3.4 Control of Excess Water

The water balance described in Section 5.2.4 indicates that an average of 58 gpm of excess water will develop at the site. This rate varies from 25 to 69 gpm. Various alternatives were evaluated to minimize the excess water at the site. These include:

- limiting open landfill cell development to small cells of 4 acres or less
- separating and handling upstream surface water by diversion ditches around the operation site
- keeping the operating site as small as possible
- staging mine development to limit the initial pit area to a minimal value
- reducing groundwater inflow into the mine pit by intercepting with upgradient dewatering wells or diverting around the pit area by grouting bedrock fractures

With the exception of the groundwater flow into the mine pit, all of these alternatives were adopted in the proposed design. Methods to reduce and control groundwater inflow into the pit that were considered include:

- upgradient groundwater intercepting ditch in till overburden

- upgradient bedrock relief
    - fracturing the bedrock trench
    - intercepting groundwater with collection wells
- drainage gallery in the upgradient bedrock discharging to local faults
- upgradient grouting of bedrock fractures

Based on this evaluation, it did not appear that these techniques were economically feasible nor technically reliable to reduce excess groundwater at the site. While the technology is available and well known, the effectiveness of these techniques is difficult to predict with any degree of reliability. As such, the effectiveness of these alternatives would not be known until they had been implemented at great expense. A review of the water balance indicated that excess water would still have to be handled in some fashion even if the groundwater flow could be eliminated. Considering this and the economic and technical challenges of these alternatives, attempts to intercept or divert groundwater around the mine is not proposed as part of the mining plan.

The potential for controlling groundwater can only realistically be evaluated during operations. As discussed in the application, if dominant seeps are encountered in isolated defined fractured areas or fault zones during operations, investigations will be made to evaluate the potential of intercepting this water prior to encountering the exposed footwall rock. Water collected upgradient of the pit will be discharged into the perimeter ditches as clean water and routed to the detention basins located downgradient of the mine. Alternatively, it may be possible to segregate seeps in the mine pit to separate acid from non-acid water quality. These alternatives will be evaluated during operations to further reduce excess water and reduce the loadings to the storage ponds and land application areas.

8.3.5 Treatment of Excess Water

Excess water is limited to groundwater and surface water collected in the mine pit and runoff from the process area. The water quality is expected to be reflective of existing groundwater conditions (WA.040, 1997). The excess water is expected to be somewhat acidic and contain elevated metals. To mitigate this, various treatment alternatives were evaluated and include but are not limited to:

- pretreatment using filtration and precipitation techniques
- full treatment alternatives including filtration, precipitation, ion exchange, and various polishing alternatives

- land application using:
    - * area north of the pit
    - * constructed wetlands
- use of manufactured and natural wetlands and/or peat for additional treatment

The water quality is already close to background conditions. Based on this analysis, there is no need for extensive treatment beyond buffering the pH, storing for a period, and discharging to a land application area (EE.010, 1997). Excess water will be detained in storage ponds located to the south of the facility on the opposite side of Bald Mountain Brook. During the growing season, water will be applied to a land application area located along Carr Pond Road. All other treatments were eliminated from consideration due to the unnecessary expense.

8.4 RECLAMATION ALTERNATIVES

At closure, the ore processing facility will be completely dismantle and placed in the landfill. The till stockpile will be graded to a uniform slope, topsoil placed on the surface, and mulched and seeded to promote vegetation. To limit exposure of acid generating rock, a layer of till will be placed on the bottom and against the footwall rock in the mine pit and the excavation flooded with water to limit exposure.

Backfilling the entire pit with till was considered. The environmental gain was determined to be marginal and prohibitively expensive. For this reason, this alternative was discarded.

When facility removal and site revegetation is completed, the area will revert back to natural appearance. Other alternatives would be less involved, less expensive, and more intrusive on the appearance of the site after the mine has shut down. To help minimize the long term impacts of the project on the environmental, complete removal of the mill facilities and enhanced capping of the landfill has been incorporated into the design.

