MN-053

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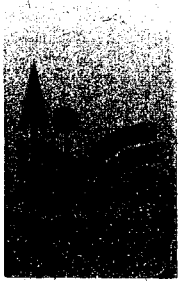

PHASE II ENVIRONMENTAL ASSESSMENT OF THE MACTUNG ABANDONED MINE SITE

prepared for:

Action on Waste Program
Indian and Northern Affairs Canada

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Executive Summary

The Mactung exploration site is located at 63 ° 16' 51" N, 130 ° 08' 54" W, approximately 185 km northeast of the village of Ross River and adjacent to the Yukon - N.W.T. border. Environmental Services, Public Works and Government Services Canada was retained to conduct an assessment of the Mactung abandoned mine site to a) identify specific environmental and human safety risks and aesthetic concerns; b) provide clean-up recommendations; and c) provide a Class "D" cost estimate for recommended remediation or mitigation measures. The Mactung mine site was inspected by PWGSC on 16 August, 1996.

Assessment components included mine openings and workings, buildings and infrastructure, waste disposal areas, waste rock disposal areas, surface water (including waste rock seepage and receiving waters), and hazardous and non-hazardous materials on the site.

The assessment concluded that a partly-collapsed adit remains open and accessible. Two site buildings (former core storage building and generator shed) are in good condition and should not be demolished. Non-hazardous waste materials are rated as a minor aesthetic concern, and hydrocarbon-stained soil near the generator shed are a minor environmental concern. Waste rock and ore piles are potential acid generators, and metals could be mobilized and transported to an unnamed stream southeast of the site.

Recommended actions include:

1. Sealing the adit with waste rock.

2. A minimum five-year water quality sampling program to monitor the potential onset and effects of acid generation from waste rock and ore piles on receiving waters. The monitoring program should provide water quality data for spring freshet, middle summer and late fall runoff conditions. Should further development occur on the site, regulatory agencies should ensure that an acid drainage prevention plan is developed.

3. Until the site is permanently decommissioned, the former core storage and generator buildings should remain standing and accessible for use as emergency shelters.

4. The areas of staining should be scarified and fertilized to promote in-situ bioremediation.

5. Solid waste materials should be consolidated and buried on site with available waste rock.

6. A preliminary assessment of site hydrology should be completed to identify potential pathways and receiving waters for metals mobilized by acid-generation.

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1. 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 or mitigation work, as appropriate.

At the Mactung site, the overview assessment (INAC, 1994) identified no obvious environmental or safety concerns and low-priority concerns with respect to site infrastructure and debris. No rock, soil or water samples were collected for this overview assessment.

Indian and Northern Affairs Canada has determined that further investigation is warranted. Environmental Services, Public Works and Government Services Canada was retained to conduct an environmental assessment of the Mactung abandoned mine site to a) identify specific environmental and human safety risks and aesthetic concerns; b) provide clean-up recommendations; and c) provide a Class "D" cost estimate for recommended remediation or mitigation measures. The Mactung mine site was inspected by PWGSC on 16 August, 1996.

1.1 Location

The Mactung exploration site is located at 63 ° 16' 51" N, 130 ° 08' 54" W, approximately 185 km northeast of the village of Ross River and adjacent to the Yukon - N.W.T. border. Mactung's portal is about 150 m south of the territorial border.

1.2 Overview of Site Development

The project was first staked by Amax Exploration Ltd., through a subsidiary, Southwest Potash Corporation, in 1962. Mapping and trenching were conducted on the property between 1963 and 1967. Diamond drilling commenced in 1968 and a tote road was constructed to the site in 1970. Underground exploration took place on the property between 1973 and 1983.

810 m of underground development, consisting of an adit and drifting, and an 18 m raise were driven in 1973. Approximately 24,200 tonnes of waste rock was produced, assuming that the rock had a specific gravity of 2.65 and the mine openings are 3 m by 4 m.

Between 1974 and 1976, environmental and feasibility studies were conducted on the project and a legal land survey was completed in 1977. A 91-tonne sample was shipped from the property for testing in 1979, and in 1984, 180-tonne sample was collected. The last reported development work on the property was in 1985, when road construction, surface surveys, and engineering studies were completed.

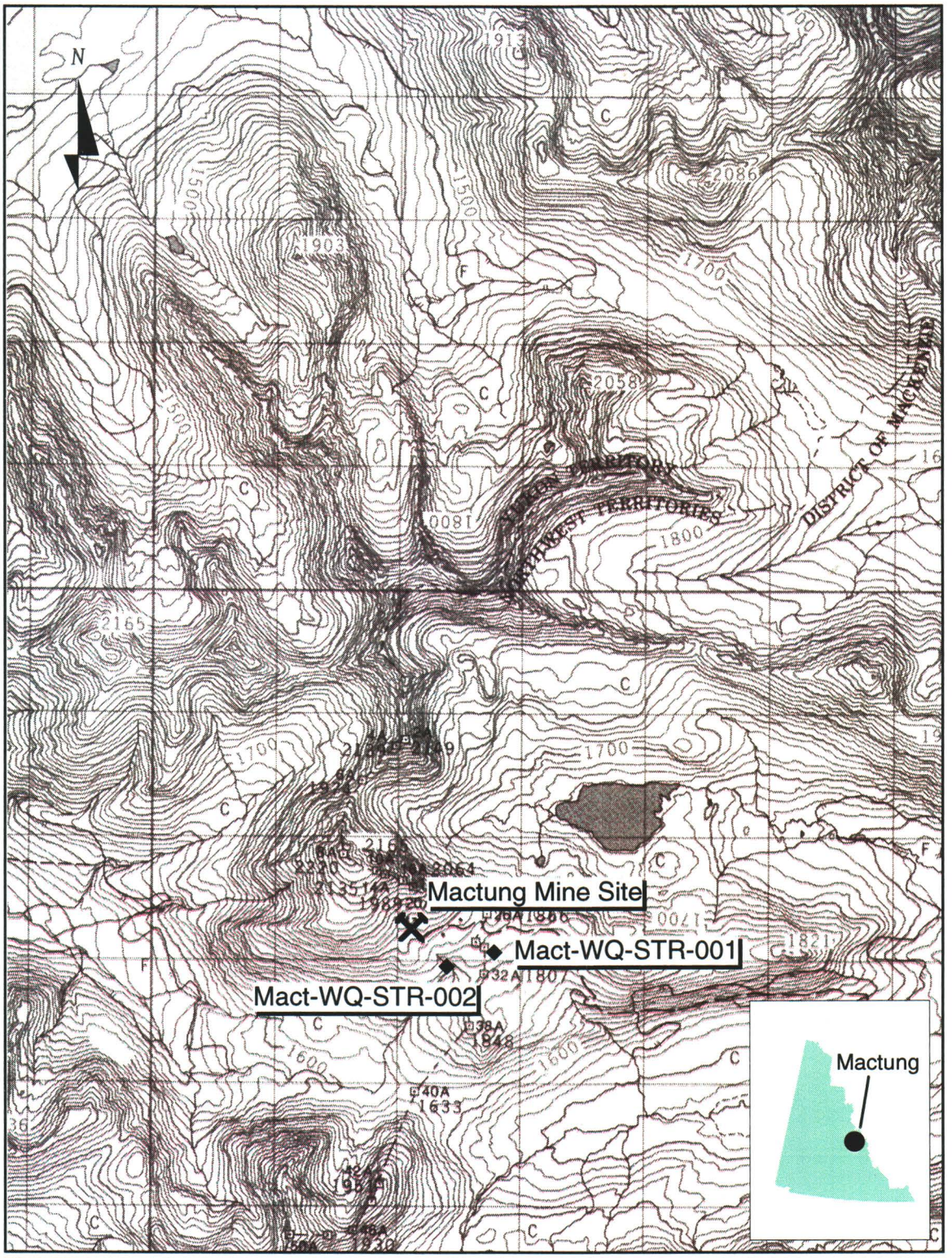
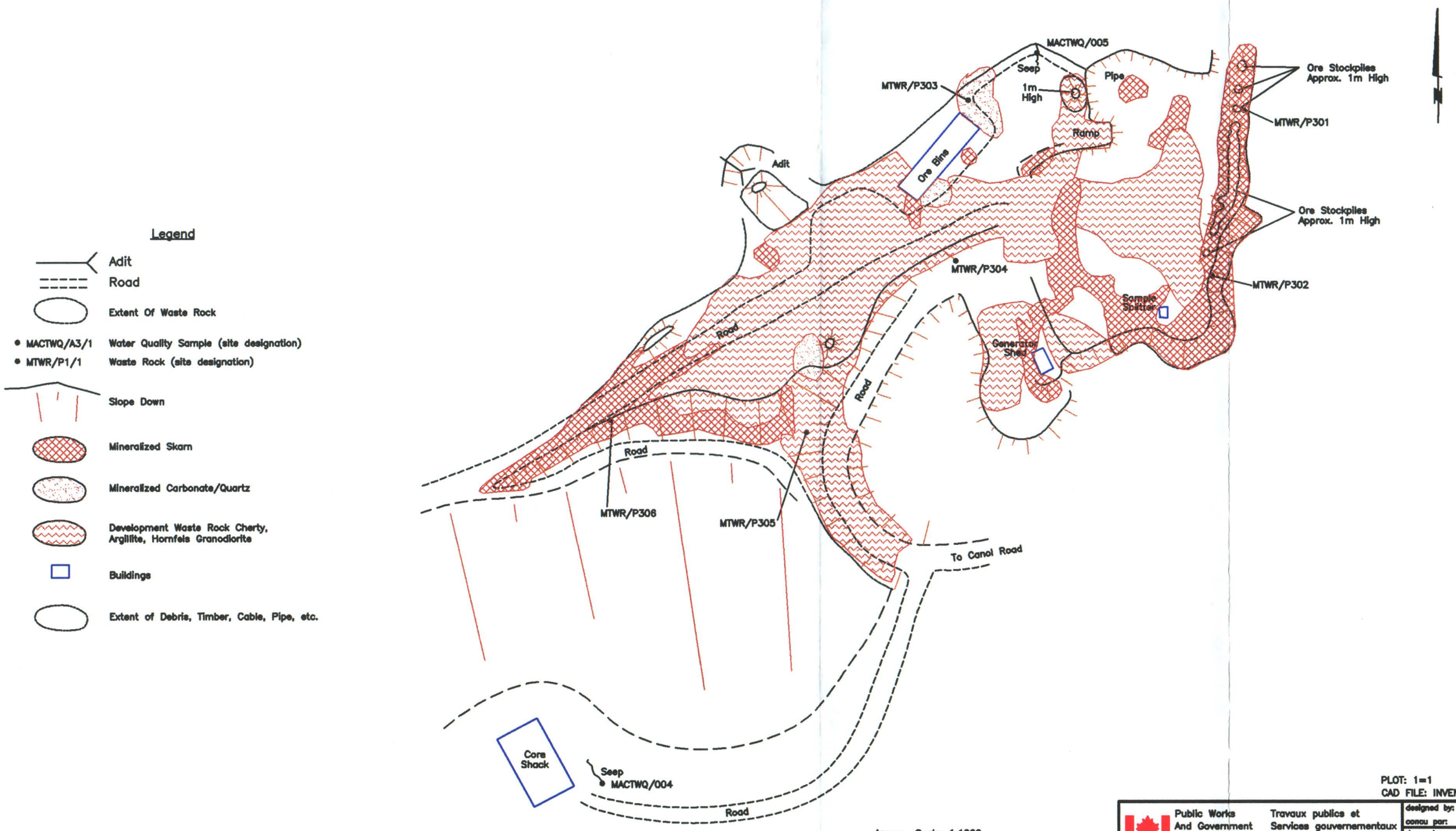


