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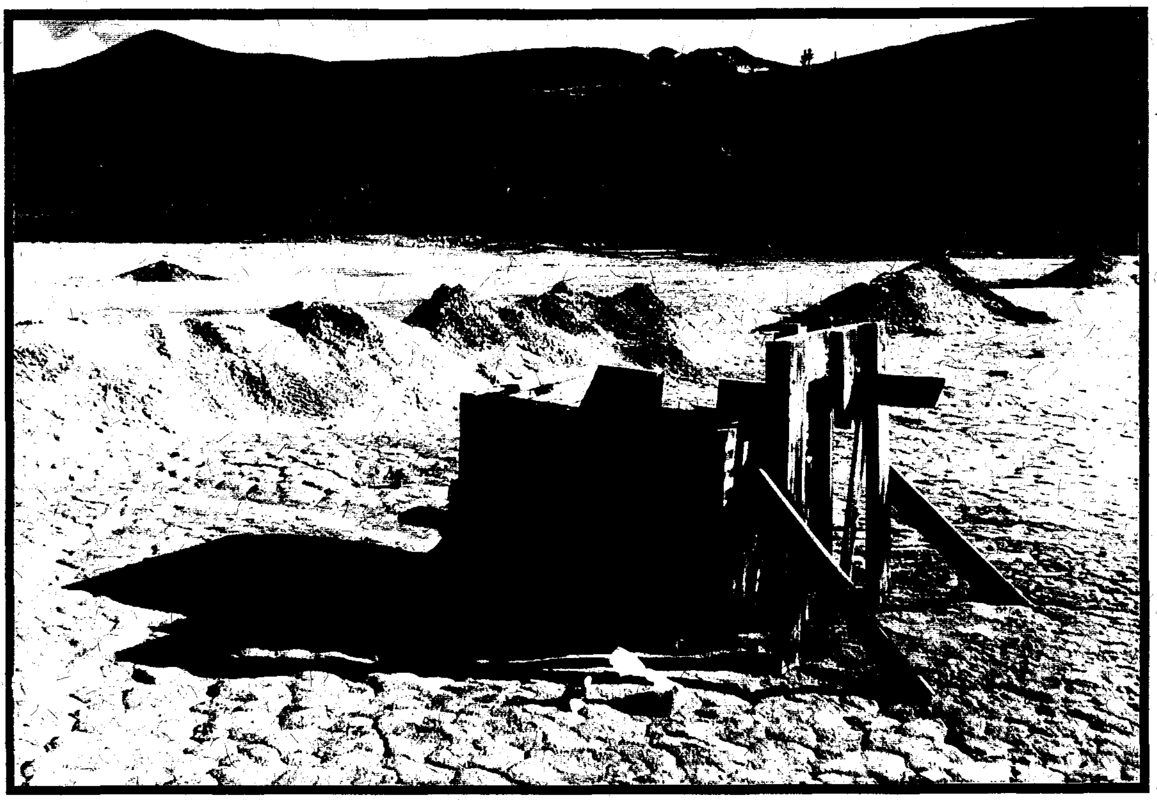
Quality in Environmental Services

PHASE III ENVIRONMENTAL ASSESSMENT OF THE ARCTIC GOLD & SILVER

MILL AND TAILINGS IMPOUNDMENT



prepared for:
Waste Program
Indian and Northern Affairs Canada
Whitehorse, Yukon

prepared by:
Environmental Services
Public Works and Government Services Canada
Western & Northern Region

March, 1998

Public Works and Government Services Canada
Travaux publics et Services gouvernementaux Canada

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EXECUTIVE SUMMARY

A phase III environmental assessment was conducted at the Arctic Gold and Silver abandoned mill and tailing impoundment site (60° 08' 00"N, 134° 43' 20"W) in August, 1997 by Environmental Services, Public Works and Government Services Canada for the Action on Waste Program, Indian and Northern Affairs Canada. The pupose of the assessment was to a) identify potential environmental and human health risks associated with the present condition of the mine site, and if required b) provide recommendations for remediation of those risks.

A field investigation of the mill and tailings site was conducted to evaluate these concerns with respect to site specific features such as: mine openings and workings; buildings and infrastructure; waste disposal areas; waste rock disposal areas; tailing impoundments, surface water (including adit and waste rock seepage, and receiving waters); and hazardous and non-hazardous materials on the site.

The results of the investigation concluded that The tailings in the Arctic Gold and Silver impoundment are currently generating acid, and are discharging low pH seepage into a small lake adjacent to the impoundment. The seepage contained significant metals concentrations. A small fan of reddish-brown sediment has formed where the seepage enters the lake, and analysis of lake waters collected in this area indicate that the seepage is impacting the lake water quality. The west side of the tailings impoundment does not appear to be of adequate strength or height to act as a long-term retainment structure. A small breach exists in the berm at the north end of the impoundment. Suitable borrow material is present adjacent to the site. The load-out ramp at the north end of the impoundment shows signs of decay in the log cribbing supporting the west face. Numerous pieces of abandoned equipment lay scattered throughout the site. As well, foundations, wooden structures and concrete pillars lie exposed.

Using applicable federal and territorial criteria as well as northern mine reclamation guidelines, the recommendations are:

1. Action should be taken to reduce or eliminate drainage from the tailings. A low permeability cover should be placed on the pile to reduce infiltration. The cover should be contoured to shed water and ensure that precipitation does not pond on the pile surface. Although there was no evidence of seepage or impact to the surrounding soil from the small ore piles, these piles should be removed. If the tailings are to be reclaimed, the simplest solution would be to dispose of the waste on the tailings before the tailings are covered. Metal rich sediment deposited in the small lake, as well as material deposited along the seepage drainage path between the impoundment and the lake, should be excavated and placed on the impoundment before covering.

2. It is recommended that berm repairs be made to restrict further lateral migration of the tailings from the breached section of the berm and to provide enhanced stability to the west section of the berm. The load-out ramp should be leveled and used as berm/cover material. This can be done in conjunction with the reclamation work done on the tailings.

3. It is recommended to proceed with a ground truthing and test pitting exercise in order to verify the quality and quantity fine grained borrow material prior to further design consideration.

4. It is recommended that a hydrogeological assessment be carried out prior to site reclamation in order to determine the ground water contribution to the tailings impoundment.

5. It is recommended that the mill foundations and pillars be demolished to grade and possibly buried on-site. The building be demolished and burned on site. The wood waste can be burned and metal should be collected and disposed at a suitable nearby landfill. The loadout facilities should be dozed and the areas restored to the original slopes by dozing. The trailer should be relocated and salvaged by a local interested party. These activities can be accomplished using locally available resources and labour.

Table 1: Summary of Potential Hazards at the Arctic Gold and Silver Mill and Tailings Impoundment Site

ASSESSMENT COMPONENT	RISK	RECOMMENDATION
1. Building, Infrastructure, and Equipment		
Mill Foundation/pillars - concrete	Aesthetic concern	Leave as is
Loadout ramp	Health and safety concern	demolish
Building - wood	Health and safety concern	Burn and bury ashes on site
Trailer - steel	Aesthetic concern	salvage
Derelict vehicles and assort. Industrial debris	Aesthetic concern	collect and dispose off site
2. Hazardous Materials		
no hazardous materials observed		
3. Water Quality		
Tailings seepage	Significant environmental risk	Tailings impoundment reclamation
Receiving Waters - Unnamed Lake	Potential environmental risk	Tailings impoundment reclamation
Adjacent stream	No significant environmental risk	Hydrogeological assessment to determine groundwater flow into impoundment
4. Waste Rock Disposal Areas		
2 ore piles	No significant environmental risk	Incorporate into tailings impoundment (if reclaimed)
5. Mine Openings		
no mine openings observed		
6. Tailings		
620,000 m^3 of ARD generating tailings, mine water discharge to lake	Significant environmental risk	Tailings impoundment reclamation

1.0 INTRODUCTION AND BACKGROUND

In 1993 assessments of 49 abandoned Yukon mine exploration and development sites were completed under the Arctic Environmental Strategy - Action on Waste program by DIAND Technical Services. These assessments were intended to: provide a general overview of historical activities; describe site infrastructure, workings and wastes; describe existing environmental or safety concerns on each site; and provide general recommendations for remediation and/or mitigation work, as appropriate.

Not assessed in the 1993 program was the Arctic Gold and Silver mill and tailings impoundment site. Records indicate that the Arctic Caribou and Big Thing exploration sites, which were assessed in 1993, went into production in 1968 where ore was milled for two years and 50,751 tonnes were treated and tailings deposited at the Arctic Gold and Silver site (Minfile 105D 009).

