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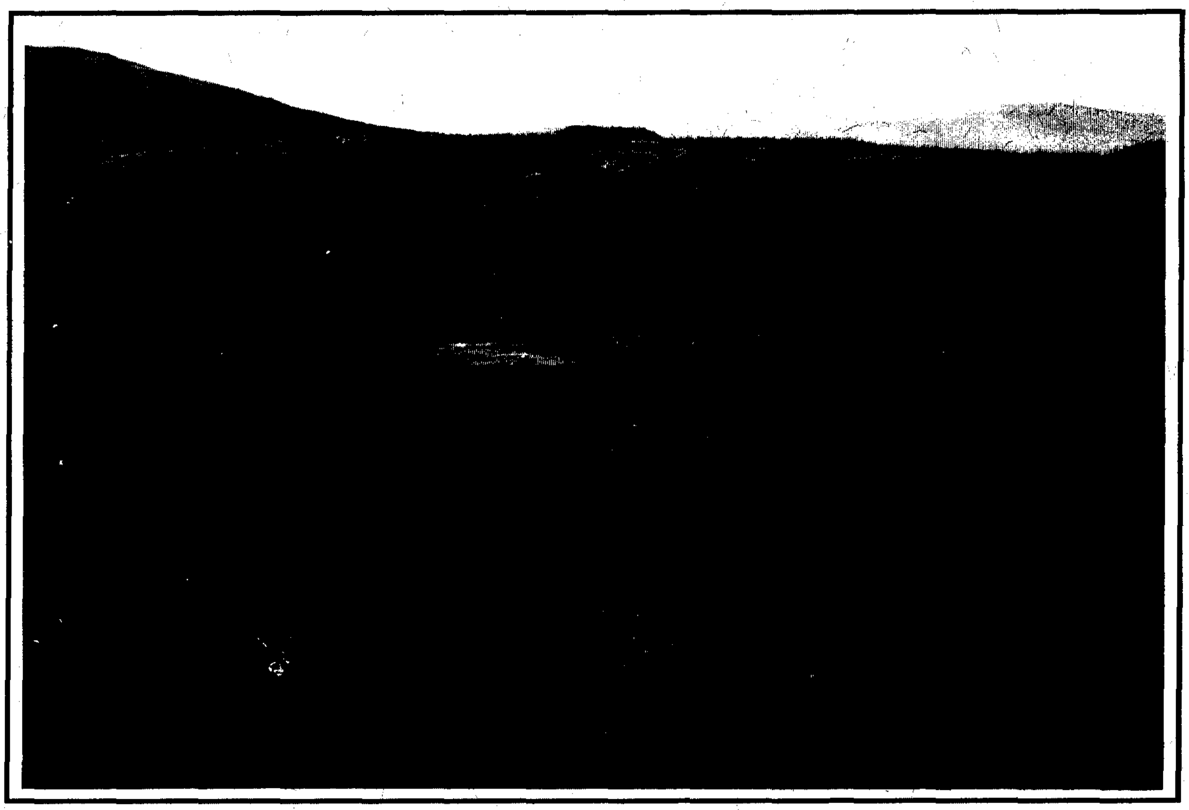
PWGSC

Quality in Environmental Services

PHASE II ENVIRONMENTAL ASSESSMENT
OF THE
SOUTH GAMBLER
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

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EXECUTIVE SUMMARY

A phase II environmental assessment was conducted at the South Gambler abandoned mine site (63°57'41" N, 135°17'04" W) in 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 1994 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 Phase II investigation observed numerous health and safety concerns on the South Gambler site arising from the presence of a wood loadout structure, and an adit that is not adequately secured from public and wildlife access. In addition, groundwater flow from this mine and two other mines has been directed through a deformed culvert that runs directly through the bottom of a waste rock dump on the site. Environmental hazards on the South Gambler abandoned mine site arise from hydrocarbon-stained soil. Aesthetic concerns include extensive non-hazardous waste across the site and the wood loadout structure.

Using applicable federal and territorial criteria as well as northern mine reclamation guidelines, the recommendations are to demolish and bury the wood loadout structure and to bury all non-hazardous waste found on the site. At the adit opening, a culvert with metal mesh across the opening should be constructed to prevent access into the abandoned mine while permitting water to continue to flow out of the adit. The groundwater flowing out of this adit should be redirected past the waste rock pile, which would require approximately 100 m of lined diversion ditch to be constructed.

No further test work is recommended on the waste rock as an assessment of the acid rock drainage potential shows that the risk to the environment due to the presence of waste rock are of minor significance. Once the flow of water has been diverted around the rock pile, a water quality monitoring program should be undertaken to determine if the waste rock is significantly impacting the receiving environment. The results of the monitoring program can then be used to determine if covering the waste rock pile is necessary. 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.

SUMMARY OF CONCLUSIONS & RECOMMENDATIONS

ASSESSMENT COMPONENT	RISK	RECOMMENDATION
1. Building, Infrastructure, Equipment		
Wooden remnants of powerhouse	Health & Safety / Aesthetic	Demolish & burn on site.
Wooden remnants of mechanics workshop	Health & Safety / Aesthetic	Demolish & burn on site.
Wood waste scattered by site	Health & Safety / Aesthetic	Burn on site.
2. Non-Hazardous Waste Material		
Metal ore car, rusting car body, empty rusting 205 litre barrels, & miscellaneous metal waste scattered about site.	Aesthetic Concern	Bury on site using available waste rock as cover
Wooden loadout structure	Health & Safety / Aesthetic	Burn on site
Wood waste scattered about site.	Aesthetic Concern	Burn on site
3. Hazardous Materials		
Approx. 3 m^2 of heavy grease & oily stained soil	Environmental Concern	Spread, scarify, mix and fertilize on site
4. Water Quality		
Mine Seepage/Site Drainage	Moderate Env. Risk	Construct diversion ditch
Receiving Waters	Minor Env. Risk	Monitor 1/4'ly every 5 years
5. Waste Rock Disposal Areas		
Waste rock low potential for acid generation - 22000 tonnes	Minor Environmental Concern at this time	Monitor after adit water diversion ditch installed
6. Mine Openings		
Adit open and accessible	Health and Safety Concern	Secure with galvanized metal mesh to allow water flow to continue through adit.
7. Tailings		
None	None	None

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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.

For the South Gambler abandoned mine site, the 1993 preliminary report recommended further investigation into possible environmental impacts resulting from previous mining activities. According to the Phase I report, the potential areas of concern included: groundwater flow through the adit and beneath the waste rock dump; health and safety concerns due to mine openings, infrastructure and site debris; environmental concerns due to hydrocarbon stained soil; and aesthetic concerns due to non-hazardous waste materials. No rock, tailings, soil or water samples were collected in the Phase I assessment.

In light of these preliminary findings, 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 South Gambler abandoned mine site to a) identify specific environmental and human safety risks; b) provide clean-up recommendations; and c) provide a Class "D" cost estimate for remediation or mitigation of those risks.

1.1 LOCATION

The South Gambler abandoned mine site is located in the central Yukon at 63°57'41" N latitude and 135°17'04" W longitude, at an elevation of approximately 1100 m above sea level **(Figure 1)**. The mine site is approximately 0.8 km north of the abandoned mining community of Wernecke, on the lower part of the west facing slope of Keno Hill and is accessible during the summer by road from the community of Keno Hill.

1.2 OVERVIEW OF SITE DEVELOPMENT

The adit and waste rock pile was created between 1921 and 1933 when a drainage tunnel over 900 meters in length, the 600 Ladue tunnel, and over 275 meters of drifting on the ore zone occurred (GSC Summary Report, 1929, Part A, p. 4A). The Ladue No. 2 shaft joins the drainage tunnel 730 meters from the adit entrance. Production from the Ladue Mine ceased in 1933. During the period 1955 to 1957 the 600 Ladue tunnel was rehabilitated and minor development work was completed. In 1968 the 600 Ladue tunnel and the Ladue No. 2 shaft were rehabilitated to their junction point (GSC Paper 68-68, p. 22-23). A limited amount of waste rock was likely generated during the rehabilitation and subsequent underground exploration program. A camp was established at the 600 Ladue portal for the most recent rehabilitation and exploration program (GSC Paper 68-68, p. 23).

