MIN-050

PWGSC

Quality in Environmental Services

**PHASE II ENVIRONMENTAL ASSESSMENT
OF THE
LOGTUNG
ABANDONED MINE SITE**

prepared for:

Action on Waste Program
Indian and Northern Affairs Canada

prepared by:

Environmental Services
Public Works and Government Services Canada

February 1997

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

Canada

Printed on recycled paper

PHASE II
ENVIRONMENTAL ASSESSMENT
of the
LOGTUNG MINE SITE

Prepared for:

Action on Waste Program
Indian and Northern Affairs Canada

Prepared by:

Environmental Services
Public Works and Government Services Canada

[redacted] 1997
FEB

EXECUTIVE SUMMARY

A phase II environmental assessment was conducted at the Logtung abandoned mine site (60° 00' 19'' N, 131° 35'36'' W) in July, 1996 by Environmental Services, Public Works and Government Services Canada for the Action on Waste Program, Indian and Northern Affairs Canada. Based on the findings of the Phase I investigation performed in 1993 by DIAND Technical Services, a phase II assessment was conducted to a) identify potential environmental and human health risks associated with the present condition of the mine site, and b) provide recommendations and preliminary cost estimates for remediation of those risks.

A field investigation of the abandoned mine site was conducted to evaluate environmental and human safety concerns with respect to: mine openings and workings; buildings and infrastructure; waste disposal areas; waste rock disposal areas; 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 single mine opening is unstable and inadequately secured from public and wildlife access. A loadout structure at the western end of the upper exploration area and 5 collapsing core storage sheds at the lower level encampment area are physically unstable and pose a health and safety hazard to humans visiting the site. An assessment of the acid rock drainage potential shows that the risk to the environment due to the presence of waste rock and adits is moderately low. Aesthetic concerns arose from over two hundred and fifty (250) 205 litre metal barrels, timbers, and metal debris scattered along a service road below the upper site as well as located on pallets across from the core storage sheds at the exploration camp site.

Using applicable federal and territorial criteria as well as northern mine reclamation guidelines, the recommendations are to secure the single mine opening using surrounding rock and soil, remove core trays from collapsing core sheds and burn collapsing core storage sheds and assorted timber from both levels on site, transport metal drums containing waste rock to upper level, empty and bury together with empty drums from other areas of site. No further test work is recommended on the waste rock. No further water quality sampling is required to monitor the impact of the acid generating waste on the receiving environment.

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

ASSESSMENT COMPONENT	RISK	RECOMMENDATION
1. Building, Infrastructure, Equipment		
Wooden core sheds	Health & Safety	Remove core trays from sheds & store on site; burn wood structures on site
Sewage Lagoon	Aesthetic concern	None
Loading platform at upper level	Aesthetic concern	Disassemble & Burn on site
2. Non-Hazardous Waste Material		
Timbers, misc. wood waste below adit	Aesthetic concern	Burn on site
250 drums containing ore samples	Aesthetic concern	Dump waste rock at upper level and bury.
Misc. metal drums along service roads	Aesthetic concern	Transport to upper level and bury on site
3. Hazardous Materials		
None		
4. Water Quality		
Mine Seepage - minor flow	Minor Environmental Risk	None
Site Drainage	Minor Environmental Risk	None
Receiving Waters - Creek 400 m	Insignificant Environmental Risk	None
5. Waste Rock Disposal Areas		
Numerous small piles - total = 5000 m^3	Minor Environmental Risk	None
6. Mine Openings		
One adit at upper level unsecured and partially accessible.	Health & Safety Concern	Seal by covering with waste rock using heavy equipment.
7. Tailings		
None		

TABLE OF CONTENTS

EXECUTIVE SUMMARY

TABLE OF CONTENTS (Con't)

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 or mitigation work, as appropriate.

At the Logtung site, the overview assessments identified concerns associated solely with site clean up:

(a) removal of waste barrels scattered about the exploration area
(b) removal and storage of recoverable core samples from the site, and
(c) the burning of wood structures in a suitable area

No aesthetic concern was expressed with respect to existing buildings' deterioration. 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 Logtung 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.

1.1 Location:

The Logtung site is located at 60°00'19"N, 131°35'36"W and is located approximately 13 km south southeast of Rancheria, YT **(Figure 1)**. The mine site consists of 1 adit located adjacent to a moderate slope at the upper level (1676 m) plateau. West Logjam Creek drains through and across the B.C./Yukon border less than a kilometre to the south.

1.2 Overview of Site Development:

Work completed on the Logtung property dates back to its original discovery by the Geological Survey of Canada (GSC) in the early 1950's with the first claims staked in 1976. Work to date completed by Amax Potash Ltd. from 1977 to 1981 on the main molybdenum-tungsten deposit includes geological, geochemical and geophysical surveys, drilling of 51 diamond drill holes totalling 11,628 metres, the driving of a 496 metre, 2.4 m x 2.4 m decline, and underground mining of a 15,000 tonne bulk sample. A sample handling and crushing facility was established at the portal area, and the rejects from the sampling have been stockpiled as separated piles in the waste dump area. Additional soil geochemical sampling and 2 drill holes were completed by NDU Resources Ltd. in 1993 in an area to the southeast of the portal area to test for possible associated gold mineralization.

The property hosts a significant molybdenum-tungsten deposit of 230 million tonnes grading 0.104% tungsten oxide (WO_3) and 0.05% molybdenite (MoS_2). Detailed bulk sampling was undertaken between 1977 and 1981, requiring the driving of a 496 m decline. As a result, any serious environmental effects resulting from activity on the site would likely impact areas under B.C. jurisdiction. Waste rock piles extend to the west and occupy a significant portion of the upper site.