In light of this information, Indian and Northern Affairs Canada has determined that an investigation is warranted. Environmental Services, Public Works and Government Services Canada was retained to conduct an environmental assessment of the Arctic Gold and Silver mill and tailings impoundment to a) identify specific environmental and human safety risks; and b) provide clean-up recommendations.

1.1 LOCATION

The Arctic Gold and Silver mill and tailings impoundment is located at 60° 08' 00"N latitude and 134° 43' 20"W longitude (Figure 1). It is located approximately 4 km south of the village of Carcross on the road to both the Arctic Caribou and Big Thing mines.

1.2 OVERVIEW OF SITE DEVELOPMENT

The ore deposit that eventually came to be called Arctic Gold Silver Mines Ltd. was discovered in 1905 and was worked extensively until the mid 1920s. In 1964 the owners re-investigated the property and initiated a drilling program which culminated in the construction of a mill, with the mine going into production in mid-May, 1968. Between then and October, 1969, the mill and mines were operated intermittently. A basic flotation process was employed, without the use of potassium cyanide for gold extraction, and the sulphides were collected for shipment.

Reserves at the end of 1967 were 231,336 tonnes averaging 23.3 g/tonne of Gold and 675.4 g/tonne of Silver. 50,751 tonnes were treated before the mill closed due to unsatisfactory recoveries.

Figure 1. Location of Arctic Gold & Silver Mill and Tailings Site - 1:50,000, NTS- 105 D/2 [Energy Mines and Resources Canada: 1986]

2.0 PURPOSE AND SCOPE OF WORK

The following assessment activities were completed:

- Inspection of mine openings and workings, buildings and infrastructure, and waste disposal areas;
- Photo documentation and mapping of relevant site features;
- Sampling of waste rock disposal areas, stained soils, surface water (including adit and waste rock seepage, and receiving waters) and barrel contents;
- Identification and inventory of hazardous and non-hazardous materials on the site;
- Identification of potential or actual environmental pathways and receptors for site contaminants; and
- Assessment of human safety hazards and potential for accidental or deliberate access to hazardous areas.

Upon completion of these activities, recommendations were generated to meet the following remediation/mitigation requirements:

- Physical stabilization of waste rock disposal areas;
- Chemical stabilization of the waste rock disposal areas as appropriate to local and background conditions, taking into account impact, on-site resources, and accessibility;
- Sealing of all mine openings;
- Consolidation and landfill of all non-hazardous, non-combustible solid wastes;
- Remediation or removal and disposal of contaminated soils as required to meet the more stringent of: Yukon Government's Contaminated Sites Regulations (1996) Schedule 1; and Canadian Council of Ministers of the Environment's Interim Canadian Environmental Quality Criteria for Contaminated Sites (1991) Commercial/Industrial criteria for soils;
- Removal and disposal of hazardous solid wastes;
- Draining, cleaning and disposal of drums or other containers containing petroleum products or other liquid hazardous wastes;
- Onsite flaring or removal and off-site disposal of petroleum products and other liquid hazardous wastes; and
- Demolition of buildings and infrastructure to foundation level and burning of combustible non-hazardous materials in approved location.

3.0 SITE ASSESSMENT METHODOLOGY

3.1 Assumptions

The assessment was limited to the area specifically developed or occupied for exploration or mining purposes, and adjacent areas and resources believed to be affected by these activities. Water samples were taken off-site to determine potential impact to surface water bodies due to mining activities. Access roadways to mine sites were not included in the assessments.

3.2 Assessment Criteria

3.2.1 Criteria and Guidelines

Contaminated Sites Regulations (draft) (Yukon Government, 1996)

According to these draft regulations a site is contaminated if it is used for agricultural, commercial, industrial, parkland, or residential land use and contains a substance in concentration greater than or equal to:

(I) the generic numerical soil standard of Schedule 1, or
(ii) the matrix (pathway specific) numerical soil standards of Schedule 2

and, surface or groundwater used for aquatic life, irrigation, livestock, or drinking water which exceeds a concentration greater than or equal to:

(I) the generic numerical water standard of Schedule 3, or
(ii) the local background concentration of that substance in the soil, surface water, or groundwater.

Below 3 m of the surface, commercial land use criteria is applicable.

Interim Canadian Environmental Quality Criteria for Contaminated Sites (Canadian Council of Ministers of the Environment, 1992)

The Canadian Council of Ministers of the Environment (CCME) Interim Canadian Environmental Quality Criteria for Contaminated Sites are numerical limits for contaminants in soil and water intended to protect, maintain or improve environmental quality and human health at contaminated sites in general.

CCME criteria include two types of benchmarks for soil and water quality - assessment criteria and remediation criteria. Assessment criteria are approximate background concentrations or approximate analytical detection limits for contaminants in soil and water, and remediation criteria are used as clean-up benchmarks based upon intended land use. Remediation criteria do not address site-specific conditions. They are considered generally protective of human and environmental health for specified uses of soil and water at contaminated sites. The remediation criteria for soil are classified by three land uses:

1) Agricultural,
2) Residential/Parkland, and
3) Commercial/Industrial.

Remediation criteria for water are classified by four uses of water likely of concern at contaminated sites:

1) Freshwater aquatic life,
2) Irrigation,
3) Livestock watering, and
4) Drinking water.

Mine Reclamation in Northwest Territories and Yukon (INAC, 1992)

This report defines factors which are to be considered in reclamation of abandoned mine sites operating in northern climates. Factors include:

- open pit and underground mines;
- special mines such as uranium, sand and gravel, and coal;
- waste rock and tailings disposal;
- acid generation and leaching; and
- estimating cleanup costs.

Barrel Clean Up Protocol, (INAC, 1992)

See Appendix F for protocol on testing and cleaning of barrels and contents

3.2.2 Application of Criteria and Guidelines

For the Big Thing abandoned mine site assessment the following criteria were used:

A. Soils:

CCME:	Remediation Criteria for Soil - Commercial/Industrial standard
YUKON RENEWABLE RESOURCES:	Draft Contaminated Sites Regulations - used for hydrocarbon screening parameters

B. Water:

ENVIRONMENT CANADA:	Metal Mining Liquid Effluent Regulations and Guidelines - are compared to seepage from mine openings and river/stream water quality
BACKGROUND:	Downstream water quality results of rivers and streams are compared to the results of upstream (background) water quality (where

	(available)
CCME:	Remediation Criteria for Water - Freshwater Aquatic Life standard

[Note: In this screening assessment of water quality, analytical results are also compared to background values which characterize the local environment.]

C. Mine Clean-Up and Reclamation:

INAC:	Mine Reclamation in Northwest Territories and Yukon Territory

D. Barrel Clean-Up:

INAC	Barrel Clean Up Protocol

3.3 METHODS

3.3.1 Background Information

Available background information was consolidated from the Yukon Chamber of Mines mine records, Whitehorse Public Library, Yukon Archives holdings, and records and reports from the Yukon Renewable Resources Library, Yukon Water Board, DIAND Lands Branch, DIAND Water Resources, and DIAND Library. INAC (1994) provided an overview assessment of the Big Thing abandoned mine site to that date. Other published information sources were examined for site or regional information as applicable. On the basis of available information, knowledge gaps regarding existing or potential safety and environmental risks at the site were identified and a site assessment plan was developed.

3.3.2 Site Assessment Components

A site assessment was conducted to identify existing or potential safety and environmental risks on the site. The assessment included the following components:
Waste Rock disposal areas were inspected and sampled by a professional geologist to assess acid rock drainage potential by:

- Identifying waste rock mineralization with potential to release acidic and/or metal-contaminated drainage
- Mapping and logging waste rock, tailings, pit walls and rock faces
- Collecting and field testing representative samples of mine wastes

Mine Openings were inspected and documented to identify closure requirements.

Non-Hazardous Site Debris was inventoried.

Contaminated Soil Areas were measured and sampled to determine the degree and type of contamination and estimate soil volumes for remediation.

Hazardous Materials were inventoried and sampled for analyses of contaminant constituents, as necessary.

Buildings and other Structures were inspected for hazardous materials and assessed for stability.

Borrow Sources were identified and assessed for accessibility and approximate quantity and type of granular material as applicable.

Scale site plans were prepared to identify the dimensions and locations of site structures, mine workings and adits, waste rock disposal areas, on-site sampling locations, and any other pertinent information.

3.3.3 Sampling Methods and Quality Assurance

Test Pit Sampling

Test pits were excavated to a depth of about 0.3 to 1.0 m. Horizons in the test pit walls were logged, noting colour/weathering, rock composition, primary and secondary mineralization, particle size distribution, paste pH and paste conductivity, and moisture content. The test pit was photographed and its location was marked on the field map.