8.5 SITING ALTERNATIVES

The mine pit are dictated by the location of the ore body. However, the siting of the processing facility, tailings landfill, and storage ponds have been done to limit wetland impacts to less than one acre. Likewise, the proposed layout of the site has been designed to avoid and minimize impacts to the greatest extent practicable by limiting site runoff from the area.

The tailings landfill has been sited to keep activities within the Bald Mountain Brook watershed, thus restricting any theoretical impacts to surface and ground water to a single watershed. An in depth search for landfill sites had been conducted by Superior Mining and Boliden Resources (S.017, 1982; S.242, 1990). These extensive reports are available for review upon request. With the exception of the selected site, other areas encroach upon the watersheds of other surface water bodies. The landfill area has reduced in size drastically with limiting ore extraction to the gossan and producing a sand-like dry agglomerated tailings. The smaller landfill size greatly reduces wetlands impacts and eliminates the need to impact surface water bodies as proposed with the large mine design.

The site has been selected to keep mine disposal, ore processing and waste disposal within one watershed. This focuses the concentration of operational and closure monitoring to one area. The landfill's location near the mine and processing facility assures that any unanticipated behavior which does not conform to the intended plan will be readily visible. As a result, remedial actions, if necessary, can be developed and implemented in a timely manner before variations from the plan impact the environment. Likewise, placing the landfill next to the other facilities allows for a unified reclamation plan concentrated in one area.

8.6 ASSESSMENT SUMMARY

Exclusive of the no-action alternative, Black Hawk has selected development processes and management techniques which have the lowest environmental risk during operations and especially during the closure and post-closure period. While a cyanide leach process is used to extract the metal from the ore, steps (described in this report and summarize here) have been incorporated into the mine plan to assure no release to the environment. All beneficiation takes place within a closed building. As a net water user, all process water can and must be recycled during the operations. Cyanide is drained and washed from the agglomerated ore prior to removal from the processing plant. At closure, the remaining cyanide will be destroyed with the INCO SO_2 process.

The ore is crushed and then agglomerated with lime and cement. This neutralizes acid producing potential of the tailings. As such, the agglomerated tailings are classified as a Group B waste. The material is a sand like material that will be trucked to the landfill and placed in a stable, relatively incompressible deposit. Any residual cyanide that may be present in the pore space of the tailings will be collected in the landfill leachate collection facility and recycled back to the plant for use as make up water. At closure, the landfill will be capped with a composite barrier which exceeds the minimum requirements in the Rules. This is done to assure no infiltration will occur during the post-closure period. At closure, the residual moisture in the tailings deposit will be collected, tested, and, if needed, recycled back to the process plant to destroy any residual cyanide.

Acid producing waste rock will remain in the mine pit at all times. During operations, runoff will be collected with the other groundwater inflow and routed to storage ponds and land application area for treatment and discharge. To minimize the potential for acid production, the acid producing waste rock will be placed against the footwall rock slope of the mine pit, buried in a layer of till, and submerged at closure.

Based on the ore processing system and waste management techniques, there is virtually no risk for process water to escape to the environment. The tailings will be encapsulated in a stable, incompressible deposit which has been capped with a composite barrier to eliminate infiltration. Acid producing waste rock remains in the mine pit during operations and is buried and submerged under water at closure.

With these steps, the risks to public health and the environment have been minimized by selecting the ore processing method, reagent alternatives, and waste management techniques which have the lowest possible impact, if any, on these receptors.

STATE OF MAINE
DEPARTMENT OF ENVIRONMENTAL PROTECTION

ANGUS S. KING, JR.
GOVERNOR

EDWARD O. SULLIVAN
COMMISSIONER

June 23, 1998

James Hendry
Vice President, Mining
Black Hawk Mining Inc.
95 Wellington Street West, Suite 2000
Toronto, Ontario M5J 2N7

Re: NNM Resources, Inc., Bald Mountain Gold Project

Dear Mr. Hendry:

This letter follows up on our conversation at the May 20, 1998 meeting regarding potential "fatal flaw issues" for the Bald Mountain Gold Project. During the meeting you requested a list from the Department that details the issues that may present significant obstacles for your company to overcome in the permitting process. None of these should come as a surprise as they have been noted to Black Hawk and its consultants in the past.