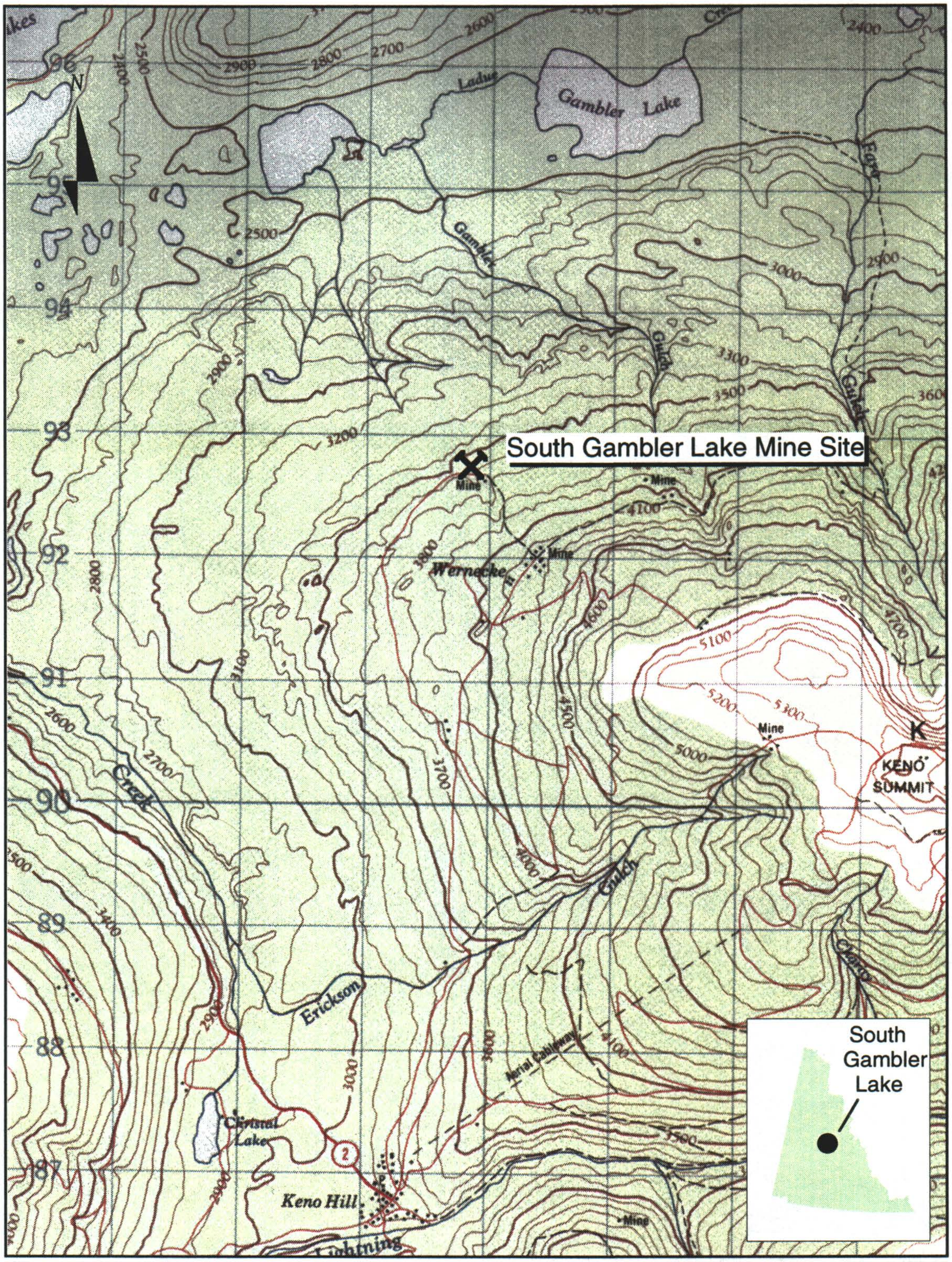


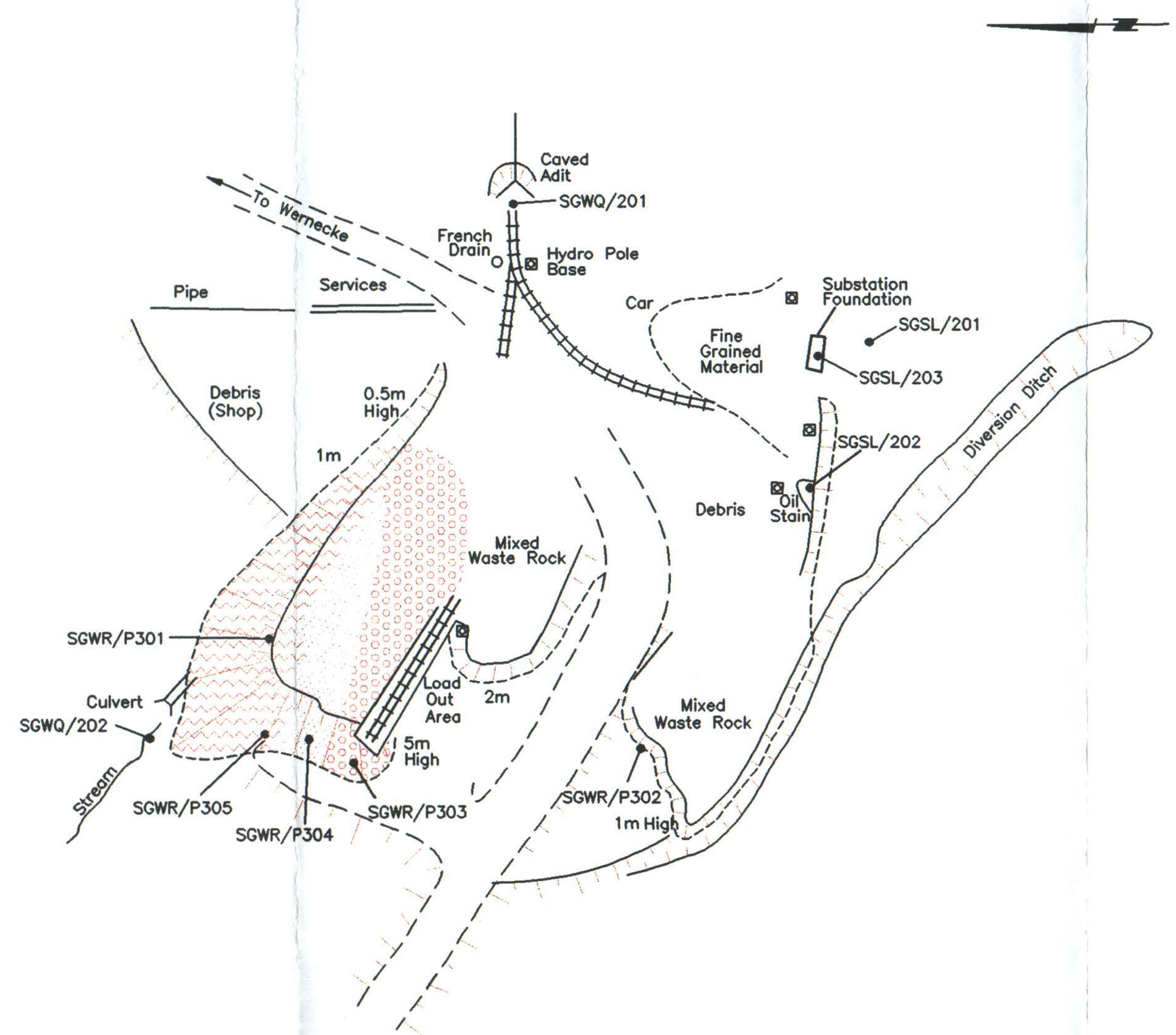
Figure 1: SOUTH GAMBLER LAKE SITE

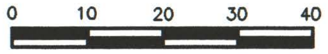
N.T.S. 105 M/14 Map Name: Keno Hill Map Scale: 1:50,000

Latitude: 63° 57' 41" N Longitude: 135° 17' 04" W

Legend

- Outcrop Boundry
- W/R — Waste Rock
- O/C — Outcrop
- Adit
- Road
- Culvert
- Extent Of Waste Rock
- Track
- • SGWQ/A3/1 — Water Quality Sample (site designation)
- • SGS/1 — Soil Sample (site designation)
- • SGWR/P1/1 — Waste Rock (site designation)
- Slope Down
- Chloritic Waste Rock
- Graphitic Waste Rock
- Cardonitized Waste Rock
- Buildings
- Extent of Debris, Timber, Cable, Pipe, etc.





Scale 1:1000

Waste Rock Sample No.	Paste PH	Paste Conductivity us/cm
SGWR/P301	8.01	110
SGWR/P302/1	7.92	280
SGWR/P302/2	8.28	310
SGWR/P303	8.08	60
SGWR/P304	7.46	>1990
SGWR/P305	8.12	40

Approx. Scale 1:1000

PLOT: 1=1
CAD FILE: INVEN-96\GAMBLER\GAMBLE1

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

Architectural & Engineering Services
Western Region

Drawing title: / Titre du dessin:

South of Gambler Lake Mine
Site Development
Yukon Territory

designed by: / concu par:	date:
drawn by: / dessine par: R.N.	Nov. /96
approved by: / approuve par:	
revisions:	
project no. / no. du projet: 626967	dwg. no. / dessin no. 1 of 1

1.3 SITE ACCESS

The South Gambler abandoned mine site is located 6 km north of the community of Keno. The site is reached by taking a poorly defined trail that is now overgrown with vegetation that may be traveled by ATV and is located about 1 km north of the abandoned mining community of Wernecke. An alternate route, which leads directly to the site and is in better condition than the route previously described, branches of the road approximately 1.5 km south of Wernecke. This road, 3 km in length, is wet in places but can be traveled by a four-wheel drive vehicle in dry weather.