Approximately 2 kg of rock was collected at each sample site. For test pits showing a homogeneous wall face, a plastic sheet was placed at the bottom of the test pit and the pit wall was cut vertically down with a cleaned shovel. All rock larger than 75 mm in size was discarded. The sample was coned and quartered, discarding opposite quarters, until a 2 kg sample was obtained.

For test pit walls showing clearly-distinguishable horizons (distinguishable by the sulphide and carbonate contents), the horizons were sampled individually.

Water Sampling

Samples were collected from surface streams upstream and downstream of mine related flows, and from representative seeps emanating from waste rock, tailings, pit walls, and/or adits.

250 ml water samples were collected by hand, facing upstream, ensuring that the sample was not contaminated by disturbed sediment, debris and other floating materials. Sample

bottles were rinsed three times with water from the sample stream prior to collecting the sample.

2 ml of HNO_3 were immediately added to water samples destined for metals analyses. For analyses of non-metallic parameters, water samples were brim-filled to minimize head space, placed in a cooler, and maintained at 4° C until delivery to the laboratory.

Soil Sampling

Soil lithology was recorded from observations of the side walls of the test pit, and soil samples for both field and laboratory testing were collected. Observations were recorded for each soil sample site, including soil particle size, consistency, colour, moisture, discoloration, stratification, odour, and any other observations of significance.

Samples were collected at depth intervals selected on the basis of stratigraphic observations and anticipated or apparent contamination. The lab samples were collected using disposable latex gloves and decontaminated stainless steel sampling utensils. All samples intended for organic analyses were stored in laboratory-cleaned 250 ml glass jars; samples intended for metals analyses were placed in new "Whirl-Pak" bags. All samples were placed in a cooler for shipment to the laboratory.

Barrel Sampling

Barrels containing hydrocarbons were sampled with 1.2 m clean hollow glass rods ("drum thieves"), capable of extracting up to 25 ml of product. The rods were inserted into the drum or pail, and the uppermost open tip was sealed to maintain the sample within the rod as it was extracted from the drum or pail. The sampled hydrocarbon was then drained into a 40-ml laboratory-cleaned vial. The extractions were repeated until at least 20 - 30 ml of product was obtained. The vial was then sealed and placed in a container for shipment to the laboratory. Each used drum thief rod was subsequently destroyed to prevent accidental re-use.

Since hydrocarbon samples were collected only for analyses of Total Halides and metals, no cooling or other preservative was required.

Quality Assurance

Quality Assurance (QA) is a set of procedures for ensuring that the results of chemical analyses are, and can be shown to be, accurately representative of field conditions. A complete QA program includes both a field component and a laboratory component.

In addition to the standard sample collection methods outlined above, the field QA measures that were implemented for this assessment study include:

- chain of custody procedures and forms;
- a sample labeling and sample location identification scheme;

- laboratory preparation of all sampling containers;
- laboratory defined sample preservation and shipping procedures; and
- regular maintenance (including re-calibration) and cleaning of field equipment.

Laboratory QA measures included replicate analyses of selected soil and water samples. Replicate analytical results were submitted with each analytical report.

4.0 ENVIRONMENTAL SETTING

4.1 Surface Hydrology

Both the site and regional drainage are to the west draining approximately 20 metres into a small nearby unnamed lake that feeds Tank Creek which discharges about 300 metres further west into Bennet Lake. As well, there is a stream running along the southeast corner of the tailings impoundment drains southwest and ultimately into the unnamed lake.

Drainage from a corroded pipe directed through the tailings dam flows westwards downstream along the ground surface for about 20 metres before entering the unnamed lake. The source of this seepage is unknown but is believed to be primarily precipitation which infiltrates through the tailings. It is possible that upstream groundwater is contributing to this seepage.

4.2 Climate

The closest climatological information is from the town of Carcross, 60° 11' N, 134° 41' W; 663 m above sea level (Environment Canada, 1980). Total annual precipitation is 211.4 mm. This consists of 118.7 mm of rainfall and 101.3 mm of snowfall. Highest levels of rainfall occur in August and highest levels of snowfall occur in January. Temperatures range from -19.4° C in January to 12.7° C in July. The mean annual temperature is -1.4° C.

4.3 Vegetation

At a higher elevation the Arctic Caribou and Big Thing mine sites occur within the Stikine Highlands ecoregion. Alpine tundra dominates at higher elevations including the area of the mine site, with vegetation including scrub heather, dwarf birch, willow species, grass and lichen. At lower elevations, at the Arctic Gold and Silver mill and tailings impoundment, the subalpine ecosystem is dominated by white spruce, alpine fir and white birch. Much of the area surrounding the access road consists of second growth birch and alder that appears to have been cleared in the past.

4.4 Fish and Wildlife Resources

Typical carnivores in the area include grizzly and black bear and wolf. Arctic ground squirrel, pika and yellow-bellied marmots are common rodents in the area. A small colony of hoary marmots was noted at the site. Bird species representative of this alpine habitat include several ptarmigan species and rosy finch. A number of raptors hunt and nest in the area, and waterfowl such as mergansers and harlequin ducks are found in the rivers at lower elevations.

It is not currently known whether the unnamed stream and lake adjacent to the tailings impoundment supports a fish population. However, it is known from a previous study (Weagle, Robson, and Gullen, 1976) that at the time Tank Creek did not sustain a fish population and that Bennet Lake did sustain a fish population. A species composition study which determined percent biomass was conducted on Bennet Lake in 1990 (Renewable Resources, YTG, 1990). The findings were: Lake Trout (32%), Lake Whitefish (27%), Round Whitefish (10.5%), Long-nose Sucker (29.7%), Burbot (0.2%), Least Ciscoe (0.1%), Arctic Grayling (0.4%).

4.5 Site Topography and Soils

The site is situated within a morainal till along the west facing slopes of Montana Mountain. This material is typically composed of a heterogenous mixture of sand and silt with some gravel.

4.6 Permafrost

Big Thing is in an area of discontinuous permafrost. No evidence of permafrost was discovered during the site visit and is not likely to affect project components.

5.0 SITE DESCRIPTION AND FINDINGS

5.1 Building, Infrastructure, Equipment

The building, infrastructure and equipment observed in and around the site are listed in Table 2.

5.2 Hazardous Materials

No hazardous materials were observed at the site.

Table 2: Buildings, Infrastructure and Equipment

Inventoried Material	Number/ Volume	Location	Comments
Mill Foundation - concrete	12 pillars & ass. rubble - 300m^3	immediately north of site	volume estimate is for concrete above grade
Loadout ramp	approx. 500m^3	adjacent to north end of tailing pond	signs of decay in log cribbing; material may be used to level depressions
Building - wood	1 single storey	immediately northeast of site	unpainted
Trailer - steel	single, work type	immediately northwest of site	may have salvage value
Derelict vehicles and assort. Industrial debris	3 vehicles and 50 m^3 debris	scattered throughout north end of site	may have salvage value

5.3 Surface Water Quality

Water quality samples were collected from the tailings seepage (97-BTT-WQ-S-1), the lake into which the seepage drains (97-BTT-WQ-L-1), and from the stream running along the south and east sides of the impoundment (97-BTT-WQ-STR-1). Running along the south side of the impoundment and along the stream is the remnants of a road that is partly overgrown. The impact of this road or of the milling activity on this stream is unknown.

Water quality test results are summarized in Table 3. Seepage from the tailings flowed out of the embankment at a rate of approximately 0.5L/m. The tailings seepage water had concentrations of aluminum, arsenic, cadmium, copper, iron, lead, nickel, selenium, and zinc above the CCME guidelines. Concentrations of these metals were lower in the lake water because of dilution, but, except for nickel, were still above guideline concentrations. For example, the arsenic content in the seepage was 28 mg/L compared to 0.07 mg/L in the lake water. It should be noted that the lake water sample was collected where the seepage enters the lake and this water quality is probably not representative of the water quality of the lake as a whole.

The stream water had a neutral pH, and low conductivity (126 µS/cm) and sulphate concentrations (1.8 mg/L). Concentrations of aluminum (0.62 mg/L), cadmium (0.0002 mg/L), copper (0.003 mg/L), and iron (2.56 mg/L) were above the CCME aquatic life guidelines for these metals.

Detailed sampling results are shown in Appendix A.

Table 3: Surface Water Samples - Significant Results

Sample ID	Sample Location	pH	Conductivity (μmhos/cm)	Metallic Parameters Exceeding FAC
BTT-WQ-S1	tailings seepage	2.55	3,300	Al, As, Cr, Cu, Fe, Pb, Ni, Se, Au, Zn
BTT-WQ-L1	receiving lake at west end	6.8	121	Al, As, Cu, Fe, Se, Au, Zn
BTT-WQ-STR1	adjacent stream at south end	7.65	126	Al, Cr, Fe, Hg

5.4 Waste Rock Disposal Areas

At the north end of the tailings pond are two small piles of crushed ore, a total of approximately 30 m^3. A grab sample (97BTT-ORE1-1) was collected from ore stockpiled at the mill site. This material was reddish-brown from the presence of iron oxides and was homogeneous pebble to sand size. The sample was analyzed for acid generating potential by Acid Base Accounting and for total metals concentrations by ICP. Summary results are presented in Table 4. Detailed results are in Appendix A.