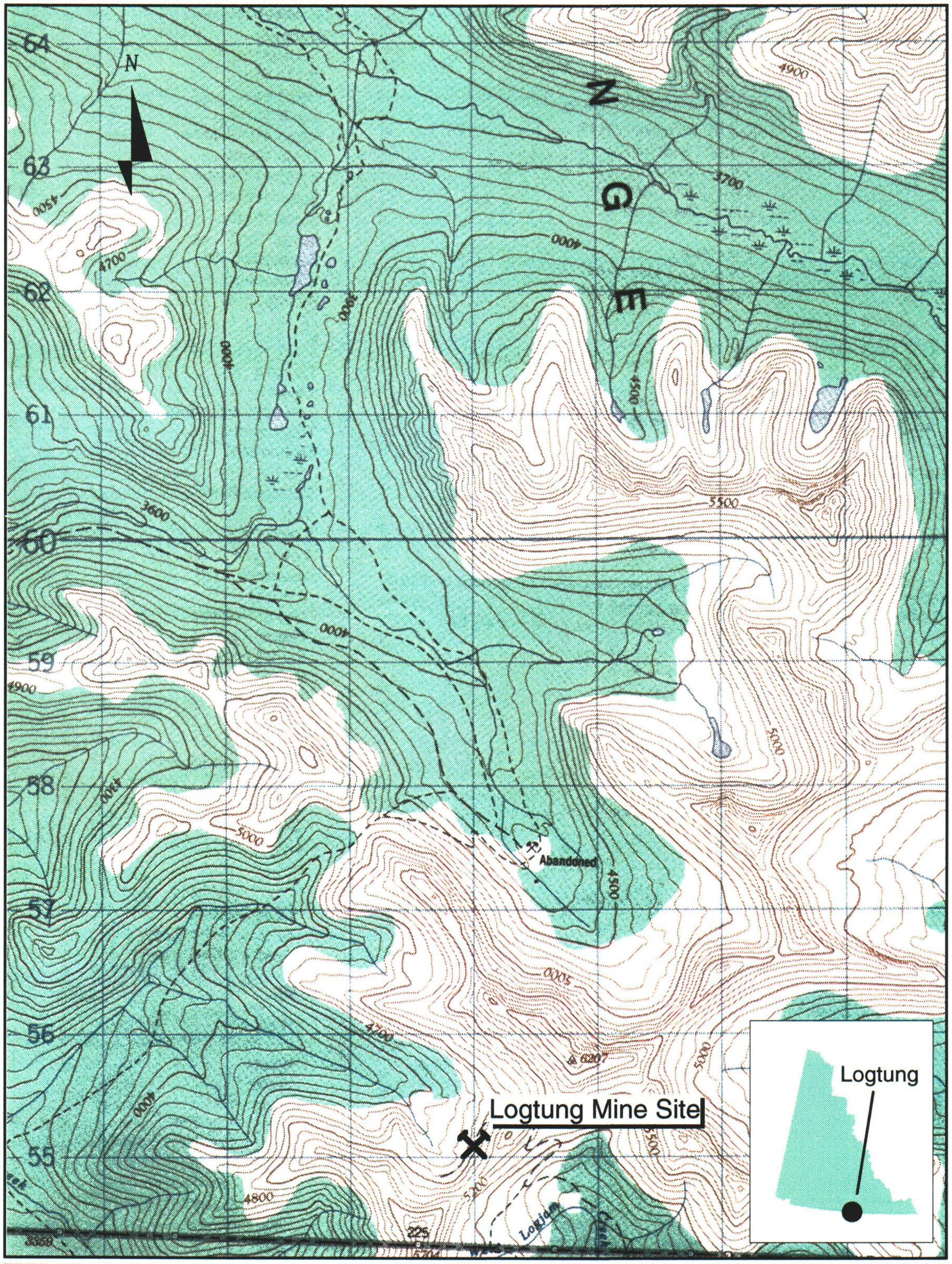
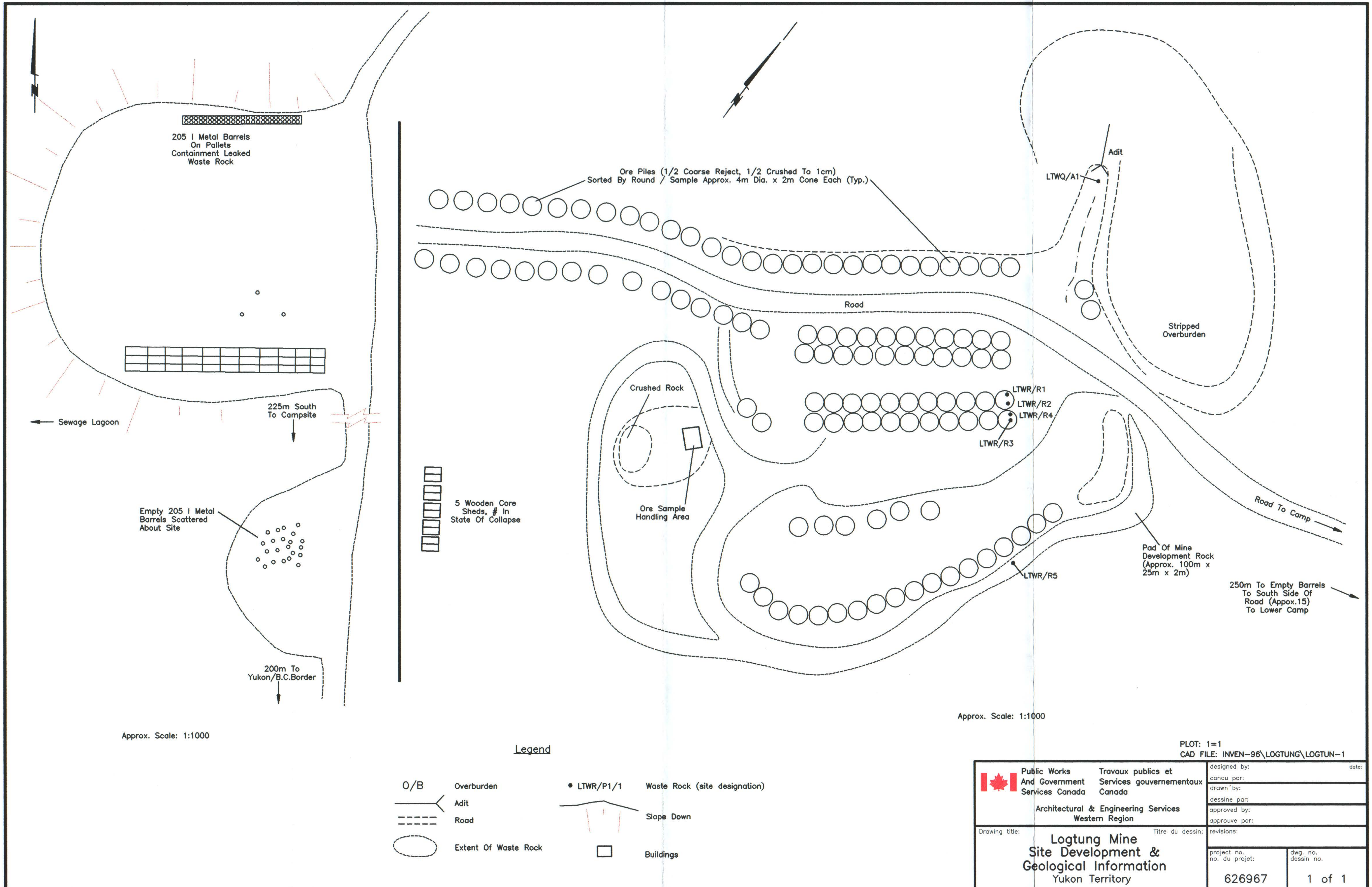


Figure 1: LOGTUNG SITE

N.T.S. 105 B/4 Map Name: Dorsey Lake Map Scale: 1:50,000

Latitude: 60° 00' 19" N Longitude: 131° 35' 56" W



205 l Metal Barrels On Pallets Containment Leaked Waste Rock
Sewage Lagoon
225m South To Campsite
Empty 205 l Metal Barrels Scattered About Site
200m To Yukon/B.C.Border
5 Wooden Core Sheds, # In State Of Collapse
Ore Piles (1/2 Coarse Reject, 1/2 Crushed To 1cm) Sorted By Round / Sample Approx. 4m Dia. x 2m Cone Each (Typ.)
Road
Crushed Rock
Ore Sample Handling Area
LTWR/R1
LTWR/R2
LTWR/R4
LTWR/R3
LTWR/R5
Adit
LTWQ/A1
Stripped Overburden
Road To Camp
Pad Of Mine Development Rock (Approx. 100m x 25m x 2m)
250m To Empty Barrels To South Side Of Road (Appox.15) To Lower Camp
Approx. Scale: 1:1000
Approx. Scale: 1:1000
Legend
O/B Overburden
Adit
Road
Extent Of Waste Rock
• LTWR/P1/1 Waste Rock (site designation)
Slope Down
Buildings
PLOT: 1=1
CAD FILE: INVEN-96\LOGTUNG\LOGTUN-1
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:
Logtung Mine Site Development & Geological Information Yukon Territory
project no. no. du projet: 626967
dwg. no. dessin no. 1 of 1

A barrel storage area camp lies approximately 800 m south of the adit area at 1625 m level **(see Photo 4)**. Another barrel storage area lies across from core storage shacks located a further 300 m down the access road, south of the main site **(see Photos 13 & 14)**. A level excavated area (presumably the site of the camp) a settling pond and four partially collapsed, covered core sheds are located 750 m southeast of the portal site **(see Photo 11)**. A 15 km all weather road exists into the site from the Alaska Highway to the south. Approximately 3.5 km of road have been constructed on the Yukon side of the Yukon-B.C. border.