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 Silver Hart 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 Silver Hart 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.

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.

4.0 ENVIRONMENTAL SETTING

4.1 MINERALIZATION

The Silver Hart property is located along the eastern contact of Cretaceous granodiorites of the Cassiar Batholith and Cambrian to Late Proterozoic marble and quartz - biotite - sericite - chlorite schists of the Atan Group. The metasedimentary rocks have a general northerly trend and east dip (Poole et al. 1960; Norecol, 1987). Mineralization in the Silver Hart area includes a variety of occurrence types, including:

- shear hosted quartz-carbonate-sulphide veins of galena, tetrahedrite and sphalerite;
- scheelite - molybdenum - galena - sphalerite skarn developed along intrusive - metasedimentary contact, and;
- halcopyrite enriched pyritic zones within the sericite schists.

The veins are the primary ore of the Silver Hart mine with assays ranging from 0.3 g/t Au, 507.4 g/t Ag, 29.6% Pb and 4.9 % Zn across 0.6 metres to 0.6 g/t Au, 4,145.1 g/t Ag, 18.3% Pb and 0.7 % Zn across 0.6 metres. Reserves outlined in 1987 were 97,000 tonnes grading 1025 g/t Ag. Over 60 vein or float occurrences of galena grading up to 8,571 g/t Ag.

4.0 ENVIRONMENTAL SETTING

4.1 MINERALIZATION

The Keno Hill-Galena Hill silver-lead ores occur in erratic shoots and lenses lying in vein-faults that cut fine-bedded to massive quartzite, intercalated greenstone sills and lenses, and various schistose rocks (GSC Paper 68-68, p. 21). The wall rocks are highly shattered greenstone (chlorite schists) and phyllite, and the orebody consists of a stockwork of veinlets containing principally siderite ($FeCO_3$), galena (PbS), sphalerite ((ZnFe)S), freibergite (silver-bearing tetrahedrite ($(CuFe)_{12}Sb_4S_{13}$)), pyrite (FeS_2) and a small amount of quartz (SiO_2) (GSC Bulletin 111, p. 33). Pyroxenite was also observed on the surface of the dump.

The major commodity identified at this site is silver.

4.2 SURFACE HYDROLOGY

At the time of site inspection, approximately 600-800 liters/minute of water was observed flowing out one of the adits into a vertical shaft beside the adit. Upslope of the site, a poorly defined gully was observed to channel snowmelt and water from seasonal subsurface thawing across the site past the waste rock dump and continuing downslope into a gully below the site. Some vegetation stress in this gully, both above and below the site, was evident due to sediment accumulation.

? Only one adit, no shafts shown on plan.

4.3 CLIMATE

The closest climatological information is from the town of Elsa, 63°55' N, 135°29' W; 814 m above sea level (Environment Canada, 1980). Total annual precipitation is 413.0 mm. This consists of 219.5 mm of rainfall and 202.9 mm of snowfall. Highest levels of rainfall occur in July and highest levels of snowfall occur in October. Temperatures range from -25.1 °C in January to 14.1 °C in July. The mean annual temperature is -4.4 °C.

4.4 VEGETATION

The South Gambler exploration site is located within the Mayo Lake-Ross River Ecoregion. The mine site is located at an elevation of approximately 1100 m a.s.l. The predominant species of vegetation cover is willow with approximately 30% cover of black spruce.

In this Ecoregion, the terrain below the treeline (1350 m to 1500 m a.s.l.) consists extensive forests of open black spruce, and occasionally lodgepole pine, with moss, ericaceous shrubs, and willows, dominating the understory. White spruce, occasionally with aspen or lodgepole pine, occurs on warmer and better drained sites. In drier environments, lichen development is common. Alpine fir occurs in the subalpine and alpine vegetation consists of mountain avens, dwarf willow, birch, ericaceous shrubs, grasses, and mosses.

4.5 FISH AND WILDLIFE RESOURCES

This area supports a number of carnivorous species including wolf, coyote, grizzly bear, and black bear. Ungulates include caribou, Dall's sheep, and moose. Beaver, fox, and hare are also common. Typical bird species include raven, rock and willow ptarmigan, and golden eagle. No fish habitat appears to be close to the site.

4.6 SITE TOPOGRAPHY AND SOILS

The site is on a gentle northwest facing slope covered by silt and gravel till overlying bedrock. The dominant soil development in the area is turbic cryosolic and eutric brunisolic with the occasional occurrence of dystric brunisols over coarse materials **(See Photo 1)**

4.7 PERMAFROST

South Gambler is in an area of discontinuous permafrost, although no evidence of permafrost was discovered during the site visit.

5.0 SITE DESCRIPTION AND FINDINGS

5.1 BUILDING, INFRASTRUCTURE, EQUIPMENT

Buildings remaining on site include a former powerhouse, a mechanic's workshop (both of which are derelict), a log cabin located 80 m north of adit (in fair condition) and an elaborate (deteriorating) wooden loadout facility **(See Photos 2 - 8)**. Infrastructure identified on site includes the mine adit drainage system which channels water from the adit beneath the waste rock pile and discharges 70 m to the northeast **(See Photos 9 & 10)**.

A large amount of wood waste was found scattered throughout the site including timbers supporting rails on trestles running out from the adit **(See Photo 5)**. Equipment found on site includes one ore car, one car body, three empty 205 L barrels, assorted metal mining debris near to the entrance of the adit including rail and pipe, and wood waste dumped over the bank of the waste rock pile. Buildings, infrastructure and equipment identified on site are summarized in **Table 1** below.

Table 1: Buildings, Infrastructure & Equipment

Structure	Construction Features	Interior Contents
Wooden remnants of powerhouse	Dilapidated wooden structures collapsed	Demolish & burn on site.
Wooden remnants of mechanics workshop	Dilapidated wooden structures collapsed	Demolish & burn on site.
Wood waste scattered about site	None	Burn on site
Wooden load out facility.	Located west of adit entrance	Demolish & burn on site.

According to the Research Report on the Heritage Resources in the Contaminant Site Remediation Project, the Gambler site (105 M-14-08) located at 63°56' 53" N latitude and 135°13'06" W longitude (near to the South Gambler site located at 63°57' 41" N latitude and 135°17' 04" W longitude) has been deemed as having heritage value.

The above-mentioned report requires a historical record of the Gambler site to be completed prior to site remediation. Due to the proximity of the South Gambler site to the Gambler site, the historical significance of South Gambler should be confirmed with the Keno Mining Museum prior to commencing with any site remediation work.

5.2 NON-HAZARDOUS WASTE MATERIALS

The 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
Metal Ore car	1	Near adit entrance	Rusting near trestle and water course.
Car Body	1	Near adit entrance	No salvage value.
Barrels	3	Near adit entrance	Empty & rusting
Miscellaneous Metal Waste	<15 m^2	Near adit entrance	Rusting and scattered about area
Wood Loadout Structure	1	100 m from adit near waste rock dump	Wooden structure constructed upon waste rock pile, unstable.
Wood Waste	< 20 m^2	Waste rock pile	Combustible.

5.3 HAZARDOUS MATERIALS

Approximately 3 m^2 of hydrocarbon-stained soil was observed on the South Gambler abandoned mine site.

5.4 SURFACE WATER QUALITY

Three water samples were collected at the South Gambler abandoned mine site. Sample **SGWQ/201** was collected from the water discharging out of the adit and sample **SGWQ/Str-202** was collected 2 meters below the waste rock pile. Approximately 1250 meters downstream of the waste rock pile, and 5 meters below the confluence of a small tributary, sample **GambWQ/St-001** was collected. No background water samples were collected for comparison with the water quality downstream of the site.

All the water samples had laboratory pH values between 7.9 and 8.2 and laboratory conductivity readings between 560 µS/cm and 640 µS/cm. All of the samples exceeded or were equivalent to the CCME freshwater aquatic life criteria for silver and zinc. Concentrations of aluminum, copper, iron, silver, and zinc in the adit discharge water exceeded the CCME freshwater aquatic life criteria. Lead and selenium concentrations were equivalent to those established by CCME for freshwater aquatic life. Below the waste rock pile the water quality of the creek exceed CCME freshwater aquatic life criteria for aluminum, iron, silver, and zinc. Approximately 1200 meters below the mine site the zinc concentration in the water was increased compared to the sample collected below the rock pile. The zinc concentration exceeded the CCME freshwater aquatic life criteria. Selenium concentrations (0.0022 ppm) were above the CCME criteria and silver concentrations were equivalent to the CCME criteria (0.0001 ppm). Significant laboratory results of surface water samples are summarized below in **Table 3**.