Results of the laboratory testing, showed that the ore sample was acidic (pH=3.1) but, unlike the tailings samples, most of the sulphur is present as sulphide. The ore has little neutralizing potential and will continue to oxidize. The ore sample (97BTT-ORE1-1) contained higher concentrations of copper, iron, silver, and zinc than the tailings samples. Concentrations of all other metals were similar.

5.5 Mine Openings And Excavations

There were no mine openings nor open pit excavations observed at the site.

5.6 Tailings

The tailings impoundment measures 190m by 130 m. The facility was built on a slope so that the depth of the tailings varies from approximately 5 m on the west to ground surface on the east. The volume of tailings is estimated to be approximately 62,000m^3. The tailings are contoured to collect water in the southeast corner of the impoundment. In the center of the pond area is a wooden water collection box approximately 1 metre square and open on the top. A 30 cm diameter metal pipe runs from the box through the tailings and empties into another wooden structure of the same length and width, but 4.5 m deep.

A portion of the pipe exiting the smaller water collection box was left exposed to the air and has corroded and, in some places, completely dissolved. Drainage collected in the deeper structure is piped through the tailings dam and released on the face of the tailings embankment. This seepage travels along the ground surface for approximately 20 metres before entering the adjacent small lake. See Drawing 1 for site details.

Geochemical/ARD Observations:

Iron oxide staining resulting from oxidation of iron sulphides was visible in places on the tailings surface. In addition, the bed along which the tailings solutions drain between the tailings embankment and the lake is coated with dark red iron oxide precipitates. Seepage from the tailings impoundment was not seen at any other location.

Tailings samples were collected at six locations across the impoundment, three during the 1996 visit (AS/T/P/301, 302, 303) and three during the 1997 visit (97BTT-TL1, 2, and 3). Samples were collected using a hand auger. The auger was advanced through the tailings to the underlying ground surface. Sample locations are shown in Drawing 1. The number of samples collected at each location depended on the depth to the original ground surface.

The tailings and till samples were analyzed for acid generating potential by Acid Base Accounting and for total metals concentrations by ICP. The 1997 samples were also analyzed for soluble metals concentrations using leach extraction tests. The lake sediment sample was analyzed for total metals concentrations.

ABA results are summarized in Table 4. Tailings samples collected in both 1996 and 1997 had acidic paste pH values ranging from 1.8 to 3.5 and high conductivities (range=650 to 2200 µS/cm). In the 1997 surficial samples (97BTT-TL1-1, TL2-1, TL3-1), nearly all of the sulfur has been oxidized to sulphate. These samples contained less than 0.05% sulphide. In the samples collected deeper in the tailings, from 30% to over 80% of the sulphur remains as sulphide. These sulphide concentrations, together with the lack of neutralizing capacity, suggest that the tailings will continue to generate acid. Samples collected in 1996 show the same trend, although only samples with total sulfur concentrations above 1 were analyzed for sulphate. The data shows that all the 1996 surficial samples (AS/T/P301/1, 302/1, and 303/1) had total sulfur concentrations below 1, whereas all but one of the eight subsurface samples had total sulphur concentrations above 1.

The grab sample of glacial till from the loading ramp (97BTT-DR-1) had a pH of 7.7 and a low conductivity (160 µS/cm). This material has a low total sulphur concentration and does not have the potential to generate acid.

The tailings contained high concentrations of antimony (mean = 208 ppm), arsenic (6712 ppm), lead (1730 ppm), and zinc (183 ppm), and moderate concentrations of chromium (86 ppm), copper (164 ppm), and silver (82 ppm). Apart from the analytical variability, there was more chemical variability than is seen in tailings currently produced at most mines. Whether this variability reflects variability in the ore or inconsistencies in the milling process is unknown.

Metals concentrations in the sample of glacial till (97BTT-DR-1) from the loading ramp were generally low, except for 194 ppm arsenic and 137 ppm chromium. These concentrations could results from contamination of the ramp material during operation, or reflect the presence of metal-rich material in the till.

Results of analysis of bottle roll test leachates for the tailings samples had pH values below 3 and conductivities ranging from 494 µS/cm to greater than 5500 µS/cm (Tables 1 and 2). Sulphate concentrations ranged from 147 mg/L to 1960 mg/L. Dissolved metals concentrations were more variable than concentrations in the solids. Arsenic concentrations, for example, ranged from 0.3 mg/L in TL3-1 to 50 mg/L in TL1-2, and iron concentrations ranged between 6 mg/L and 287 mg/L. Samples BTT-TL1-2 and TL2-1 generally have higher metal concentrations than the other two tailings samples. Metals concentrations in the till sample leachate were low.

Table 4: Summary Acid/Base Accounting Test Results

Sample #	Paste pH	Total S (%)	SO4 (%)	Net NP (NP - AP)	NP/AP
BTT-TL1-1	3.5	0.32	0.3	-3.1	<0.1
BTT-TL1-2	2.2	0.67	0.36	-18.7	<0.1
BTT-TL2-1	2.5	0.62	0.58	-12.7	<0.1
BTT-TL3-1	3.2	0.5	0.46	-13	<0.1
BTT-ORE1-1	3.1	2.95	0.36	-91.8	<0.1
BTT-DR-1	7.7	0.02	0.01	1.90	7.2

Geotechnical Observations:

A geotechnical investigation showed that the impoundment berm is constructed from a well graded sand and gravel with some silt and appeared to be stable throughout its length. At the west end the berm consisted of a lower bench and an upper section with a total height of approximately 5 metres. The upper section of the berm did not appear to be placed with compaction and does not appear to be stable as a long term retainment structure. However, since the tailings at this elevation are unsaturated and a thickness of only 1 to 1.5 metres, the lateral earth pressure acting on the berm had not caused extensive failure. On exception to this to this is at the north edge of the berm where there appeared to be a berm breach and subsequent lateral migration of the tailings material beyond the impoundment area.

Suitable borrow material for restoration purposes appears to be located in the immediate vicinity of the site where there is morainal fill along the west facing slopes of Montana Mountain. This material is typically composed of a heterogeneous mixture of sand and silt, with some gravel. If the till has a sufficient quantity of silt and fine sand and it is well graded, the material would be suitable as a low permeability cover. The till deposit appears to be fine grained and of sufficient thickness as evidenced by pronounced gully formations in this area. Further, since the area has been previously developed and is road accessible, the approval for a land use permit would be a less onerous process than with other undisturbed areas near Carcross.

There is no specific borehole information available for the proposed borrow source area near the site. However, the results of the terrain analysis are consistent with the surficial geology maps for the study area.

6.0 CONCLUSIONS

The tailings in the Arctic Gold and Silver impoundment are currently generating acid, and are discharging low pH seepage into a small lake adjacent to the impoundment. The seepage contained significant metals concentrations. A small fan of reddish-brown sediment has formed where the seepage enters the lake, and analysis of lake waters collected in this area indicate that the seepage is impacting the lake water quality.

There appears to be little impact on the receiving environment from the rest of the mill site except from an aesthetic point of view.

The west side of the tailings impoundment does not appear to be of adequate strength or height to act as a long-term retainment structure. A small breach exists in the berm at the north end of the impoundment. Suitable borrow material is present adjacent to the site.

The load-out ramp at the north end of the impoundment shows signs of decay in the log cribbing supporting the west face.

Numerous pieces of abandoned equipment lay scattered throughout the site. As well, foundations, wooden structures and concrete pillars lie exposed.

6.1 Health and Safety Risks

The primary potential health risk is from ingestion of water and/or aquatic life downstream of the tailings water discharge. Soluble metal uptake in the aquatic food chain may concentrate to toxic levels to downstream receptors an ultimately to humans. Sampling of downstream waters off-site or aquatic biotica was not within the scope of this assessment.

The ramp is considered a health and safety risk due to the possibility of an inadvertent accident by recreational users who frequent this area in off-road vehicles.

6.2 Environmental Risks

Potentially significant environmental risks are present on site due to two factors. Aquatic receptors may be potentially impacted by the effects of acid rock drainage which contributes soluble heavy metals in to the food chain. Soluble heavy metals are currently being discharged into a small lake, through Tank Creek and into Bennet Lake, which is a fish bearing habitat. The second risk arises from potential catastrophic failure of the impoundment's west end berm. The upper 1.5 metre section is unsuitable for a long-term retainment structure. A possible failure of the berm will spill large volumes of tailings material in the downstream bush and drainage channel and ultimately into the small lake 20 metres downstream of the impoundment.