First, we are concerned about the elevated levels of arsenic associated with the ore deposit. According to your waste characterization report, "The tailings from the vat leach operation, when deposited in the landfill, are predicted to release large quantities of arsenic during periods of active infiltration and seepage." "Reductions in arsenic concentrations overtime has not been observed." We are aware of the fact that the quality of groundwater directly below the ore deposit indicates high levels of arsenic. Since no treatment mechanisms for arsenic is proposed in your application, we are concerned that the existing groundwater quality in the vicinity of the mine site will be further degraded by the concentrations of arsenic in the tailings landfill.

Second, we have reservations regarding the post-closure water quality of the mine pit. In your application you state that the final pit water quality will be similar to the existing groundwater quality in the ore deposit. Since a majority of the water entering the mine pit during the final phases of operation will be through the reactive footwall rocks, it seems reasonable to expect that the pit water quality will be lower than initially predicted. We are in agreement that the post-closure water quality of the mine pit will not be that of pristine surface water. Pursuant to the Metallic Mining Rules, the Department and LURC can set performance requirements based on naturally occurring background concentrations. However, if the water quality in the mine pit deteriorates substantially below background levels, this impact would negate our ability to make a positive finding of no adverse environmental impact in the permitting process.

Third, is our concern regarding the drawdown of water levels in the cedar swamp located below the mine site. In your failure analysis, you indicate that a water level drop of 8 feet may occur in the wetland due to the dewatering activities at the mine pit. Although your dewatering activities at the mine pit are temporary in nature (less than 3.5 years), it may substantially affect the wetland characteristics of the cedar swamp. It is imperative that the dewatering operation be further evaluated to determine the magnitude and duration of any potential impacts to the wetland.

As I stated to you during our meeting, we do not consider our engineering review comments to be fatal flaw issues. I am confident that Black Hawk can readily address these issues by submitting the additional design information requested in our March 31, 1998 letter.

We strongly recommend that we discuss the above referenced key concerns, as well as any other outstanding issues, of Black Hawk's proposed gold project as soon as possible. If you have any questions, please feel free to contact me.

Sincerely,

Mark Stebbins

Mark Stebbins
Mining Coordinator
Bureau of Land & Water Quality

cc. J. Madore, MDEP
Brooke Barnes, MDEP
M. Kirkpatrick, MDEP
J. Williams, LURC
C. Varney, LURC
R. Wardwell
D. Martin, Aroostook County Commissioners

J.S. Cummings
7043 Surfside Lane
Grand Prairie, TX 75054

September 7, 2012

Open letter to: Representative John L. Martin
STATE of MAINE, HOUSE of REPRESENTATIVES
Augusta, ME 04333

Re: The Bald Mountain matter

Dear John:

Since your submittal of LD 1853 in March of this year I have tried, without success, to communicate with the current owners of mineral-rights at Bald Mountain (i.e. J.D. Irving Ltd of Canada and Prentiss & Carlisle of Bangor). As you are a public servant and also have played a role on behalf of the Irving group in Maine, I am addressing this letter to you with copies to interested parties.

SECTION 1 - Executive Summary

(A) During the ballyhoo following your submittal of LD 1853, the failure of you and the Irving group to even mention my name during comments to the general public and/or the press, is inexcusable. After introducing LD 1853, you and the Irving group played-up the great benefits that the Bald Mountain Deposit could bring to Aroostook County. It is evident that without invoking the Bald Mountain Deposit, LD 1853 would have been on life-support. The complete blackout of my name in comments and statements by you and Irving personnel with regard to the Bald Mountain matter has caused me emotional distress and diminished my hard-won reputation in the field of metallic resources.

(B) In a pre-production, color brochure (circa 1981) titled: MAINE'S BALD MOUNTAIN PROJECT, the corporations funding my exploration (The Superior Oil Company and The Louisiana Land & Exploration Company) stated on page 4 that a thirteen year search by the Maine firm J.S. Cummings, Inc. has resulted in the discovery of the Bald Mountain Deposit. On January 7, 1980, you signed, as Speaker of the House, a declaration by the MAINE SENATE and HOUSE of REPRESENTATIVES recognizing me for the Bald Mountain discovery.

