
**ENVIRONMENTAL ASSESSMENT
CHOUTLA SCHOOL SITE
CARCROSS, YUKON**

0201-11151
TAC-154 # 34
August, 1993

EXECUTIVE SUMMARY

Choutla School, Carcross, Yukon

The Choutla School in Carcross, Yukon has been abandoned since the 1970's. In order to determine the environmental concerns related to the abandonment and decay of the school site, Public Works Canada, A&ES, Technical Services retained EBA Engineering Consultants Ltd. (EBA) to conduct an Environmental Assessment of the site.

In March, 1993, EBA conducted an investigation composed of a ground penetrating radar survey (GPR), the drilling of nine boreholes and the installation of six groundwater monitoring wells to collect representative soil and ground water samples. Sludge samples were collected from the transformer bases in the power house and the water in Grayling Creek was also collected and tested.

Based on the field testing program and the subsequent laboratory testing programs, five items of environmental concern were noted at the subject site. None of the soil samples tested exceeded the CCME criteria for Parkland or Residential soil remediation.

However, comparisons between chemical analysis results and BC or CCME remediation criteria as well as Canadian Drinking Water Standards have determined the following:

- Benzene levels in the ground water around the power house area exceed the CCME drinking water guidelines.
- Ethylbenzene and 1,2,dichlorobenzene levels in ground water exceed aesthetic standards in the power house area.

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- No faecal coliforms were noted in ground water samples; however, total coliforms (likely naturally occurring) exceeded the Canadian Drinking Water Standard at the mouth of Grayling Creek.
 - Two underground fuel storage tanks exist at the site and should be removed along with the contaminated soil noted between the power house and the school where two tanks had been removed prior to this investigation.
 - PCB contamination was noted on the concrete surfaces of the transformer bases in the power house.

Based on the results of this investigation, recommendations presented in this report include:

- The PCB contamination clean-up in the power house should be completed.
- The two existing fuel tanks which are still buried on site should be rendered inert, removed, and disposed of. Contaminated soil adjacent to the two existing tanks, as well as in the area of Borehole 11151-04 should be removed or landfarmed on-site.
- Residents in the area should be advised of the threat of benzene contamination in ground water and total coliform levels in Grayling Creek and be instructed to haul in drinking water.
- If the area should be considered for residential development in the future, a risk assessment should be completed to determine the possible effects of benzene in ground water on the area residents.
- A yearly monitoring program should be implemented to determine if the ground water quality improves once the contaminated soils are removed.

ENVIRONMENTAL ASSESSMENT
CHOUTLA SCHOOL SITE
CARCROSS, YUKON

submitted to:

PUBLIC WORKS CANADA

prepared by:

EBA ENGINEERING CONSULTANTS LTD.
WHITEHORSE, YUKON

0201-11151

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TABLE OF CONTENTS

1.0	INTRODUCTION	1
1.1	General	1
1.2	Authorization	1
1.3	Project Methodology	1
2.0	SITE EVALUATION	2
2.1	General Location	2
2.2	Topography and Vegetation	2
2.3	Choutla School Complex	3
2.4	Existing Site Conditions	3
2.5	Ground Penetrating Radar (GPR) Survey	3
2.6	GeoEnvironmental Drilling/Sampling Program	4
2.7	Existing Soil Conditions	6
3.0	SITE CONTAMINATION ASSESSMENT	7
3.1	Environmentally Related Field Work	7
3.2	Soil Testing	8
3.2.1	Hydrocarbon Vapour Testing	8
3.2.2	Chemical Testing of Soil and Water Samples	9
3.3	Chemical Analysis Results Compared to Relevant Regulatory Guidelines	10
4.0	DISCUSSION OF REMEDIAL OPTIONS	11
4.1	Benzene contamination of Soil and Groundwater	11
4.1.1	Remedial Options for Benzene Contamination	12
4.1.2	Remediation Alternative Assessment and Ranking System	12
	• Health and Public Safety	14
	• Ecosystem Protection	14
	• Technical Feasibility	15
	• Potential for Redevelopment	15
	• Short Term Costs	15
	• Long Term Costs	15
	• Compliance with Regulatory Objectives	15
4.1.3	Ranking of Remedial Alternatives for Benzene Contamination	16
4.1.4	Excavation and Selective Landfarming	16
4.1.5	Risk Assessment and Monitoring of Benzene in Ground Water at Choutla School Site	17

1.0 INTRODUCTION

1.1 General

EBA Engineering Consultants Ltd. (EBA) was retained by Public Works Canada, A&ES Technical Services to conduct an environmental assessment at the Choutla School site at Carcross, Yukon.