Figure 1: MACTUNG SITE

N.T.S. 105 O/8 Map Name: Keele Peak Map Scale: 1:50,000

Latitude: 63° 16' 51" N Longitude: 130° 08' 54" W



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Public Works And Government Services Canada / Travaux publics et Services gouvernementaux Canada

Architectural & Engineering Services
Western Region

designed by: / dessine par: R.N. / date: Sept. /96
drawn by: / dessine par:
approved by: / approuve par:
revisions:

Drawing title: / Titre du dessin:

MacTung Mine
Site Development & Geological Information
Yukon Territory

project no. / no. du projet: 626967

dwg. no. / dessin no. 1 of 1

Physical disturbance is limited to the mapped area. Access and drill roads have been constructed on the mountainside west of the underground workings (Photos 1 - 2).

1.3 Site Access

Mactung is accessible by 4-wheel drive vehicles along an 8 km compacted gravel road branching from the North Canol road. Mactung also attracts occasional hikers travelling the North Canol roadway; all on-site areas can be accessed by foot.

2. PURPOSE AND SCOPE OF WORK

This assessment was carried out by PWGSC for Indian and Northern Affairs Canada to a) identify potential environmental and human safety risks associated with specific abandoned mine sites and b) to provide recommendations and preliminary cost estimates for remediation or mitigation of those risks. Accordingly, 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 waste rock seeps 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
- Assessment of human safety hazards and potential for accidental or deliberate access to hazardous areas
- Assessment of acid rock drainage potential in waste rock and mine development areas

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

- Physical and chemical stabilization of waste rock disposal areas
- Sealing of all mine openings
- Consolidation and landfill of all non-hazardous, non-combustible solid wastes
- Remediation and/or removal and disposal of contaminated soils as required to meet CCME Commercial/Industrial criteria for soils
- Removal and disposal of hazardous solid wastes
- Draining, cleaning and disposal of drums, ASTs, 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
- Demolition of buildings and infrastructure to foundation level and burning of combustible non-hazardous materials in approved location

3. SITE ASSESSMENT METHODOLOGY

3.1 Assumptions

At the Mactung mine site, the assessment was limited to the area specifically developed or occupied for mine exploration or mining purposes and off-site environmental resources potentially affected by mine exploration or development activities. The access road to Mactung was not included in this assessment.

3.2 Assessment Criteria

CCME Criteria

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 for specified uses of soil and water. Remediation criteria are for generic use and 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.

For the Yukon mine assessments, Commercial/Industrial criteria were used to assess soil contaminants and the Freshwater Aquatic Life criteria were used to assess surface water quality.

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.

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 Mactung 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, pit walls and rock faces as appropriate
- 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 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 depths between 0.3 m and 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. Test pits were photographed and the locations 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.

Where test pit walls showed distinct horizons (distinguishable by the sulphide and carbonate contents), each horizon was sampled.

Water Sampling

Samples were collected from surface streams upstream and downstream of mine-related flows, and from representative seeps emanating from waste rock, 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 intended for metals analyses. For analyses of non-metallic parameters, water samples were brim-filled to minimise 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.

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 labelling 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. ENVIRONMENTAL SETTING

4.1 Mineralization

Regional geology consists primarily of sedimentary rocks, with a small component of granitic rocks. Principal mineral types include quartzite, conglomerate, slate, phyllite, shale, limestone, dolomite, sandstone, argillite, chert, granodiorite and quartz diorite (Douglas and MacLean 1963).

Scheelite (tungsten ore) occurs in five separate skarn horizons formed from the limy layers in a 300 metre thick sequence of Lower Cambrian phyllite near the margin of a Cretaceous intrusive stock. The lowest zone occurs in a lens of limestone slump breccia surrounded by phyllite. The upper zone appears to be conformable with overlying black shale of the Ordovician to Lower Devonian Road River formation. The skarn zones are separated by hornsfelsed argillite, quartzite and minor conglomerate. The two lower zones consist of scheelite ($CaWO_4$), pyrrhotite ($Fe_{1-x}S$), chalcopyrite ($CuFeS_2$) and minor occurrences of molybdenite (MoS_2) and garnet in dark green diopside skarn (DIAND, 1994).

Tungsten and copper were the minerals of interest at Mactung.

4.2 Surface Hydrology

Regional drainage is toward the southwest, combining to become the headwaters of the Pelly, Ross, MacMillan, Hess and Rogue rivers.

Local runoff and snowmelt on the east of the Mactung generator shed, ore bins and adit drains towards an unnamed stream situated approximately 2 km to the southeast. The western portion of the site (which includes most of the trenches) drains south toward a second unnamed stream located 200 m from the base of the trenched slope. Hydrological/water quality records are not available for streams in the Mactung area.

Several waste rock seeps were evident along the base of the trenched slope and in the area of the adit. No adit seep was observed.

4.3 Climate

Burns (1974) indicates the Mactung area lies within a 760 mm mean annual precipitation isohyet. MacMillan Pass, at 1409 m elevation, receives about 680 mm. Inferences from data at surrounding stations indicates the annual precipitation increases rapidly from west to east, particularly in the north, as elevations increase. Mean annual temperatures, estimated from isotherm lines of Burns (1973), are between -6°C to -9°C.

4.4 Vegetation

Mactung lies above the treeline at about the 1775 m to 1930 m elevation range. The site is characterized by alpine vegetation consisting of lichens, moss, sphagnum, willows, ericaceous shrubs and some forbs. Lichens are present on tussocks, hummocks, and peat plateaus below the site and on well-drained shattered rock. Talus slopes above the mine buildings have little or no vegetation.

4.5 Fish and Wildlife Resources

Fish inventory maps obtained from Yukon Renewable Resources indicate no fish were present during the fisheries assessment at the top of the unnamed creek running south and west of Mactung (i.e. the reach nearest Mactung). Dolly Varden char were believed present (though presence was unconfirmed) in this unnamed creek at a point about 4 km from Mactung, and were known to be present about 6 km downstream.

4.6 Site Topography and Soils

The MacMillan Pass area was glaciated during the most recent ice advance, and probably during earlier glacial periods. Only mountain peaks stood above the ice masses. Ice movement was generally in a westward direction, moving down from the mountains. Scouring was more intense in this area than further south, probably due to greater ice accumulation. Surficial deposits mantle most of the mid and lower slopes. Morainal deposits and glaciofluvial material are generally deep in valley bottoms. Upper slopes consist of talus material and bare rock.

Mactung trenches are situated on a 35° south-facing slope, but all structures have been constructed on flat waste rock pads. The core shed, generator building and ore bins are at an approximate elevation of 1900 m above sea level, and waste rock disposal areas and trenches extend approximately from 1875 m to 2100 m elevation.

Topography below the mine site includes typical upper-alpine features such as stone nets and felsenmeer interspersed with hummocky tundra. Steep upper slopes are covered with talus. Topography around the site include low rolling hills to the south, and a steep slope to the south and southwest. Soils are patchy, thin and peaty, with bedrock usually found within 0.2 m to 1 m of the surface.

5. SITE DESCRIPTION AND FINDINGS

5.1 Buildings, Infrastructure, and Equipment

A core shed, generator shed, ore storage bins and ore sample splitter are the only

significant structures at the Mactung site (Photos 3 and 4). An ATCO-style office trailer noted in the INAC (1994) report has been removed. Details of construction features and interior contents are summarized in Table 5.1.

A timber-retained waste rock loading ramp is located approximately 30 m southeast of the ore storage bins. One welded steel propane tank is located approximately 25 m west of the core shed. Eleven tungsten ore piles (each approximately 1.8 m in height and 4 m in diameter at the base) are located about 60 m southeast of the ore bins.

About 525 m northeast of the core shed, a 20 x 20 m dugout has been excavated to collect surface runoff water for drilling and possibly potable water uses.

5.2 Non-Hazardous Waste Materials

Three non-hazardous material storage/disposal areas were identified on the Mactung property. Locations and inventoried materials are summarized in Table 5.2.

5.3 Hazardous Waste Materials

Stained soils near the generator shed and ore sample splitter were assessed and sampled.

Sample MC-SL-201 was a composite of two heavily-stained patches located 5 and 10 m north of the generator shed on a waste rock, gravel and sandy silt pad. The combined stained area was about 12 m^2. Areas of heaviest staining were excavated to a depth of 15 cm; excavation was terminated at that depth due to time constraints and the difficulty of digging with hand tools. The soil profile in both excavations consisted of mixed, compacted waste rock (50% >50 mm) and sandy silt to a depth of 15 cm; similar materials appeared to extend past that depth. Staining and oily odour were noted in soil from all levels of the excavation. The coarse granular nature of the pad suggests hydrocarbons have penetrated beyond 15 cm depth. Metal and hydrocarbon analyses identified copper above CCME Commercial/Industrial criteria, but PAH compounds were all within CCME C/I limits.

Sample MC-SL-202 was collected from the surface of a heavily-stained 10 m^2 area located 3 m north of the ore sample splitter on a waste rock, gravel and sandy silt pad. The area of heaviest staining was excavated to a depth of 15 cm. The soil profile was essentially the same as observed near the generator shed. Discoloration and a very strong oily smell was noted at all levels of the excavation. The coarse granular nature of the sampled area suggests hydrocarbons have penetrated beyond the sampling depth. Hydrocarbon analyses showed all PAH compounds to be within CCME Commercial/Industrial limits.

