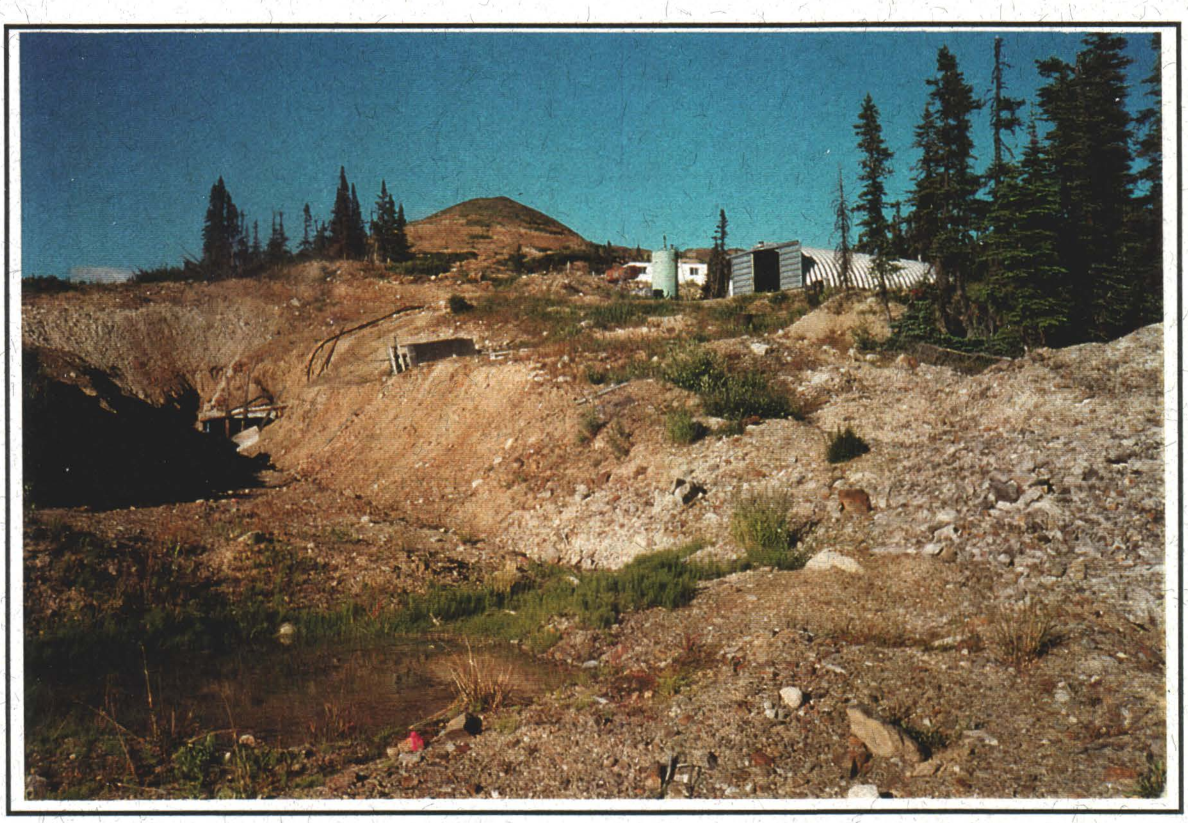
MN·071 / WL-028

PWGSC

Quality in Environmental Services

**PHASE II ENVIRONMENTAL ASSESSMENT
OF THE
SILVER HART
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

PHASE II ENVIRONMENTAL ASSESSMENT of the SILVER HART MINE SITE

Prepared for:

Action on Waste Program
Indian and Northern Affairs Canada

Prepared by:

Environmental Services
Public Works and Government Services Canada

March 1997

EXECUTIVE SUMMARY

A phase II environmental assessment was conducted at the Silver Hart abandoned mine site ($60^0$19'20" N, $130^0$40'30" 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 although the single mine opening is stable, it is not adequately secured from public and wildlife access. An assessment of the acid rock drainage potential for the site shows that the risk to the environment due to the presence of waste rock and adit is currently a moderate concern. Environmental concerns also exist concerning mine seepage, numerous 205 litre barrels of diesel oil, aviation fuel and waste oil scattered about the site and oil stained soil in the maintenance area.

Aesthetic concerns arise from the presence of 6 above ground fuel storage tanks (ranging in size from 2270 litres to 22700 litres) in the maintenance area, empty metal barrels, collapsing tent frames in the upper exploration camp as well as assorted metal and plastic waste scattered about the site.

Using applicable federal and territorial criteria as well as northern mine reclamation guidelines, recommendations are to secure the single adit opening using surrounding rock and soil, decommission above ground fuel storage tanks on site by cutting up and burying using available fill on site, flare off diesel and aviation fuels on site, remove waste oil barrels and miscellaneous oily materials off site for incineration, scarify and fertilize heavily oil stained soils on site, disassemble metal quonset hut and dispose of off site, remove prefabricated trailers and haul off site for salvage and demolish and burn wooden structures and combustible waste on site.

Further test work is required on the moderately acid generating waste rock disposal areas. It is recommended that every five years a monitoring program be undertaken to obtain water quality data for mine seepage and receiving waters for the spring freshet, middle summer and late fall conditions. Should further development occur on the site, regulatory agencies should ensure that an acid drainage prevention plan is developed which includes detailed measures for handling and disposal of mineralized waste rock.

SUMMARY OF CONCLUSIONS & RECOMMENDATIONS

ASSESSMENT COMPONENT	RISK	RECOMMENDATION
1. Building, Infrastructure, Equipment		
17 x 18 metal quonset hut	Aesthetic Concern	Disassemble dispose off-site
6 pre-fabricated trailers, 4 @ lower site and 2 @ upper site	Aesthetic Concern	Haul out for site salvage
Tent frames	Aesthetic Concern	Demolish & burn on site
Road access	Aesthetic Concern	Upgrade access to site.
2. Non-Hazardous Waste Material		
1 x 2270 litres, 3 x 4540 litres and 1 x 22,700 litres ASTs	Environmental Concern	Clean and cut tanks, bury on site
Oily rags & oily waste materials	Aesthetic Concern	Burn on site
Misc. metal and plastic wastes	Aesthetic Concern	Bury on site
3. Hazardous Materials		
Stained soil inside quonset hut	Environmental Concern	Spread, scarify, mix and fertilize on site
17 drums diesel & 2 drums of Jet B aviation fuel	Environmental Concern	Use 2 barrels to burn on site. Incinerate 5 barrels off site.
4. Water Quality		
Mine Seepage	Minor Env. Risk	Monitor 1/4'ly every 5 years
Site Drainage	Minor Env. Risk	None
Receiving Waters	Minor Env. Risk	Monitor 1/4'ly every 5 years
5. Waste Rock Disposal Areas		
Waste rock moderately acid generating - 7,040 m^3	Environmental Concern	Monitor every 5 years
6. Mine Openings		
Adit open and accessible	Health and Safety Concern	Seal with available waste rock
7. Tailings		
None	None	None

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

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 Silver Hart abandoned mine site, the 1993 report recommended further investigation into possible environmental impacts resulting from the previous mining activities. According to that report, the potential areas of concern included damage to vegetation as a result of exploration activity, the uncertainty of the risk of groundwater contamination from adit seepage, unsecured adit entrance, proliferation of fuel tanks and drums on site, and the removal of remaining buildings from the site. No rock, tailings, soil or water samples were collected in this 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 Silver Hart 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 Silver Hart mine site is located at $60^{0}19'20"$N, $130^{0}40'30"$W and approximately 43 km north northeast of Rancheria, YT and 2.5 km north northeast of Edgar Lake. The access road to the site is steep and rough from Edgar Lake to the main site and crosses an unnamed stream (which feeds Edgar lake) 2.5 km from the adit entrance The mine site consists of one adit at the main mine level of 1440 m with a raise and shaft at upper trenching level of 1480 m.