(C) From what I read in the press it appears that the Irving group's mining plan for the hard-rock deposit at Bald Mountain follows the prior mind-set: mine it by open-pit.

(D) The Bald Mountain hard-rock deposit SHOULD NOT be mined by open-pit.

(E) Mining the hard-rock Bald Mountain deposit by open-pit would result in extracting millions of tons of rock containing paltry amounts of copper and zinc and millions of tons of barren waste rock.

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(F) Mining the hard-rock deposit by open-pit greatly increases the likelihood of serious environmental problems, particularly those related to the tailings-pond.

(G) It appears that on the order of 60 to 90 percent of the copper available in the envisioned hard-rock open-pit, might be obtained from compact, high-grade, underground operations.

(H) The porphyry system of ore-deposit delineation, employing dominantly vertical-holes, was engendered shortly after discovery and approved by later parties. Such has resulted in a failure to specially define the grade, tonnage and configuration of the high-grade, eastern copper zone, the western copper zone, and the central, high-grade zinc zone.

(I) Numerous drill holes in the eastern copper zone belie the notion that Bald Mountain contains only low-grade copper. Three parallel angle-holes that were designed by me, before the porphyry experts took over, show numerous intercepts in excess of 6% copper, and one hole (BM 29) showed numerous intercepts varying from 11 to 15% copper.

(J) Analysis of total footage of vertical-holes versus total footage of angle-holes within the eastern copper zone reveals that for a defined minimum footage and a defined minimum percent copper, approximately 30 percent more high-grade zones would be evident if the footage employed in the vertical-holes had been employed as angle-holes.

(K) A vertical shaft or incline with underground crosscuts or drifts would be required to delineate the tonnage, grade and configuration of the eastern copper zone. If successful the same thing should be done in the western copper zone and the eentral zinc zone. with the objective being to mine such zones by underground methods.

(L) The text within SECTION 3 lays out minimum technical data to support the foregoing.

(M) The soft-rock gold-silver gossan, with a gross dollar value of at least $200 million (allowing for a 20% decrease in Au-Ag prices) should yield a very high 'net', probably in the range of 40 percent in consideration of low-cost mining and treatment. Proper mining would allow the natural overburden (excepting gossan) to be redistributed over the exposed bedrock if the hard-rock open-pit scenario is not employed.

SECTION 2 - Significance of J.S. Cummings metallic resource efforts in Maine

There was much posturing by both corporate and government officials in the late 1980's and early 90's with regard to the Bald Mountain matter. However, the only written documentation as to the ineptness, of both government and corporate entities, which led to the descent of Bald Mountain and the demise of tens of millions in exploration expenditures, is contained in my brief book: *Metals in the Maine Earth,* Cummings, J.S., 2008 - URSUS), a copy of which I mailed to you in 2008. The last sentence on the last page of text (p.44) states:

> *The historical evidence (1991-2008) establishes that Maine's metallic mining regulations represent a 'de facto' ban on metal mining in the state and thus such regulations should be expunged.*

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To say the 1991 regulations needed to be 'expunged' is not to say that metallic mining regulations were not needed. To my knowledge I am the only person that ever stated in writing that the 1991 rules were a 'de facto' ban on mining. If you had previously put forth such a judgment in writing, I am unaware of such. Such entities as the Maine Geological Survey and the UMO geology department have been 'blind' to the eradication of metal-exploration that followed the passage of the 1991rules. Then, 'out of the blue' in March of 2012 you shocked many in the state with your apparently original proposal as submitted to the legislature. The old rules were not 'just' amended by LD 1853, but in line with my words 'expunged' (your words "...to replace current mining law ...").

Bald Mountain was just one of numerous potential treasures that I discovered. Although the Bald Mountain Deposit has received the bulk of attention, my discovery of the Ledge Ridge Deposit in the early 1970's (Cummings, J.S., 1988, pgs. 234-256 – URSUS) in the western interior is as notable from the standpoint of successful exploration strategy as is Bald Mountain. The same can be said of my post-Bald Mountain discovery of the CL Deposit, located close by the Bald Mountain Deposit. Such discoveries resulted from an innovative geochemical and geologic system, as standard prospecting procedures could never have discovered these concealed deposits.