Table 5.1 Mactung Building Construction Features and Interior Contents

Structure	Construction Features	Interior Contents	Photo No.
Core shed	- 11.2 x 18.3 m in plan, 4 m height - concrete slab foundation - two 2 x 4 m work areas with fibreglass insulation - "2 x 4" wood frame - plywood interior and exterior cladding - sheet aluminum roof covering - swinging side doors installed at west side of shed	- 7 empty drums, wood pallets and scrap lumber, numerous plywood core trays, steel re-bar core racks, galvanised steel ducting. - small work areas contain plywood work benches and miscellaneous lab plasticware - All core samples have been removed since DIAND 1993 site visit.	5, 6
Generator shed	- 3.7 x 4.4 m in plan and 3 m in height - 10 x 10 cm and 15 x 15 cm beam foundation - "2 x 4" wood frame, fibreglass insulation - plywood floor and exterior cladding - asphalt shingle roof covering - 2 x 3 m fluorescent light fixtures (no PCB ballasts)	- 23 empty drums - miscellaneous steel parts & scrap lumber - mattress	7
Ore sample splitter	- 1.5 x 1.5 m x 4 m steel beam and steel components	None	8
Ore bins	- 8 x 24 m in plan; six segregated bins in series - 4 x 8 m ⅜" sheet steel floors; 2 x 4 m ⅜" sheet steel backs - seven 2 x 8 m wood plank bin sides - bin frame constructed from 21 3-metre length and 18 1.2-metre length steel I-beams	- 4 bins contain ore to approx. ⅓ to ½ of bin volume	9, 10

Table 5.2 Mactung Non-Hazardous Waste Materials

Area	Location	Inventoried Materials	Photo No.
Loading ramp	40 m northeast of ore storage bins	- sledge frame, 1.5 x 2.5 x 1.8 m, 100 mm tubular steel construction - approx. 42 m of tubular steel pipe, 25 - 100 mm diameters - small lengths of steel cable	
Water storage dugout	525 m northeast of core shed	- Two 10 cm steel tube sledge frames, one with wood plank deck and the other bare. Sledge frame dimensions are 5 x 2.5 x .5 m - steel 2.5-ton truck box; dimensions 4 x 2.5 x .5 m - two wood & steel sledge runners - 27 steel and aluminum tubes, 50 - 62.5 mm diameter, 6 m length - approx. 35 pieces of steel pipe, 75 - 100 mm diameter and averaging 8 m in length, located 80 m north of dugout - eight 30 x 30 cm timbers, miscellaneous wood planking and plywood, 21 pieces of 37.5 to 62.5 mm diameter 3-metre lengths of steel tubing, 6 metres of 37.5 mm steel drill stem, 80 m of 75 mm diameter steel water line located 55 m north of dugout	
Area between portal and water dugout		- approx.490 m of 75 mm steel water line in 6m-long sections	

5.4 Surface Water Quality

To identify possible metallic inputs from the mine site, surface water samples were obtained from two small streams below the mine and from seeps above and below the mine site. Complete analytical results are provided in Appendix B; significant results are summarized in Table 5.3.

Table 5.3 Significant Results - Mactung Surface Water Samples

Sample ID	Sample Location	pH	Conductivity (μmhos/cm)	Metallic Parameters	Other Parameters
MACT-WQ-STR-001	Intermittent stream approx. 450 m southeast of core shed	4.9 [4.0]	150 [110]	Cu, Zn > CCME F.A.L. criteria	Sulphate = 61.6 mg/l
MACT-WQ-STR-002	Stream approx. 300 m south of core shed	7.7 [3.2]	192 [130]	Se > CCME F.A.L. criteria	Sulphate = 55.5 mg/l
MACT-WQ-STR-003	Seep at base of talus slope, 45m southwest of core shed	8.1 [8.5]	222 [140]	Al, Cd, Cu, Fe, Se, Ag, Zn > CCME F.A.L. criteria	Sulphate = 52.9 mg/l
MACT-WQ-STR-004	Ground-level seep, 7m east of core shed	7.0 [8.1]	365 [240]	Al, Cd, Cu, Fe, Se, Ag, Zn > CCME F.A.L. criteria	Sulphate = 151 mg/l
MACT-WQ-STR-005	Seep at base of talus slope, 22m northeast of ore bins	7.1 [8.5]	50.5 [20]	Al, Cu, Fe, Pb, Ag, Zn > CCME F.A.L. criteria	Sulphate = 15.4 mg/l

Notes: 1) pH and conductivity readings in square brackets are field measurements; non-bracketed readings are lab measurements
2) Low field pH reading for MACT-WQ-STR-002 may have been due to a pH meter calibration error
3) "CCME F.A.L." refers to "CCME Freshwater Aquatic Life"

MACT-WQ-STR-001 was taken from an unamed stream travelling through tundera; the low pH value for that sample is probably due to humic acids.

5.5 Waste Rock Disposal Areas

Limited waste rock is present at the site as a result of the underground development. Approximately 25,000 tonnes of waste rock covers an 10,000 m^2 area. The waste rock consists of 27% mineralized skarn, 6% mineralized quartzite and limestone, and 67% development rock on surface. Development rock is made up of hornfelsed argillite, and chert. Approximately 500 tonnes of crushed ore is stockpiled at the Mactung site (Photo

11).

Six pits were dug in the waste rock and are stockpiles. Nine samples collected for Acid Base Accounting (ABA testing) and metals analysis using Inductively Coupled Plasma - Atomic Emission Spectrophotometry (ICP-AES). The sample locations are shown on the site map. ABA test results are summarized in Table 5.4. An evaluation of the acid rock drainage potential prepared by Steffen Robertson and Kirsten is included in Appendix D.

Table 5.4 Acid-Base Accounting Test Results - Mactung Waste Rock Samples

Sample #	Paste pH	Total Sulphur (%)	Sulphur as SO_4 (%)	AP	NP	Net NP	NP/AP
MTWR/P301-1	5.43	11.20	7.41	118.4	5.4	-113.0	<0.1
MTWR/P301-2	5.32	12	0.72	352.5	-7.9	-360.4	<0.1
MTWR/P302	7.66	3.35	0.41	91.9	141.5	49.6	1.5
MTWR/P303	8.10	1.59	0.39	37.5	277.8	240.3	7.4
MTWR/P304-1	7.24	0.84	No assay	26.3	21.4	-4.8	0.8
MTWR/P304-2	7	0.24	No assay	7.5	10.6	3.1	1.4
MTWR/P305	7.92	1.77	0.42	42.2	34.3	-7.9	0.8
MTWR/P306-1	6.92	6.97	0.51	201.9	17.1	-184.8	<0.1
MTWR/P306-2	7.17	10.5	0.59	309.7	27.5	-282.2	<0.1

AP - Acid Potential in tonnes $CaCO_3$ equivalent per 1000 tonnes of material
NP - Neutralization Potential in tonnes $CaCO_3$ equivalent per 1000 tonnes of material
Net NP - Net Neutralization Potential equals tonnes $CaCO_3$ equivalent per 1000 tonnes of material

The paste pH results indicate that the ore stockpiles are the only rock material on site that are currently acid generating. While not yet acidic, it is anticipated that the waste rock on site will also become acid generating. ABA results suggest that the potential for acid generation from the overburden is insignificant.

All rock samples contained elevated concentrations of tungsten. The ore stockpiles and mineralized skarn also contained elevated concentrations of bismuth, and copper.

5.6 Mine Opening

An adit measuring 2.1 x 1.2 m is located 80 m west of the loading ramp. Access to the underground workings is partially restricted by a waste rock pile and a 1.5 x 1.5 m door

constructed of 2" x 4" lumber and plywood (Photo 12). At the time of inspection (16 August, 1996), the adit was partially obstructed by ice but still accessible for a distance of about 6 m beyond the entrance.

6. CONCLUSIONS

Existing or potential health and safety hazards or environmental/aesthetic concerns associated with the Mactung mine site are summarized in Table 6.1, and are examined more fully in sections 6.1 - 6.3.

Table 6.1 Summary of Hazards or Concerns at Mactung Mine Site

Site Assessment Component	Hazard or Concern
Buildings, Infrastructure, and Equipment	Ore sample splitter and wood loading ramp are minor aesthetic concerns
Non-Hazardous Waste Materials	Non-hazardous wastes near the water dugout and upper level trenches are minor aesthetic concerns
Waste Rock Disposal Areas	Waste rock is potentially acid-generating
Mine Openings	Adit near loading ramp is open and shaft is accessible
Hazardous Materials	Hydrocarbon-stained soil near generator shed is a minor environmental concern

6.1 Health and Safety

Access to the underground workings is still possible, and therefore poses a medium-level hazard to human safety. The former core storage and generator buildings appear to be structurally sound and are not a health and safety risk.

6.2 Environmental Risks

Waste rock at the Mactung project is not presently acid-producing, but may become acid-generating in the future; 500 tonnes of stockpiled crushed ore are marginally producing acid. Although waste rock and ore oxidation are occurring slowly, the rate will likely accelerate as acid conditions develop in the waste rock. Under acidic conditions, there is a potential for metal mobilization to the unnamed stream southeast of Mactung.

Areas of stained soil in the vicinity of the generator shed and ore sample splitter are not believed to be of significant environmental concern, although uncertainty exists with

respect to the depth of soil contamination by hydrocarbons.

6.3 Aesthetic Concerns

The non-hazardous waste materials are rated a minor aesthetic concern because of the distance of the site from major tourist highways. Generally, the area adjacent to the core shed and generator buildings is relatively free from waste materials; only the steel water pipeline between the adit and trench areas and miscellaneous wastes located near the water dugout pose any aesthetic concern.

7. RECOMMENDATIONS

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

Recommendation 1. Assuming no further site development, the adit should be sealed with waste rock. A front-end loader could be used to demolish and deposit available waste rock over the entrance.

Recommendation 2. Until the site is permanently decommissioned, the former core storage and generator buildings should remain standing and accessible. Both buildings are suitable for use as emergency shelters.

Recommendation 3. Additional water quality sampling is recommended to monitor effects of possible acid generation from waste rock and ore piles. Samples should be collected at MACT-WQ-STR-001 and MACT-WQ-STR-002, at least two downstream locations, and from a background control location. Samples should be analyzed for dissolved metals, pH, conductivity, and sulphate, and the results compared to the CCME criteria for Freshwater Aquatic Life. The monitoring program extend for at least 5 years and provide water quality data for spring freshet, middle summer and late fall runoff conditions.