1.2 OVERVIEW OF SITE DEVELOPMENT:

Exploration on the Silver Hart property has focused on a variety of occurrences including a tungsten rich skarn and a system of parallel or en echelon silver-rich sulphide veins. The Silver Hart mine site was the focus of a significant exploration effort between 1986-87 (DIAND 105B-07-2; MinFile 105B-021). Work on the Hart site began in 1947 Based on Department of Indian Affairs and Northern Development (DIAND) and Yukon Territorial Government (YTG) assessment file and MinFile data.

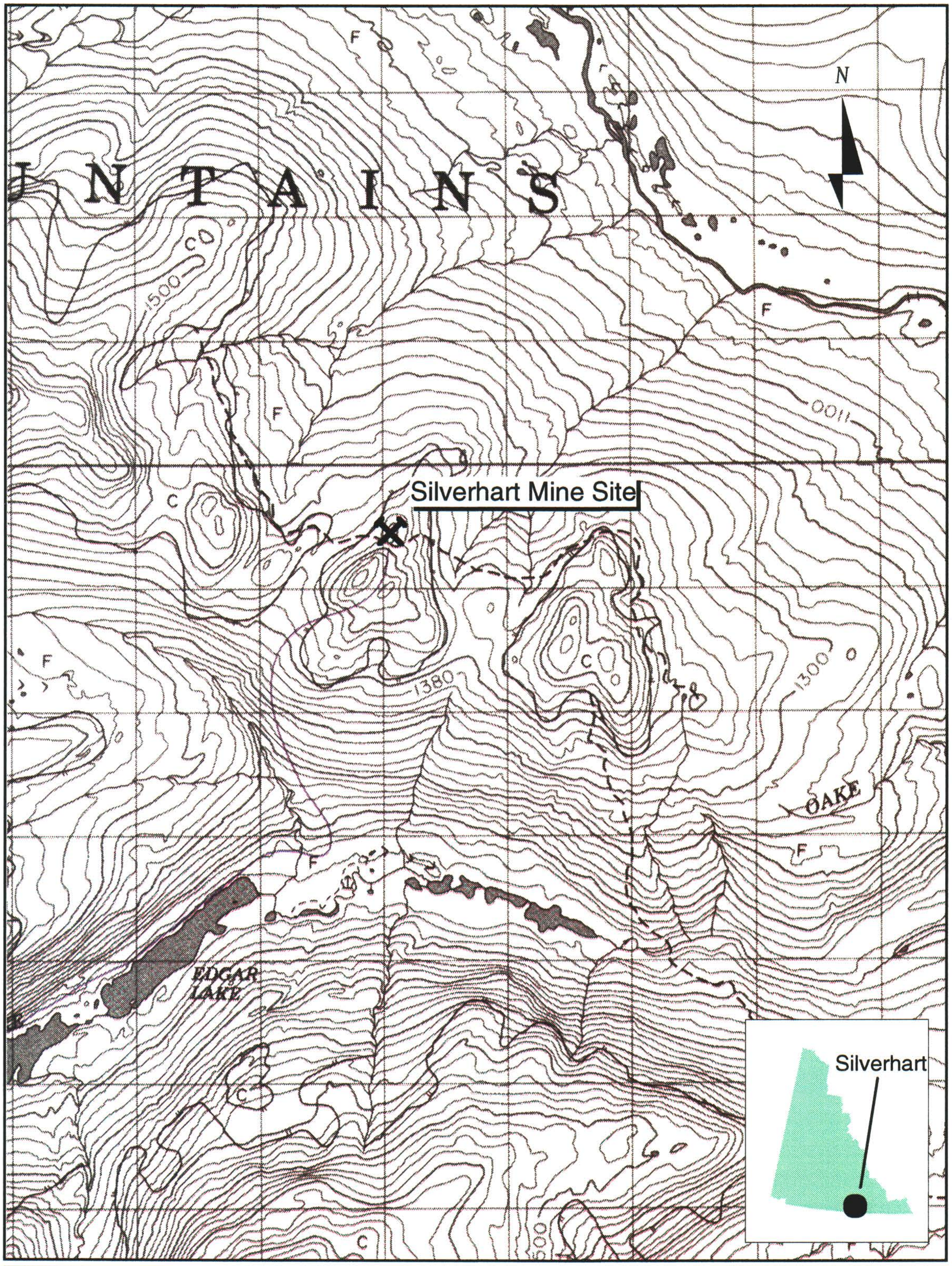
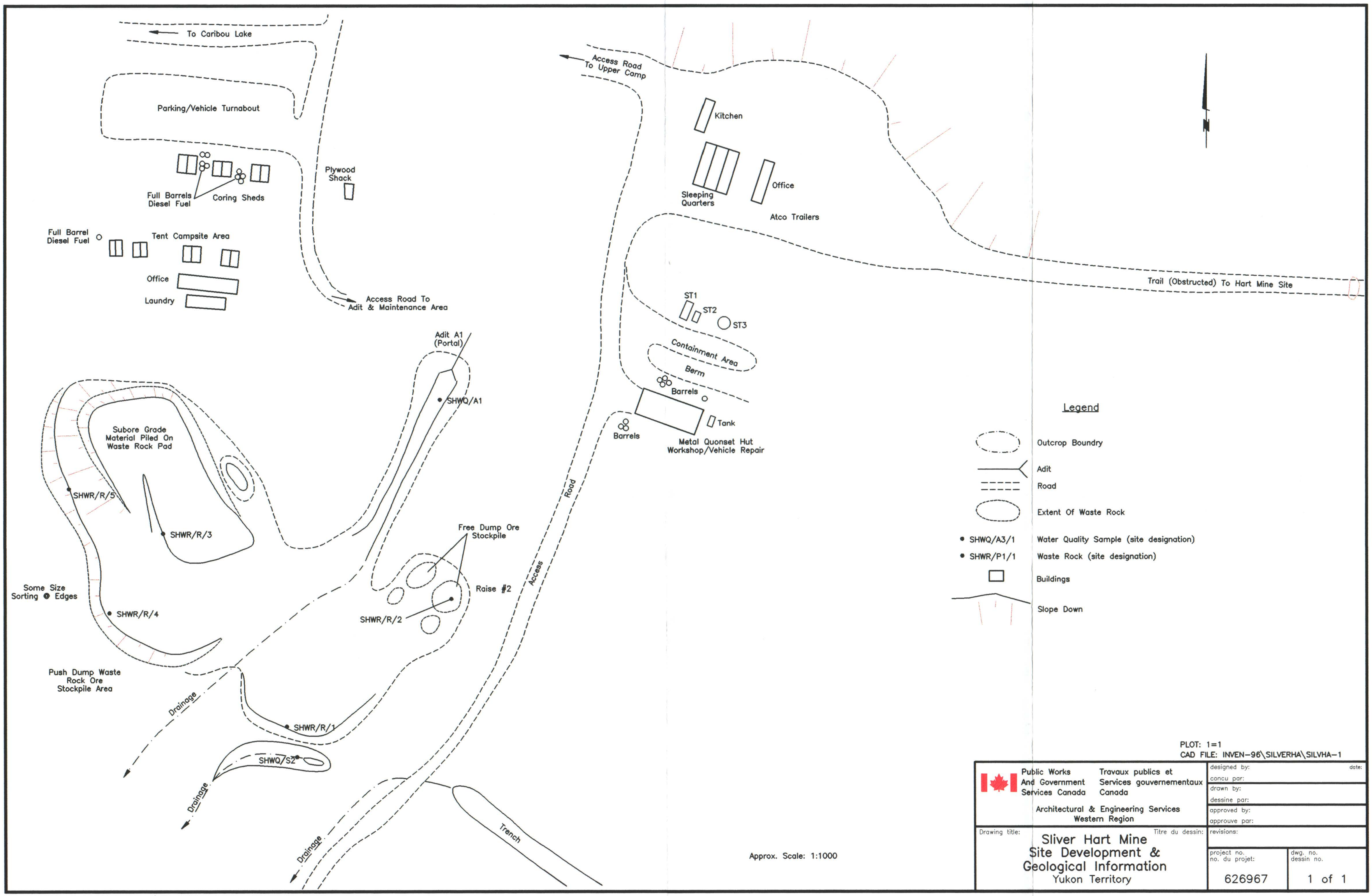