6.3 Aesthetic Concerns

Aesthetic concerns arise from the range of infrastructure, equipment and debris, both metal and wood, noted throughout the site, particularly the mill foundations, concrete pillars, heavy equipment, trailer and wooden structures.

7.0 RECOMMENDATIONS

Recommended remediation and management actions are compliant with applicable federal or territorial regulations and criteria, are reliant upon available technology, and are intended to be appropriate for local conditions and sensitivities.

Recommendation 1.

Action should be taken to reduce or eliminate drainage from the tailings. A low permeability cover should be placed on the pile to reduce infiltration. The cover should be contoured to shed water and ensure that precipitation does not pond on the pile surface. Although there was no evidence of seepage or impact to the surrounding soil from the small ore piles, these piles should be removed. If the tailings are to be reclaimed, the simplest solution would be to dispose of the waste on the tailings before the tailings are covered. Metal rich sediment deposited in the small lake, as well as material deposited along the seepage drainage path between the impoundment and the lake, should be excavated and placed on the impoundment before covering.

Recommendation 2.

It is recommended that berm repairs be made to restrict further lateral migration of the tailings from the breached section of the berm and to provide enhanced stability to the west section of the berm. The load-out ramp should be leveled and used as berm/cover material. This can be done in conjunction with the reclamation work done on the tailings.

Recommendation 3.

It is recommended to proceed with a ground truthing and test pitting exercise in order to verify the quality and quantity fine grained borrow material prior to further design consideration.

Recommendation 4.

It is recommended that a hydrogeological assessment be carried out prior to site reclamation in order to determine the ground water contribution to the tailings impoundment.

Recommendation 5.

It is recommended that the mill foundations and pillars be demolished to grade and possibly buried on-site. The building be demolished and burned on site. The wood waste can be burned and metal should be collected and disposed at a suitable nearby landfill. The loadout facilities should be dozed and the areas restored to the original slopes by dozing. The trailer should be relocated and salvaged by a local interested party. These activities can be accomplished using locally available resources and labour.

8.0 COST ESTIMATES TO IMPLEMENT RECOMMENDATIONS

A cost estimate of expected site remediation costs to an accuracy of 25% is provided under a separate cover. The cost estimate includes contractor and project management costs and contingency.

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APPENDIX A

ACID ROCK DRAINAGE AND WATER QUALITY TABLES

Table 11
Water Quality Data
Arctic Gold and Silver Mill Site

PARAMETER Date Location	UNITS	D.L.	97-BTT-WQ-S-1 August, 1997 Seep on W side of tailings	97-BTT-WQ-L-1 August, 1997 Lake sample	97-BTT-WQ-STR-1 August, 1997 Stream on S side of impoundment
pH		0.1	2.55	6.8	7.65
Electrical conductivity	uS/cm	0.1	3300	121	126
Hardness	mg/L	0.1	852	43.2	57.5
Alkalinity, total	mg/L	1	<1	22	72
Sulphate	mg/L	0.3	2480	38.2	1.8
Chloride	mg/L	0.5	0.7	<0.5	<0.5
Bicarbonate	mg/L	5	<5	27	88
NO2&NO3-N	mg/L	0.05	<0.05	<0.05	<0.05
Ionic Balance	%	0.1	~54.0	~79.4	~84.2
Total Dissolved Solids	mg/L	1	2800	70	69
Aluminum	mg/L	0.00005	27	0.367	0.622
Antimony	mg/L	0.005	0.048	<0.005	<0.005
Arsenic	mg/L	0.01	28.4	0.07	0.03
Cadmium	mg/L	0.00006	0.0993	0.00138	0.00022
Calcium, dissolved	mg/L	0.1	245	12.4	17.2
Calcium, total	mg/L	0.002	234	15.1	21.1
Chromium	mg/L	0.00006	0.0153	0.00113	0.00102
Cobalt	mg/L	0.00003	0.417	0.00668	0.00166
Copper	mg/L	0.00003	1.44	0.0132	0.00298
Iron, dissolved	mg/L	0.04	574	1.55	0.05
Iron, total	mg/L	0.003	865	3.1	2.56
Lead	mg/L	0.0003	0.358	0.0025	0.0007
Magnesium, dissolved	mg/L	0.1	58.1	3	3.5
Magnesium, total	mg/L	0.005	50.6	2.9	3.77
Manganese, dissolved	mg/L	0.003	25.9	0.245	0.005
Manganese, total	mg/L	0.00002	5.54	0.373	0.697
Mercury	mg/L	0.0001	<0.0001	<0.0001	0.0035
Molybdenum	mg/L	0.00007	0.00257	0.00068	0.00107
Nickel	mg/L	0.0001	0.204	0.0048	0.0028
Selenium, dissolved	mg/L	0.003	0.233	0.005	<0.003
Silver	mg/L	0.00005	0.00227	0.00026	<0.00005
Strontium	mg/L	0.00002	0.527	0.0598	0.0926
Zinc	mg/L	0.0002	9.76	0.162	0.0152

Table 12
Acid Base Accounting Results of Arctic Gold and Silver Tailings

Sample Number	Depth (cm)	Paste pH	Paste Conductivity* (uS/cm)	S(T) %	$S(SO_4)$ %	$S(S^{2-})$ % (calc)	24 hr pH	AP	NP	NET NP	NP/AP
1996 Samples											
AS/T/P301/1	un	2.18	–	0.87	–	–	–	27.19	-11.88	-39.06	<0.1
AS/T/P301/2	un	1.75	–	2.07	1.50	0.57	–	17.81	-38.41	-56.22	<0.1
AS/T/P301/3	un	2.35	–	1.21	0.52	0.69	–	21.56	-12.25	-33.81	<0.1
AS/T/P301/4	un	2.00	–	1.24	0.70	0.54	–	16.88	-19.06	-35.94	<0.1
AS/T/P302/1	un	3.14	–	0.49	–	–	–	15.31	-6.44	-21.75	<0.1
AS/T/P302/2	un	3.51	–	1.02	0.24	0.78	–	24.38	-4.94	-29.31	<0.1
AS/T/P302/3	un	2.80	–	0.39	–	–	–	12.19	-4.75	-16.94	<0.1
AS/T/P302/4	un	2.02	–	1.65	0.76	0.89	–	27.81	-23.50	-51.31	<0.1
AS/T/P303/1	un	2.20	–	0.88	–	–	–	27.50	-15.50	-43.00	<0.1
AS/T/P303/2	un	2.17	–	1.88	1.31	0.57	–	17.81	-20.19	-38.00	<0.1
AS/T/P303/3	un	2.85	–	3.57	0.63	2.94	–	91.88	-15.00	-106.88	<0.1
1997 Samples											
97BTT-TL1-1	40	3.5	1600	0.32	0.30	0.02	1.76	0.6	-2.5	-3.1	<0.1
97BTT-TL1-2	100	2.2	2200	0.67	0.36	0.31	1.71	9.7	-9.0	-18.7	<0.1
97BTT-TL2-1	10-30	2.5	2100	0.62	0.58	0.04	1.72	1.3	-11.5	-12.7	<0.1
97BTT-TL3-1	30	3.2	650	0.50	0.46	0.04	1.75	1.3	-11.7	-13.0	<0.1
97BTT-ORE1-1	na	3.1	870	2.95	0.36	2.59	1.83	80.9	-10.9	-91.8	<0.1
97BTT-DR-1	na	7.7	160	0.02	0.01	0.01	1.57	0.3	2.3	1.9	7.2

– not analyzed
un unknown
na not applicable
AP = Acid Potential in tonnes $CaCO_3$ equivalent per 1000 tonnes of material
NP = Neutralizing Potential in tonnes $CaCO_3$ equivalent per 1000 tonnes of material
Net NP = Net neutralizing potential = tonnes $CaCO_3$ per 1000 tonnes of material.
*Paste conductivity using pulverized material and a 1:1 liquid to solid ratio.