Should further development occur on the site, regulatory agencies should ensure that an acid drainage prevention plan is developed which includes detailed measures for handling and disposal of mineralized waste rock.

Recommendation 4. The areas of staining should be scarified with a front-end loader blade to the depth of visible staining. In-situ bioremediation of residual hydrocarbons can then be enhanced by addition of slow-release fertilizer with an N:P:K ratio approximating 18-3-0.

Recommendation 5. Solid waste materials should be consolidated and buried on site

with available waste rock. The preferred burial location would be at or near the adit to a) isolate those materials from the stream to the southwest of the site, and b) to take advantage of adjacent waste rock as cover material.

Recommendation 6. A preliminary assessment of site hydrology should be completed to identify potential pathways and receiving waters for metals mobilized by acid-generation.

8. COST ESTIMATES TO IMPLEMENT RECOMMENDATIONS

An estimated breakdown of expected remediation/mitigation costs to an accuracy of 25% is provided under separate cover to this report. The cost estimate includes contractor and project management costs and contingency.

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Appendix A

Determination of Acid Rock Drainage Potential

P118105

MACTUNG
ACID ROCK DRAINAGE
ASSESSMENT REPORT

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P118105

MACTUNG
ACID ROCK DRAINAGE
ASSESSMENT REPORT

1.0 INTRODUCTION

This site specific report has been prepared in conjunction with the *Phase II Environmental Assessment of the Mactung Abandoned Mine Site*, prepared by Environmental Services, Public Works and Government Services Canada (PWGSC). The reader is directed to that report for a complete environmental assessment of the Mactung site.

The Mactung site is located in the Selwyn Mountains along the Yukon/Northwest Territories boundary, approximately 185 km northeast of the Village of Ross River, Yukon Territory. The site is accessible by vehicle.

Mining related disturbances observed on site include an adit, waste rock piles and ore stockpiles. The waste rock at Mactung was produced from underground development carried out between 1963 and 1983 (Yukon Minfile #1050 002).

The site is located above the treeline and is covered with short grasses and alpine vegetation below the exploration site. At the exploration site, vegetation is limited to lichens attached to the fractured rock.

This report reviews the existing, and the potential for, acid rock drainage (ARD) conditions at the Mactung site and provides recommendations for remediation. This site specific report is part of the *Acid Rock Drainage Review Report, Yukon Abandoned Mine Site Assessments*, prepared by Steffen Robertson and Kirsten (SRK). The reader is directed to that report for detail regarding the scope of work, site assessment methodology, ARD remediation options and the evaluation of potential remediation options.

2.0 GEOLOGY AND MINERALIZATION

Scheelite (tungsten ore) occurs in five separate skarn horizons formed from the limy layers in a 300 metre thick sequence of Lower Cambrian phyllite near the margin of a Cretaceous intrusive stock. The lowest zone occurs in a lens of limestone slump breccia surrounded by phyllite. The upper zone appears to be conformable with overlying black shale of the Ordovician to Lower Devonian Road River formation. The skarn zones are separated by hornsfelsed argillite, quartzite and minor conglomerate. The two lower zones consist of scheelite ($CaWO_4$), pyrrhotite ($Fe_{1-x}S$), chalcopyrite ($CuFeS_2$) and minor occurrences of molybdenite (MoS_2) and garnet in dark green diopside skarn (DIAND, 1994).

3.0 WASTE ROCK DISPOSAL AREAS

3.1 Description

The volume of waste rock produced from historical underground development is estimated to be 24 200 tonnes. The assumptions made to derive this estimate are:

- a specific gravity of 2.65;
- 830 metres in total of underground development; and,
- 3 by 3.6 metre mine openings.

Approximately 500 tonnes of ore is currently stockpiled at the Mactung site. This estimate is based on observed dimensions of the piles. On surface, the waste rock consists of 27% mineralized skarn, 6% mineralized quartzite and limestone, and 67% development rock. The development rock is made up of hornfelsed argillite and chert. Secondary iron mineralization was observed on the mineralized skarn. The distribution of mineralization in the waste rock and ore stockpiles is shown on the site map, Drawing 2.

3.2 Samples

Six pits were dug in the waste rock and ore stockpiles. Nine samples were collected for laboratory analysis. The sample locations are shown on the site map, Drawing 2.

Samples (MTWR/*) P301/1, P301/2, P303, P306/1 and P306/2 were collected from mineralized rock. Samples (MTWR/*) P304/1, P304/2 and P305 were collected in overburden and unmineralized rock. Pit 301 was excavated in an ore stockpile. Pits P302 and P306 were excavated in mineralized skarn waste rock. Pit P304 was excavated in disturbed overburden and P305 was excavated in typical development rock. Summaries of the test pit logs are provided in Table 1.

Water samples were collected from two streams downstream of the mine site and from seeps both above and below the mine workings. Samples (MACTWQ/*) STR001 and STR002 were collected from streams 450 metres southeast and 300 metres south of the core shed, respectively. Sample MACTWQ/005 was obtained from a seep at the base of the talus slope as it flowed onto the mine site. MACTWQ.STR003 was collected from a seep 45 metres southwest of the core shack and MACTWQ/STR004 was collected from a spring at the core shack. Both seeps are below the waste rock.

3.3 Analytical Results

Results of geochemical analyses of waste rock samples are provided in Table 2 and the analytical results for the water samples are provided in Table 3.

Paste Parameters

The paste pH values for the nine rock samples ranged from 5.32 to 8.10. The two samples collected from the ore stockpiles had low paste pH values while the samples from the waste rock were neutral or slightly alkaline. The paste pH results indicate that the ore stockpiles are the only rock material on site that are currently acid generating.

Acid Base Accounting

Samples collected from the mineralized skarn and development rock had Neutralization to Acid Potential (NP:AP) ratios of less than 1.5, indicating that the materials are potentially acid generating. The NP:AP ratio for sample MTWR/P303, the quartz/limestone, is 7.41, This material is present only in minor quantities, as shown on the site map. The NP:AP results for the overburden suggest that it is not acid generating, since the sulphur grades are lower. Therefore the potential for acid generation from the overburden is insignificant.

Metals Concentrations

All rock samples contained elevated concentrations of tungsten. The ore stockpiles and mineralized skarn also contained elevated concentrations of bismuth, and copper.

Water Quality

All water samples contained elevated concentrations of aluminium; however, at the prevailing pH in the seeps it is believed to be present as suspended mater. The seep samples, both above and below the mine site were also above the CCME freshwater aquatic life guidelines for copper, iron, silver and zinc. The upstream sample was also elevated in lead. The seeps are not currently acidic.

Samples MACTWQ/STR001 and MACTWQ/STR002 were collected over 300 metres from the Mactung site. Sample STR001 was acidic, at a pH of 4.87. Drainage from the mine site is not the cause of the low pH, since none of the seeps are currently acidic. Humic acid from the tundra is probably the cause of the cause of the low pH. It also contained elevated concentrations of copper, nickel and zinc.

4.0 EXISTING AND POTENTIAL ACID ROCK DRAINAGE CONDITIONS

Sample analysis of the various rock types suggests that the 500 tonnes of stockpiled crushed ore is marginally generating acid. The sulphur grades indicate that acid generation is likely to increase from the ore stockpiles. While not yet acidic, it is anticipated that the waste rock on site will also become acid generating. However, since no development work has been undertaken since 1973, it is clear that the waste rock and ore are oxidizing at a slow rate. This rate will likely change once acidic conditions develop in the waste rock.

The water quality results of samples collected from seeps near the waste rock and ore stockpiles indicate that drainage currently is not significantly impacted by the mined material. Measured sulphate values indicate that oxidation products are reaching the southern parts of the site.

5.0 REMEDIATION OPTIONS

Typical reclamation and control options for acid generating mine waste and mine openings include:

- source control which includes limiting further oxidation, for instance, by placing the waste under water thus preventing oxygen entry;
- migration control which limits the mobility of oxidation products, for example, by reducing infiltration to the waste by placing a low permeability cover; and,
- release control by collecting and treating contaminated flows prior to discharge.

The acid base accounting results suggest that most of the waste rock at Mactung may become acid generating. Remediation is not an immediate requirement however since: at present oxidation is proceeding at a relatively slow rate and it may be several years before net acidic conditions develop; and the site is relatively distant from any surface water that would be significantly impacted. Should remediation become necessary, the options that may be applicable have been assessed below.

Collection and treatment of the runoff from the Mactung site is not considered a viable option due to its remote location, and the lack of runoff from the mine site. Relocation of the waste rock was also not considered since there is no secure placement location readily available, such as the underground workings or an open pit, to place the material.

Placement of a soil cover to control the migration of ARD was considered a viable remediation option. This option is compared to the "do nothing" option in the following table.

Matrix for Evaluating Applicable/Potential Remediation

Option versus Evaluation Criteria	Mactung			
	Collect and Treat	**Relocate**	**Cover**	**Leave as is**
Public Health and Safety 5 = provides full protection of public 1 = provides no protection of public	not applicable	not applicable	5	5
Worker Health and Safety 5 = relative low risk to workers 1 = high risk to workers	not applicable	not applicable	4	5
Ecosystem Preservation and Protection 5 = relative low risk to environment 1 = relative high risk to environment	not applicable	not applicable	4	2
Impact on Mineral Resource 5 = allows for continued exploration 1 = impedes continued exploration	not applicable	not applicable	5	5
Direct Costs (mobilization & materials) 5 = relative low cost 1 = relative high cost	not applicable	not applicable	1	5
Monitoring and Maintenance Costs 5 = relative low cost 1 = relative high cost	not applicable	not applicable	2	3
Acceptability 5 = positive response anticipated 1 = negative response anticipated	not applicable	not applicable	4	3
Total Score	**0**	**0**	**25**	**28**

The waste rock pile and ore stockpiles at the Mactung site do not represent a significant health and safety risk, except to workers during the placement of the cover.

Placing a cover on the waste rock and ore stockpiles would decrease the amount of infiltration through the pile. However, the recent site visit indicated that the waste rock and ore are not significantly impacting the local environment. Covering the waste also entails a moderate risk to the ecosystem for two reasons. First, disturbing the waste may cause a short term release of soluble metal constituents into the receiving environment, and secondly an additional site would be disturbed to provide the cover material. The

risk to the receiving environment is small since the nearest surface water bodies are fairly remote. It is however considered that the risk to the environment is higher if no remediation action is undertaken since the neutralizing capacity of the unmineralized rock could be depleted in the future.