Figure 1: SILVERHART SITE

N.T.S. 105 B/7 Map Name: Sab Lake Map Scale: 1:50,000

Latitude: 60° 19' 20" N Longitude: 130° 40' 30" W



PLOT: 1=1
CAD FILE: INVEN-96\SILVERHA\SILVHA-1

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

Architectural & Engineering Services
Western Region

Drawing title: / Titre du dessin:
Sliver Hart Mine
Site Development &
Geological Information
Yukon Territory

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

Work to date includes:

- original discovery of galena in leached gossans (1947)
- grid soil sampling and detailed mapping (1971)
- trenching (1980)
- geochemical sampling, mapping and drilling of two holes totalling 197 metres (1982)
- bulldozer trenching (1983);
- bulldozer trenching, drilling 50 holes totalling 3,658 metres, 673 metres of underground development, including a 3 by 3 metre adit and 2 raises, construction of a 40 kilometre road from the Alaska Highway and construction of a trailer camp (1985-86);
- preliminary mine engineering and feasibility studies completed (1987) and; four drill holes totalling 609.6 metres (1987).

1.3 SITE ACCESS:

Access to the site is available via a service road which branches north from mile 720 of the Alaska Highway, 16 km west of Rancheria, Y.T. This service road in turn follows the east bank of the Rancheria River north to Northwind Lake, jogs eastward past Roy Lake and Edgar Lake, then jogs north to the mine site. Estimated distance from the Alaska Highway to the campsite is approximately 42 km over rough road. A number of creeks cross the access road prior to reaching Northwind Lake. No culverts have been provided to channel runoff so that deep ruts have been left in the road.

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.

Four above-ground storage tanks (AST) were identified in the maintenance area north of the adit entrance. One vertical AST (22700 litres) was sampled with a stainless steel Bacon bomb sampler. A plunger at the tip of the sampler depressed when contact with the tank bottom was made, allowing any petroleum product to enter the body of the sampler. When the sampler was raised, the plunger closed to seal the sampler and allow removal of the sample from the AST. The sampled petroleum product was then drained into a 40-ml laboratory-cleaned vial which was then sealed and placed in a container for shipment to the laboratory. A water/petroleum mixture (85%/15%) was found when the bomb was extracted. The bomb sampler was cleaned with laboratory-grade detergent between sampling events. All remaining ASTs were inspected and found to be empty.

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;
- cheelite - 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.

4.2 SURFACE HYDROLOGY

Creeks flow both north to the Meister River and south to Edgar Lake from the Silver Hart property area. The mine area is drained by a creek approximately a kilometre to the south of and 200 metres lower in elevation than the adit. Surface water run-off from groundwater was observed in the area of the adit and flows to the main creek to the south. A small lake above the adit has been completely removed by trenching.

The Rancheria River is reported to support a sport fishery for Arctic Grayling, Dolly Varden Char (Foothills Pipelines Ltd., 1976). Both the Rancheria and Meister River systems possess important overwintering habitats for many fish species that move into smaller tributaries in the spring following breakup. Two unnamed creeks located northwest of Oake Creek drain to the northeast and into Meister River about 3 and 4 km downstream from Caribou Lake.

4.3 CLIMATE

The Silver Hart mine site lies in the Pelly Mountain Ecoregion which comprises an area of 31,712 km^2 and is situated within the southeastern portion of the Yukon. 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. This ecoregion receives mean annual precipitation from 375 mm to 625 mm with higher levels at higher elevations in the north and south. Temperature isotherms of -4^0 C to -6^0 C are common for this area. (Ecoregions of Yukon Territory, Oswald, E.T. & Senyk, J.P., p. 14 & p. 32)

4.4 VEGETATION

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, alpine fir in the subalpine and feathermoss laces with sphagnum 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

Fish species reported to be found in the Liard River system generally include: Arctic Grayling, Burbot, Dolly Varden Char, Emerald Shiner, Finescale Dace, Flathead Chub, Goldeye, Inconnu, Lake Chub, Lake Trout, Lake Whitefish, Longnose Dace, Longnose Sucker, Mountain Whitefish, Ninespinie Stickleback, Northern Pike, Rainbow Trout, Round Whitefish, Slimy Sculpin, Spottail Shiner, Trout Perch, White Sucker, and Yellow Walleye. The species of most importance to domestic and sports fisheries includes Arctic Grayling, Dolly Varden Char, Lake Trout and Northern Pike. (Foothills Pipelines Ltd. 1976).

4.6 SITE TOPOGRAPHY AND SOILS

The Silver Hart area is situated above the tree line at an elevation of 1400 metres on a south facing peak along an southeast trending mountain ridge. Topography slopes moderately steep off to the south, but more gently to the north and northeast. Above 1500 metres elevation, about 70 % of the area is under a cover of colluvium, with outcrop exposed over 20% of the area. Below 1500 m, the area is partially covered by ablation till, reworked glacial deposits, outcrop and colluvium (Klassen, 1983). Test pits established for the Silver Hart mine site feasibility work indicated most of the till deposits have been reworked as colluvium (McLeod, 1987).

Surficial deposits in the valley bottoms are largely alluvial. Kame deposits have formed side channel valleys behind moraine dams.

4.7 PERMAFROST

The Silver Hart 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 Silver Hart mine site consists of a lower level exploration area and single adit and an upper encampment area **(See Photo 1)**. A number of service buildings are located north of the adit entrance along the service road. A large corrugated metal quonset hut has functioned as a machine shop and a horizontal above ground fuel storage tank lies behind **(See Photo 2).** Immediately north of the quonset hut / maintenance shed, three above ground storage tanks are located on a slight berm above the quonset hut **(See Photos 3 & 4).** Four prefabricated trailers were located above the maintenance shed area with 3 used for sleeping and one as a kitchen **(See Photos 5 & 6)**. Further north and up the access road, a wood frame and plastic covered tent encampment was situated adjacent to two more prefabricated trailers which made up an office and laundry facility **(See Photo 9)**. Buildings, infrastructure and equipment identified on site are detailed in **Table 1** below.