Any thinking, that had I not found the Bald Mountain Deposit in1977, another entity would have discovered such in the last few decades, reveals a lack of knowledge on the subject. During the 1960's the Maine wildlands were a 'hotbed' for metal exploration, but by 1972 all had given-up on northern Maine (e.g. Exxon, Texaco, Kennecott, Anaconda, American Metals, ASARCO, etc., etc.) without so much as finding even a 'poor' metal prospect. Prior to my explorations in northern Maine, Exxon (a.k.a. Humble) held a mineral lease on the ground where I eventually found the Bald Mountain and other metal deposits.

At the Maine Geological Survey (MGS) one may find a so-called history of metal activity in the state, but that rendition is clearly tainted. From the early1960's until the discovery of the Bald Mountain Deposit in the late 1970's, the MGS treated me as a 'pariah' as I was a vehement critic of their metal investigations and policies. This adversarial relationship brought me close to the 'brink' only months before the Bald Mountain discovery. If you doubt the foregoing you should contact former Commissioner of Conservation, Richard Barringer.

During the early 1970's, at which time all metal exploration corporations (large and small) had abandoned northern Maine, two of my three remaining 'backers' pulled-the-plug. Superior Oil, was adamant that they would not support my program on a 'solo' basis. J.S. Cummings, Inc. was one step from bankruptcy when I secured the Louisiana Land & Exploration company (LL&E) to go partners with Superior

In 1974, as a result of my recommendations. Superior and LL&E obtained mineral-rights leases on extensive acreage in northern Maine, including the as yet undiscovered Bald Mountain Deposit. At that time the woodlands in the Bald Mountain area (T 12 R 8) were owned by Great Northern Paper Co. and Prentiss & Carlisle of Bangor. My royalty rights, for discovery of valuable minerals in the areas where Superior and LL&E obtained leases on mineral-rights are contained in an agreement with Superior and LL&E dated January 1, 1974. These royalty rights passed to and were accepted by Chevron, Boliden and Black Hawk. (Black Hawk was never a 'player'. See page 42, Cummings, J.S., 2008. *The Boliden – Black Hawk Charade).*

About six months after discovery, Superior (SMC), by prior agreement, assumed control of mine development, and in conjunction with prior JSC drilling, completed plus 200 holes. I continued exploration beyond the perimeters of the potential mining zone and served on the pre-mining committee. The groups that followed SMC - LL&E (i.e. Chevron Minerals and Boliden Mining) did

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minimal orebody delineation by physical means, instead, concentrating on such things as metallurgy, tonnage-grade calculations, plant design and state mining regulations. These post-discovery efforts did not enhance or diminish the basic Bald Mountain model developed in the period 1978 to 1982.

At the time that the 1991 rules were passed you must have been aware, as Speaker of the House, that such were the rules-to-nowhere. These rules not only eviscerated metal exploration, but signaled to the mining companies that you will never be able to 'mine metal' in the State of Maine. My 'technical' loss of 'royalty' rights is tied to the passage of the 1991 rules and the fall-out resulting from such.

As I did not receive advance notice from the last Lessee that the Bald Mountain mineral - rights were being relinquished to the landowners (clearly as a result of the 1991 rules), I did not have the opportunity to solicit funding to establish a new group which could have maintained the Lease until the 1991 rules were expunged. This would have prevented the mineral-rights from reverting to the landowners. Thus my royalty rights were abrogated both as a result of legislative action and unethical actions by the last two Bald Mountain Lessees.

The foregoing is pertinent and belies the notion that a series of groups acquired and then periodically released the Bald Mountain mineral-rights back to the landowners. I held royalty rights on Bald Mountain and other sites for approximately 26 years. Because of the 1991 rules, the mineral rights lease at Bald Mountain and other areas were eventually surrendered to the landowners, as it was perceived (correctly) that no company would ever be able to mine metals in Maine as a result of those rules.

Had it not been for the 1991 rules, at this time the Irving group, which acquired the Bald Mountain mineral-rights as a result purchasing GNP lands in northern Maine, would be subject to the original Lease executed by Superior and LL&E and subsequently passed on to Chevron, Boliden and Black Hawk. Such would have put the Irving group in the position of Lessor.