Table 3 Surface Water Samples - Significant Laboratory Results

Parameter	SGWQ/201 *(Discharge from adit)*	SGWQ/Str-202 *(Below waste rock dump)*	GambWQ/St-001 *(Downstream of site)*	Guidelines for Freshwater Aquatic Life
Conductivity (umhos/cm)	620	561	638	--
Hardness $CaCo_3$ (mg/L)	307	307	340	--
pH	7.92	8.12	8.22	6.5-9.0
Aluminum (μg/L)	416	184	95	5-100
Arsenic (μg/L)	4.9	4.4	1.1	50
Chromium (μg/L)	< 1.0	< 1.0	< 1.0	2-20
Iron (μg/L)	1020	570	220	300
Lead (μg/L)	7	< 1	2	1-7
Mercury (μg/L)	< 0.05	< 0.05	< 0.05	0.1
Selenium (μg/L)	1.0	0.8	2.2	1
Silver (μg/L)	0.2	0.2	0.1	0.1
Zinc (μg/L)	459	462	543	30

5.5 WASTE ROCK DISPOSAL AREAS

The waste rock pile at the South Gambler abandoned mine site was created with the development of a drainage tunnel over 900 meters in length, the 600 Ladue tunnel, and over 275 meters of drifting on the Ladue vein on the 600 level. A raise connects the 600 Ladue tunnel to the Ladue No. 2 shaft (GSC Summary Report 1929, Part A, p. 4A).

Approximately 22,000 tonnes of waste rock from underground development covers an area 3800 m^2 at South Gambler. The surface of the waste rock pile is covered with 20% moderately carbonitized rock, 15% moderately chloritized greenstone and pyroxenite and 6% graphitic schist. The remaining surface area is covered with a mixture of greenstone, quartzite, and various schistose rocks. The distribution of the rock types and alteration on the waste rock is shown on the site map.

Five pits were dug in the waste rock, from which six samples were gathered for laboratory analysis. The sample locations are shown on the site map. Samples **SGWR/P301** and **SGWR/P305** were collected from waste rock that exhibited iron carbonate staining on the surface. Sample **SGWR/P304** was collected from an area mineralized graphite schist that exhibited whitish secondary mineralization on the surface. Sample **SGWR/P303** was collected from the chlorite schist rich portion of the dump. Sample **SGWR/P302/1** was collected from the mixed waste rock material on the south side of the pile. Sample **SGWR/P302/2** was collected from the iron carbonate stained soil beneath the waste rock. The samples were submitted for Acid Base Accounting (ABA) test and determination of metals by Inductively Coupled Plasma - Atomic Emission Spectrophotometry (ICP-AES). Results of these analyses are presented in **Appendix B** and summarized in **Table 4.** Descriptions of waste rock samples is summarized in **Table 5**. All rock samples collected had field and laboratory paste pH values near between 7.5 and 8.5, indicating that the material is not currently generating acid. The Neutralization Potential to Acid Potential (NP:AP) ratios in **SGWR/P302/1** and **SGWR/P304** were 2.6 and 1.3, indicating that the material is potentially acid generating. Sample P301 has low acid generating potential. It has a NP:AP ratio of 3.0. The remaining samples had NP:AP ratios above 3, indicated a low potential for acid generation.

All the rock samples contained elevated concentrations of silver, iron, and manganese. Sample **SGWR/P304** contained elevated concentrations of cadmium, lead, and zinc. Samples **SGWR/P301** and **SGWR/P305** also contained elevated concentrations of lead and zinc. An assessment of the acid rock drainage and metal leaching potential of the waste rock at South of Gambler Lake has been completed by Steffen Robertson and Kirtsen Consulting Engineers and is included in **Appendix A**.

Table 4 **Summary Acid/Base Accounting Test Results**

Sample #	Paste pH	Total S (%)	SO4 (%)	AP	NP	Net NP	NP/AP
WR/P301	8.01	1.22	0.21	31.56	95.94	64.38	3.04
WR/P302/1	7.92	1.41	0.18	38.44	101.44	63.00	2.64
WR/P302/2	8.28	0.47	n/a	14.69	225.88	211.19	15.38
WR/P303	8.08	0.40	n/a	12.50	82.75	70.25	6.62
WR/P304	7.46	2.36	0.27	65.31	86.38	21.06	1.32
WR/P305	8.12	0.57	0.21	11.25	105.38	94.13	9.37

5.6 MINE OPENINGS AND EXCAVATIONS

One adit is located at the east end of the site on a moderately steep, northwest facing slope. The shaft has collapsed, limiting access into the mine opening; however, the adit is open and accessible **(See Photos 4 & 5)**. Minewater, from this mine and the Ladue mill and mine site in Wernecke, flows through the adit and is directed into a 0.5 m corrugated steel culvert (French Drain) that passes directly beneath the waste rock dump. The culvert empties at the northwest end of the site, 85 m downslope of the adit entrance. The estimated flow of the mine seepage at the time of site assessment was 3.5 liters/second **(See Photos 9 & 10)**. Adit features are summarized below in **Table 6.**

5.7 TAILINGS

No milling of ore was done on site. Therefore, no tailings are present.

Table 5 Waste Rock Sample Description

Sample ID	Sample Description	Discussion of Results
SGWR/P301	Sample collected at the crest of the rock pile's northern edge in material that exhibited iron carbonate staining on the surface. Sample was collected over a thickness of 20 cm in dark grey/brown silt, sand and gravel size material that included chlorite schist and pyroxenite with minor galena and sphalerite.	Field paste pH was 8.0 and conductivity 110 µS/cm. NP:AP ratio 3.0, high concentrations of Ag, Fe, Mn, Pb, and Zn.
SGWR/P302/1	Sample collected from mixed waste rock material at southern edge of the rock pile over a thickness of 30 cm. Material consisted of graphite schist with <1% of the surface exhibiting staining.	Field paste pH was 7.9 and conductivity 280 µS/cm. NP:AP ratio 2.6, high concentrations of Ag and Mn.
SGWR/P302/2	Sample collected over a thickness of 20 cm in sand and silt sized brown soil below P302/1.	Field paste pH was 8.3 and conductivity 310 µS/cm. NP:AP ratio 15.4, high concentrations of Ag, Fe, and Mn.
SGWR/P303	Sample collected in chlorite schist and greenstone below the load out facility. The sample was collected over a thickness of 40 cm in grey/green in coloured sand and gravel size material.	The field paste pH was 8.0 and conductivity 60 µS/cm. NP:AP ratio 6.6, high concentrations of Ag, Fe, and Mn.
SGWR/P304	Sample collected from mineralized graphitic schist on the northwest edge of the rock pile. The surface had a whitish precipitate. The sand and gravel size material was collected over a thickness of 30 cm. 1% of the material was cobble size up to 8 cm.	The field paste pH was 7.5 and the conductivity >1990 µS/cm. NP:AP ratio 1.3, high concentrations of Ag, Cd, Mn, Pb, and Zn.
SGWR/P305	Sample collected at the toe of the rock pile northwest corner in material similar to P301. The sample was collected over a thickness of 35 cm in moist dark grey/brown sand and gravel size material.	The field paste pH was 8.1 and the conductivity 40 µS/cm. NP:AP ratio of 9.4, high concentrations of Ag, Fe, Mn, Pb and Zn.

Table 6: Mine Openings

Adit	Location	Drift Length	Condition
A1	1067 m elev.	Limited access; draft length unknown	Adit overgrown with vegetation and collapsed, however water seep is prominent.

6.0 CONCLUSIONS

The primary concerns on the South Gambler abandoned mine site arise from health and safety concerns over the deteriorated condition of the loadout facility, the open and accessible adit, and a French drain directing water from the adit beneath the waste rock dump. Secondary concerns on this site include the environmental implications of a small grease deposit, and the aesthetic appearance of scattered timbers, metal and other debris located throughout the site. The overall priority rating assigned to the clean-up and remediation recommendations for the South Gambler abandoned mine site is Medium.

6.1 HEALTH AND SAFETY

There are several health and safety concerns at the South Gambler abandoned mine site. These concerns include the presence of a dilapidated load out facility, an open and accessible adit, and a French drain directing water from the adit beneath the waste rock dump.

6.2 ENVIRONMENTAL RISKS

The majority of the 22,000 tonnes of waste rock at the South Gambler site has a low acid generating potential. The mineralized graphite schist waste rock; however, may become acid generating. There is approximately 1500 tonnes of this material at the site, assuming that this material's distribution observed on the surface is representative of the whole pile.

Based on the limited water samples collected, the waste rock pile at the South Gambler site does not appear to significantly affect the downstream water quality, despite relatively high concentrations of silver, manganese and lead in the rock pile. Drainage from Wernecke appears to be having a greater impact on the receiving environment.

Surface water originating at the Ladue mill and mine site in Wernecke has resulted in drainage channels containing significant sediment loads (possibly with high metal concentrations) that have been diverted by ditches around the South Gambler site. A substantial amount of vegetation within the drainage channels has died. New growth however, was observed within the channels during the site assessment.

While the adit at South of Gambler Lake is discharging water elevated in aluminum, iron, silver and zinc to the creek, it appears that CCME freshwater aquatic life criteria are not being met downstream since a substantial amount of contamination in the form of zinc and selenium has originated in the sediment loaded drainage channels from Wernecke.

6.3 AESTHETIC CONCERNS

Aesthetic concerns arise from assorted mining debris located throughout the site (including an ore car and rails, empty 205 L barrels, wood waste), derelict buildings (including a mechanic's workshop, a former powerhouse and a log cabin). These old structures may have heritage values and the Keno Mining Museum must be notified prior to site remediation.