5.2 NON-HAZARDOUS WASTE MATERIALS

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

5.3 HAZARDOUS MATERIALS

The major portion of hazardous materials remaining consists of full 205 litre barrels of diesel fuel = 2 in trailer camp + 8 in upper exploration tent camp area; full 205 litre barrels of Jet "B" aviation fuel = 2 in upper exploration tent camp area **(see Photos 9, 10, & 11)**; full 205 litre barrels of diesel fuel/water mixture (in the case of deteriorated barrels) and or waste diesel fuel = 6 outside in maintenance area + 16 within quonset hut **(see Photo 12)**. An area of ground in the quonset hut appeared to have been subjected to waste diesel oil staining to a depth of approximately 150 mm. Approximate area of staining = $< 20\ m^3$ **(see Photo 12)**.

Table 1: Buildings, Infrastructure & Equipment

Structure	Construction Features	Interior Contents
Metal Quonset Hut	- fabricated in place galvanized metal quonset hut; 17.6 m X 18.3 m	- auto workshop incl. waste oil barrels, empty oil containers
Prefabricated "ATCO" trailers	- 3 @ 3.1 m wide X 15.9 m long & 1 @ 3.1 m X 12.2 m wood frame & metal clad north of maintenance area	-3 used as sleeping quarters & 1 used as kitchen facility
Prefabricated "ATCO" trailers	- 1 @ 3.1 X 9.2 m & 1 @ 4.2 m X 8.5 m located at upper encampment	- laundry facilities and office
Wood frame wood clad structure	- 3.1 m X 4.3 m addition to lower sleeping quarter complex	- no access
Wood tent frame & canvas structures	- 4 @ 3.6 m X 4.7 m wood frame and canvas clad structures located in upper encampment area.	- no interior contents, structures are dilapidated; used as sleeping quarters
Wood tent frame & canvas structures	- 3 @ 3.6 m X 4.7 m wood frame and canvas clad structures located in upper encampment area	- used as core storage sheds

Table 2 Non-Hazardous Waste Materials

Waste Material	Number/ Volume	Location	Comments
2270 litre fuel tank	1	Maintenance Area	Horizontal; empty, valve secured, no staining, fair condition
4540 litre fuel tank	1	Maintenance Area	Horizontal; empty, valve secured, no staining, fair condition
22700 litre fuel tank	1	Maintenance Area	Vertical; approx. 0.3 m depth of diesel/H_20 mix; valve secured at bottom
4540 litre fuel tank	2	Trailer Camp area	Horizontal; empty, valve secured, no staining, fair condition
205 litre barrel	1	Exploration Camp Area	Empty, non-burnable and rusted
205 litre barrel	3	Maintenance Area	Empty, non-burnable and rusted
Timbers, core boxes, wood waste	< 85 m^3	Core sheds in Exploration Camp Area	Non-preserved, burnable

5.4 SURFACE WATER QUALITY

Field analysis of seepage from the adit area (discussed in **Section 5.6**) and the main creek draining south were completed. Samples were collected, but were lost in shipping. **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 (□mhos/cm)	Metallic Parameters
SHWQ-C1-2	Edgar Lake Tributary	7.1	30	
SHWQ-A1-1	Adit Drainage	7.2	340	Cadmium, Zinc
SHWQ-S1-2	Settling Pond Overflow	6.6	310	Iron & Zinc (Norecol '87)

Notes: 1) Ph and conductivity readings in square brackets are field 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

The analysis for **SHWQ-C1-2** was conducted at the bridge crossing on the road where Norecol established a monitoring station (Site M2) and installed a staff gauge. The field results above are indicative of the general health of the stream. A staff gauge reading of 0.44 metres was observed, although no flow readings or stream profile data were taken at this time. The same site was used by the Water Resources Division of DIAND (Site 8).

Water quality result data from these previous studies was not available but is referred to in the Norecol report (1987). Annual precipitation in the area is expected to be moderately low based on results from a monitoring station at Swift River approximately 70 km to the south. The Swift River station reported a mean annual precipitation of 580 mm, 235 mm of which was recorded as rain and 330 cm of snowfall (Norecol, 1987).

The underground workings at Silver Hart produce a small flow of mine water that seeps through the rubble blocking the portal and then over the surface of the waste rock. The flow was not traced beyond the waste rock pad area but does not directly access the creek 0.7 km to the southeast. A small settling pond exists directly blow the waste rock piles. A larger settling pond is reported just down slope from the adit but was not investigated.

Samples were collected from the drainage coming from the adit **(SHWQ-A1-1)** and from the overflow out the settling pond below the waste rock piles **(SHWQ-S1-2)**. Water flow rates were observed to be low, totalling less than 5 litres per second. The portal is partially blocked by backfill, damming a considerable volume of water over 0.5 metres deep and back more than 50 metres. The adit sample was analysed, but the settling pond overflow sample was lost in shipping. Analysis was done to the standards of the 1995 Canadian Council of Ministers of the Environment (CCME) fresh water guidelines for aquatic life, however the sample was stored for approximately a month at room temperatures.

At 200 times the CCME fresh water aquatic life guidelines (0.03 mg/L Zn), the elevated zinc in the water sample **(SHWQ-A1-1)** is significant, even at moderate pH and high hardness. The effect on aquatic life is expected to be more chronic than acute in hard water conditions. Zinc can be expected to be removed from solution through coprecipitation with iron and manganese, and adsorption of up to 100% with clays at pH >7.0. This high result may be in part the result of its lengthy and poor storage conditions.

Cadmium levels are elevated above CCME guideline levels of 0.0018 mg/L. Cadmium is easily coprecipitated by hydrous iron, aluminum and manganese oxides and carbonate, all of which are readily available in solution and in the surrounding soils and bedrock. Concentrations of cadmium in the tissues of aquatic organisms decreases with increases in water hardness. The results for arsenic and lead are also slightly elevated, but at a hardness of >180 mg/L, they are both below the CCME water quality guidelines. Results of the field analysis of the waste rock seepage **(SHWQ-S1-2)** from the settling pond indicate that conductance in both the adit and overflow water samples are high. This is likely in part the result of the high zinc and sulphate content.

5.5 WASTE ROCK DISPOSAL AREAS:

Waste rock from the underground mining has been push dumped to form a level pad of approximately 0.7 hectares on the slope immediately south of the portal. Ore and subgrade ore stockpiles have been free dumped and push dumped respectively on the waste rock pad. The waste rock is composed of five main rock types including biotite schist, marble, granodiorite, skarn and quartz sulphide ore in varying quantities. The samples collected were representative of each compositionally distinct portion of the waste dumps and are described below :

SHWR-R1 - development waste rock;

- 70% biotite schist, 15% hornfels, 10% quartz vein (+/-sulphides), 5% marble;
- 30% coarse, 30% medium and 40% fine textured;
- 95% green yellow and 5% bright orange brown.

SHWR-R2 - high-grade ore stockpile;

- 70% quartz-sphalerite-galena-tetrahedrite vein, 20% marble, 10% biotite schist;
- 30% coarse, 30% medium and 60% fine textured;
- 90% green yellow and 10% bright orange brown.

SHWR-R3 - sub-grade ore stockpile;

- 60% biotite schist, 20% marble, 20% quartz sulphide vein;
- 50% coarse, 20% medium and 30% fine textured;
- 95% green yellow and 5% bright orange brown.

SHWR-R4 - development waste rock;

- 60% granodiorite, 30% marble, 5% biotite schist, 5% quartz vein (+/-sulphides);
- 40% coarse, 20% medium and 40% fine textured;
- 99% yellow green and 5% bright orange brown.

SHWR-R5 - development waste rock;

- 80% granodiorite, 10% marble, 5% biotite schist, 5% quartz vein (+/-sulphides);
- 60% coarse, 20% medium and 20% fine textured;
- 95% light brown and 5% bright yellow orange.