Had you sought to do in 1991 what you have recently done for the Irving group, my royalty rights would be intact.

As a Maine native I spent most of my adult life trying to bring Maine's potential metallic resources out of the dark ages, only to find that those who seek to profit from my struggle and sacrifices, have shunned me. However, such persons cannot 'undo' my numerous discoveries nor the fact that I wrote the book on 'how to' successfully explore for metal deposits in the state, (*Geochemical detection of volcanogenic massive sulphides in humid-temperate terrain* - Cummings, J.S., 1988, 298 pgs. - URSUS). It is pertinent to my story to note that during the 'long haul', neither I nor my company ever received a 'penny' in the form of grants, contracts, etc, from either the State of Maine or federal agencies.

Your role as a longtime prominent public servant in the State of Maine and one who is familiar with the Bald Mountain past, causes the omission of my name during the LD 1853 scenario, to be doubly disturbing. Following submittal of LD 1853, you invoked the Bald Mountain Deposit, citing the potentially great economic benefits to Aroostook County if the rules were changed. Without invoking the Bald Mountain Deposit, it is certain that LD 1853 would have met a rapid demise.

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SECTION 3 - Conceptual and empirical failure of the mining-model for Bald Mountain

It appears that if the Irving group proceeds and acquires the necessary permits, they intend to mine the hard-rock copper-zinc concentrations at Bald Mountain by means of a large open-pit. This scenario is a prescription for a debacle, meaning either that the permits may never be granted, or if such are granted then undoubtedly there will be unwanted environmental problems down-the-road. If the Bald Mountain mass were viewed within its genetic - empirical constraints and developed within those constraints, some of the most harsh environmental criticisms would be partially or completely ameliorated.

During the discovery period (through drill hole 43), Superior had been a constant critic of my angle-hole pattern. As a result, at the time SMC took over the development program a vertical-hole regimen was instituted. That mind-set has persisted over the decades. The vertical-hole regimen did not signal that angle-holes were never drilled, rather such meant that vertical-holes were the norm. SMC's president had come from a porphyry copper background in the southwestern U.S. where the vertical system was a foregone conclusion.

There is no problem with a vertical-hole regimen as long as one is dealing with porphyries or gently dipping or flat-lying systems. However, genetically the Bald Mountain Deposit, which is classed as a volcanogenic massive sulphide (VMS), is far removed from a porphyry copper system. In VMS types of deposits, layers, bands, or masses of metals of variable configuration may have a wide variety of attitudes, from gently dipping to vertical. It is easy to visualize the problem if one tried to determine the configuration and tonnage of a series of narrow, vertical or near-vertical ore masses by using vertical holes.

Prior investigations have indicated that approximately 33 million tons of the sulphide mass contains approximately 1.1 -1.3% copper and approximately 1.0 % zinc. If the copper-zinc minerals were spread more or less uniformly throughout the sulphide mass, one might make a case for a hard-rock open-pit mine at Bald Mountain. However, there is at least one zone of very high-grade copper and another of modest grade, in addition to a high-grade zinc zone. Such means that millions of tons of rock that were included in the calculated average-grade for the projected hard-rock open-pit, (i.e. pre Irving) contain paltry amounts of copper and zinc.

The sulphide mass that would be extracted by hard-rock open-pit mining is made up of iron-sulphide minerals that contain approximately 40 to 53% sulphur, exclusive of copper and zinc sulphide minerals. Tonnage showing copper &/or zinc levels above the cut-off grade would be subject to grinding and milling, with tonnage below the cut-off grade going to the waste-rock storage area. In addition to the above, another 10 to 15 million tons of perimeter hard-rock would be mined to enable the pit to expand with depth. Such would also go to waste rock storage.

If the deposit were subjected to hard-rock open-pit mining similar to the scenario noted above, then approximately 94% of the sulphide mass that was subject to grinding and milling, (i.e. 31 million tons of high-sulphide slurry) would go to the tailings-pond, with the remaining 5- 6% (plus or minus) going into the concentrate for sale to a smelter.