Table 13
Total Metals Concentrations (ICP) in Tailings at Arctic Gold and Silver

Element	Units	Lower Detection Limit	1996 Samples: AS/T/P/										
			301/1	301/2	301/3	301/4	302/1	302/2	302/3	302/4	303/1	303/2	303/3
Aluminum	%	0.01	0.29	0.34	0.22	0.21	0.18	0.16	0.18	0.18	0.25	0.24	0.41
Antimony	ppm	1	163	341	125	138	135	114	92	221	257	317	468
Arsenic	ppm	1	9839	>10000	6168	>10000	>10000	>10000	5080	>10000	>10000	>10000	>10000
Barium	ppm	1	38	49	25	20	25	19	23	14	49	43	49
Beryllium	ppm	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Bismuth	ppm	1	15	42	13	10	10	6	8	9	24	21	69
Cadmium	ppm	0.1	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100
Calcium	%	0.01	0.12	0.24	0.10	0.07	0.02	0.02	0.12	0.09	0.04	0.06	0.08
Chromium	ppm	1	71	30	184	151	120	118	126	112	19	28	37
Cobalt	ppm	1	5	11	4	6	3	3	2	8	7	9	26
Copper	ppm	1	123	196	64	105	29	30	37	158	85	175	1266
Gallium	ppm	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Iron	%	0.01	2.14	3.91	1.89	2.32	1.96	2.23	1.13	3.79	3.40	5.73	5.51
Lead	ppm	1	1492	2814	1042	1386	1028	936	923	1956	2140	2715	4222
Lithium	ppm	1	2	2	2	2	<1	2	2	2	2	2	3
Magnesium	%	0.01	0.03	0.04	0.02	0.02	<0.01	<0.01	<0.01	0.02	0.03	0.03	0.04
Manganese	ppm	1	91	128	45	54	14	12	16	34	131	109	125
Molybdenum	ppm	1	31	53	26	31	38	31	21	44	46	63	72
Nickel	ppm	1	7	11	8	8	6	7	4	10	9	13	17
Phosphorus	ppm	10	170	260	90	130	200	170	90	260	200	250	270
Potassium	%	0.01	0.26	0.28	0.21	0.19	0.19	0.16	0.16	0.13	0.26	0.38	0.29
Silver	ppm	0.1	74.0	137.0	69.7	86.7	51.5	42.3	37.9	88.6	125.3	163.1	>200
Sodium	%	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01
Strontium	ppm	1	11	15	7	5	8	6	9	4	18	24	15
Thallium	ppm	1	<1	4	<1	<1	2	<1	<1	<1	4	<1	2
Tin	ppm	1	<1	2	<1	<1	<1	<1	<1	2	<1	2	2
Titanium	%	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Tungsten	ppm	1	4	<1	9	7	6	6	7	5	<1	<1	<1
Uranium	ppm	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Vanadium	ppm	1	1.0	0.9	0.7	0.6	0.7	0.4	0.7	0.4	1.0	0.4	0.7
Zinc	ppm	1	136	225	86	189	49	39	54	385	260	349	643

* The detection limit was used for values that are less than (<) or greater than (>) the detection limit.

Table 13
Total Metals Concentrations (ICP) in Tailings at Arctic Gold and Silver

Element	Units	Lower Detection Limit	1997 Samples: 97BTT							Mean*
			TL1-1	TL1-2	TL2-1	TL3-1	ORE1-1	DR-1	LAKESED	
Aluminum	%	0.01	0.09	0.10	0.15	0.23	0.16	1.08	0.23	0.22
Antimony	ppm	1	81	166	142	357	456	6	224	207.80
Arsenic	ppm	1	3193	8015	7978	>10000	>10000	194	>10000	6712.17
Barium	ppm	1	20	14	22	43	24	48	40	30.20
Beryllium	ppm	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.15
Bismuth	ppm	1	12	15	14	42	42	1	33	20.67
Cadmium	ppm	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.10
Calcium	%	0.01	0.11	0.09	0.05	0.01	0.02	0.54	0.04	0.08
Chromium	ppm	1	73	118	80	28	131	137	28	86.33
Cobalt	ppm	1	1	1	2	1	7	8	2	5.93
Copper	ppm	1	29	46	52	70	244	15	36	164.33
Gallium	ppm	1	1	1	1	3	4	3	8	1.50
Iron	%	0.01	1.06	1.66	2.00	3.91	5.09	2.06	10.36	2.84
Lead	ppm	1	590	1032	935	2742	2734	27	2044	1730.20
Lithium	ppm	1	1	1	1	1	1	9	2	1.79
Magnesium	%	0.01	0.01	0.01	0.01	0.01	0.02	0.77	0.06	0.02
Manganese	ppm	1	11	14	37	17	22	276	34	55.87
Molybdenum	ppm	1	14	27	23	51	62	3	52	38.07
Nickel	ppm	1	1	1	2	1	3	24	2	7.00
Phosphorus	ppm	10	90	130	140	340	240	610	450	186.00
Potassium	%	0.01	0.12	0.11	0.16	0.24	0.16	0.10	0.39	0.21
Silver	ppm	0.1	25.2	54.3	51.7	141.5	200.0	0.9	88.7	82.06
Sodium	%	0.01	0.01	0.01	0.01	0.01	0.01	0.04	0.03	0.01
Strontium	ppm	1	8	6	8	13	11	25	58	10.47
Thallium	ppm	1	7	11	15	32	29	15	59	9.63
Tin	ppm	1	1	1	1	1	1	1	1	1.50
Titanium	%	0.01	0.01	0.01	0.01	0.01	0.01	0.08	0.01	0.01
Tungsten	ppm	1	1	2	2	1	4	1	1	4.55
Uranium	ppm	1	3	5	6	12	15	6	34	6.50
Vanadium	ppm	1	1.5	1.9	2.4	4.5	5.8	40.6	18.8	1.19
Zinc	ppm	1	33	79	112	106	329	37	80	183.00

Table 14
Total Soluble Metal Concentrations in Big Thing Tailings

Parameter	Units	Sample Number					
		TL1-1	TL1-2	TL2-1	TL3-1	ORE-1	DR-1
Sample Weight	g	250	250	250	250	250	250
Volume H_2O	mL	500	500	500	500	500	500
pH - 3 Hr.		2.83	2.21	2.42	2.96	2.38	6.23
- 24 Hr.		2.73	2.11	2.35	2.87	2.37	6.75
Conductivity - 3 Hr.	µS/cm	1074	3630	2670	494	1888	80
- 24 Hr.		1680	5720	3690	743	2410	108
Redox Potential	mv	517	537	543	512	525	403
Acidity - pH 4.5	mg/L $CaCO_3$	175.0	1270.0	1080.0	94.0	430.0	0.0
- pH 8.3		215.0	1450.0	1490.0	129.0	555.0	3.3
Alkalinity - pH 4.5	mg/L $CaCO_3$	0.0	0.0	0.0	0.0	0.0	4.5
Sulphate	mg/L $CaCO_3$	565	1920	1960	147	570	32
Dissolved Metals							
Aluminum	mg/L	4.2	23.9	99.0	3.1	10.0	<0.2
Antimony	mg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Arsenic	mg/L	0.7	49.6	16.0	0.3	5.6	<0.2
Cadmium	mg/L	0.04	0.364	0.865	0.07	0.225	<0.01
Calcium	mg/L	150	187	96.1	12.9	7.28	14.1
Chromium	mg/L	0.02	0.13	0.18	0.01	0.01	<0.01
Cobalt	mg/L	<0.01	0.10	0.44	0.02	0.07	<0.01
Copper	mg/L	0.34	5.84	6.40	1.15	1.83	<0.01
Iron	mg/L	20.0	287	232	6.46	87.2	0.03
Lead	mg/L	<0.05	3.74	0.46	<0.05	0.29	<0.05
Magnesium	mg/L	1.14	5.43	23.7	1.93	3.23	1.95
Manganese	mg/L	0.170	0.908	6.39	0.296	0.284	0.023
Mercury	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum	mg/L	<0.03	0.07	0.03	<0.03	<0.03	<0.03
Nickel	mg/L	<0.02	0.04	0.22	<0.02	<0.02	<0.02
Selenium	mg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Silver	mg/L	0.03	0.13	0.20	0.12	0.05	<0.01
Zinc	mg/L	0.361	7.32	13.0	1.53	6.91	<0.005

APPENDIX B

SITE PHOTOGRAPHS

Photo# 1: Aerial View of the Tailings Impoundment and Drainage to Lake

Photo# 2: Tailings Surface looking North West (note oxidation)