A volume of 1,840 m^3 of waste rock from the development of the adit was used to build a pad to stockpile the ore sample material. The 5,200 m^3 of development rock is composed of biotite schist, granodiorite, marble and skarn with 3% fine to medium grained, disseminated pyrite, chalcopyrite, sphalerite. The sulphide content of the sub-grade and high grade ores is comprised of 10% to 40% disseminated and massive to semi-massive sphalerite-galena-tetrahedrite vein material with trace pyrite. Samples from rock dumps were elevated in zinc, lead, silver, arsenic cadmium, copper, antimony & iron, as listed below.

Sample **SHWR-R1** had the highest levels of iron, likely more from biotite than pyrite, but was low in all other elements. All the other samples assayed over 1% zinc and were high in lead and silver, suggesting the presence of numerous minor veins.

Sample **SHWR-R2** from the ore stockpile was high in all the above elements. The paste pH of the Silver Hart samples are relatively neutral. Conductivities are high in samples **SHWR-R1** and **SHWR-R2**, likely the result of the high SO_4 content and the high metals content of the ore respectively. Results of the static analysis and acid-base accounting (ABA) for the Silver Hart property are summarized in **Table 5** below.

Table 4: Silver Hart 1995 Site Assessment Sample Results:

Sample No.	Zn (ppm)	Pb (ppm)	Ag (ppm)	As (ppm)	Cd (ppm)	Cu (ppm)	Sb (ppm)	Fe (%)
SHWR-R 1	534	83	2.8	1	0.1	124	6	9.18
SHWR-R 2	>10000	>10000	>200	994	>100	2728	1461	3.30
SHWR-R 3	>10000	2316	148.8	1550	>100	500	140	2.94
SHWR-R 4	>10000	1160	101.2	836	94.7	363	65	1.94
SHWR-R 5	>10000	1425	67.8	1	2.1	159	46	2.25

Table 5: Summary Acid/Base Accounting Test Results

Sample No.	Field Paste pH	Lab Paste pH	Sulphur (Total) %	Sulphur (SO_4) %	Acid Potential (AP*)	Neutral. Potential (NP*)	Net NP*	NP/AP
SHWR-R1	8.1	7.75	2.22	1.60	19.4	42.3	-22.9	2.2
SHWR-R2	6.5	6.57	7.23	0.15	221.3	9.5	-211.8	<0.1
SHWR-R3	6.5	6.76	2.81	0.09	85.0	6.6	-78.4	<0.1
SHWR-R4	7.1	7.75	1.83	0.09	54.4	15.4	-39.0	0.3
SHWR-R5	7.2	7.91	0.70	0.00	21.9	12.3	-9.6	0.6

***AP and NP reported in tonnes $CaCO_3$ equivalent per 1000 tonnes of material.**

The NP/AP ratios from samples **SHWR-R2** through **SHWR-R5** are all below 1.0 and all Net NP's are negative suggesting that the waste rock at the Silver Hart site is likely to generate acidity **(See Photo 14)**. Sample **SHWR-R1** has a higher NP/AP ratio resulting from over 70% of the sulphur being oxidized likely due to the schistose nature of the rock. It is also likely that all the waste rock will some generate acid drainage. Total sulphur content is generally moderate, however it is predominantly in zinc and lead sulphides which are less prone to acid generation.

The sulphide mineralization occurs in both disseminated and as coarse massive to semi-massive veins. The disseminated sulphides are likely to be in intimate contact with neutralizing minerals and the coarse texture of the sulphide vein material would make physical weathering or oxidation difficult. This would reduce the potential for acid generation. Marble in bedrock and derived soils and substrate are also expected to provide additional buffering capacity. Based on the risk of acid generation from the waste and ore stockpiles, the potential total amount of H_2SO_4 that could be produced from the rock dumps at the Silver Hart site is approximately 570 tonnes, assuming 100% of the unoxidated sulphur was available and is converted, a pore space of 30% in the stockpiles, a H_2SO_4 to sulphur ratio of 3.06:1 and the specific gravities outlined above.

Conclusions based on the acid base accounting results from the Norecol study state a low risk of acid generation. However, the NP/AP results range from very low to moderately high, suggesting some risks as indicated by the results of this study.

5.6 Mine Openings

The Silver Hart property was explored by a single adit and two raises, commencing from the portal along azimuth 040^0 at an elevation of approximately 1,450 m. The portal area has been excavated back 60 metres into the slope of the hill to collar in sound bedrock. The portal of the 2 m by 3 m adit has been constructed with steel beams at 1 m centres for about the first 50 m along the drift. **(See Photo 1)**

Table 6: Mine Openings

Adit	Location	Drift Length	Condition
A1	1450 m elev.	137 metres	Excavated 60 m into slope of hill; 2 m X 3 m with steel beams @ 1 m centres for first 50 m along drift; good condition

Loose overburden and rock has fallen in front of the portal resulting in partial blockage and damming up over 0.5 m of water in the drift. Approximately 60% of the area above the adit to the north has been trenched by bulldozer with large volumes of stripped overburden ramped out into stockpiles. The total area of disturbance is over 100 hectares, including a grid of trenches to 6 m deep and numerous roads.

5.7 Tailings

There has been no milling or ore processing on the Silver Hart site and there are no mill tailings present on the site as a result.

6.0 CONCLUSIONS

6.1 HEALTH AND SAFETY:

Risks relating to mine safety at the Silver Hart mine site are moderately low since the portal appears to be very soundly constructed. However, the portal should be permanently closed as it is likely that humans or wildlife could easily gain access. A minor amount of risk exists from the presence of the existing tanks on site as the curious visitor may be inclined to climb the vertical above ground storage tank and suffer an injury from a fall. The tent frame structures could collapse due to the wear and tear of the elements in the next few years and also pose a concern.

6.2 ENVIRONMENTAL RISKS:

The overall environmental risks of the Silver Hart site relating to the mining and exploration activity are considered medium low with limited potential for acid generation. Some effort to properly culvert the water emanating from the adit should be made before any attempt to block the adit with fill. The present rock dumps are likely to generate acid drainage based on the ABA analysis, although paste pH readings are neutral. The assessment of the potential risks to the receiving environment resulting from acid generation caused by the mine and waste rock piles are considered medium low based on the following data:

- the limited volume of material in the mine dumps;
- the maximum total potential sulphuric acid is low, estimated at 570 tonnes;
- the neutral paste pH of the bulk of the material;
- the near absence of iron sulphides;
- the coarse texture of the sulphides present;
- the presence of marble within the host stratigraphy, and;
- climatic conditions are dry with a moderately low annual precipitation, approximately half of which is stored in the winter snow pack.

The potential for release of metals into the environment is considered a low risk. Release of zinc and cadmium in solution at levels above the CCME guidelines has been suggested. The receiving environment is conducive to their precipitation out of solution before reaching the creek over 600 metres away. Re-contouring of the stripped areas and general site reclamation are considered the most important environmental concerns at the Silver Hart site. The results of this environmental assessment of the potential for acid generation and metals contamination caused by the mining and exploration work done on the site are limited by the following parameters.

1. The static analytical procedures used for the ABA can only be considered indicative of the potential for acid generation and requires kinetic testing to

establish a more accurate prediction model;

2. Assumptions built into the calculation of the total potential H_2SO_4, including the percentage of pour space and specific gravity of the rock, and;

3. Total metals analysis of the water samples was possibly compromised by the poor and lengthy storage of the sample.

The results of this environmental assessment of the geologically related aspects of the Silver Hart site can be considered indicative of the present state of the site and its potential to adversely affect the immediate surrounding environment.