7.0 RECOMMENDATIONS

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

Recommendation 1.

It is recommended that the mine opening be secured from human and animal access for health and safety reasons. The adit should be covered with a galvanized metal mesh to prevent access while allowing water flow through the adit to continue. Should the mine need to be reopened, access to workings is achievable by removal of the mesh.

Recommendation 2.

It is recommended that the groundwater flow out of the adit be redirected such that it no longer flows beneath the waste rock pile. This requires the construction of approximately 100 m of lined diversion ditch.

Recommendation 3

It is recommended that all the loadout structure be demolished, wood waste burned on site, and any metal waste buried on site for health and safety reasons. All other debris on-site, including empty 205 L barrels, an ore car, and miscellaneous metal debris, should be buried along with any non burnable material from the loadout structure.

Recommendation 4.

No further test work is recommended on the waste rock as an assessment of the acid rock drainage potential shows that the risk to the environment due to the presence of waste rock is of minor significance. Once the flow of water has been diverted around the rock pile, a water quality monitoring program should be undertaken to determine if the waste rock is significantly impacting the receiving environment.

It is recommended that every five years a monitoring program be undertaken to obtain water quality data for spring freshet, middle summer and late fall conditions. The results of the monitoring program can then be used to determine if covering the waste rock pile is necessary.

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.

8.0 COST ESTIMATES TO IMPLEMENT RECOMMENDATIONS

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

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APPENDIX A

DETERMINATION OF ACID ROCK DRAINAGE POTENTIAL

P118105

SOUTH OF GAMBLER LAKE ACID ROCK DRAINAGE ASSESSMENT REPORT

1.0 INTRODUCTION

This site specific report has been prepared in conjunction with a *Phase II Environmental Assessment of the South of Gambler Lake 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 associated with the site, which is the subject of this report. The reader is directed to the PWGSC report for a comprehensive environmental assessment of the South of Gambler Lake site.

This report assesses existing, and potential acid rock drainage (ARD) conditions at the South of Gambler Lake 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 SRK, which includes similar assessments for a number of sites. 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.

The South of Gambler Lake site is located on the northwest slope of Keno Hill, six kilometres north of the village of Keno Hill, Yukon Territory. The site is accessible by four wheel drive vehicle. The abandoned Wernecke mill and mine is located one kilometre to the southeast of the site.

Mine related disturbances observed during the site assessment consist of one adit and one waste rock pile. No mill site or tailings pond is present at the site. The adit serves as a drainage tunnel that connects the underground workings at South of Gambler Lake to the Sadie Ladue workings at Wernecke. The drainage tunnel was driven between 1921 and

1929 (GSC Memoir 284, p. 520; and GSC Summary Report, 1929, Part A, p. 4A.). The tunnel was last rehabilitated in the 1970's (pers. comm. J.B. O'Neill).

The site is located in an area of discontinuous permafrost within a western boreal forest of spruce and willow. A creek emerges from the adit for 10 metres before flowing into a french drain. The creek reappears at a culvert below the waste rock pile. At the time of the site assessment the creek was flowing at 3.5 L/sec (visual estimate). Surface runoff drainage paths, marked by a build up of sediment and vegetation kill, extend from the workings at Wernecke through and around the South of Gambler site before joining up with the creek. The drainage paths were dry at the time of the site assessment.

2.0 GEOLOGY AND MINERALIZATION

The Keno Hill-Galena Hill silver-lead ores occur in erratic shoots and lenses lying in vein-faults that cut fine-bedded to massive quartzite, intercalated greenstone sills and lenses, and various schistose rocks (GSC Paper 68-68, p. 21). The wall rocks are highly shattered greenstone (chlorite schists) and phyllite, and the orebody consists of a stock-work of veinlets containing principally siderite ($FeCO_3$), galena (PbS), sphalerite ($(Zn,Fe)S$), freibergite (silver-bearing tetrahedrite ($(Cu,Fe)_{12}Sb_4S_{13}$)), pyrite (FeS_2) and a small amount of quartz (SiO_2) (GSC Bulletin 111, p. 33). Pyroxenite was also observed on the surface of the dump.

3.0 WASTE ROCK DISPOSAL AREAS

3.1 Description

The waste rock pile at the South of Gambler Lake site was created with the development of a drainage tunnel over 900 metres in length, the 600 Ladue tunnel, and over 275 metres of drifting on the Ladue vein on the 600 level. A raise connects the 600 Ladue tunnel to the Ladue No. 2 shaft (GSC Summary Report 1929, Part A, p. 4A).

The volume of waste rock produced from the underground development is estimated to be 22,000 tonnes. The assumptions made to derive this estimate are:

- a specific gravity of 2.65;
- a total 1200 metres of lateral development, which used the 600 Ladue tunnel for waste haulage; and,
- mine openings 2.5 metres by 2.7 metres.

The waste rock covers an area 3800 m^2. The surface of the waste rock pile is covered with 20% moderately carbonitized rock; 15% moderately chloritized greenstone and pyroxenite and 6% graphitic schist. The remaining surface area is covered with a mixture of greenstone, quartzite, and various schistose rocks. The distribution of the rock types and alteration on the waste rock is shown on the site map, Drawing 2.

3.2 Sampling

Five pits were dug in the waste rock, from which six samples were gathered for laboratory analysis. The sample locations are shown on the site map, Drawing 2.

Samples SGWR/P301 and SGWR/P305 were collected from waste rock that exhibited iron carbonate staining on the surface. P301 was collected from the crest of the waste rock pile, where the material was predominantly sand / silt size, and P305 was collected from the toe of the pile, where the average size of the material was larger.

Sample SGWR/P304 was collected from an area of mineralized graphite schist that exhibited whitish secondary mineralization on the surface. Sample SGWR/P303 was collected from the chlorite schist rich portion of the dump. Sample SGWR/P302/1 was collected from the mixed waste rock material on the south side of the pile. Sample SGWR/P302/2 was collected from the iron carbonate stained soil beneath the waste rock. The test pit logs are summarized in Table 1.

Three water samples were collected at the South of Gambler Lake site. Sample SGWQ/201 was collected from the water discharging out of the adit and sample SGWQ/Str-202 was collected 2 metres below the waste rock pile. Approximately 1250 metres downstream of the waste rock pile, and 5 metres below the confluence of a small tributary, sample GambWQ/St-001 (also referred to as SGWQ/Str-001) was collected. No background water samples were collected for comparison with the water quality downstream of the site.

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

All rock samples collected had field and laboratory paste pH values near between 7.5 and 8.5, indicating that the material is not currently generating acid. Field paste conductivity values ranged from 40 μS/cm to >1990 μS/cm, with the mineralized graphite schist exhibiting the highest value. The chlorite schist waste rock and the coarser iron carbonate altered waste rock had the lowest conductivity values.

Acid Base Accounting

The Neutralization Potential to Acid Potential (NP:AP) ratios of the graphite schist samples P302/1 and P304 were 2.6 and 1.3, indicating that the material is potentially acid generating. Total sulphur concentrations were 1.41% and 2.36%, respectively. Between 13% and 11% of the sulphur has been oxidized to sulphate. However, the net NP of sample P302/1 is 63 kg $CaCO_3$, suggesting that it is unlikely that this material would become net acid generating.

Sample P303, representing the chlorite rich waste rock, has an NP:AP ratio of 9.4. Sample P302/2, representing the soil underlying the dump and sample P305, from the coarser iron carbonate stained waste rock, have NP:AP ratios of 15.4 and 6.6. Total sulphur concentrations in the three samples ranged from 0.4% to 0.6%. These materials have low acid generating potential. Sample P301, from the finer iron carbonate stained waste rock, also has low acid generating potential. It has a NP:AP ratio of 3.0, a total sulphur concentration of 1.22%, with 17% as sulphate, and it has a net NP of 65 kg $CaCO_3$.

Metals Concentrations

All the rock samples contained elevated concentrations of silver (27 ppm to >200 ppm), iron (3.5% to 12.3%), and manganese (5817 ppm to >10000 ppm). The mineralized graphite schist, P304, contained elevated concentrations of cadmium (>100 ppm), lead (>10000 ppm) and zinc (>10000 ppm). The iron carbonate waste rock, P301 and P305, also contained elevated concentrations of lead (6186 ppm and 6259 ppm) and zinc (8678 ppm and 3521 ppm).

Water Quality

All the water samples had laboratory pH values between 7.9 and 8.2, and laboratory conductivity readings between 560 μS/cm and 640 μS/cm. All of the samples exceeded or were equivalent to the CCME freshwater aquatic life criteria for silver and zinc.

Discharge from the adit had a near neutral pH of 7.9, total alkalinity was 170 mg/L and acidity 6.5 mg/L. Sulphate concentrations were approximately 140 mg/L. Metal concentrations in the adit discharge water met the Metal Mine Liquid Effluent (MMLE, 1977) guidelines for base metal mines. Concentrations of aluminum (0.416 ppm), copper (0.005 ppm), iron (1.02 ppm), silver (0.0002 ppm) and zinc (0.462 ppm) exceeded the CCME freshwater aquatic life criteria. Lead concentrations were equivalent to those established by CCME (0.007 ppm) for freshwater aquatic life.