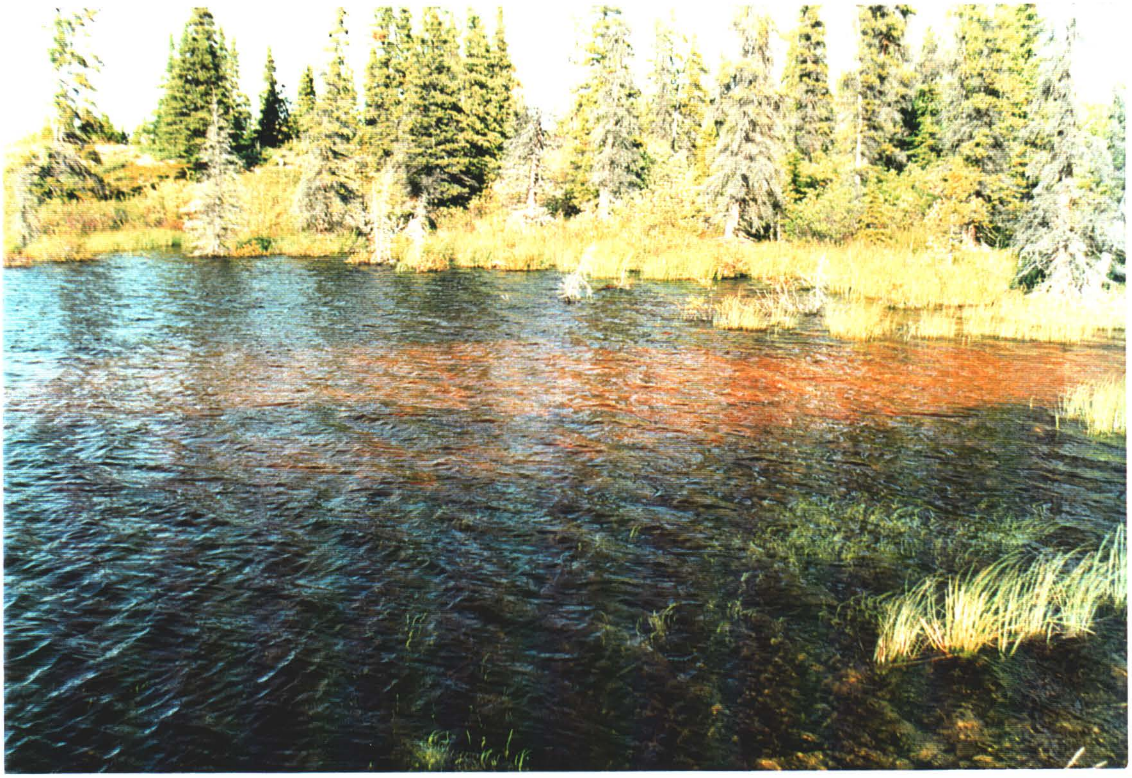
Photo# 3: Berm - West End

Photo# 4: Decant Pipe (note low lying wet area)

Photo# 5: Drainage Decant Box

Photo# 6: West End of Tailings Impoundment

Photo# 7: Drainage Trench to Lake



Photo# 8: Tailings in Lake

Photo# 9: Tailings Sampling Profile; South End of Loadout Ramp

Photo# 10: Log Cribbing at West End of Loadout Ramp

Photo# 11: Mill Site Foundation and Ore Piles

Photo# 12: Concrete Pillars on Foundation

Photo# 13: Mill Foundation and Debris

Photo# 14: Derelict Vehicles, Equipment and Trailer

APPENDIX C

LABORATORY REPORT - WATER ANALYSIS

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PUBLIC WORKS CANADA
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MICHAEL NAHIR
WATER/BASELINE

WATER ANALYSIS REPORT

SAMPLE		1 97-BTT-WQ-L-1 LAKE NEAR TAILINGS	2 97-BTT-WQ-S-1 N. SIDE OF TAILINGS	3 97-BTT-WQ-STR-1
ROUTINE WATER				
pH		6.80	2.55 –	7.65
ELECTRICAL COND	uS/cm	121	3300 –	126
CALCIUM	mg/L	12.4	245	17.2
MAGNESIUM	mg/L	3.0	58.1	3.5
SODIUM	mg/L	1.9	6.0	2.1
POTASSIUM	mg/L	<0.60	12.4	0.64
IRON	mg/L	1.55	574	0.05
MANGANESE	mg/L	0.245	25.9	0.005
SULPHATE	mg/L	38.2	2480	1.8
CHLORIDE	mg/L	<0.5	0.7	<0.5
BICARBONATE	mg/L	27	<5	88
T ALKALINITY	mg/L	22	<1	72
HARDNESS	mg/L	43.2	852	57.5
T DIS SOLIDS	mg/L	70	2800	69
IONIC BALANCE	%	-79.4	-54.0	-84.2
WATER NUTRIENTS				
NO2&NO3-N	mg/L	<0.05	<0.05	<0.05
TOTAL, COLD VAPO				
MERCURY	mg/L	<0.0001	<0.0001	0.0035
TRACE ICP,TOTAL				
ALUMINUM	mg/L	0.367	27.0	0.622
ANTIMONY	mg/L	<0.005	0.048	<0.005
ARSENIC	mg/L	0.07	28.4 –	0.03
BARIUM	mg/L	0.00734	0.00781	0.0456
BERYLLIUM	mg/L	<0.00001	0.00179	<0.00001
BISMUTH	mg/L	<0.0004	0.0092	<0.0004
BORON	mg/L	<0.002	<0.002	<0.002
CADMIUM	mg/L	0.00138	0.0993	0.00022
CALCIUM	mg/L	15.1	234	21.1
CHROMIUM	mg/L	0.00113	0.0153 –	0.00102
COBALT	mg/L	0.00668	0.417	0.00166
COPPER	mg/L	0.0132	1.44 –	0.00298
IRON	mg/L	3.10	865	2.56

Lab Manager: [signature]

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LETHBRIDGE PH. (403) 329-9266 FAX (403) 327-8527
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PAGE 2

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EDMONTON, AB
T5J 4E2

MICHAEL NAHIR
WATER/BASELINE

WATER ANALYSIS REPORT

SAMPLE		1 97-BTT-WQ-L-1 LAKE NEAR TAILINGS	2 97-BTT-WQ-S-1 N. SIDE OF TAILINGS	3 97-BTT-WQ-STR-1
TRACE ICP,TOTAL				
LEAD	mg/L	0.0025	0.358	0.0007
LITHIUM	mg/L	0.00119	0.0674	0.00160
MANGANESE	mg/L	0.373	5.54	0.697
MAGNESIUM	mg/L	2.90	50.6	3.77
MOLYBDENUM	mg/L	0.00068	0.00257	0.00107
NICKEL	mg/L	0.0048	0.204	0.0028
PHOSPHORUS	mg/L	0.020	0.108	0.069
POTASSIUM	mg/L	2.31	12.3	0.72
SILVER	mg/L	0.00026	0.00227	<0.00005
SELENIUM	mg/L	0.005	0.233	<0.003
SILICON	mg/L	4.74	19.9	8.54
STRONTIUM	mg/L	0.0598	0.527	0.0926
SODIUM	mg/L	1.71	7.16	2.00
THALLIUM	mg/L	<0.001	<0.001	<0.001
SULPHUR	mg/L	13.8	877	0.936
TITANIUM	mg/L	0.00092	0.00613	0.0333
TIN	mg/L	<0.0002	0.0066	<0.0002
VANADIUM	mg/L	0.00018	0.0232	0.00204
ZINC	mg/L	0.162	9.76	0.0152

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MICHAEL NAHIR
WATER/BASELINE

WATER ANALYSIS REPORT

note	pH	pH REPORTED AT ROOM TEMP
note	ELECTRICAL COND	'ELECTRICAL COND' (EC) is in microsiemens/cm and is a measure of solids in solution E.C. CORRECTED TO 25C
note	T ALKALINITY	'ALKALINITY' is CARBONATE/BICARBONATE expressed as CALCIUM CARBONATE
note	HARDNESS	'HARDNESS' is calcium and magnesium expressed as CALCIUM CARBONATE
note	NO2&NO3-N	is expressed as nitrogen

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MICHAEL NAHIR
WATER/BASELINE