Monitoring of the creek water upstream from Edgar Lake is recommended in 5 years to test for metals contamination. More intense sampling and definitive analytical procedures would be required to accurately test those parameters identified in this study as a potential risk. A moderate risk could be said to exist as a result of the large number of barrels of diesel fuel at the exploration area as well as waste oil in the maintenance area which could puncture and leak to the surrounding environment.

The environmental risks of development of the Silver Hart site were examined by Norecol in 1986-87. Results of the water quality work were not available at the time of writing this report.

6.3 AESTHETIC CONCERNS

The primary aesthetic concern at the Silver Hart site is the proliferation of 205 litre metal barrels full of diesel fuel, Jet "B" aviation fuel or waste oil scattered about the maintenance shed area as well as the exploration camp area of the site. A secondary aesthetic concern consists of the presence of a total of 6 aboveground fuel storage tanks located primarily in the maintenance area.

Other aesthetic concerns at this site include the significant amount of building infrastructure remaining on site consisting of prefabricated trailers, metal quonset hut, wooden tent frames, and a large amount of core boxes left exposed to the weather in the upper exploration camp area stained soils in the maintenance area.

7.0 RECOMMENDATIONS

Recommendation 1.

Since waste rock is moderately acid generating, waste rock disposal areas should be monitored every 5 years to determine the acid generating potential over the long term.

Recommendation 2.

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 for mine seepage as well as receiving waters. The method detection limits used should meet the CCME criteria for fresh water aquatic life

Recommendation 3.

Clean above ground fuel storage tanks, cut up and bury on site using waste rock on site. Incinerate barrels of diesel fuel and jet fuel on site. Use 2 barrels of waste oil for burning combustibles on site and incinerate remaining barrels of waste oil off site. Burn oily rags and waste materials off site. Scarify soil heavily stained with oil inside quonset hut, mix and fertilize on site.

Recommendation 4.

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

Recommendation 5.

Disassemble metal quonset hut, cut up and bury on site. Haul out prefabricated trailers off site for salvage. Bury miscellaneous plastic and metal waste on site. Burial can occur by covering waste material with surrounding rock and soil on a clearing adjacent to a rock slope. Retain wood core boxes from tent frame structures and burn tent frame structures 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:

Cathro, R.J.. 1982. Report on Underground Mapping and Sampling. Assessment Report 091503, Watson Lake Mining District. A.M.P. Explorations and Mining Co. Ltd.

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

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: 1993; Assessment Report 105B-04-2, Silver Hart.

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

Miller, D.C.. 1986. Geological, Geochemical, Diamond Drilling and Underground Excavation Report on the Barb and Log Claims, Silver Hart Silver-Gold Property. Assessment Report 092160, Watson Lake Mining Division, Yukon. A.M.P. Explorations and Mining Co. Ltd.

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

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

Phendler, R.W.. 1984. Report on the Silver Hart Silver Property. Watson Lake Mining Division, Yukon. Prospectus, A.M.P. Explorations and Mining Co. Ltd.

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

Steffen, Robertson, and Kirsten (B.C.), 1992. Mine Reclamation in Northwest Territories and Yukon. Prepared for Northern Water Resource Studies, Northern Affairs Program, DIAND. Report No. QS-8476-000-EF-A1, Minister of Supply and Services Canada.

Yukon MinFile: 105B 038. Update October, 1995. Exploration and Geological Services Division, Department of Indian Affairs and Northern Development.

APPENDIX A

DETERMINATION OF ACID ROCK DRAINAGE POTENTIAL

P118105

SILVER HART
ACID ROCK DRAINAGE
ASSESSMENT REPORT

TABLE OF CONTENTS

LIST OF TABLES

P118105

SILVER HART
ACID ROCK DRAINAGE
ASSESSMENT REPORT

1.0 INTRODUCTION

This report has been prepared in conjunction with a *Phase II Environmental Assessment of the Silver Hart 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 PWGSC report for a comprehensive environmental assessment of the Silver Hart site.

The following report reviews the existing, and the potential for, acid rock drainage (ARD) conditions at the Silver Hart 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 detail regarding the scope of work, site assessment methodology, ARD remediation options and the evaluation of potential remediation options.

The Silver Hart site is located in the southern Yukon, approximately 43 kilometres northeast of Rancheria and 2 kilometres northwest of Edgar Lake.

Mining related disturbances observed during the site assessment consist of an adit, one of two raises, one of two settling ponds, stockpiled ore, a waste rock pile, and trenches. The mine rock was excavated from the underground workings between 1985 and 1986.

The site is located above the tree line, near the height of land, at an elevation of 1400 metres on a south facing peak along a southeast trending mountain ridge. The mine workings drain into a tributary of Edgar Lake. A water quality sample/ hydrology site used by the Water Resources Division of DIAND (Site 8) and during preliminary engineering studies is located 700 metres below the adit at a bridge crossing of this tributary (Norecol, 1987).

2.0 GEOLOGY AND MINERALIZATION

Mineralization at the Silver Hart property is located along the eastern contact of a granodiorite intrusion with marble, quartz-biotite-sericite-chlorite schists, and metasediments (hornfels). The area hosts a variety of mineral occurrence types, including:

- Shear hosted quartz-carbonate-sulphide veins of galena (PbS), tetrahedrite ($(Cu,Fe)_{12}Sb_4S_{13}$) and sphalerite ($(Zn,Fe)S$);
- Scheelite ($CaWO_4$) - molybdenite (MoS_2) - galena - sphalerite skarn developed along the intrusive-metasedimentary contact; and,
- Chalcopyrite ($CuFeS_2$) enriched pyritic (FeS_s) zones within the sericite schists.

3.0 WASTE ROCK DISPOSAL AREAS

3.1 Description

The volume of waste rock produced from the underground development work is estimated to be 17,000 tonnes. The assumptions made to derive this estimate are:

- a specific gravity of 2.65;
- 675 metres of lateral underground development; and
- 3 by 3 metre mine openings.

In order to collar the adit entrance (portal) in solid bedrock, overburden and weathered bedrock was excavated back 60 metres into the slope of the hill.

The waste rock, overburden and weathered bedrock has been pushed dumped to construct a 0.7 ha pad on the slope to the south of the adit. Ore stockpiles have been free dumped on the pad and subgrade ore has been pushed dumped on the pad.

The waste rock is composed of five main rock types in varying quantities: biotite schist; marble; granodiorite; skarn; and quartz-sulphide ore.

Trenching has occurred to the north of the adit. Approximately 60% of the area above the adit has been trenched by a bulldozer, resulting in large volumes of overburden being pushed into stockpiles. The total area of disturbance is over 100 ha, including a grid of trenches up to 6 metres deep.

3.2 Samples

Five samples were collected to represent each of the main rock types observed at the mine site. The sample locations are shown on the site map, Drawing 2. Samples SHWR-R1, SHWR-R4 and SHWR-R5 were collected from the waste rock in the pad. R1 was predominately biotite schist material. R4 was predominately a blend of granodiorite and marble and R5 was predominately granodiorite. Sample SHWR-R2 was collected from a stockpile of ore near Raise #2 and sample SHWR-R3 was collected from subgrade ore material.