The field pH value of the water below the waste rock pile was 8.1 and the field conductivity was 620 μS/cm. Total alkalinity was approximately 170 mg/L and acidity 5.2 mg/L. Sulphate concentrations were approximately 135 mg/L. Metal concentrations met the MMLE guidelines for base metal mines. Concentrations of aluminum (0.184 ppm), iron (0.57 ppm), silver (0.0002 ppm), and zinc (0.459 ppm) exceeded the CCME freshwater aquatic life criteria. Selenium concentrations were equivalent to those established by CCME (0.001 ppm) for freshwater aquatic life.

Approximately 1200 metres below the mine site the zinc concentration in the water increased to 0.543 ppm, which exceeds both the CCME freshwater aquatic life criteria and the MMLE guidelines. Selenium concentrations (0.0022 ppm) were above the CCME criteria and silver concentrations were equivalent to the CCME criteria (0.0001 ppm). The field pH value was 8.1. Total alkalinity was 185 mg/L and acidity was reduced to 1.5 mg/L. Sulphate concentrations were approximately 165 mg/L.

4.0 EXISTING OR POTENTIAL ACID ROCK DRAINAGE CONDITIONS

The majority of the 22,000 tonnes of waste rock at the South of Gambler Lake site has a low acid generating potential. The bulk of the waste rock has been in place for 60 years and is not currently acid generating. The mineralized graphite schist waste rock, however, may become acid generating. There is approximately 1500 tonnes of this material at the site, assuming that this material's distribution observed on the surface is representative of the whole pile. Any acid generated by this material will likely be neutralized by the surrounding waste rock.

Based on the limited water samples collected, the waste rock pile at the South of Gambler Lake site does not appear to significantly affect the downstream water quality, despite relatively high concentrations of silver, manganese and lead in the rock pile. Drainage from Wernecke appears to be having a greater impact on the receiving environment.

Surface water originating at the Ladue mill and mine site in Wernecke has resulted in drainage channels containing significant sediment loads (possibly with high metal concentrations) that have been diverted by ditches around the South of Gambler Lake site. A substantial amount of vegetation within the drainage channels has died. New growth however, was observed within the channels during the site assessment.

While the adit at South of Gambler Lake is discharging water elevated in aluminum, iron, silver and zinc to the creek, it appears that CCME freshwater aquatic life criteria are not being met downstream because a substantial amount of contamination in the form of zinc and selenium has originated in the sediment loaded drainage channels from Wernecke.

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.

Relocation of the waste rock was not considered in the following evaluation since there is no secure placement location readily available, such as underground workings or and open pit. The benefits of collecting and treating the site discharge water are compared to covering the waste rock and leaving the site as is in the table below.

Matrix for Evaluating Applicable/Potential Remediation

Option versus Evaluation Criteria	**South of Gambler Lake**			
	Collect and Treat	**Relocate**	**Cover**	**Do Nothing**
Public Health and Safety 5 = provides full protection of public 1 = provides no protection of public	3	not applicable	4	3
Worker Health and Safety 5 = relative low risk to workers 1 = high risk to workers	4	not applicable	4	5
Ecosystem Preservation and Protection 5 = relative low risk to environment 1 = relative high risk to environment	4	not applicable	3	2
Impact on Mineral Resource 5 = allows for continued exploration 1 = impedes continued exploration	4	not applicable	5	5
Direct Costs (mobilization & materials) 5 = relative low cost 1 = relative high cost	1	not applicable	4	5
Monitoring and Maintenance Costs 5 = relative low cost 1 = relative high cost	1	not applicable	3	4
Acceptability 5 = positive response anticipated 1 = negative response anticipated	2	not applicable	4	3
Total Score	**19**	**0**	**27**	**27**

4.0 EXISTING OR POTENTIAL ACID ROCK DRAINAGE CONDITIONS

The majority of the 22,000 tonnes of waste rock at the South of Gambler Lake site has a low acid generating potential. The bulk of the waste rock has been in place for 60 years and is not currently acid generating. The mineralized graphite schist waste rock, however, may become acid generating. There is approximately 1500 tonnes of this material at the site, assuming that this material's distribution observed on the surface is representative of the whole pile. Any acid generated by this material will likely be neutralized by the surrounding waste rock.

Based on the limited water samples collected, the waste rock pile at the South of Gambler Lake site does not appear to significantly affect the downstream water quality, despite relatively high concentrations of silver, manganese and lead in the rock pile. Drainage from Wernecke appears to be having a greater impact on the receiving environment.

Surface water originating at the Ladue mill and mine site in Wernecke has resulted in drainage channels containing significant sediment loads (possibly with high metal concentrations) that have been diverted by ditches around the South of Gambler Lake site. A substantial amount of vegetation within the drainage channels has died. New growth however, was observed within the channels during the site assessment.

While the adit at South of Gambler Lake is discharging water elevated in aluminum, iron, silver and zinc to the creek, it appears that CCME freshwater aquatic life criteria are not being met downstream because a substantial amount of contamination in the form of zinc and selenium has originated in the sediment loaded drainage channels from Wernecke.

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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.

Relocation of the waste rock was not considered in the following evaluation since there is no secure placement location readily available, such as underground workings or and open pit. The benefits of collecting and treating the site discharge water are compared to covering the waste rock and leaving the site as is in the table below.

Matrix for Evaluating Applicable/Potential Remediation

Option versus Evaluation Criteria	South of Gambler Lake			
	Collect and Treat	Relocate	Cover	Do Nothing
Public Health and Safety 5 = provides full protection of public 1 = provides no protection of public	3	not applicable	4	3
Worker Health and Safety 5 = relative low risk to workers 1 = high risk to workers	4	not applicable	4	5
Ecosystem Preservation and Protection 5 = relative low risk to environment 1 = relative high risk to environment	4	not applicable	3	2
Impact on Mineral Resource 5 = allows for continued exploration 1 = impedes continued exploration	4	not applicable	5	5
Direct Costs (mobilization & materials) 5 = relative low cost 1 = relative high cost	1	not applicable	4	5
Monitoring and Maintenance Costs 5 = relative low cost 1 = relative high cost	1	not applicable	3	4
Acceptability 5 = positive response anticipated 1 = negative response anticipated	2	not applicable	4	3
Total Score	**19**	**0**	**27**	**27**

The acid base accounting results indicate that the waste rock at South of Gambler Lake is unlikely to generate acid; however, metals may be leaching into the receiving environment.

Portions of the waste rock pile are steep and therefore present a public safety risk. The water discharging from the adit is not suitable for drinking and therefore represents a public health risk. Contouring and covering the rock pile would reduce the public safety risk. Collecting and treating the discharge water alone would not improve the safety risk and the chemicals stored on site to treat the water may also present a health risk to the public.

Workers would be exposed to a safety risk during the construction of a treatment facility and while contouring and covering the rock pile.

The water discharging from the underground workings contains elevated concentrations of metals that would adversely impact freshwater aquatic life and the rock pile has the potential to leach metals. Therefore, leaving the site as is represents a relatively high risk to the environment. The risk to the environment would be reduced if the rock pile were covered and the infiltration of water reduced, thereby reducing the migration of oxidation products. Collecting and treating the discharge water would effectively eliminate this sources risk to the environment.

Covering the rock pile and doing nothing to remediate the site would not impede future exploration activity at the site. The treatment facility would restrict movement and development at the site and is therefore considered to slightly impede future exploration activity.

Collection and treatment facilities are costly to construct and operate. Costs incurred to contour and covering the rock pile would be relatively low in comparison. The cover would require periodic maintenance. Monitoring of the site would likely occur no mater which remediation option was chosen.

Constructing a treatment facility would not improve the aesthetic appearance of the site significantly and it may receive a negative reaction from the public. Covering the waste rock pile would improve the aesthetic appearance of the site and is therefore ranked higher.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The evaluation of the potential remediation options does not clearly indicate if the rock pile should be covered or left as is. Further study will be required to allow a more definitive assessment.

The waste rock at South of Gambler is unlikely to become acid generating, since most of the rock has been in place for 60 years and it is not currently generating acid. From the limited sampling and testing for this assessment it appears that metal leaching from the rock pile and metals in the water discharging from the adit could be detrimental to freshwater aquatic life; however, drainage from the mine and mill at Wernecke appears to be having a greater negative impact on the water quality in the creek.

The adit discharge water is currently flowing through a buried drain at the edge of the waste rock pile. Buried waterways are undesirable, since they may cave or otherwise plug up and cause uncontrolled surface runoff.

6.2 Recommendations

The water discharging from the 600 Ladue tunnel should be directed away from the waste rock pile and the french drain by a ditch. The ditch would ideally be dug beside the abandoned pipe line to the north of the adit and then angled westward to join up with the existing creek below the waste rock pile.