1.3 Site Access:

Access to the site is available by means of a trail 20 km in length travelling north from the Alaska Highway (Mile 756) along the east side of the Smart River. The previous 1993 DIAND mine assessment report indicated that this road is in a severe state of disrepair and some work would need to be undertaken on approaches and bridge abutments. The project team chose to fly in by chartered helicopter from a base of operations at the east end of Edgar Lake located 90 km east northeast of the site. Both the Logjam and Logtung sites were visited in this manner. The Logjam camp site is located at an elevation 1760 m on a small plain encompassing an unnamed creek which flows westward 7 km to the Smart River.

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, preliminary cost estimates 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:

At each mine site, the assessment was limited to the area specifically developed or occupied for mine exploration or mining purposes and immediately adjacent areas within applicable claim boundaries as well as off-site environmental resources believed to be affected by mine exploration or development 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

Metal Mining Liquid Effluent Regulations and Guidelines (Environmental Protection Service, Environment Canada, 1977)

The intent of the requirements defined in this document is to limit the discharge of deleterious substances from base-metal, uranium and iron ore mines. These requirements are uniformly applied national standards and intended to provide protection for fish and other aquatic life.

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.

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

According to these draft regulations a site is contaminated if it 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 metres of the surface, commercial land use criteria is applicable.

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.

3.2.2 Application of Criteria and Guidelines

The following assessment criteria were used for the Logtung abandoned mine site:

A. Soils:

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

B. Water:

Envir. 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.

CCME: Remediation Criteria for Water - Freshwater Aquatic Life guideline for river and stream water quality

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

C. Mine Clean-Up and Reclamation:

INAC: Mine Reclamation in Northwest Territories and Yukon

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 Logtung 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 identification of contaminant constituents, as necessary.

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

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

Scale site plans were prepared to identify the dimensions and locations site structures, mine workings and adits, waste rock disposal areas, on-site sampling locations (as applicable), 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 m 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 and 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 is 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. Two (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 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, discolouration, 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, Pail, and Above-Ground Storage Tank Sampling

Barrels and pails suspected as 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.

No above-ground storage tanks (ASTs) were identified on site. However, numerous 205 litre metal barrels were identified clustered in several locations at the upper development area and the lower encampment area. All of these barrels seem to either hold graded waste rock or be empty. No petroleum derivative products of any type were found on site in these barrels.

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

The Logtung deposit is situated within the Yukon Tanana terrane. The regional geology includes rocks of the Yukon Cataclastic Complex, an allocthonous assemblage of tectonically interleaved Triassic diorite to ultramafic dykes and Carboniferous and younger sediments and volcanics. The Logtung deposit is described in the MinFile data records as a scheelite-molybdenite "...multi-stage stockwork vein system developed in a quartz porphyry plug [of Cretaceous age], and disseminated in a vein stockwork system which cuts garnet-diopside skarn and hornfels peripheral to fluorite-rich quartz monzonite stock..." intruded into Carboniferous argillites and quartzites. Later mafic and pyritic felsic dykes also intrude the package. Mineralization is controlled by 4 stages of superimposed veining that include:

(1) quartz-molybdenum along the north and west flanks;
(2) quartz-pyrite-scheelite proximal to felsic dykes;
(3) quartz-molybdenum near the felsic dykes, and;
(4) polymetallic sheeted veins.

All vein stages include some amount of pyrite, and varying quantities of pyrrhotite, sphalerite, galena, chalcopyrite and marcasite, although overall percentages are not reported. Field inspection of the waste dump piles on the property identified most ore hosts 0.5% to 2.0%, fine to medium grained pyrite, primarily disseminated along vein fractures. The development rock contains 1.0% to 3.0% pyrite and pyrrhotite along vein fractures and disseminated in the host rock. The ore material commonly appeared broken along mineralized fracture surfaces.

4.2 SURFACE HYDROLOGY

West Logjam Creek drains through the property area from the Yukon into B.C. **(Figure 1)** It was sampled (LTWQ-C1-2) where it crosses the Yukon/B.C. border at an elevation of 1350 metres, just southwest of the camp area and 900 metres southeast and down current of the adit and stockpile area. At the time of sampling, the creek was approximately 2 metres wide and 0.2 metres deep, and exhibited abundant algae growth and manganese staining.

4.3 CLIMATE

The Logtung mine site lies in the Liard River Ecoregion which comprises an area of 21,275 km^2 and is situated within the southeastern portion of the Yukon Territory. The site is subject to a predominating cold continental climate which provides colder winter and warmer summer temperatures than other areas of the Yukon which are under a more significant marine influence. Generally speaking, the climate of this portion of the Yukon consists of long cold winters and short warm summers. Mean annual temperatures are below freezing and vary from a low of -25 °C to a high of 15 °C with annual precipitation varying from 375 mm to 500 mm, increasing with elevation and during the summer months of July, August and September. More specifically, for the Liard River Ecoregion, annual precipitation averages 430 mm with amounts in the west averaging 400 mm and increasing to 625 mm in the eastern portions of the ecoregion.

Mean annual temperature is -3 °C at an elevation of 685 m with a January mean of -25 °C and a July mean of 15 °C. (Ecoregions of Yukon Territory, Oswald, E.T. & Senyk, J.P., p. 14 & p. 26)

The closest climatological information available geographically is from the town of Teslin, 60° 10' N, 132° 45' W; 711 m above sea level (Environment Canada, 1990). Total annual precipitation is 340.5 mm consisting of 190 of rainfall and 159 of snowfall. Highest levels of rainfall occur in July and highest levels of snowfall occur in January. Temperatures range from -19.9° C in January to 13.5° C in July. The mean annual temperature is -1.6° C.

4.4 VEGETATION

The Logtung site is situated within the extreme southern edge of the Pelly Mountain Ecoregion is included in the Eastern Yukon (B26c) forest subregion. While treeless tundra is common at higher elevations, white and black spruce predominate at lower elevations, white spruce and lodgepole pine on warmer sites, with alpine fir and shrub birch-willow in subalpine areas. Tree level hovers about 1350 m - 1500 m with moderately high precipitation and moderate temperatures. While much of the region at higher elevations is treeless and lies in tundra, lower elevation plateaus are in the B26c forest region with open growing black & white spruce occurring at the lower slope areas as well as in valleys.

Lodgepole pine is common in burned over areas and alpine fir in the subalpine. Feathermoss laces with sphagnum is common in plateaux understory. Ericaceous shrubs & willows occur over much of the area however forbs are scarce. Shrub birch and willow are common in the subalpine and form extensive patches in protected areas above treeline. Alpine tundra areas are dominated by lichens, ericaceous shrubs and willows whereas sedge tussocks dominate alpine wetlands. (Soil, Site & Land Classification, Rowe, J.S. 1972).

4.5 FISH AND WILDLIFE RESOURCES

No data concerning fish species for the Teslin Lake system was available. The Logtung site is considered within established mountain goat range. Golden eagles are known to nest in surrounding mountains and likely hunt around the site. (Val Loewen, YTG Habitat Inventory Specialist).