Exploration on the site would not be impeded by either remediation measure.

The cost to consolidate and cover the waste rock would be relatively high due to the remoteness of the site. Maintenance of the cover would likely be required. Monitoring of the receiving waters would occur for either option.

Covering the waste rock pile would improve the aesthetic appearance of the site and is therefore ranked slightly higher for acceptability.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The data collected from the Mactung site indicate that the ore stockpiles and the mineralized skarn are oxidizing. The potential for future acid generation from these sources is significant.

An environmental study was conducted on the Mactung site between 1974 and 1976. This report was not available for examination during the course of this project. It is recommended that this report be reviewed for background data contained therein to confirm the above conclusion.

The data collected from and the observations at the Mactung site indicate that the local environment is not being significantly impacted. No immediate remediation action is required. However, the site may become net acid generating in the future. It is recommended that a preliminary assessment be completed to estimate the surface drainage from the mine site, and the potential environmental impact should all of the material become acid generating.

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TABLE 1 Mactung Waste Rock Sample Descriptions

Sample ID	Sample Description
MTWR/P301/1	crushed <1" ore from stockpile. Light buff/red in colour, surface has slight salty appearance on pebbles and reddish rust stains on the fine grained material. Sample collected from upper 10 cm of pit.
MTWR/P301/2	crushed <1" ore from stockpile, collected below MTWR/P301/1, 35 cm thick horizon sampled, darker buff/red colour than surface sample.
MTWR/P302	crushed <1" development rock and 5% ore from stockpile. Greenish/brown colour, 40 cm thick horizon sampled, small 5cm x 5cm section of rusty material near top of pit.
MTWR/P303	quartz/limestone (cherty dolomite rich) 40%, development rock 40%, mineralized skarn 20%. Sand and small pebbles. Sample collected over a thickness of 30 cm.
MTWR/P304/1	overburden, hornfels used in road and laydown area construction. Upper 10 cm is brown in colour and contains sand and pebbles.
MTWR/P304/2	overburden, hornfels used in road and laydown area construction. Sample collected below MTWR/P304/1 over 30 cm of thickness. Brown/grey coloured, silty - sticky - slightly wet to touch
MTWR/P305	development rock, fresh hornfels/argillite. Contains 4% sulphide rich material, dark grey colour, fragments up to 2' x 1' x 1', cobbles generally <3", pit is 40 cm deep.
MTWR/P306/1	oxidized mineralized skarn, red brown colour, upper 5 cm of pit.
MTWR/P306/2	mineralized skarn, collected below MTWR/P306/2, 25 cm thick horizon sampled, dark grey/green colour, garnet rich cobbles up to 1' that contain pyrite and pyrrhotite and contain minor bands of chert.

TABLE 2 Mactung Waste Rock ABA and ICP Results

Parameter	Units	Sample Number MTWR								
		P301/1	P301/2	P302	P303	P304/1	P304/2	P305	P306/1	P306/2
Lab Paste pH		5.43	5.32	7.66	8.10	7.24	7.00	7.92	6.92	7.17
Total Sulfur	%	11.20	12.00	3.53	1.59	0.84	0.24	1.77	6.97	10.50
Sulfate	%	7.41	0.72	0.41	0.39	na	na	0.42	0.51	0.59
AP		118.44	352.50	91.88	37.50	26.25	7.50	42.19	201.88	309.69
NP		5.44	-7.94	141.50	277.75	21.44	10.56	34.25	17.13	27.50
NET NP		-113.00	-360.44	49.63	240.25	-4.81	3.06	-7.94	-184.75	-282.19
NP/AP		<0.1	<0.1	1.54	7.41	0.82	1.41	0.81	<0.1	<0.1
Aluminum	%	2.31	2.28	2.00	0.72	2.54	2.02	3.22	2.87	2.79
Antimony	ppm	82	80	50	36	22	8	35	87	110
Arsenic	ppm	<1	<1	<1	<1	26	50	64	<1	<1
Barium	ppm	15	12	15	15	187	137	105	21	49
Beryllium	ppm	<0.1	<0.1	3.3	5.8	<0.1	<0.1	0.8	<0.1	<0.1
Bismuth	ppm	425	402	318	43	66	<1	32	309	423
Cadmium	ppm	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Calcium	%	3.08	3.02	7.56	10.70	2.03	1.43	3.26	3.24	3.68
Chromium	ppm	136	104	103	46	95	74	147	80	76
Cobalt	ppm	38	40	18	9	14	8	13	34	45
Copper	ppm	3646	3732	632	202	407	73	400	2367	2221
Gallium	ppm	<1	<1	<1	<1	<1	<1	<1	5	<1
Iron	%	15.00	14.93	6.33	2.60	3.53	2.00	2.96	10.66	13.02
Lead	ppm	88	10	21	10	9	<1	23	6	<1
Lithium	ppm	12	10	8	5	34	26	30	21	25
Magnesium	%	0.17	0.16	0.35	0.18	0.79	0.77	0.63	0.31	0.40
Manganese	ppm	602	451	2166	1080	436	259	295	545	709
Molybdenum	ppm	37	35	24	17	23	20	35	30	36
Nickel	ppm	34	35	30	15	43	31	43	30	38
Potassium	%	0.07	0.06	0.03	0.03	0.35	0.39	0.37	0.12	0.16
Potassium	ppm	2960	2880	1340	2010	4090	3330	1250	1710	2760
Silver	ppm	1.9	1.0	0.7	0.8	0.2	<0.1	0.2	0.6	0.7
Sodium	%	0.06	0.06	0.03	<0.01	0.03	0.02	0.08	0.07	0.07
Strontium	ppm	42	45	72	166	103	45	108	46	52
Thorium	ppm	<1	<1	<1	<1	<1	<1	<1	<1	<1
Tin	ppm	9	9	5	2	3	2	2	6	8
Titanium	%	<0.01	<0.01	<0.01	<0.01	0.04	0.03	0.04	<0.01	<0.01
Tungsten	ppm	615	616	299	294	114	12	158	613	769
Uranium	ppm	<1	<1	<1	<1	<1	<1	<1	<1	<1
Vanadium	ppm	4.0	3.5	26.3	11.6	143.3	139.7	206.0	6.3	11.6
Zinc	ppm	67	42	117	59	162	194	116	31	29

AP = Acid Potential in tonnes $CaCO_3$ equivalent per 100 tonnes of material

NP = Neutralization Potential in tonnes $CaCO_3$ equivalent per 1000 tonnes of material

Net NP = Net Neutralization Potential = tonnes $CaCO_3$ equivalent per 1000 tonnes of material

na = no assay / analysis

< = lower detection limit

> = upper detection limit

Steffen, Robertson and Kirsten
February 1997

TABLE 3 Mactung Water Quality Results

Parameter	Units	Sample Number MACT-WQ-				
		STR-001	STR-002	3	4	5
Field Conductivity	umhos/cm	110	130	140	240	20
Field pH		4	3.2	8.5	8.1	8.5
Conductivity	umhos/cm	150	192	222	365	50.5
Hardness CaCO3	mg/L	49.6	91.3	447	171	36.1
Moisture %	%	-	-	-	-	-
pH		4.87	7.66	8.06	6.95	7.1
Acidity (to pH 8.3) CaCO3	mg/L	15	2.3	2.7	2.7	3.8
Alkalinity-Total CaCO3	mg/L	<1.0	34.5	54.5	7.1	1.2
Chloride Cl		-	-	-	-	-
Sulphate SO4	mg/L	61.6	55.5	52.9	151	15.4
Aluminum T-Al	mg/L	1.96	0.035	14.3	1.09	5.23
Antimony T-Sb	mg/L	-	-	-	-	-
Arsenic T-As	mg/L	0.0001	0.0001	0.0181	0.0011	0.035
Barium T-Ba	mg/L	0.08	0.01	0.29	0.05	0.13
Beryllium T-Be	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005
Boron T-B	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium T-Cd	mg/L	0.0004	0.0003	0.0048	0.002	0.0011
Calcium T-Ca	mg/L	10.9	33.7	165	64.5	12
Chromium T-Cr	mg/L	<0.001	<0.001	0.017	0.003	0.02
Cobalt T-Co	mg/L	0.03	<0.02	<0.02	<0.02	<0.02
Copper T-Cu	mg/L	0.02	<0.001	0.139	0.024	0.072
Iron T-Fe	mg/L	0.2	<0.03	13.4	1.37	6.93
Lead T-Pb	mg/L	0.001	0.002	0.007	0.002	0.02
Lithium T-Li	mg/L	0.02	<0.02	<0.02	<0.02	<0.02
Magnesium T-Mg	mg/L	5.42	1.75	8.67	2.46	1.49
Manganese T-Mn	mg/L	1.41	<0.005	1.36	0.057	0.261
Mercury T-Hg	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum T-Mo	mg/L	<0.03	<0.03	<0.03	<0.03	<0.03
Nickel T-Ni	mg/L	0.05	<0.02	<0.02	<0.02	<0.02
Selenium T-Se	mg/L	0.0006	0.0015	0.0013	0.0019	0.001
Silver T-Ag	mg/L	0.0001	0.0001	0.0004	0.0002	0.0004
Sodium T-Na	mg/L	<2	<2	<2	<2	<2
Tin T-Sn	mg/L	-	-	-	-	-
Vanadium T-V	mg/L	<0.03	<0.03	0.05	<0.03	<0.03
Zinc T-Zn	mg/L	0.082	<0.005	0.196	0.072	0.065