A sample, SHWQ-A1-1 was collected of the water discharging from the adit at < 5 L/sec (visual estimate). Water is ponding to a depth of 0.5 metres behind a rock dam created by a failure of the overburden and rock in front of the adit. The flow was not traced beyond the waste rock pad area.

Water was observed to be seeping through the waste rock pad and collecting in a small settling pond. The pH, conductivity, and temperature of the water was tested in the field at the location marked SHWQ/S2 on the site map. A larger settling pond was reported just downslope of the mine workings.

Field tests were also recorded for the tributary of Edgar Lake that receives drainage from the mine workings. A staff gauge marked the established sample site along the access road to the mine.

3.3 Analytical Results

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

Paste Parameters

The laboratory paste pH values for the five rock samples ranged from 6.5 to 7.9, indicating that the material is not currently generating acid.

Acid Base Accounting

Results of acid base accounting (ABA) tests on samples 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 2.2. Total sulphur contents range from 0.70% to 7.23%. 73% of the total sulphur present in sample R1 is in the form of sulphate, whereas less than 5% of the total sulphur present in samples R2, R3, and R4 is in the form of sulphate.

Metals Concentrations

All rock samples contained elevated concentrations of copper, manganese and zinc. The samples from the stockpiled ore and granodiorite rich waste rock contained elevated concentrations of lead and silver. The sample of high grade ore was also elevated in antimony, arsenic, cadmium, and tungsten. The sample of low grade ore and the waste rock sample with 60% granodiorite and 30% marble also contained elevated concentrations of arsenic, and cadmium.

Water Quality

The water sample collected from the adit discharge, SHWQ-A1-1, had a pH of 7.2 (field measurement). The conductivity was 340 μS/cm (field measurement), indicating the presence of sulphate and/or metals in the water. Sample SHWQ-A1-1 was shipped to the laboratory 23 days after it was collected; during the interim it was stored at ambient temperature. Conductivity, hardness, pH, acidity, alkalinity, and sulphate laboratory results are therefore not considered in this assessment. The total metals sample was preserved with HNO_3 and the results are used as an indication of potential metals of concern. Laboratory analysis indicated elevated concentrations of arsenic, cadmium, lead, manganese, silver and zinc.

The pH of the water seeping through the waste rock pad and collecting in the small settling pond was 6.6. The conductivity of the water was 310 μS/cm, indicating the presence of sulphate and/or dissolved metals.

The pH of the water 700 metres downstream of the adit, at the bridge crossing, was 7.1. The conductivity of the water was 30 μS/cm.

4.0 EXISTING AND POTENTIAL ACID ROCK DRAINAGE CONDITIONS

Neutral or near neutral paste pH values of the mine rock indicates that this material is not currently generating acid. However ABA tests indicate that the mine rock has the potential to generate acid.

The quality of the adit discharge indicates some sulphide oxidation is occurring in the adit. At present, the acid associated with this oxidation is being effectively neutralized. The pH of the water in the settling pond and 700 metres downstream of the adit are neutral. The impact of elevated metal concentrations from the adit discharge on the receiving environment was not assessed.

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 the waste rock at Silver Hart are potentially acid generating.

Collection and treatment of the runoff from Silver Hart site is not considered a viable option because of the remote location of the site and the high cost of operating a treatment facility. Relocation of the mined material is not considered, since there is no secure placement location readily available, such as underground workings or an open pit.

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.

The waste rock and ore stockpiles at the Silver Hart site likely represent a health and safety risk to the public due to instability of the material around the adit. Workers would also be exposed to a health and safety risk 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 be disturbed in order to obtain the cover material, and during the contouring of the piles a short term release of soluble metal constituents would likely occur. However, the risk to the environment is considered high because the current quality of the downstream water is not known.

Covering the ore stockpiles could obstruct exploration on the site, 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 higher.

Matrix for Evaluating Applicable/Potential Remediation

Option versus Evaluation Criteria	Silver Hart			
	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	4
Worker Health and Safety 5 = relative low risk to workers 1 = high risk to workers	not applicable	not applicable	3	5
Ecosystem Preservation and Protection 5 = relative low risk to environment 1 = relative high risk to environment	not applicable	not applicable	4	1
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	2
Total Score	**0**	**0**	**25**	**25**

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The waste rock and ore stockpiled on site has the potential to become acid generating. However, the evaluation of the potential remediation options does not clearly indicate which option is preferable for the long term. There is currently insufficient information to determine whether leaving the piles as is will be environmentally acceptable.

6.2 Recommendations

No further laboratory test work is recommended on the waste rock and ore stockpiles. However, further water quality and hydrology data is required to assess the potential impacts. This study is required to develop an effective remediation plan for the waste rock and ore stockpiles.

It is recommended that for 1997 a sampling program be undertaken to obtain water quality and hydrology data during spring freshet, middle summer and late fall conditions. Water samples should be collected at SHWQ-A1-1, SHWQ-S2, and at the bridge below the adit. Additional seeps observed at the base of the waste rock pad should also be sampled and analyzed. The method detection limits used should correspond to the CCME freshwater aquatic life criteria. It is also recommended that water quality and hydrology data collected during past environmental studies on the property be gathered and compiled. The results can then be used to determine appropriate remediation measures and future monitoring requirements.

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-07-2, Silver Hart Abandoned Mines Assessment. Indian and Northern Affairs Canada.

DIAND Exploration and Geological Services Division, 1994. Yukon Minfile # 105B 020, Silver Hart.

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

McLeod, H.N., Olsen M.T., 1987. Geotechnical Report, Silver Hart Property, Watson Lake Area, Yukon Territory. Klohn Leonoff Ltd. Whitehorse, Yukon.

Norecol Environmental Consultants Limited, 1987. Silver Hart Project Overview Report. Vancouver, B.C.

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

Smith, F.M., 1983. Report on the CMC Claims, NTS 105B/7, Edgar lake Area, Watson Lake Mining District. Assessment Report No. 092034.

TABLE 1 Silver Hart Waste Rock Sample Descriptions

Sample ID	Sample Description
SHWR-R1	Waste rock sample consisted of 70% biotite schist, 15% hornfels, 10% quartz vein, and 5% marble. 30% of the material was coarse, 30% medium and 40% fine textured. 95% was a green yellow colour, the remaining 5% a bright orange brown. The field paste pH was 8.1.
SHWR-R2	High grade ore stockpile sample of 70% quartz-sphalerite-galena-tetrahedrite vein material, 20% marble and 10% biotite schist. 25% of the material was coarse, 25% medium and 50% fine textured. 90% was a green yellow colour, the remaining 10% a bright orange brown. The field paste pH was 6.5.
SHWR-R3	Subgrade ore stockpile sample of 60% biotite schist, 20% marble and 20% quartz sulphide material. 50% of the material was coarse, 20% medium and 30% fine textured. 95% was a green yellow colour, the remaining 5% a bright orange brown. The field paste pH was 6.5.
SHWR-R4	Waste rock sample of 60% granodiorite, 30% marble, 5% biotite schist and 5% quartz vein. 40% of the material was coarse, 20% medium and 40% fine textured. 99% was a green yellow colour, the remaining 1% a bright orange brown. The field paste pH was 7.1.
SHWR-R5	Waste rock sample of 80% granodiorite, 10% marble, 5% biotite schist and 5% quartz vein. 60% of the material was coarse, 20% medium and 20% fine textured. 95% was a green yellow colour, the remaining 5% a bright orange brown. The field paste pH was7.2