4.6 SITE TOPOGRAPHY AND SOILS

The Logtung mine site is situated at an elevation of 1775 metres within a broad, south facing, shallow sloping cirque basin. The higher walls of cirque are 40% outcrop and 60% colluvium and talus. The valley floor is mapped as covered with mixture of 90% colluvial and 10% rock outcrop. The Logtung exploration development work area extends 800 m west along the length of the shear zone that hosts the Logtung vein **(see Drawing 1)**. The creek valley and adjacent ridges trend northwest. The valley has a broad glacially formed U-shape with a thick cover of colluvium and till obscuring the bedrock on the valley bottom and much of the east facing slopes, except on the steeper sections between 1420 metres and 1520 metres elevation. Rocky cliffs are exposed through the colluvium and till cover up most of the steeper west facing slopes to the ridges which are broad with large areas of exposed outcrop sloping moderately off to the east **(see Photos 3 & 5)**.

The Logtung site was covered by a minimum of three ice advances which moved north from the Cassiar Mountains. Each of these advances was in turn deflected eastward by the Pelly Mountains and again when the Cassiar ice came in contact with ice moving southward from the Selwyn and Logan Mountains. As the area is permeated with glacial deposits of the morainal, glaciofluvial and lacustrine variety, few rocky outcroppings remain. (Ecoregions of Yukon Territory, Oswald, E.T. & Senyk, J.P., p.26)

4.7 PERMAFROST

The Logjam site is situated within the scattered subzone of discontinuous permafrost zone that stretches in a band across the southwestern portion of the land mass of the Yukon. In this area, permafrost tends to be localized with the active layer varying in thickness and depth. Quite often, the relative distribution of permafrost varies according to terrain and elevation with variations in local terrain conditions responsible for the occurrence in discontinuous zones as well as the thickness in these zones (Ecoregions of Yukon Territory, Oswald, E.T. & Senyk, J.P., 19).

5.0. SITE DESCRIPTION AND FINDINGS

5.1 BUILDINGS, INFRASTRUCTURE & EQUIPMENT

The Logtung site consists of a single adit at an upper exploration level with a single loading platform located at the western edge of the ore stockpiling area **(see Photo 2)**. No additional structures are located on the upper exploration level of the site. A lower level area contains a total of five (5) wood frame core sheds with 3 in a state of collapse and 2 in fair shape **(see Photos 11 & 12)**. Approximately 35 barrels (½ containing ore and the remainder empty) lay along a service road running from the upper exploration area to the lower encampment site **(see Photos 4 & 11)**. Another 20 empty barrels were scattered directly across from the core storage area **(see Photos 11 & 16)**. Approximately 1000 m south of the exploration area 258 metal barrels containing ore samples are stacked on wood pallets in a cleared out area **(see Photos 14)**. A sewage lagoon was also identified however no discernible signs of sewage were identified during the site visit.

Table 1: Buildings, Infrastructure, Equipment

Structure	Construction Features	Interior Contents
Load-out Structure	Metal support structure and wood platform	2 waste barrels & metal rollers
Wooden Core Sheds	Wood frame, metal clad roof, (total =5);; 3 collapsing & 2 in fair shape	- wood racking system with core boxes full

5.2 NON-HAZARDOUS WASTE MATERIALS

Non-hazardous waste materials observed in and around the site are listed in **Table 2**:

Table 2 Non-Hazardous Waste Materials

Waste Material	Number/ Volume	Location	Comments
steel barrels	35 @ 205 litres each	South of access road from loadout to camp area	empty, non-burnable and rusted
steel barrels	20 @ 205 litres each	Directly across from core storage shed	empty, non-burnable and rusted
steel barrels	20 @ 205 litres each	Directly across from core storage shed	contain waste rock, non-burnable and rusted
steel barrels	258 @ 205 litres each	North of core storage area in cleared area	contain waste rock, non-burnable and rusted
core boxes,	est. 40 m^3	in core storage area	non-preserved, burnable
timbers, wood waste	30 m of 100 mm X 100 timber	in front of upper adit entrance	non-preserved, burnable
steel rollers & assembly	est. 30 m in length	load out facility	non-burnable and rusted

5.3 HAZARDOUS MATERIALS:

No signs of stained soils were observed during the course of the site inspection and consequently no soil samples were taken at this location. Consequently, no samples were submitted for analysis.

5.4 SURFACE WATER QUALITY:

The underground workings at the Logtung mine site produce a small flow of mine water which seeps through rubble blocking the portal and then over the surface of the waste rock. The flow was not traced beyond the waste rock pad area however it does not access West Logjam Creek directly which is 0.4 kilometres to the south. No groundwater seeps were observed in the area of the rock dumps on the Logtung property.

Table 3 identifies the significant findings of the sampling program conducted to determine the potential impact of the site on surface water bodies. Samples were collected only from site drainage courses and field measurements of pH and conductivity were taken. Complete analytical results are provided in **Appendix C**.

Table 3 Surface Water Samples - Significant Laboratory Results

Sample ID	Sample Location	pH	Conductivity (μmhos/cm)	Metallic Parameters
LTWQ-A1-1	Unnamed creek adj. to exploration camp	7.5 [7.5]	260 [170]	n/a

Notes: 1) Ph and conductivity readings in square brackets arefield measurements; non-bracketed readings are lab measurements
2) Low field conductivity readings for all samples may have been due to a calibration error on the conductivity meter.
3) n/a indicates that none of the readings from analytical samples submitted to the lab exhibited levels beyond parameters identified

A single elevated assay response of 0.29 mg/litre molybdenum was produced from the water sample collected at the adit. This not considered significant given the low volume of water at the adit and that the sample **(LTWQ-C1-2)** taken from West Logjam Creek down current from the mine area was below detection. There is no CCME aquatic fresh water life guideline for molybdenum and the result is below the B.C. Ministry of Environment, Lands and Parks 1995 Approved and Working Criteria for Water Quality for aquatic life of 2 mg/litre Mo. Since molybdenum sulphide exhibits limited solubility and oxidated molybdenum (molybdate) is easily precipitated by hydrous oxides of iron and aluminum, this result is not considered indicative of an environmental risk (CCME, 1995).

All water sample concentrations (except for Ag for LT-WQ-A1-1) were found to be below method detection limits for all elements identified as parameters for "Freshwater Aquatic Life Remediation Criteria for Water" by Canadian Council of Ministers of the Environment (CCME). 1995. Canadian Water Quality Guidelines.

5.5 WASTE ROCK DISPOSAL AREAS:

Underground development work on the Logtung property consisted of the collection of a 15,000 tonne bulk sample. Waste rock from development of the decline was used to build a pad to stockpile ore sample material. The development rock is composed of hornfels and altered sediments with 1% to 3% fine to medium grained, stringer vein, hosted and disseminated pyrite and pyrrhotite. There is approximately 5,000 m^3 of waste rock.

Ore material was stockpiled on a per mining round basis west of the portal area resulting in 116 individual piles of approximately 8 m^3 of ore material totalling approximately 960 m^3. Each ore pile has been split and is now a composite of 2/3 coarse rejects and 1/3 minus 10 mm crushed sample material. A total of 29 of the 116 ore piles are composed of quartz porphyry material with vein fracture coatings with 1% molybdenum and 2% pyrite (96 m^3 crushed, 144 m^3 coarse rejects).

The remaining 87 piles are composed of diorite and hornfels material with 5% sheeted veins with 2% pyrite and molybdenum (288 m^3 crushed, 432 m^3 coarse rejects). Sampling was conducted to represent each of the crushed and coarse rejects material of each of the two main ore types. Samples from the rock dumps were slightly to moderately elevated in copper **(LTWR-R4: 144 ppm)**, molybdenum **(LTWR-R1: 435 ppm)**, tungsten **(LTWR-R4: 107** ppm), and **zinc (LTWR-R4: 216 ppm)**.