< = lower detection limit

Steffen Robertson and Kirsten
February, 1997

Appendix B

Site Photographs

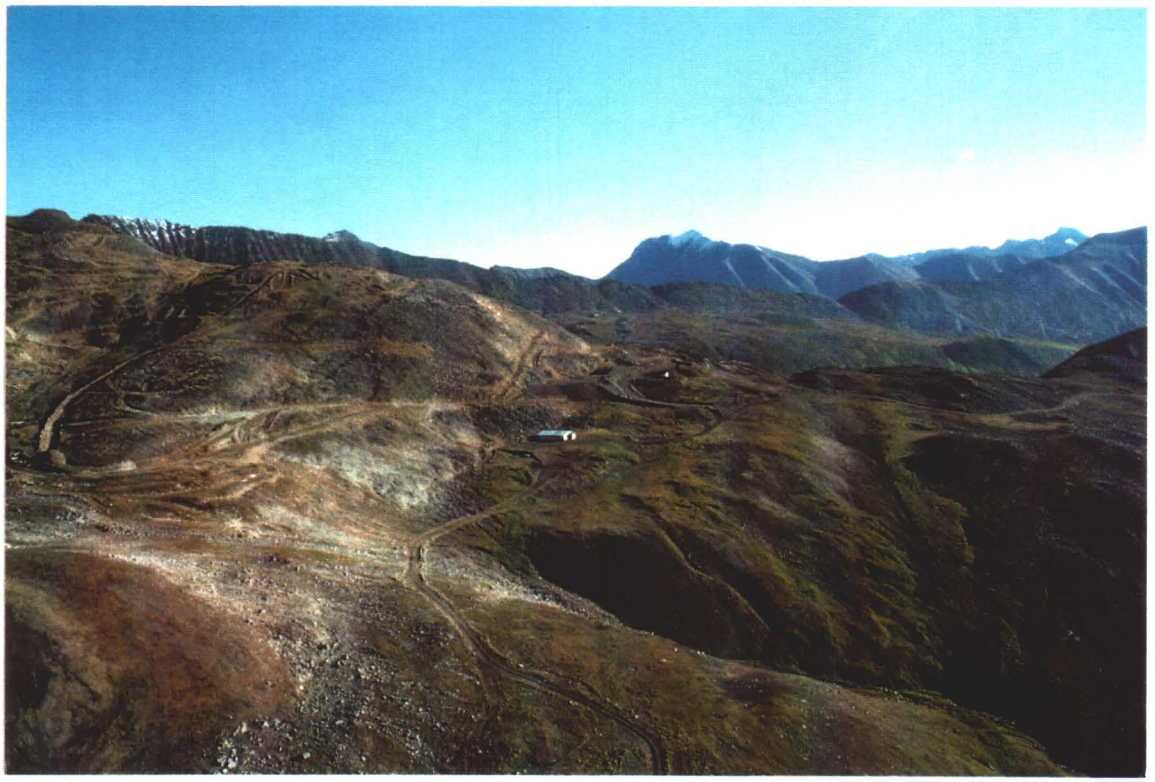

Photo 1. View of Mactung mine site looking northeast. Core storage building is visible at centre of photo.

Photo 2. View of trenching and road network immediately north and west of the core storage building.

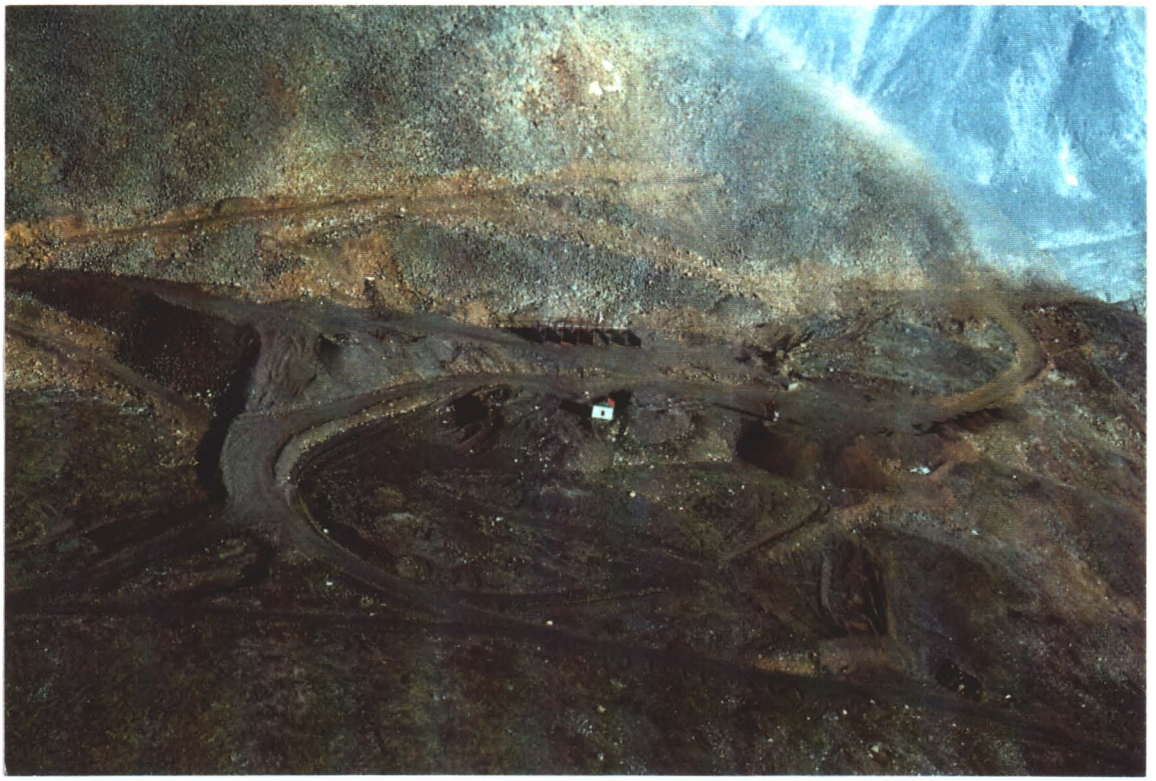

Photo 3. Overview of generator building and ore bins (photo centre), and sample splitter and ore piles (right centre of photo).

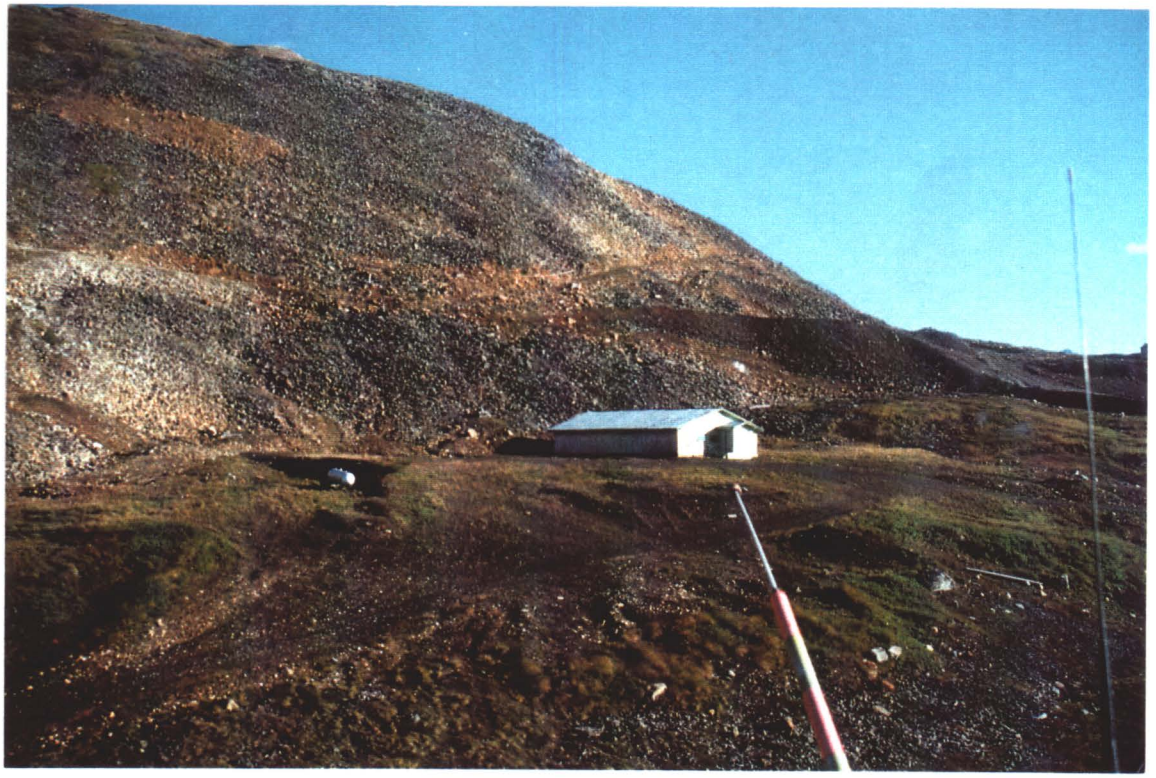

Photo 4. Core shed and propane tank.

Photo 5. Empty core storage racks, west side of core storage building.

Photo 6. Wood and metal wastes, east side of core storage building.

Photo 7. Generator shed, looking southwest.

Photo 8. Ore sample splitter, viewed toward east.

Photo 9. Steel-and-timber ore bins.

Photo 10. Ore bins constructed from steel I-beams, sheet steel back walls and floors, and timber side walls.

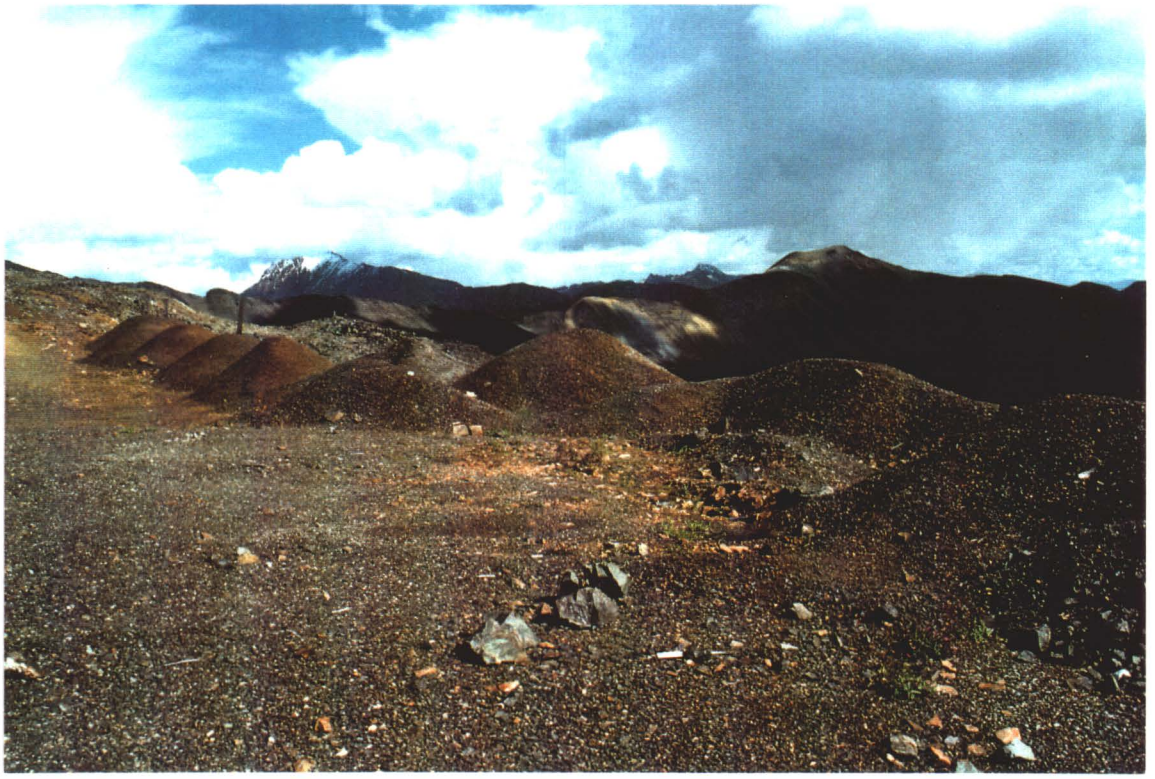

Photo 11. Ore concentrate piles east of ore bins and sample splitter.