Once the flow has been diverted around the rock pile a water quality monitoring program should be undertaken to determine if the waste rock is significantly impacting the receiving environment. The results of the monitoring program can then be used to determine if covering the waste rock pile is necessary.

The impact of the water discharging from the adit can not be considered in isolation of the Sadie Ladue mine site, since this is the source of the water and because of the cumulative impact affects of the surface runoff from the mine workings in the area on the creek. A water quality monitoring program should look at the adit's discharge in conjunction with the Sadie Ladue mine site.

It is recommended that for 1997 a monitoring program be undertaken to obtain water quality data during spring freshet, middle summer, and late fall conditions. The method detection limits used are to be less then or equal to the CCME freshwater aquatic life criteria. The results can then be used to determine appropriate remediation measures and future monitoring of the water discharging from the adit.

7.0 REFERENCES

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APPENDIX B

SITE PHOTOGRAPHS

Photo 1. Aerial view of site looking south with old Wernecke mine site at upper left.

Photo 2. Delapidated wood frame structure at mine site.

Photo 3. Deteriorated condition of load out facility necessitates expedient demolition.

Photo 4. Trestle leading towards covered adit entrance. Note ore cars (rear) & French drain (left).

Photo 5. View from adit entrance looking south.

Photo 6. Residue of waste material from building collapse common to site.

Photo 7. Heavy oil / grease stains at south side of mine site in suspected shop area.

Photo 8. Further instances of building waste material with empty barrels and load out (rear).

Photo 9. Furthest extension of French drain downslope 85 m from adit entrance.

Photo 10. French drain entry adjacent to adit opening.

Photo 11. Pipe providing services to adjacent cabin.

Photo 12. Site of SG-SL-201 taken beneath floorboards of suspected generator shack.

Photo 13 Vehicle wreckage located at eastern portion of site.

Photo.14 Rough hewn log cabin in fair condition could be used as emergency shelter.

Photo 15. Damaged cribbing used to support power poles.

Photo 16. Miscellaneous wood waste downslope from waste rock storage area.

Photo 17. Further instances of heavy oil/grease staining on site.

Photo 18. Detail of trestle and covered over entrance to adit.

Photo 19. Adit seepage draining to French drain.

Photo 20. Test pit SG-WR-P305 looking east and located on northwest side of waste rock pile.

Photo 21. Test pit SG-WR-P304 located on northwest side of waste rock pile.

Photo 22. Test pit SG-WR-P301 looking northwest and located on north side of waste rock pile.

Photo 23. Test pit SG-WR-P301 looking northwest and located on north side of waste rock pile.

Photo 24. Test pit SG-WR-P303 looking south southeast & located at toe of load out facility.

APPENDIX C

ANALYTICAL RESULTS

TABLE 1 South of Gambler Lake Waste Rock Sample Descriptions

Sample ID	Sample Location and Description
SGWR/P301	Sample collected at the crest of the rock pile's northern edge in material that exhibited iron carbonate staining on the surface. Sample was collected over a thickness of 20 cm in dark grey/brown silt, sand and gravel size material that included chlorite schist and pyroxenite with minor galena and sphalerite. Field paste pH was 8.0 and conductivity 110 μS/cm.
SGWR/P302/1	Sample collected from mixed waste rock material at southern edge of the rock pile over a thickness of 30 cm. Material consisted of graphite schist with <1% of the surface exhibiting staining. Field paste pH was 7.9 and conductivity 280 μS/cm.
SGWR/P302/2	Sample collected over a thickness of 20 cm in sand and silt sized brown soil below P302/1. Field paste pH was 8.3 and conductivity 310μS/cm.
SGWR/P303	Sample collected in chlorite schist and greenstone below the load out facility. The sample was collected over a thickness of 40 cm in grey/green in coloured sand and gravel size material. The field paste pH was 8.0 and conductivity 60 μS/cm.
SGWR/P304	Sample collected from mineralized graphitic schist on the northwest edge of the rock pile. The surface had a whitish precipitate. The sand and gravel size material was collected over a thickness of 30 cm. 1% of the material was cobble size up to 8 cm. The field paste pH was 7.5 and the conductivity >1990 μS/cm.
SGWR/P305	Sample collected at the toe of the rock pile northwest corner in material similar to P301. The sample was collected over a thickness of 35 cm in moist dark grey/brown sand and gravel size material. The field paste pH was 8.1 and the conductivity 40 μS/cm.

TABLE 2 South of Gambler Lake Waste Rock ABA and ICP Results

Parameter	Unit	Sample Number SGWR					
		P301	P302/1	P302/2	P303	P304	P305
Field Paste pH		8.01	7.92	8.28	8.08	7.46	8.12
Field Cond	uS/cm	110	280	310	60	>1990	40
Lab Paste pH		8.31	8.25	8.41	8.49	8.07	8.38
Total Sulfur	%	1.22	1.41	0.47	0.40	2.36	0.57
Sulfate	%	0.21	0.18	na	na	0.27	0.21
AP		31.56	38.44	14.69	12.50	65.31	11.25
NP		95.94	101.44	225.88	82.75	86.38	105.38
NET NP		64.38	63.00	211.19	70.25	21.06	94.13
NP/AP		3.04	2.64	15.38	6.62	1.32	9.37
Aluminum	%	0.19	0.54	0.10	1.66	0.55	0.64
Antimony	ppm	129	43	30	32	287	211
Arsenic	ppm	<1	<1	<1	<1	<1	61
Barium	ppm	444	78	343	454	69	86
Beryllium	ppm	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Bismuth	ppm	<1	<1	<1	<1	<1	<1
Cadmium	ppm	<0.1	<0.1	<0.1	<0.1	>100	9.1
Calcium	%	2.20	3.56	5.53	3.00	2.89	3.22
Chromium	ppm	58	63	47	53	67	75
Cobalt	ppm	14	15	15	25	15	9
Copper	ppm	168	78	63	193	379	255
Gallium	ppm	<1	<1	<1	<1	<1	<1
Iron	%	10.75	4.77	12.31	6.71	4.29	3.49
Lead	ppm	6186	1190	418	834	>10000	6259
Lithium	ppm	<1	4	<1	19	6	8
Magnesium	%	1.34	1.18	2.19	1.74	1.02	1.40
Manganese	ppm	>10000	8389	>10000	8311	5817	6304
Molybdenum	ppm	28	19	30	20	20	15
Nickel	ppm	114	66	144	63	55	46
Potassium	%	0.10	0.10	0.07	0.19	0.11	0.13
Phosphate	ppm	570	1170	340	1020	1090	1310
Silver	ppm	140.5	61.4	48.2	27.2	>200	>200
Sodium	%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	ppm	9	46	7	81	55	68
Thorium	ppm	<1	<1	<1	<1	<1	<1
Tin	ppm	9	4	11	6	4	3
Titanium	%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Tungsten	ppm	11	<1	<1	<1	18	6
Uranium	ppm	<1	<1	<1	<1	<1	<1
Vanadium	ppm	8.0	13.0	12.9	73.2	13.2	13.6
Zinc	ppm	8678	1802	237	1300	>10000	3521

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 South of Gambler Lake Water Quality Results

Parameter	Units	Sample Number SGWQ/		
		STR-202	201	ST-001
Field Conductivity		na	620	410
Field pH		na	8.13	8.1
Conductivity	umhos/cm	561	565	638
Hardness CaCO3	mg/L	307	307	340
Moisture %	%	-	-	-
pH		8.12	7.92	8.22
Acidity (to pH 8.3) CaCO3	mg/L	5.2	6.5	1.5
Alkalinity-Total CaCO3	mg/L	169	170	185
Chloride Cl	mg/L	-	-	-
Sulphate SO4	mg/L	136	137	166
Aluminum T-Al	mg/L	0.184	0.416	0.095
Antimony T-Sb	mg/L	-	-	-
Arsenic T-As	mg/L	0.0044	0.0049	0.0011
Barium T-Ba	mg/L	0.02	0.03	0.05
Beryllium T-Be	mg/L	<0.005	<0.005	<0.005
Boron T-B	mg/L	<0.1	<0.1	<0.1
Cadmium T-Cd	mg/L	0.0033	0.0033	0.0054
Calcium T-Ca	mg/L	77.8	77.8	92.7
Chromium T-Cr	mg/L	<0.001	<0.001	<0.001
Cobalt T-Co	mg/L	<0.02	<0.02	<0.02
Copper T-Cu	mg/L	0.003	0.005	0.001
Iron T-Fe	mg/L	0.57	1.02	0.22
Lead T-Pb	mg/L	<0.001	0.007	0.002
Lithium T-Li	mg/L	<0.02	<0.02	<0.02
Magnesium T-Mg	mg/L	27.4	27.3	26.3
Manganese T-Mn	mg/L	0.058	0.081	0.029
Mercury T-Hg	mg/L	<0.00005	<0.00005	<0.00005
Molybdenum T-Mo	mg/L	<0.03	<0.03	<0.03
Nickel T-Ni	mg/L	<0.02	<0.02	<0.02
Selenium T-Se	mg/L	0.001	0.0008	0.0022
Silver T-Ag	mg/L	0.0002	0.0002	0.0001
Sodium T-Na	mg/L	2	2	<2
Tin T-Sn	mg/L	-	-	-
Vanadium T-V	mg/L	<0.03	<0.03	<0.03
Zinc T-Zn	mg/L	0.459	0.462	0.543

na = no assay / analysis   < = lower detection limit

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 - Sediment/Soil[1] File No. G4270