The quartz porphyry ore samples were relatively lower in iron **(LTWR-R1: 0.38%)** compared to the results from the metasedimentary rock material **(LTWR-R4: 1.61%)**. Results of the static analysis and acid-base accounting (ABA) for the Logtung property are summarized below:

Table 4: Summary of Acid/Base Accounting Test Results

LOGTUNG PROPERTY ACID-BASE ACCOUNTING RESULTS									
Pile	**Sample No.**	**Field Paste pH**	**Lab Paste pH**	**Sulphur (Total) %**	**Sulphur (SO_4) %**	**Acid Potential (AP*)**	**Neutral. Potential (NP*)**	**Net NP***	**NP/ AP**
1/fine	**LTWR-R1**	5.6	7.81	0.13	0.00	4.1	5.5	1.4	1.4
1/crs.	**LTWR-R2**	4.6	7.67	0.08	0.00	2.5	2.4	-0.1	1.0
2/fine	**LTWR-R3**	7.0	8.40	0.71	0.00	22.2	12.5	-9.7	0.6
2/crs.	**LTWR-R4**	7.8	8.19	0.94	0.00	29.4	11.9	-17.5	0.4
Base	**LTWR-R5**	7.0	8.45	0.96	0.00	30.0	13.9	-16.1	0.5

AP and NP reported in tonnes $CaCO_3$ equivalent per 1000 tonnes of material.
Pile 1=quartz porphyry ore; Pile 2=hornfels ore. Fine=crushed sample; Crs.= coarse rejects; Base=waste.

NP/AP ratios are all near or below 1.0 and the Net NP is negative suggesting that the waste rock at the Logtung site is likely to generate acidity. Total sulphur content is low, but based on the sulphide mineralization forming fracture coatings, a high proportion of it would be available to weathering and oxidation and partially removed from intimate contact with neutralizing minerals. This would likely reinforce the potential for acid generation depending on climatic conditions.

Soils, substrate and bedrock are not expected to provide much additional buffering capacity based on the composition of the regional geology. The paste pH of the **LTWR-R1** and **LTWR-R2** samples was considerably lower measured in the field, with pH's of 5.6 and 4.6 respectively. The lower result may be indicative of the low buffering capacity of the quartz porphyry ore.

5.6 MINE OPENINGS

The Logtung deposit was explored by a single decline commencing from the portal at UTM coordinates 356800 metres North and 6654680 metres East at an elevation of 1510 metres. The decline is collared at azimuth 325^0. The portal area has been partially backfilled with broken rock and rubble, leaving less than 0.5 metres of the timbered portal is exposed. The adit has been closed off with timbers and chainlink fencing. No repair has been done to the sagging fencing (noted in the 1993 site assessment by DIAND Technical Services), but the portal is otherwise in sound condition **(see Photo 6)**.

Table 5 Mine Openings

Adit	Location	Drift Length	Condition
A1	1510 m elev.	undetermined, no access	- wood timbers in crib fashion covering adit entrance; 0.3 m X 0.9 m max. opening; timbers in fair condition; waste rock piled in front to within 1.5 m of adit roof

5.7 TAILINGS

Activity on the Logtung property has been limited to exploration only and there are no mill tailings present on the site as a result. The ore samples were crushed and prepared for bulk sampling however this was localized in the stockpile area and has not produced a significantly different material.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 HEALTH AND SAFETY

The primary concern at the Logtung mine site is the heatlh and safety of humans and wildlife from collapsing core sortation sheds at the lower elevations as well as unsecured adit openings at the upper exploration area. Risks relating to mine safety are low, although in the future the wooden portal will rot and begin to collapse, requiring backfilling with coarse rock. This can be easily done considering the shallow topography of the site.

6.2 ENVIRONMENTAL RISKS

Recommended remediation and management actions will be in compliance with applicable federal or territorial regulations and criteria, rely upon available technology, and be appropriate for local conditions and sensitivities. Cost estimates for proposed remediation or management actions will be provided as necessary for each mine site.

The environmental risks relating to mineral exploration activities on the Logtung property are considered low, largely due to the limited volume of the resource present, the limited scale of development work done on the site, the lack of mine waters draining the site and workings, and low levels of metals. The overall environmental risks of the Logtung site relating to the mining and exploration activity are considered low to medium-low. There is limited potential for acid generation.

The present rock dumps (totalling an estimated 12,500 tonnes) are more than likely to generate acid drainage based on the limited data available. The maximum total potential sulphuric acid is estimated to be 350 tonnes. The neutral paste pH of the bulk of the material after 15 years of exposure suggests the rate of release of acid has been limited and is expected to be very long term. The low paste pH from the field results of the limited amount of quartz porphyry ore in stockpile is indicative of it having very limited buffering capacity.

The potential for release of metals into the environment is considered a low risk. Metals with known toxicities are not present or in low concentrations in the Logtung deposit. Based on a low potential for acid generation, a significant increase in the levels of dissolved metals caused by a decrease in pH is considered unlikely.

Based on the climatic conditions of the site (dry with a moderately low annual precipitation, approximately half of which is stored in the winter snow pack), this would be further limited. Also, surface water run-off is generally considered uncommon due to the highly porous conditions of the underlying colluvium and the waste rock material itself. As a result of these points and the limited volume to material in the dumps, the overall oxidation and potential volume of acid generation of the rock dumps is predicted to be moderately low. The overall risk from acid rock drainage is considered moderately low.

6.3 AESTHETIC CONCERNS

Aesthetic concerns arise primarily from the presence of a large number of 205 litre metal barrels located in several areas about the site as well as the deteriorating buildings and infrastructure. Many of barrels were empty however many more contain graded waste rock. The upper level loading platform area and miscellaneous wood waste below the adit also represent an aesthetic concern.

7.0 RECOMMENDATIONS

Recommendation 1.

The single adit should be secured from human and animal access for health and safety reasons. Since site access is fair to good, the adit should be covered with surrounding rock using readily available equipment. Should the mine need to be reopened, access to workings is achievable with heavy equipment.

Recommendation 2.

All metal from the upper level loading platform should be removed and buried on site. Remaining wood timbers from the platform should be combined with timbers in front of adit and burned on site. Emtpy waste rock from all barrels and spread over large expanse of existing waste rock piles at upper level and bury barrels under waste rock piles.

Recommendation 3.

Brace sheds in place remove core boxes and brace with angle iron. Remove core boxes from 2 core sheds (in fair condition) at lower site. Burn remaining sheds on site.

8.0 COST ESTIMATES TO IMPLEMENT 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. 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 contingencies.

The estimated cost to implement the recommendations is provided under separate cover.

REFERENCES:

1. Oswald, E.T., and Senyk, J.P., Ecoregions of Yukon Territory, Canadian Forestry Service, p. 26

2. Canadian Council of Ministers of the Environment (CCME). 1995. Canadian Water Quality Guidelines.

3. DIAND Technical Services: 1993; Assessment Report 105B-04-1, Logtung. Eaton, D.. 1994. Geochemical and Drilling Report on the Logtung Property, Smart River Area, Yukon. NDU Resources Ltd.. Assessment Report No. 093178.

4. Indian and Northern Affairs Canada. "Yukon Abandoned Mines Assessment. Assessment Report 105B-01-1, Logtung". Prepared by DIAND Technical Services, October, 1993.

5. Klassen, R. W.; 1983; Wolf Lake Surficial Geology; Map 14-1982; Geological Survey of Canada.

6. Nagpal, N.K. 1995. Approved and Working Criteria for Water Quality-1995. Water Quality Branch. B.C. Ministry of Environment, Lands and Parks.