Photo 12. Adit near loading ramp, accessible through opening at lower centre of photo.

Appendix C

Analytical Results

1988 Triumph Street, Vancouver, B.C., Canada V5L 1K5 analytical service laboratories ltd. FAX: 604 253-6700 TEL: 604 253-4188

CHEMICAL ANALYSIS REPORT

Date: September 24, 1996

ASL File No. G4270

Report On: Soil, Water And Product Analysis

Report To: **Public Works & Gov't Services**
Environmental Services
204-1166 Alberni Street
Vancouver, BC
V6E 3W5

Attention: **Mr. Tim Sackmann**, Manager, Contaminated Sites

Received: August 20, 1996

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Heather A. Ross, B.Sc.
Project Chemist

Frederick Chen, B.Sc.
Supervisor, Trace Metals Lab

RESULTS OF ANALYSIS - Water[1]

File No. G4270

			MACT-WQ-STR-001 96 08 15 11:00
Physical Tests			
Conductivity (umhos/cm)			150
Hardness		CaCO3	49.6
pH			4.87
Dissolved Anions			
Acidity		CaCO3	15.0
Alkalinity - Total		CaCO3	<1.0
Sulphate	SO4		61.6
Total Metals			
Aluminum	T-Al		1.96
Arsenic	T-As		0.0001
Barium	T-Ba		0.08
Beryllium	T-Be		<0.005
Boron	T-B		<0.1
Cadmium	T-Cd		0.0004
Calcium	T-Ca		10.9
Chromium	T-Cr		<0.001
Cobalt	T-Co		0.03
Copper	T-Cu		0.020
Iron	T-Fe		0.20
Lead	T-Pb		0.001
Lithium	T-Li		0.02
Magnesium	T-Mg		5.42
Manganese	T-Mn		1.41
Mercury	T-Hg		<0.00005
Molybdenum	T-Mo		<0.03
Nickel	T-Ni		0.05
Selenium	T-Se		0.0006
Silver	T-Ag		0.0001
Sodium	T-Na		<2
Vanadium	T-V		<0.03
Zinc	T-Zn		0.082

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
[1]Results are expressed as milligrams per litre except where noted.

RESULTS OF ANALYSIS - Water[1]

File No. G4270

			MACT-WQ-STR-002	MACT-WQ-003	MACT-WQ-004	MACT-WQ 005
			96 08 15 11:15	96 08 15 11:30	96 08 15 13:00	96 08 15 13:15
Physical Tests						
Conductivity (umhos/cm)			192	222	365	50.5
Hardness		CaCO3	91.3	447	171	36.1
pH			7.66	8.06	6.95	7.10
Dissolved Anions						
Acidity		CaCO3	2.3	2.7	2.7	3.8
Alkalinity - Total		CaCO3	34.5	54.5	7.1	1.2
Sulphate	SO4		55.5	52.9	151	15.4
Total Metals						
Aluminum	T-Al		0.035	14.3	1.09	5.23
Arsenic	T-As		0.0001	0.0181	0.0011	0.0350
Barium	T-Ba		0.01	0.29	0.05	0.13
Beryllium	T-Be		<0.005	<0.005	<0.005	<0.005
Boron	T-B		<0.1	<0.1	<0.1	<0.1
Cadmium	T-Cd		0.0003	0.0048	0.0020	0.0011
Calcium	T-Ca		33.7	165	64.5	12.0
Chromium	T-Cr		<0.001	0.017	0.003	0.020
Cobalt	T-Co		<0.02	<0.02	<0.02	<0.02
Copper	T-Cu		<0.001	0.139	0.024	0.072
Iron	T-Fe		<0.03	13.4	1.36	6.92
Lead	T-Pb		0.002	0.007	0.002	0.020
Lithium	T-Li		<0.02	<0.02	<0.02	<0.02
Magnesium	T-Mg		1.75	8.67	2.46	1.49
Manganese	T-Mn		<0.005	1.36	0.057	0.261
Mercury	T-Hg		<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum	T-Mo		<0.03	<0.03	<0.03	<0.03
Nickel	T-Ni		<0.02	<0.02	<0.02	<0.02
Selenium	T-Se		0.0015	0.0013	0.0019	0.0010
Silver	T-Ag		0.0001	0.0004	0.0002	0.0004
Sodium	T-Na		<2	<2	<2	<2
Vanadium	T-V		<0.03	0.04	<0.03	<0.03
Zinc	T-Zn		<0.005	0.196	0.072	0.065

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
[1]Results are expressed as milligrams per litre except where noted.

Appendix 1 - QUALITY CONTROL - Replicates

File No. G4270

Water[1]			MACT-WQ-005 96 08 15 13:15	MACT-WQ-005 QC # 70792
Physical Tests				
Conductivity (umhos/cm)			50.5	48.7
Hardness		CaCO3	36.1	37.1
pH			7.10	7.08
Dissolved Anions				
Acidity		CaCO3	3.8	2.8
Alkalinity - Total		CaCO3	1.2	1.5
Sulphate	SO4		15.4	14.4
Total Metals				
Aluminum	T-Al		5.23	5.75
Barium	T-Ba		0.13	0.13
Beryllium	T-Be		<0.005	<0.005
Boron	T-B		<0.1	<0.1
Cadmium	T-Cd		0.0011	0.0011
Calcium	T-Ca		12.0	12.0
Chromium	T-Cr		0.020	0.018
Cobalt	T-Co		<0.02	<0.02
Copper	T-Cu		0.072	0.083
Iron	T-Fe		6.92	7.79
Lead	T-Pb		0.020	0.020
Lithium	T-Li		<0.02	<0.02
Magnesium	T-Mg		1.49	1.73
Manganese	T-Mn		0.261	0.271
Mercury	T-Hg		<0.00005	<0.00005
Molybdenum	T-Mo		<0.03	<0.03
Nickel	T-Ni		<0.02	<0.02
Selenium	T-Se		0.0010	0.0011
Silver	T-Ag		0.0004	0.0004
Sodium	T-Na		<2	<2
Vanadium	T-V		<0.03	0.03
Zinc	T-Zn		0.065	0.076

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
[1]Results are expressed as milligrams per litre except where noted.

dichloromethane followed by a clean-up using silica gel column chromatography. This clean-up procedure has been found to effectively remove aliphatic and heterocyclic hydrocarbons which could potentially interfere with the analysis. The final extract is analysed by capillary column gas chromatography with mass spectrometric detection.

Conventional Parameters in Water

These analyses are carried out in accordance with procedures described in "Methods for Chemical Analysis of Water and Wastes" (USEPA), "Manual for the Chemical Analysis of Water, Wastewaters, Sediments and Biological Tissues" (BCMOE), and/or "Standard Methods for the Examination of Water and Wastewater" (APHA). Further details are available on request.

Metals in Water

This analysis is carried out in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater" 19th Edition 1995 published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion or filtration (EPA Method 3005), followed by instrumental analysis by atomic absorption spectrophotometry (EPA Method 7000), inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010), and/or inductively coupled plasma - mass spectrometry (EPA Method 6020).

Mercury in Water

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 19th Edition 1995 published by the American Public Health Association. A cold-oxidation procedure involving bromine monochloride is used, followed by instrumental analysis by cold-vapour atomic absorption spectrophotometry (CVAAS).

End of Report

APPENDIX

CHAIN OF CUSTODY FORMS

CHAIN OF CUSTODY / ANALYTICAL REQUEST FORM

analytical service laboratories ltd.
Specialists in Environmental Chemistry
1988 Triumph Street
Vancouver, BC
Canada V5L 1K5
FAX: (604) 253-6700
TEL: (604) 253-4188
TOLL FREE: (800) 665-0243

CLIENT: PWGSC ENVIRONMENTAL SERVICES
204 - 1166 ALBERNI ST.
VANCOUVER B.C.
V6E 3W5
PH/FAX#: (604) 623 6388 / (604) 623-6239
CONTACT: TIM SICKMANN.
SAMPLED BY: T. SICKMANN, A. LAUDRUM, D. CHARBONEAU

PAGE 1 OF 5

YUKON A.M.D., PHASE II ACC/96

ASL CONTACT: HEATHER THOMAS
CLIENT PROJECT #:
PO #:
DATE SUBMITTED:
RESULTS REQUIRED BY:

64270

ANALYSIS REQUESTED

LAB USE	SAMPLE IDENTIFICATION	SAMPLE TYPE	DATE/TIME SAMPLED (Y M D)	FIELD PRESERVATION	TOTAL METALS	IMMEDIATES	TOTAL VOLATILES	P.A.H.	CHLORIDES	COMMENTS
1	RU - BL - 1	BARREL	96 14 08 11:00 AM PM	Ø	✓	✓				
2	RU - BL - 2	"	96 14 08 11:00 AM PM	Ø	✓	✓				
3	RU - BL - 5	"	96 14 08 11:00 AM PM	Ø	✓	✓				
4	RU - BL - 6	"	96 14 08 11:00 AM PM	Ø	✓	✓				
5	RU - BL - 7	"	96 14 08 11:00 AM PM	Ø	✓	✓				
6	RU - SL - 201	SOIL	96 15 08 1:00 AM PM	Ø	✓		✓			
7	RU - SL - 202	"	96 15 08 1:00 AM PM	Ø	✓		✓			
8	RU - SL - 203	"	96 15 08 1:00 AM PM	Ø	✓		✓			
9	RU - SL - 204	"	96 15 08 1:00 AM PM	Ø				✓		
10	RU - SL - 205	"	96 15 08 1:00 AM PM	Ø	✓		✓			
11	RU - SL - 206	"	96 15 08 1:00 AM PM	Ø	✓		✓			
12	RU - SL - 207	"	96 15 08 1:00 AM PM	Ø	✓		✓			
13	FO - SL - 201	"	96 20 08 11:00 AM PM	Ø	✓		✓			
14	FO - SL - 301	"	96 13 08 11:00 AM PM	Ø	✓		✓			
15	SG - SL - 203	"	96 17 08 11:30 AM PM	Ø	✓					