TABLE 2 Silver Hart Waste Rock ABA and ICP Results

Parameter	Units	Sample Number SHWR				
		R1	R2	R3	R4	R5
Field Paste pH		8.1	6.5	6.5	7.1	7.2
Lab Paste pH		7.75	6.57	6.76	7.76	7.91
Total Sulfur	%	2.22	7.23	2.81	1.83	0.70
Sulfate	%	1.60	0.15	0.09	0.09	na
AP		19.38	221.25	85.00	54.38	21.88
NP		42.25	9.50	6.56	15.38	12.25
NET NP		22.88	-211.75	-78.44	-39.00	-9.63
NP/AP		2.18	<0.1	<0.1	0.28	0.56
Aluminum	%	1.96	0.28	0.25	0.39	0.21
Antimony	ppm	6	1461	140	65	46
Arsenic	ppm	<1	994	1559	836	<1
Barium	ppm	52	22	12	19	13
Beryllium	ppm	<0.1	<0.1	<0.1	<0.1	<0.1
Bismuth	ppm	38	59	8	6	<1
Cadmium	ppm	<0.1	>100	>100	94.7	2.1
Calcium	%	2.23	0.48	0.18	0.65	0.44
Chromium	ppm	86	79	159	146	138
Cobalt	ppm	35	9	7	6	3
Copper	ppm	724	2728	500	363	159
Gallium	ppm	<1	<1	<1	<1	<1
Iron	%	9.18	3.30	2.94	1.94	2.25
Lead	ppm	83	>10000	2316	1160	1425
Lithium	ppm	35	<1	2	6	<1
Magnesium	%	0.76	0.09	0.07	0.17	0.09
Manganese	ppm	1295	8510	7796	3246	6754
Molybdenum	ppm	56	84	22	17	20
Nickel	ppm	46	43	37	22	30
Potassium	%	0.32	0.11	0.16	0.14	0.14
Phosphate	ppm	370	660	620	600	510
Silver	ppm	2.8	>200	148.8	101.2	67.8
Sodium	%	0.04	<0.01	<0.01	<0.01	<0.01
Strontium	ppm	65	35	22	38	23
Thorium	ppm	<1	<1	<1	<1	<1
Tin	ppm	6	11	7	4	3
Titanium	%	0.04	<0.01	<0.01	<0.01	<0.01
Tungsten	ppm	6	250	111	69	33
Uranium	ppm	<1	<1	<1	<1	<1
Vanadium	ppm	25.1	5.6	1.8	4.0	1.6
Zinc	ppm	534	>10000	>10000	>10000	>10000

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 Silver Hart Water Quality Results

Parameter		**Units**	**SHWQ A1-1**
Field Conductivity		umhos/cm	*
Field pH			7.2
Conductivity		umhos/cm	507
Hardness	CaCO3	mg/L	*
Moisture	%	%	-
pH			7.65
Acidity (to pH 8.3)	CaCO3	mg/L	*
Alkalinity-Total	CaCO3	mg/L	*
Chloride	Cl	mg/L	-
Sulphate	SO4	mg/L	*
Aluminum	T-Al	mg/L	0.031
Antimony	T-Sb	mg/L	-
Arsenic	T-As	mg/L	0.036
Barium	T-Ba	mg/L	0.01
Beryllium	T-Be	mg/L	<0.005
Boron	T-B	mg/L	<0.1
Cadmium	T-Cd	mg/L	0.0134
Calcium	T-Ca	mg/L	77.3
Chromium	T-Cr	mg/L	<0.001
Cobalt	T-Co	mg/L	<0.02
Copper	T-Cu	mg/L	<0.001
Iron	T-Fe	mg/L	<0.03
Lead	T-Pb	mg/L	0.002
Lithium	T-Li	mg/L	<0.02
Magnesium	T-Mg	mg/L	15.6
Manganese	T-Mn	mg/L	0.163
Mercury	T-Hg	mg/L	<0.00005
Molybdenum	T-Mo	mg/L	<0.03
Nickel	T-Ni	mg/L	<0.02
Selenium	T-Se	mg/L	<0.0005
Silver	T-Ag	mg/L	0.0001
Sodium	T-Na	mg/L	2
Tin	T-Sn	mg/L	-
Vanadium	T-V	mg/L	<0.03
Zinc	T-Zn	mg/L	6.73

< = lower detection limit

Sample held for approximately 30 days at room ten

APPENDIX B

SITE PHOTOGRAPHS

Photo 1. View upslope (looking north) of site with adit (left) maintenance area (right) and trailer camp (background).

Photo 2. Prefabricated metal maintenance shed with AST and adit area (background).

Photo 3. View of 2 horizontal ASTs and 1 vertical AST in maintenance area below trailer camp.

Photo 4. View of maintenance area ASTs with main adit and waste rock area below.

Photo 5. Prefabricated "Atco" trailers for sleeping & dining north of maintenance area.

Photo 6. Detail of sleeping quarters in trailer camp area.

Photo 7. Twin ASTs in trailer camp area.

Photo 8. Service road to upper tent camp area with twin ASTs in trailer camp area (right) and tent camp area (background).

Photo 9. Sleeping tent frames with wood waste at right and metal barrels strewn about site.

Photo 10. Further detail of area surrounding tent frame sleeping quarters.

Photo 11. Wooden core storage racks behind tent frame sleeping quarters.

Photo 12. View of interior of maintenance shed. Note obvious signs of soil staining and waste oil containers (right rear).

Photo 13. Barrels of Jet B fuel found near upper level tent frame area.

Photo 14. Detail of test pit area SH-WR-R4 at south western edge of push dump waste rock ore stock pile area west of main adit.

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[1] File No. G4270

			SH-WQ-A1 -1	DU-WQ-STR-302	FO-WQ-STR-001	FO-WQ-STR-301	FO-WQ-STR-302
			96 07 29 10:00	96 08 17 09:30	96 08 13 11:00	96 08 13 11:30	96 08 13 11:30
Physical Tests							
Conductivity (umhos/cm)			507	60.2	618	615	1020
Hardness		CaCO3	257	25.8	339	336	589
pH			7.65	7.26	8.08	8.11	7.73
Dissolved Anions							
Acidity		CaCO3	16.1	3.8	5.0	3.6	13.4
Alkalinity - Total		CaCO3	150	11.7	136	135	234
Sulphate	SO4		123	15.5	192	168	409
Total Metals							
Aluminum	T-Al		[redacted]	0.010	0.017	0.008	[redacted]
Arsenic	T-As		0.0360	0.0012	0.0024	0.0024	0.0014
Barium	T-Ba		0.01	0.07	0.04	0.04	0.04
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]	<[redacted]	[redacted]	[redacted]	[redacted].0009
Calcium	T-Ca		77.3	7.53	103	102	145
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	<0.001	[redacted]
Iron	T-Fe		<0.03	<0.03	0.11	0.10	0.15
Lead	T-Pb		0.002	<0.001	0.001	0.001	0.004
Lithium	T-Li		<0.02	<0.02	<0.02	<0.02	<0.02
Magnesium	T-Mg		15.6	1.70	19.5	19.3	54.9
Manganese	T-Mn		0.163	<0.005	0.106	0.099	0.006
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	<0.02
Selenium	T-Se		<0.0005	0.0007	0.0009	0.0010	0.0007
Silver	T-Ag		0.0001	<0.0001	0.0002	0.0002	0.0002
Sodium	T-Na		2	<2	<2	<2	2
Vanadium	T-V		<0.03	<0.03	<0.03	<0.03	<0.03
Zinc	T-Zn		[redacted]	0.005	0.237	0.228	0.052

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:

rror 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 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