7. Poole, W. H., J. A. Roddick, L.H. Green; 1960; Wolf Lake Geology; Map 10-1960; Geological Survey of Canada.

8. Update July, 1994. Exploration and Geological Services Division, Department of Indian Affairs and Northern Development. Yukon MinFile: 105B 039

APPENDIX A

DETERMINATION OF ACID ROCK DRAINAGE POTENTIAL

ATTACHMENT G

Logtung
Acid Rock Drainage
Assessment Report

P118105

LOGTUNG
ACID ROCK DRAINAGE
ASSESSMENT REPORT

TABLE OF CONTENTS

LIST OF TABLES

P118105

LOGTUNG
ACID ROCK DRAINAGE
ASSESSMENT REPORT

1.0 INTRODUCTION

This report has been prepared in conjunction with a *Phase II Environmental Assessment of the Logtung Abandoned Mine Site*, prepared by Environmental Services, Public Works and Government Services Canada (PWGSC). As part of the Phase II assessment prepared by PWGSC, Steffen Robertson and Kirsten (SRK) was requested to assess the potential for acid rock drainage at the site, which is the subject of this report. The reader is directed to the PGWSC report for a comprehensive environmental assessment of the Logtung site.

This site specific report reviews the existing, and the potential for, acid rock drainage (ARD) conditions at the Logtung 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) which includes similar assessments for a number of other sites. The reader is directed to that report for details regarding the scope of work, site assessment methodology, ARD remediation options and the evaluation of potential remediation options.

The Logtung site is located approximately 16 kilometres north of the Alaska Highway, near Rancheria, YT, and within a kilometre of the British Columbia/Yukon boundary. The site is accessible by vehicle.

Mining and related disturbances observed during the site assessment consist of an adit, a settling pond, and crushed and uncrushed ore stockpiles on a pad constructed of waste rock. The waste rock and ore at Logtung were produced from underground development carried out between 1977 and 1981.

The site is at an elevation of 1775 metres within a broad, south facing, shallow sloping cirque basin. The higher walls of the cirque are 40% outcrop and 60% colluvium and talus. The valley floor is covered with 90% colluvium and 10% rock outcrop. West Logjam Creek, which passes within 400 metres of the pad area, receives runoff from the mine site.

2.0 GEOLOGY AND MINERALIZATION

The Logtung deposit is a scheelite-molybdenite multi-stage stockwork vein system developed in a quartz porphyry plug, and disseminated in a vein stockwork system which cuts garnet-diopside skarn and hornfels peripheral to a fluorite-rich quartz monzonite stock. Mafic and pyritic felsic dykes intrude the mineral occurrence. The hornfels are a product of contact metamorphism of argillites and quartzites.

The veins include some amount of pyrite (FeS_2), and varying quantities of pyrrhotite ($Fe_{1-x}S$), sphalerite ((Zn,Fe)S), galena (PbS), chalcopyrite ($CuFeS_2$), and marcasite, although overall percentages are not reported. Examination of the mine rock piles indicated that the ore contained 0.5% to 2%, fine to medium grained pyrite, primarily disseminated along vein fractures. The development (host) rock contained 1% to 3% pyrite and pyrrhotite along vein fractures and as disseminations.

3.0 WASTE ROCK DISPOSAL AREAS

3.1 Description

The volume of waste rock produced from historical underground development is estimated to be 12,000 tonnes. The assumptions made to derive this estimate are:

- a specific gravity of 2.65;
- 496 metres of lateral underground development; and,
- 3.4 by 2.7 metre mine openings.

The waste rock has been used to construct a pad on which the ore is stockpiled.

A reported 15,000 tonne bulk sample was removed from the underground workings. Approximately 3000 tonnes of this bulk sample was stockpiled at the site in 116 individual piles. Each ore pile has been separated into 66% coarse rejects and 33% minus 10 millimetre, crushed material.

Approximately 75% of the stockpiles are composed of diorite and hornfels material with 5% sheeted veins with 2% pyrite and molybdenum. The remaining 25% of the piles are composed of quartz porphyry material having vein fracture coatings with 1% molybdenum and 2% pyrite.

There is an additional stock pile of over fifty 205 litre drums full of ore material at the campsite, southeast of the portal. The drums were sealed and were not sampled.

3.2 Samples

Five samples were collected to represent each of the two main ore types of crushed and coarse reject material and the waste rock. The sample locations are shown on the site map, Drawing 2.

Samples LTWR-R1 and LTWR-R2 were collected from quartz porphyry ore stockpiles, and LTWR-R3 and LTWR-R4 were collected from diorite and hornfels ore stockpiles. A sample of the waste rock material was also collected, LTWR - R5.

A water sample was collected from West Logjam Creek (LTWQ-C1-2, elevation 1350 metres above sea level) southeast of the camp area and 900 metres southeast and down stream of the adit and stockpile area. At the time of sampling, the creek was approximately 2 metres wide and 0.2 metres deep, and it exhibited abundant algae growth and manganese staining.

A small volume of water was discharging from the underground workings at Logtung. The water seeps through the rubble blocking the adit and then over the surface of the waste rock. The flow was not traced beyond the waste rock pad area, but it does not access West Logjam Creek directly.

3.3 Analytical Results

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

Paste Parameters

The laboratory paste pH values for the five rock samples ranged from 7.7 to 8.5, indicating that the material is not currently generating acid. The field paste pH values for the samples of the quartz porphyry were 5.6 and 4.6 however, indicating that at least part of these piles appear to be producing acid.

Acid Base Accounting

The rock samples collected from the stockpiled ore and the waste rock indicate that this material is potentially acid generating. Their Neutralizing Potential to Acid Potential ratios (NP:AP) are less than 1.4. Total sulphur contents are low, ranging from 0.13% to 0.96%. However, since the sulphide mineralization has formed on fracture coatings a high proportion of it would be available to weathering and oxidation and it may not be in contact with neutralizing minerals.

Metals Concentrations

All rock samples contained elevated concentrations of tungsten and manganese, and moderate concentrations of molybdenum.

Water Quality

The adit discharge water sample, LTWQ-A1-1, had a neutral pH, and metal concentrations were generally below the limits of detection. The conductivity was 170 μS/cm. The CCME freshwater aquatic life guidelines do not contain criteria for molybdenum; however, its concentration in the adit discharge, 0.29 mg/L, is below British Columbia's water quality criteria for freshwater aquatic life of 2 mg/L total molybdenum.

The water sample collected from West Logjam Creek, LTWQ-C1-2, had a neutral pH and metal concentrations were generally below the limits of detection.

4.0 EXISTING AND POTENTIAL ACID ROCK DRAINAGE CONDITIONS

Sample analysis of the various rock types suggests that a portion of the 750 tonnes of stockpiled quartz porphyry ore is currently generating acid. The remaining 14,250 tonnes of rock has the potential to become acid generating. However, since no development work or crushing of ore has occurred since 1981, 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 and ore.

The water quality of the adit discharge indicates that a minor amount of molybdenum dissolution is occurring in the adit.

The water quality results of the sample collected from West Logjam Creek indicates that the downstream environment is not significantly impacted by the adit discharge or the mined material.

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 Logtung may become acid generating.

Collection and treatment of the runoff from Logtung site is not considered a viable option due to the lack of surface runoff from the mine site. Relocation of the mined material is not considered a viable option either, since there is no secure placement location readily available, such as underground workings or an open pit, to place the material.

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

Matrix for Evaluating Applicable/Potential Remediation

Option versus Evaluation Criteria	Logtung			
	Collect and Treat	**Relocate**	**Cover**	**Do Nothing**
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	4	5
Direct Costs (mobilization & materials) 5 = relative low cost 1 = relative high cost	not applicable	not applicable	3	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**	**26**	**28**

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

Even though covering the mine rock would decrease the amount of infiltration through the pile it is not without risk to the environment since a second site would need to be disturbed to obtain the cover material and a short term release of soluble metal constituents would likely occur during the contouring of the piles. However, the risk to the environment is considered higher if no remediation action is undertaken since the neutralizing capacity of the waste rock and the underlying colluvium is limited.