Recovery rates, that is the percentage of copper &/or zinc that ends up in the concentrates (i.e. for sale to a smelter), are highly variable. Regardless of the average recovery rates determined by prior investigators, there is little doubt that recovery rates for low-end grades would be poor.

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As a result, undertaking to mine the large, low-grade sulphide mass by means of a hard-rock open-pit at Bald Mountain would require a vastly larger tailings-pond than would be required if a few restricted zones, showing much higher copper-zinc values, were subjected to underground mining.

The Bald Mountain sulphide mass has been considered by prior investigators to have a shallow dip or plunge to the southwest. However, this simplistic picture is refuted by drilling and my research as summarized in Figure 7-7, page 230, Cummings, J.S., 1988 – URSUS).

My pre-drilling analysis suggested that the sulphide layers in the eastern copper zone had a northerly strike and very steep (possible vertical) dips to the east. Hence the locations, bearings, and dip of holes BM 21, 27 and 29.

Figure 7-7 reveals the absurdity of employing a regimen of vertical-holes within a clearly zoned, often steeply dipping copper-zinc VMS deposit. The sinuous lines shown on the drawing represent points of equal zinc/copper ratios for the entire thickness of the sulphide mass. It is clear from my research, as shown on Figure 7-7, that the sulphide is banded or layered, and complexly folded, probably as a result of soft sediment deformation. Figure 7-7 eliminates any thought that the large, thick sulphide mass dipped uniformly and gently to the southwest.

Bands or layers that were horizontal or gently dipping would not show definitive zinc-copper pathways which represent the strike of these layered units. Such is emphasized by the large double fold portrayed in the drawing on page 230. The distinctive banding shown in the central portion of the drawing results from the rapid change in Zn/Cu ratios, such revealing the steep dips of these bands or layers. In the eastern part of the drawing, where the zinc/copper lines are widely spaced, there is virtually no 'change' in Zn/Cu ratios, such resulting from the fact the zinc content in the eastern copper zone is 'nil. Thus holes in this area show uniformly, extremely low zinc/copper ratios throughout the thickness of the mass.

On page 223 (Cummings, J.S., 1988) I noted :

> *It is considered (herein) that most of the high-grade Cu zones have steep or vertical dips (Sec. 72.6), as a result, pre-mining investigations, employing only vertical holes, did not result in effective delineation of the high-grade zones.*

As noted, three of the better copper holes drilled at Bald Mountain were early-stage, parallel angle-holes 21, 27. & 29) which I designed. Of those three holes, BM 29 is the best copper hole drilled at bald Mountain, showing 325 ft. of 5.0% copper. Angle hole BM 5, which I also designed is the best zinc hole drilled at Bald Mountain.

The foregoing confirmed my suspicions (and evidenced by Figure 7-7 and holes 21,27 &29) that in many portions of the sulphide mass we were dealing with zoned or layered metal horizons often having very steep dips (i.e. 75 to 90 degrees). Using total footage of vertical and angle holes in the eastern copper zone, and calculating the footage x % copper for minimum 5 ft intercepts showing a minimum 5% copper, my calculations show that if all of the vertical footage had been employed as angle-holes in the eastern copper zone, then there would be approximately 30 percent more high-grade copper intercepts (i.e. plus 5% Cu, plus 5ft) than presently known in the eastern copper zone.

Within this type of VMS deposit, uniformity or continuity of ore intercepts is not the norm. Rather it is expected that metal-bearing zones in the eastern copper zone would show numerous high-grade copper intercepts dispersed through tens or hundreds of feet. If subjected to proper exploration the eastern copper zone might be found to contain millions of tons of 5 to7% copper, plus possible gold and silver values. My analysis of the nature of the western copper zone, which may contain a significant tonnage of 3% copper, also suggests the need for underground exploration due to the nebulous copper pattern.

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Clearly, the eastern copper zone should be the focus of underground exploration (e.g. shaft, incline, drifts, etc) prior to considering a hard-rock open-pit plan for the entire deposit, particularly in view of the vastly larger, high-sulphide tailings pond that would result from the hard-rock open-pit. An additional environmental 'positive' that could result if it was found that underground mining could be economically undertaken, would be the likelihood of recycling some of the waste rock to underground storage.