NOTES/COMMENTS

· Immediates = SO_4^{2-}, Acidity, Alk, pH, Conductivity

CONDITION RECEIVED
FROZEN
COLD
AMBIENT
TOTAL PACKAGES

RELINQUISHED BY		
AFFILIATION		
RECEIVED BY	DB	96/08/20 (Y/M/D)
AFFILIATION	ASL	: AM PM

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1988 Triumph Street
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Canada V5L 1K5
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TEL: (604) 253-4188
TOLL FREE: (800) 665-0243

CLIENT: PACIFIC ENVIRONMENTAL SERVICES
204 / 1111 ALBERNI ST
VANCOUVER, B.C
V6E 3W5
PH/FAX#: 623 6348 / 623 6239
CONTACT: TIM SHACKLETON
SAMPLED BY: T. SHACKLETON, A. LAWRENCE, D. CHARBONNEAU

PAGE 2 OF 5
YUKON A.M.D, PHASE II, ALL QC
ASL CONTACT: HEATHER THOMAS
CLIENT PROJECT #:
PO #:
DATE SUBMITTED:
RESULTS REQUIRED BY:

ANALYSIS REQUESTED: TOTAL METALS, IMAGUMET, GEN EPR CHEMISTRY

LAB USE	SAMPLE IDENTIFICATION	SAMPLE TYPE	DATE/TIME SAMPLED (Y M D)	FIELD PRESERVATION															COMMENTS
16	SH - WQ - A1 - 1	WATER	96 07 29 10:00 AM	NITRIC	✓														
	SH - WQ - A1 - 1	"	96 07 29 :__	Ø		✓													
17	DU - WQ - STR - 302	"	96 08 17 9:30 AM	NITRIC	✓														
	DU - WQ - STR - 302	"	96 08 17 9:30 AM	Ø		✓													
18	FO - WQ - STR - 001	"	96 08 13 11:00 AM	NITRIC	✓														
	FO - WQ - STR - 001	"	96 08 13 11:00 AM	Ø		✓													
19	FO - WQ - STR - 301	"	96 08 13 11:30 AM	NITRIC	✓														
	FO - WQ - STR - 301	"	96 08 13 11:30 AM	Ø		✓													
20	FO - WQ - STR - 302	"	96 08 13 11:30 AM	NITRIC	✓														
	FO - WQ - STR - 302	"	96 08 13 11:30 AM	Ø		✓													
21	RU - WQ - STR - 001	"	96 08 14 12:30 AM	NITRIC	✓														
	RU - WQ - STR - 001	"	96 08 14 12:30 AM	Ø		✓													
22	RU - WQ - STR - 002	"	96 08 14 12:30 AM	NITRIC	✓														
	RU - WQ - STR - 002	"	96 08 14 12:30 AM	Ø		✓													
			:__ AM PM																

NOTES/COMMENTS

CONDITION RECEIVED
FROZEN ____
COLD ____
AMBIENT ____
TOTAL PACKAGES ____

RELINQUISHED BY		
AFFILIATION		
RECEIVED BY	Y / M / D :__ AM PM	Y / M / D :__ AM PM
AFFILIATION		

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TOLL FREE: (800) 665-0243

CLIENT: PWGSC ENVIRONMENTAL SERVICES
1014 / 1166 ALBERNI ST
VANCOUVER, B.C
V6E 3W5

PH/FAX#: 623 6388 / 623 6234

CONTACT: TIM SACKMANN

SAMPLED BY: T. SACKMANN A. LAURUM D. CHARBONEAU

PAGE 3 OF 4 5

YUKON A.H.D. MASKEIF NOV. 96

ASL CONTACT: VERONICA REMUS

CLIENT PROJECT #:

PO #:

DATE SUBMITTED:

RESULTS REQUIRED BY:

ANALYSIS REQUESTED

LAB USE	SAMPLE IDENTIFICATION	SAMPLE TYPE	DATE/TIME SAMPLED (Y M D)	FIELD PRESERVATION	TOTAL METALS	DISSOLVED METALS	GENERAL CHEMISTRY	COMMENTS
23	RU-WQ - STR - 003.	WATER	96 08 14 12:30 PM	NITRIC	✓			
	RU-WQ - STR - 003	"	96 08 14 12:30 PM	∅		✓		
24	SG - WQ - STR - 202.	"	96 08 17 10:00 AM	NITRIC	✓			
	SG - WQ - STR - 202	"	96 08 17 10:00 PM	∅		✓		
25	MACT - WQ - STR - 001	"	96 08 15 11:00 AM	NITRIC	✓			
	MACT - WQ - STR - 001	"	96 08 15 11:00 PM	∅		✓		
26	MACT - WQ - STR - 002	"	96 08 15 11:15 AM	NITRIC	✓			
	MACT - WQ - STR - 002	"	96 08 15 11:15 PM	∅		✓		
27	MACT - WQ - 003	"	96 08 15 11:30 PM	NITRIC	✓			
	MACT - WQ - 003	"	96 08 15 11:30 AM	∅		✓		
28	MACT - WQ - 004	"	96 08 15 1:00 AM	NITRIC	✓			
	MACT - WQ - 004	"	96 08 15 1:00 AM	∅		✓		
29	MACT - WQ - 005	"	96 08 15 1:15 AM	NITRIC	✓			
2	MACT - WQ - 005	"	96 08 15 1:15 AM	∅		✓		
			: AM PM					

NOTES/COMMENTS

CONDITION RECEIVED
FROZEN
COLD
AMBIENT
TOTAL PACKAGES

RELINQUISHED BY		
AFFILIATION		
RECEIVED BY	Y M D : AM PM	Y M D : AM PM
AFFILIATION		

CHAIN OF CUSTODY / ANALYTICAL REQUEST FORM

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1988 Triumph Street
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Canada V5L 1K5
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TEL: (604) 253-4188
TOLL FREE: (800) 665-0243

CLIENT PAUL SD ENVIRONMENTAL SERVICES
204 / 1111 ALBERNI ST.
VANCOUVER, BC
V6E 3W5

PAGE 4 OF 5

ASL CONTACT [illegible]
CLIENT PROJECT #
PO #
DATE SUBMITTED
RESULTS REQUIRED BY

PH/FAX# 623-6388 / 623-6234
CONTACT T. SACKMANN
SAMPLED BY T. SACKMANN, A. LAVALLEY, D. CHARLESON

ANALYSIS REQUESTED

LAB USE	SAMPLE IDENTIFICATION	SAMPLE TYPE	DATE/TIME SAMPLED (Y M D)	FIELD PRESERVATION	TOTAL METALS	IMMEDIATES	GENERAL CHEMISTRY	PAH	COMMENTS
30	SAMW. WQ - 001	WATER	96 08 15 2:00 PM	NITRIC	✓				
	SAMW - WQ - 001	WATER	96 08 15 2:00 PM	∅		✓			
	SAMW. - WQ - 002	"	96 08 15 2:15 PM	NITRIC	✓				
31	SAMW - WQ - 002	"	96 08 15 2:15 PM	∅		✓			
	SAMW WQ - 003	"	96 08 15 2:30 PM	NITRIC	✓				
32	SAMW WQ - 003	"	96 08 15 2:30 PM	∅		✓			
	~~[illegible]~~		: AM PM	~~NITRIC~~					
	~~[illegible]~~		: AM PM	∅					
33	SG - SL - 201	SOIL	96 08 17 11:00 AM PM	∅	✓		✓		
34	SG - SL - 202	SOIL	96 08 17 11:00 AM PM	∅	✓		✓		
35	GAMBLER - SL - 001	SOIL	96 08 17 10:45 AM PM	∅	✓		✓		
	" SL - 001		: AM PM	NITRIC	✓				
			: AM PM	∅		✓			
			: AM PM	NITRIC	✓				
			: AM PM	∅		✓			

NOTES/COMMENTS

CONDITION RECEIVED
FROZEN
COLD
AMBIENT
TOTAL PACKAGES

RELINQUISHED BY		
AFFILIATION		
RECEIVED BY	Y M D : AM PM	Y M D : AM PM
AFFILIATION		

CHAIN OF CUSTODY / ANALYTICAL REQUEST FORM

ASL Specialists in Environmental Chemistry
analytical service laboratories ltd.
1988 Triumph Street
Vancouver, BC
Canada V5L 1K5
FAX: (604) 253-6700
TEL: (604) 253-4188
TOLL FREE: (800) 665-0243

CLIENT ______________________

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PH/FAX# ______________________

CONTACT ______________________

SAMPLED BY ______________________

ASL CONTACT ______________________

CLIENT PROJECT # ______________________

PO # ______________________

DATE SUBMITTED ______________________

RESULTS REQUIRED BY ______________________

ANALYSIS REQUESTED

LAB USE	SAMPLE IDENTIFICATION	SAMPLE TYPE	DATE/TIME Y	M	D	SAMPLED	FIELD PRESERVATION	Gen. Chemistry	Total Metals	Invertebrates										COMMENTS
36	DU WQ STR 301				17	__ : __ AM PM	⌀	✓												
	301					__ : __ AM PM	NITRIC		✓											
37	Sa WQ 201					__ : __ AM PM	NITRIC													
	201					__ : __ AM PM	⌀													
38	GAMB WQ ST -001				17	__ : __ AM PM	NITRIC													
	-001				17	__ : __ AM PM	⌀													
39	FORM - WQ - STR -002				17	__ : __ AM PM	NITRIC													
	-002				17	__ : __ AM PM	⌀													
						__ : __ AM PM														
						__ : __ AM PM														
						__ : __ AM PM														
						__ : __ AM PM														
						__ : __ AM PM														
						__ : __ AM PM														
						__ : __ AM PM														

NOTES/COMMENTS

CONDITION RECEIVED
FROZEN ______
COLD ______
AMBIENT ______
TOTAL PACKAGES ______

RELINQUISHED BY		
AFFILIATION		
RECEIVED BY	Y / M / D	Y / M / D
AFFILIATION	__ : __ AM PM	__ : __ AM PM