Covering the ore stockpiles could obstruct future exploration on the site if insufficient ore samples were available for metallurgical testwork, should the feasibility of the project be reevaluated.

Monitoring costs would likely be incurred with either option and maintenance of the cover would be necessary.

Covering the waste rock and ore stockpiles would improve the aesthetic appearance of the site and is therefore ranked slightly higher.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The above evaluation illustrates that "do nothing" is the preferred option for the Logtung waste rock and ore stockpiles. This is supported by the fact that the mine rock at the Logtung site has been exposed to weathering for 15 years without any apparent negative impact on the receiving environment. Therefore, with respect to ARD and metal leaching, no immediate remediation action at Logtung is required.

6.2 Recommendations

No further laboratory test work is recommended on the waste rock and ore stockpiles. Additional water quality sampling is required to monitor the impact of the potentially acid generating waste on the receiving environment.

It is recommended that monitoring of the adit discharge, and of West Logjam Creek upstream and downstream of the site be undertaken every three years to obtain water quality data for spring freshet, middle summer and late fall conditions. The method detection limits used should correspond to those criteria approved by CCME and BC for freshwater aquatic life. A paste pH and conductivity survey of the mine rock should be conducted in conjunction of water sampling in order to detect changes in the oxidation rate of the material.

7.0 REFERENCES

Canadian Council of Ministers of the Environment, 1991. Interim Canadian Environmental Quality Criteria for Contaminated Sites. The National Contaminated Sites and Remediation Program.

DIAND Technical Services, 1994. Assessment Report 105B-04-1, Logtung Abandoned Mines Assessment. Indian and Northern Affairs Canada.

DIAND Exploration and Geological Services Division, 1994. Yukon Minfile # 105B 039, Logtung.

Eaton, D., 1994. Geochemical and Drilling Report on the Logtung Property, Smart River Area, Yukon. NDU Resources Ltd., Assessment Report No. 093178.

Klassen, R.W., 1983. Wolf Lake Surficial Geology. Geological Survey of Canada Map 14-1982.

Nagpal, N.K., 1995. Approved and Working Criteria for Water Quality - 1995. Water Quality Branch, Environmental Protection Department, British Columbia Ministry of Environment, Lands and Parks.

Poole, W.H., Roddick, J.A., and Green, L.H., 1960. Wolf Lake Geology. Geological Survey of Canada Map 10-1960.

TABLE 1 Logtung Waste Rock Sample Descriptions

Sample ID	Sample Description
LTWR-R1	Sample of stockpiled quartz porphyry ore crushed (<10 mm) material similar to LTWR-R2. Field paste pH was 5.6.
LTWR-R2	Sample of stockpiled quartz porphyry ore coarse rejects having vein fracture coatings with 1% molybdenum and 2% pyrite. Field paste pH was 4.6.
LTWR-R3	Sample of stockpiled hornfels ore crushed (<10 mm) material similar to LTWR-R4. Field paste pH was 7.0.
LTWR-R4	Sample of stockpiled diorite and hornfels ore material with 5% sheeted veins with 2% pyrite and molybdenum. Field paste pH was 7.8.
LTWR-R5	Waste rock - Hornfels and altered sediments with 1% to3% fine to medium grained stringer vein hosted and disseminated pyrite and pyrrhotite. Field paste pH was 7.0.

TABLE 2 Logtung Waste Rock ABA and ICP Results

Parameter	Units	Sample Number LTWR				
		R1	R2	R3	R4	R5
Field Paste pH		5.6	4.6	7.0	7.8	7.0
Lab Paste pH		7.81	7.67	8.40	8.19	8.45
Total Sulfur	%	0.13	0.08	0.71	0.94	0.96
Sulfate	%	na	na	na	na	na
AP		4.06	2.50	22.19	29.38	30.00
NP		5.50	2.38	12.50	11.88	13.88
NET NP		1.44	-0.13	-9.69	-17.50	-16.13
NP/AP		1.35	0.95	0.56	0.40	0.46
Aluminum	%	0.48	0.23	0.76	0.97	0.83
Antimony	ppm	10	5	9	14	6
Arsenic	ppm	128	26	62	51	72
Barium	ppm	12	5	82	97	98
Beryllium	ppm	1.3	0.6	3.1	5.2	4
Bismuth	ppm	18	7	22	17	14
Cadmium	ppm	<0.1	<0.1	<0.1	<0.1	<0.1
Calcium	%	0.45	0.27	3.09	2.95	3.07
Chromium	ppm	165	161	130	109	94
Cobalt	ppm	2	2	7	8	9
Copper	ppm	47	32	119	144	133
Gallium	ppm	<1	<1	<1	<1	<1
Iron	%	0.53	0.38	1.42	1.61	1.94
Lead	ppm	80	33	<1	11	35
Lithium	ppm	3	<1	28	29	51
Magnesium	%	0.03	<0.01	0.60	0.51	0.86
Manganese	ppm	96	34	558	590	889
Molybdenum	ppm	435	116	213	303	194
Nickel	ppm	5	4	19	19	28
Potassium	%	0.05	0.03	0.11	0.15	0.19
Phosphate	ppm	320	410	910	940	1170
Silver	ppm	0.6	0.2	0.7	0.9	1.7
Sodium	%	<0.01	<0.01	0.09	0.13	0.08
Strontium	ppm	32	13	122	144	78
Thorium	ppm	4	<1	<1	<1	<1
Tin	ppm	<1	<1	<1	2	2
Titanium	%	<0.01	<0.01	0.05	0.05	0.09
Tungsten	ppm	51	33	83	107	77
Uranium	ppm	<1	<1	<1	<1	<1
Vanadium	ppm	2.8	0.7	33.0	30.6	51.0
Zinc	ppm	64	23	100	216	118

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

TABLE 3 Logtung Water Quality Results

Parameter	Units	Sample Number LTWQ/	
		A1-1	C1-2
Field Conductivity	umhos/cm	170	70
Field pH		7.5	7.0
Lab Conductivity	umhos/cm	2.6	79.7
Lab pH		7.52	7.33
Acidity (to pH 8.3) CaCO	mg/L	2.9	1.9
Alkalinity-Total CaCO3	mg/L	24.3	14.6
Sulphate SO4	mg/L	89	22.1
Aluminum T-Al	mg/L	<0.2	<0.2
Antimony T-Sb	mg/L	<0.2	<0.2
Arsenic T-As	mg/L	<0.2	<0.2
Barium T-Ba	mg/L	<0.01	<0.01
Beryllium T-Be	mg/L	<0.005	<0.005
Bismuth T-Bi	mg/L	<0.1	<0.1
Boron T-B	mg/L	<0.1	<0.1
Cadmium T-Cd	mg/L	<0.01	<0.01
Calcium T-Ca	mg/L	42.2	11.2
Chromium T-Cr	mg/L	<0.01	<0.01
Cobalt T-Co	mg/L	<0.01	<0.01
Copper T-Cu	mg/L	<0.01	<0.01
Iron T-Fe	mg/L	<0.03	<0.03
Lead T-Pb	mg/L	<0.05	<0.05
Lithium T-Li	mg/L	<0.01	<0.01
Magnesium T-Mg	mg/L	2.56	1.22
Manganese T-Mn	mg/L	<0.005	<0.005
Molybdenum T-Mo	mg/L	0.29	<0.03
Nickel T-Ni	mg/L	<0.02	<0.02
Phosphorus T-P	mg/L	<0.3	<0.3
Potassium T-K	mg/L	<2	<2
Selenium T-Se	mg/L	<0.2	<0.2
Silicon T-Si	mg/L	6.98	4.93
Silver T-Ag	mg/L	<0.01	<0.01
Sodium T-Na	mg/L	<2	<2
Strontium T-Sr	mg/L	0.112	0.043
Thallium T-Tl	mg/L	<0.1	<0.1
Tin T-Sn	mg/L	<0.03	<0.03
Titanium T-Ti	mg/L	<0.01	<0.01
Vanadium T-V	mg/L	<0.03	<0.03
Zinc T-Zn	mg/L	0.005	<0.005

< = lower detection limit

APPENDIX B

SITE PHOTOGRAPHS

Photo 1. Aerial view of upper exploration area looking west. Note multitude of ore piles at left and adit entrance at upper right.