As noted, the hard-rock open-pit scenario that has been espoused for the Bald Mountain Deposit would result in approximately 94% of the mined sulphide mass going to the tailings-pond in the form of a high-sulphide slurry. Experts from the western U.S. will undoubtedly state that tailings-ponds associated with open-pit porphyry deposits are much larger than the tailings-pond that would result from open-pit mining at Bald Mountain. However, what those experts won't tell you is that the tailings from most porphyry deposits contain only a tiny fraction of the sulphides that would enter the Bald Mountain tailings-pond. Often, porphyry tailings consist of simply finely pulverized rock.

Calculated mining costs per ton would be 'higher' for an underground operation than for an open-pit. However, the potential problems (dams, landslides, berms, floods, subsurface fractures, faults) that might affect a large high-sulphide tailings-pond in a region of significant rain and snowfall and irregular topography, do not preclude the possibility that ultimate underground mining costs might be lower per ton than for a large hard-rock open-pit operation.

SECTION 4 - Soft-rock gold-silver open-pit

As noted the soft-rock gold-silver gossan should yield a very high 'net' (dollars) even accounting for a significant drop in Au-Ag prices. This would result from low-cost mining of unconsolidated overburden and gossan. This open-pit would be similar to a large gravel pit and would not entail mining of hard-rock. Proper mining of the gossan should allow the natural overburden (excepting gossan) to be redistributed over the exposed bedrock, assuming that the plan for a huge, hard-rock open-pit had been dispensed with.

Yours truly,

c: Interested parties

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J.S. Cummings
7043 Surfside Lane
Grand Prairie, TX 75054

May 10. 2013

Representative Jeff McCabe
State of Maine House of Representatives
Augusta, ME 04333

Dear Representative McCabe:

I read with interest a BDN summary (5/13)/pertaining to a hearing on L.D. 1302.

I'm sure you will be interested in the attached copy of a seven page certified letter which I sent to John Martin on September 7, 2012. Martin refused to sign for the letter so the post-office returned such to me. Nevertheless, I received 'positive' comments from dozens of persons to whom I sent copies.

The BDN article noted that you mentioned the Callahan open-pit and ensuing super-fund matters. The Callahan zinc-copper deposit was <u>miniscule</u> in size compared to the Bald Mountain copper-zinc deposit. For example total tons mined at the Callahan site were approximately 800,000 *(Cummings, J..S., 1988, p.49 – Geochemical Detection of Volcanogenic Massive Sulphides in Humid-Temperate Terrain – URSUS).* On the other hand, tonnage available for open-pitting at Bald Mountain would vary from 34,000,000 to 40,000,000 tons, or 42 to 50 times the tonnage mined at the Callahan deposit.

Simply from the standpoint of extractable tonnage, an open-pit at Bald Mountain presents potentially greater risks to the environment than the Callahan deposit. However, as noted in my letter to Martin, such risks are compounded by the fact that approximately 94% of the high-sulphide tonnage (i.e. 32 to 36,000,000 tons) would be relegated to the tailing-pond as high-sulphide slurry.

As if the foregoing were not enough to cause concern as to an open-pit at Bald Mountain, there is the <u>arsenic</u> problem. Some articles in the press have mentioned high levels of arsenic in some waters at the Bald Mountain site. However, to my knowledge no one has informed the public or the legislature that the <u>arsenic content of the sulphide mass is extremely anomalous</u>. The following reference to Bald Mountain drill core is quoted from page 139 *(Cummings, J.S., 1988 – URSUS):*

> *Assay data on a suite of ten massive sulphide intercepts showed arsenic (As) contents varying from 1258 ppm to 29,155 ppm (2.91%).*

Thus, the tens of millions of tons of high-sulphide slurry relegated to the tailings-pond would contain very high levels of arsenic. These extremely high arsenic contents are representative of the Bald Mountain mass and are far higher than massive sulphides in general, as my Ledge Ridge discovery (approx 160 miles southwest) showed arsenic levels of only 10 to 15 ppm.

Yours truly

c: Interested Parties

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