		RU-SL-206	RU-SL-207	FO-SL-201	FO-SL-301	SG-SL-203
		96 08 15 13:00	96 08 15 13:00	96 08 20 11:00	96 08 13 11:00	96 08 17 11:30
Physical Tests						
Moisture	%	9.8	11.8	14.3	71.3	15.3
Total Metals						
Antimony	T-Sb	<20	<20	33	<20	68
Arsenic	T-As	33.4	62.7	37.8	148	187
Barium	T-Ba	229	168	246	127	107
Beryllium	T-Be	<0.5	<0.5	<0.5	<0.5	<1.5
Cadmium	T-Cd	<2	<2	<2	115	268
Chromium	T-Cr	25	27	21	16	<6
Cobalt	T-Co	9	8	15	19	7
Copper	T-Cu	28	44	39	28	104
Lead	T-Pb	70	231	167	115	3900
Mercury	T-Hg	0.020	0.040	0.043	0.068	1.73
Molybdenum	T-Mo	<4	<4	6	<4	<12
Nickel	T-Ni	22	18	22	62	<6
Selenium	T-Se	0.2	0.2	0.6	0.6	0.4
Silver	T-Ag	3	3	4	<2	11
Tin	T-Sn	<30	<30	<30	<30	<90
Vanadium	T-V	49	49	32	26	16
Zinc	T-Zn	84	92	294	8610	21300

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

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. G4270

		SG-SL-201	SG-SL-202	Gambler-SL-001
		96 08 17 11:00	96 08 17 11:00	96 08 17 10:45
Physical Tests				
Moisture	%	20.3	5.5	15.2
Total Metals				
Antimony	T-Sb	<60	<40	<20
Arsenic	T-As	9.31	35.3	65.9
Barium	T-Ba	128	23	80
Beryllium	T-Be	<1.5	<1.0	<0.5
Cadmium	T-Cd	263	102	22
Chromium	T-Cr	14	12	11
Cobalt	T-Co	8	10	7
Copper	T-Cu	50	39	27
Lead	T-Pb	833	1400	246
Mercury	T-Hg	1.36	0.769	0.094
Molybdenum	T-Mo	<12	<8	<4
Nickel	T-Ni	9	21	19
Selenium	T-Se	0.7	0.6	0.4
Silver	T-Ag	31	6	7
Tin	T-Sn	<90	<60	<30
Vanadium	T-V	21	10	19
Zinc	T-Zn	22100	9490	1910

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RESULTS OF ANALYSIS - Sediment/Soil[1] File No. G4270

	SG-SL-201 96 08 17 11:00	SG-SL-202 96 08 17 11:00	Gambler-SL-001 96 08 17 10:45
Polycyclic Aromatic Hydrocarbons			
Acenaphthene	<0.01	<0.01	<0.01
Acenaphthylene	<0.01	0.01	<0.01
Anthracene	<0.01	<0.01	<0.01
Benzo(a)anthracene	<0.01	0.01	<0.01
Benzo(a)pyrene	<0.01	0.03	<0.01
Benzo(b)fluoranthene	<0.01	<0.01	<0.01
Benzo(g,h,i)perylene	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	<0.01	<0.01	<0.01
Chrysene	<0.01	0.07	<0.01
Dibenz(a,h)anthracene	<0.01	<0.01	<0.01
Fluoranthene	0.02	0.04	<0.01
Fluorene	<0.01	<0.01	<0.01
Indeno(1,2,3-c,d)pyrene	<0.01	<0.01	<0.01
Naphthalene	0.03	0.08	<0.01
Phenanthrene	0.02	0.07	<0.01
Pyrene	0.02	0.09	<0.01

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[1]Results are expressed as milligrams per dry kilogram except where noted.

RESULTS OF ANALYSIS - Water[1] File No. G4270

			RU-WQ-STR-001	RU-WQ-STR-002	RU-WQ-STR-003	SG-WQ-STR-202	MACT-WQ-STR-001
			96 08 14 12:30	96 08 14 12:30	96 08 14 12:30	96 08 17 10:00	96 08 15 11:00
Physical Tests							
Conductivity (umhos/cm)			155	169	159	561	150
Hardness		CaCO3	72.4	78.3	75.2	307	49.6
pH			7.66	7.81	7.70	8.12	4.87
Dissolved Anions							
Acidity		CaCO3	2.7	3.3	2.5	5.2	15.0
Alkalinity - Total		CaCO3	30.3	37.1	31.8	169	<1.0
Sulphate	SO4		45.3	42.7	45.5	136	61.6
Total Metals							
Aluminum	T-Al		0.013	0.074	0.011	[redacted]	[redacted]
Arsenic	T-As		0.0023	0.0031	0.0022	0.0044	0.0001
Barium	T-Ba		0.06	0.06	0.06	0.02	0.08
Beryllium	T-Be		<0.005	<0.005	<0.005	<0.005	<0.005
Boron	T-B		<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	T-Cd		[redacted]	0.0004	<0.0002	0.0033	0.0004
Calcium	T-Ca		22.2	24.3	23.1	77.8	10.9
Chromium	T-Cr		<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	T-Co		<0.02	<0.02	<0.02	<0.02	0.03
Copper	T-Cu		<0.001	0.001	<0.001	0.003	0.020
Iron	T-Fe		<0.03	0.13	<0.03	0.57	0.20
Lead	T-Pb		<0.001	[redacted]	<0.001	<0.001	0.001
Lithium	T-Li		<0.02	<0.02	<0.02	<0.02	0.02
Magnesium	T-Mg		4.14	4.27	4.26	27.4	5.42
Manganese	T-Mn		0.006	0.017	0.005	0.058	1.41
Mercury	T-Hg		<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum	T-Mo		<0.03	<0.03	<0.03	<0.03	<0.03
Nickel	T-Ni		<0.02	<0.02	<0.02	<0.02	0.05
Selenium	T-Se		0.0009	0.0009	0.0006	0.0010	0.0006
Silver	T-Ag		<0.0001	0.0002	0.0001	0.0002	0.0001
Sodium	T-Na		<2	<2	<2	2	<2
Vanadium	T-V		<0.03	<0.03	<0.03	<0.03	<0.03
Zinc	T-Zn		0.006	0.020	0.006	[redacted]	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

		SAMOV-WQ-002	SAMOV-WQ-003	DU-WQ-STR-301	SG-WQ-201	Gamb-WQ-ST-001
		96 08 15 14:15	96 08 15 14:30	96 08 17	96 08 17	96 08 17
Physical Tests						
Conductivity (umhos/cm)		137	137	40.8	565	638
Hardness	CaCO3	57.1	56.9	16.6	307	340
pH		7.38	7.48	7.27	7.92	8.22
Dissolved Anions						
Acidity	CaCO3	1.0	1.7	3.1	6.5	1.5
Alkalinity - Total	CaCO3	10.6	10.7	7.9	170	185
Sulphate SO4		47.7	45.9	10.7	137	166
Total Metals						
Aluminum	T-Al	0.052	0.076	0.010	[redacted]	0.095
Arsenic	T-As	<0.0001	<0.0001	0.0014	0.0049	0.0011
Barium	T-Ba	0.26	0.33	0.07	0.03	0.05
Beryllium	T-Be	<0.005	<0.005	<0.005	<0.005	<0.005
Boron	T-B	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	T-Cd	<0.0002	<0.0002	<0.0002	0.0033	0.0054
Calcium	T-Ca	18.9	18.8	4.45	77.8	92.7
Chromium	T-Cr	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	T-Co	<0.02	<0.02	<0.02	<0.02	<0.02
Copper	T-Cu	<0.001	0.001	<0.001	[redacted]	0.001
Iron	T-Fe	0.04	0.05	<0.03	[redacted]	0.22
Lead	T-Pb	<0.001	<0.001	<0.001	0.007	0.002
Lithium	T-Li	<0.02	<0.02	<0.02	<0.02	<0.02
Magnesium	T-Mg	2.43	2.41	1.33	27.3	26.3
Manganese	T-Mn	<0.005	<0.005	<0.005	0.081	0.029
Mercury	T-Hg	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum	T-Mo	<0.03	<0.03	<0.03	<0.03	<0.03
Nickel	T-Ni	<0.02	<0.02	[redacted]	[redacted]	[redacted]
Selenium	T-Se	0.0013	0.0013	0.0005	0.0008	[redacted]
Silver	T-Ag	<0.0001	0.0001	<0.0001	[redacted]	0.0001
Sodium	T-Na	<2	<2	<2	2	<2
Vanadium	T-V	<0.03	<0.03	<0.03	<0.03	<0.03
Zinc	T-Zn	<0.005	<0.005	0.006	0.462	0.543

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.

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