Photo 2. Aerial view of upper exploration area looking east. Note ore sample handling area (foreground), adit area (upper left) and access road to camp area at right.

Photo 3. Aerial view of upper exploration area from north with adit at lower right and waste rock piles in background.

Photo 4. Aerial view of upper exploration area from east with access road to camp area at left. Note barrels by side of access road(left) and adit at right.

Photo 5. View from adit area of waste rock piles looking southwest. Note mine seepage which was the site of LT-WQ-A1.

Photo 6. View from south of seepage from adit. Note collapsed conditions surrounding adit entrance.

Photo 7. Detail of test pit LT-WR-R3 taken from crushed reject ore pile material stockpiled on site.

Photo 8. Ore piles (2 m X 4 m) extending westward containing 50% crushed rock (sorted to 1 cm diameter) and 50% muck sorted by round.

Photo 9. Detail of test pit LT-WR-R4 taken from muck portion of crushed reject ore pile material stockpiled on site.

Photo 10. Completing the site plan at the upper exploration area.

Photo 11. Aerial view (looking north) of lower camp area with collapsing core sheds (centre right), as well as barrel storage areas along access road.

Photo12. Collapsing wood frame core sheds at lower camp level. Shed at left is only partially filled with core while other sheds have had core placed on upper racks.

Photo 13. Aerial view of lower camp area showing ore barrel storage area between exploration area and camp with West Logjam Creek at left..

Photo 14. Detail of ore barrel storage area (total of 258 barrels on wood skids). Most barrels in this area were in good condition and contained graded ore sample material.

Photo 15. Detail of smaller ore barrel storage area opposite core storage sheds.

Photo 16. Random empty 205 litre barrels scatterd by access road between camp area and exploration area.

APPENDIX C

ANALYTICAL RESULTS

CHEMICAL ANALYSIS REPORT

Date: INTERIM

ASL File No. G3599

Report On: 762-186 Water 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: July 31, 1996

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Heather A. Ross, B.Sc.
Project Chemist

RESULTS OF ANALYSIS - Water File No. G3599

SILVER 7 — LA JAM.

			S7WQ-C2	LJWQ-C1-1	LTWQ-A1-1	LTWQ-C1-2
			96 07 26 17:30	96 07 28	96 07 28	96 07 28
Physical Tests						
Conductivity (umhos/cm)			146	106	260	79.7
pH			7.75	7.37	7.52	7.33
Dissolved Anions						
Acidity		CaCO3	2.3	2.5	2.9	1.9
Alkalinity - Total		CaCO3	68.9	20.7	24.3	14.6
Sulphate	SO4		6.5	28.4	89.0	22.1
Total Metals						
Aluminum	T-Al		[redacted]	[redacted]	[redacted]	[redacted]
Antimony	T-Sb		<0.2	<0.2	<0.2	<0.2
Arsenic	T-As		[redacted]	[redacted]	[redacted]	[redacted]
Barium	T-Ba		<0.01	<0.01	<0.01	<0.01
Beryllium	T-Be		<0.005	<0.005	<0.005	<0.005
Bismuth	T-Bi		<0.1	<0.1	<0.1	<0.1
Boron	T-B		<0.1	<0.1	<0.1	<0.1
Cadmium	T-Cd		[redacted]	[redacted]	[redacted]	[redacted]
Calcium	T-Ca		28.1	16.7	42.2	11.2
Chromium	T-Cr		[redacted]	[redacted]	[redacted]	[redacted]
Cobalt	T-Co		<0.01	<0.01	<0.01	<0.01
Copper	T-Cu		[redacted]	[redacted]	[redacted]	[redacted]
Iron	T-Fe		<0.03	<0.03	<0.03	<0.03
Lead	T-Pb		[redacted]	[redacted]	[redacted]	[redacted]
Lithium	T-Li		<0.01	<0.01	<0.01	<0.01
Magnesium	T-Mg		0.84	0.93	2.56	1.22
Manganese	T-Mn		<0.005	<0.005	<0.005	<0.005
Molybdenum	T-Mo		<0.03	<0.03	0.29	<0.03
Nickel	T-Ni		<0.02	<0.02	<0.02	<0.02
Phosphorus	T-P		<0.3	<0.3	<0.3	<0.3
Potassium	T-K		<2	<2	<2	<2
Selenium	T-Se		[redacted]	[redacted]	[redacted]	[redacted]
Silicon	T-Si		3.20	2.22	6.98	4.93
Silver	T-Ag		[redacted]	[redacted]	[redacted]	[redacted]
Sodium	T-Na		<2	<2	<2	<2
Strontium	T-Sr		0.182	0.051	0.112	0.043
Thallium	T-Tl		<0.1	<0.1	<0.1	<0.1
Tin	T-Sn		<0.03	<0.03	<0.03	<0.03
Titanium	T-Ti		<0.01	<0.01	<0.01	<0.01
Vanadium	T-V		<0.03	<0.03	<0.03	<0.03

Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Water File No. G3599

		S7WQ-C2	LJWQ-C1-1	LTWQ-A1-1	LTWQ-C1-2
		96 07 26 17:30	96 07 28	96 07 28	96 07 28
Total Metals					
Zinc	T-Zn	<0.005	<0.005	0.005	<0.005

Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

Outlines of the methodologies utilized for the analysis of the samples submitted are as follows:

Error opening method file.

Extractable Organic Halide (EOX) in Oil

This analysis is carried out using a procedure that is consistent with the requirements of the appropriate regulatory agencies and adapted from U.S. EPA Method 9020 (Publ. # SW-846, 3rd ed., Washington, DC 20460). The procedure involves extracting a subsample with ethyl acetate and analysing the extract with a TOX analyser.

Moisture

This analysis is carried out gravimetrically by drying the sample to constant weight at 103 C.

Conventional Parameters in Sediment/Soil

These analyses are carried out on a leachable basis. The procedure involves mixing with reagent grade water and leaching for several hours. The leachate is centrifuged and analysed in accordance with "Standard Methods for the Examination of Water and Wastewater" 17th ed. published by the American Public Health Association, 1989.

Metals in Sediment/Soil

This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 Method 3050 or Method 3051, published by the United States Environmental Protection Agency (EPA). The procedures involve a digestion using a 1:1 ratio of nitric acid and hydrochloric acid, along with hotplate or microwave heating. Instrumental analysis is by atomic absorption spectrophotometry (EPA Method 7000) and/or inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010).

Method Limitation: The stated acid digestion will provide excellent results for total recoverable metals; however, it is only partially effective on mineralized or non-environmentally available metals.

Polycyclic Aromatic Hydrocarbons in Sediment/Soil

This analysis is carried out using a procedure adapted by ASL from U.S. EPA Methods 3500, 3630, and 8270 (Publ. #SW-846 3rd ed., Washington, DC 20460). The procedure involves a microwave assisted extraction with

Appendix 2 - METHODOLOGY (cont'd) File No. G4270

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