WATER ANALYSIS REPORT

---PARAMETER----	DATE OF-ANALYSIS	------ANALYZED BY-------	---PARAMETER----	DATE OF-ANALYSIS	------ANALYZED BY-------
pH	09Sep97	DARREN CRICHTON	ELECTRICAL COND	09Sep97	DARREN CRICHTON
CALCIUM	10Sep97	LANG QUE TRAN	MAGNESIUM	10Sep97	LANG QUE TRAN
SODIUM	10Sep97	LANG QUE TRAN	POTASSIUM	10Sep97	LANG QUE TRAN
IRON	10Sep97	LANG QUE TRAN	MANGANESE	10Sep97	LANG QUE TRAN
SULPHATE	10Sep97	LANG QUE TRAN	CHLORIDE	08Sep97	THERESA LIEU
BICARBONATE	09Sep97	DARREN CRICHTON	T ALKALINITY	09Sep97	DARREN CRICHTON
HARDNESS	04Sep97	LANG QUE TRAN	T DIS SOLIDS	04Sep97	LANG QUE TRAN
IONIC BALANCE	04Sep97	LANG QUE TRAN	NO2&NO3-N	08Sep97	THERESA LIEU
MERCURY	15Sep97	LANG QUE TRAN	ALUMINUM	12Sep97	LANG QUE TRAN
ANTIMONY	15Sep97	LANG QUE TRAN	ARSENIC	15Sep97	LANG QUE TRAN
BARIUM	12Sep97	LANG QUE TRAN	BERYLLIUM	12Sep97	LANG QUE TRAN
BISMUTH	12Sep97	LANG QUE TRAN	BORON	15Sep97	LANG QUE TRAN
CADMIUM	12Sep97	LANG QUE TRAN	CALCIUM	15Sep97	LANG QUE TRAN
CHROMIUM	12Sep97	LANG QUE TRAN	COBALT	12Sep97	LANG QUE TRAN
COPPER	12Sep97	LANG QUE TRAN	IRON	15Sep97	LANG QUE TRAN
LEAD	12Sep97	LANG QUE TRAN	LITHIUM	15Sep97	LANG QUE TRAN
MANGANESE	12Sep97	LANG QUE TRAN	MAGNESIUM	15Sep97	LANG QUE TRAN
MOLYBDENUM	12Sep97	LANG QUE TRAN	NICKEL	12Sep97	LANG QUE TRAN
PHOSPHORUS	15Sep97	LANG QUE TRAN	POTASSIUM	15Sep97	LANG QUE TRAN
SILVER	12Sep97	LANG QUE TRAN	SELENIUM	15Sep97	LANG QUE TRAN
SILICON	15Sep97	LANG QUE TRAN	STRONTIUM	12Sep97	LANG QUE TRAN
SODIUM	15Sep97	LANG QUE TRAN	THALLIUM	12Sep97	LANG QUE TRAN
SULPHUR	15Sep97	LANG QUE TRAN	TITANIUM	12Sep97	LANG QUE TRAN
TIN	12Sep97	LANG QUE TRAN	VANADIUM	12Sep97	LANG QUE TRAN
ZINC	12Sep97	LANG QUE TRAN			

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MICHAEL NAHIR
WATER/BASELINE

WATER ANALYSIS REPORT

The following published METHODS OF ANALYSIS were used:

10301L pH
Electrometric (pH meter)
Ref. APHA 4500-H+
02041L ELECTRICAL COND
Conductance meter
Ref. APHA 2510 B
20103 CALCIUM
ICP spectroscopy @ 317.9 nm
Ref. APHA 3120 B
12102L MAGNESIUM
ICP spectroscopy @ 285.2 nm
Ref. APHA 3120 B
11102L SODIUM
19111 POTASSIUM
Diss.,ICP Spectroscopy, Ref. APHA 3120 B
26304L IRON
16306L SULPHATE
ICP spectroscopy @ 180.7 nm
Ref. APHA 3120 B
17203L CHLORIDE
Automated colorimetry, Thiocyanate
Ref. APHA 4500 Cl-,E
06201L BICARBONATE
Potentiometric titration with standard
acid to pH 8.3 and pH 4.5
Ref. APHA 2320 B
10101 T ALKALINITY
Potentiometric titration with standard
acid to pH 4.5 & pH 8.3. Report as CaCO3
Ref. APHA 2320 B
10602 HARDNESS
Calculation from 2.5*Ca + 4.1*Mg
Reported as CaCO3
Ref. APHA 2340 B
00203 T DIS SOLIDS
SUM OF IONS CALCULATION
Ca + Mg + K + Na + SO4 + Cl + 0.6*T Alk
Ref. APHA 1030 F
NWL4994 IONIC BALANCE
00100 IONIC BALANCE 2
%Diff=(Sum Cations-Sum Anions)/
(Sum Cations+Sum Anions)*100
Ref. APHA 1030 F
07105L NO2&NO3-N
Automated colorimetry Cadmium reduction
Ref. APHA 4500-NO3-,F

Method References:
1. APHA Standard Methods for the Examination of Water and Wastewater, American Public Health Assoc., 17th ed.
2. EPA a. Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW-846, 3rd ed., US EPA, 1986
   b. Methods for Chemical Analysis of Water and Wastewater, US EPA, 1983
3. MSS Manual on Soil Sampling and Methods of Analysis, Cdn. Soc. of Soil Science, J. A. McKeague, 2nd ed.

* NORWEST SOIL RESEARCH LTD has been accredited by the STANDARDS COUNCIL of CANADA for specific tests registered with the COUNCIL.

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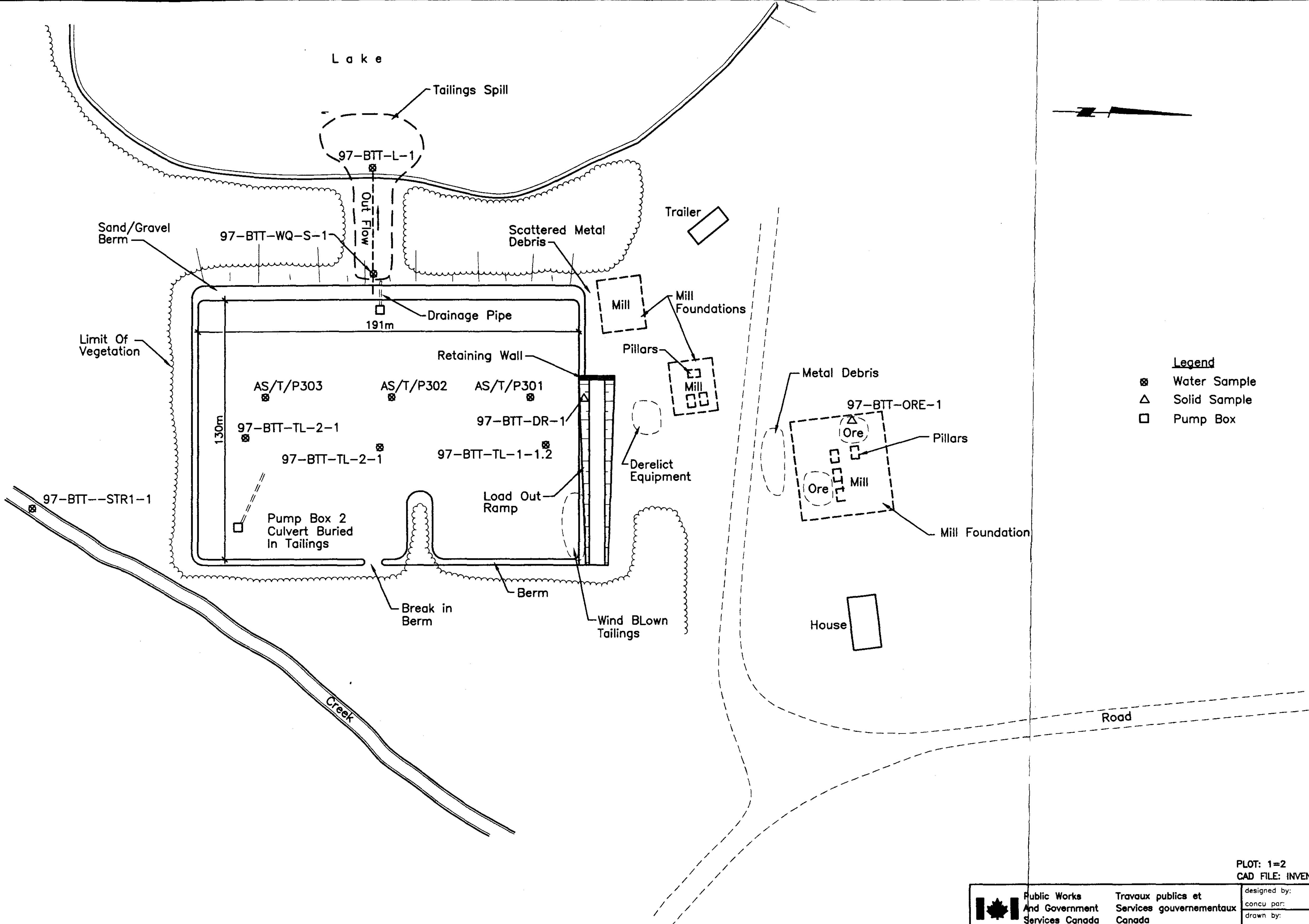
APPENDIX D

DRAWING



PLOT: 1=2
CAD FILE: INVEN-96\BIGTHING\BIG-5

Public Works and Government Services Canada — Travaux publics et Services gouvernementaux Canada

Architectural & Engineering Services
Western Region

designed by: / concu par:	date:
drawn by: / dessine par:	
approved by: / approuve par:	
revisions:	

Drawing title: / Titre du dessin:

Big Thing Mine Tailings Pond
Yukon Territory

project no. / no. du projet:	dwg. no. / dessin no.
658989	1 of 1