The project tasks consisted of identifying and delineating areas of environmental concern; determining the levels and extent of soil and water contamination; preparing a report summarizing the results of the field investigation and laboratory testing programs; and providing recommendations for required site work during remediation, including associated costs.

1.2 Authorization

Authorization to proceed with this project was received from Mr. J.G. Elliot, P.Eng., A/Regional Manager, Public Works Canada, A&ES Technical Services by phone on February 9, 1993.

1.3 Project Methodology

The methodology for this project was based on the EBA proposal dated 1993-02-03.

Site work progressed in the following order:

- A Level I Environmental Assessment was completed to document known site history, identify past and future land use, and assess environmental concerns.

-
- A ground penetrating radar survey (GPR) was conducted around the school site structures to locate buried tanks or other metal debris.
 - Based on the findings of the GPR survey, which was interpreted on site, nine boreholes were drilled at strategic locations. Sampling wells were installed in six of the nine boreholes to facilitate ground water sampling.
 - Once established, each well was purged and sampled. All selected soil samples and specific water samples were forwarded to Enviro-Test Laboratories in Edmonton, for chemical analyses.
 - A Progress Report was prepared.

2.0 SITE EVALUATION

2.1 General Location

The subject site is located along the Tagish Road approximately 1.0 km east of the South Klondike Highway intersection at Carcross, Yukon. The school is on the south side of the Tagish Road and overlooks Grayling Bay on Nares Lake.

The site location is shown on NTS map sheet 105 D/2. The applicable portion of this map is presented as the General Location Map, (Drawing No. 11090-A-01), in Appendix A of this report.

2.2 Topography and Vegetation

The Choutla School site is located on a glaciolacustrine flood plain, near the base of a fairly steep glacial till ridge. The site slopes gently towards Grayling Bay.

Vegetation surrounding the site consists primarily of large spruce in uncleared areas with stands of willows along Grayling Creek and in wet areas. Poplars exist in well-drained areas. Grass covers the central portion of the site south of the school which appears to have been a cleared field throughout the school's history.

2.3 Choutla School Complex

The school complex consists of the school structure and power house ruins, a garage structure, a warehouse structure, two single family dwellings (of which one is occupied) and a duplex (both sides are occupied). An additional dwelling is also located southeast of the site at the mouth of Grayling Creek. The area is serviced with overhead power lines, water for all dwellings is drawn from Grayling Creek, and privies are utilized for sewage disposal. Drawing No. 11151-A-02 in Appendix A presents the site as it appeared in 1980 when it was flown and photographed.

2.4 Existing Site Conditions

A photographic presentation of the site components and existing conditions is presented in Appendix D of this report.

2.5 Ground Penetrating Radar (GPR) Survey

The GPR survey commenced on 1993-03-09 and was completed on 1993-03-10. The intent of the survey was to locate buried fuel storage tanks or other metal debris, and to delineate the size and shape of the concrete septic tank located south of the school.

Two antennae were utilized for this survey. The 120 MHz antenna yielded good penetration and moderate resolution down to 5.0 m and the 500 MHz antenna was utilized for more accurate resolution at depths of 2.5 m or less.

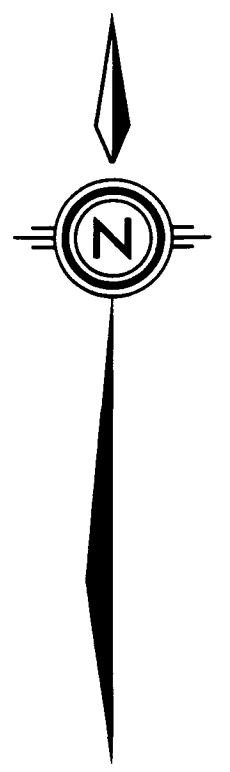
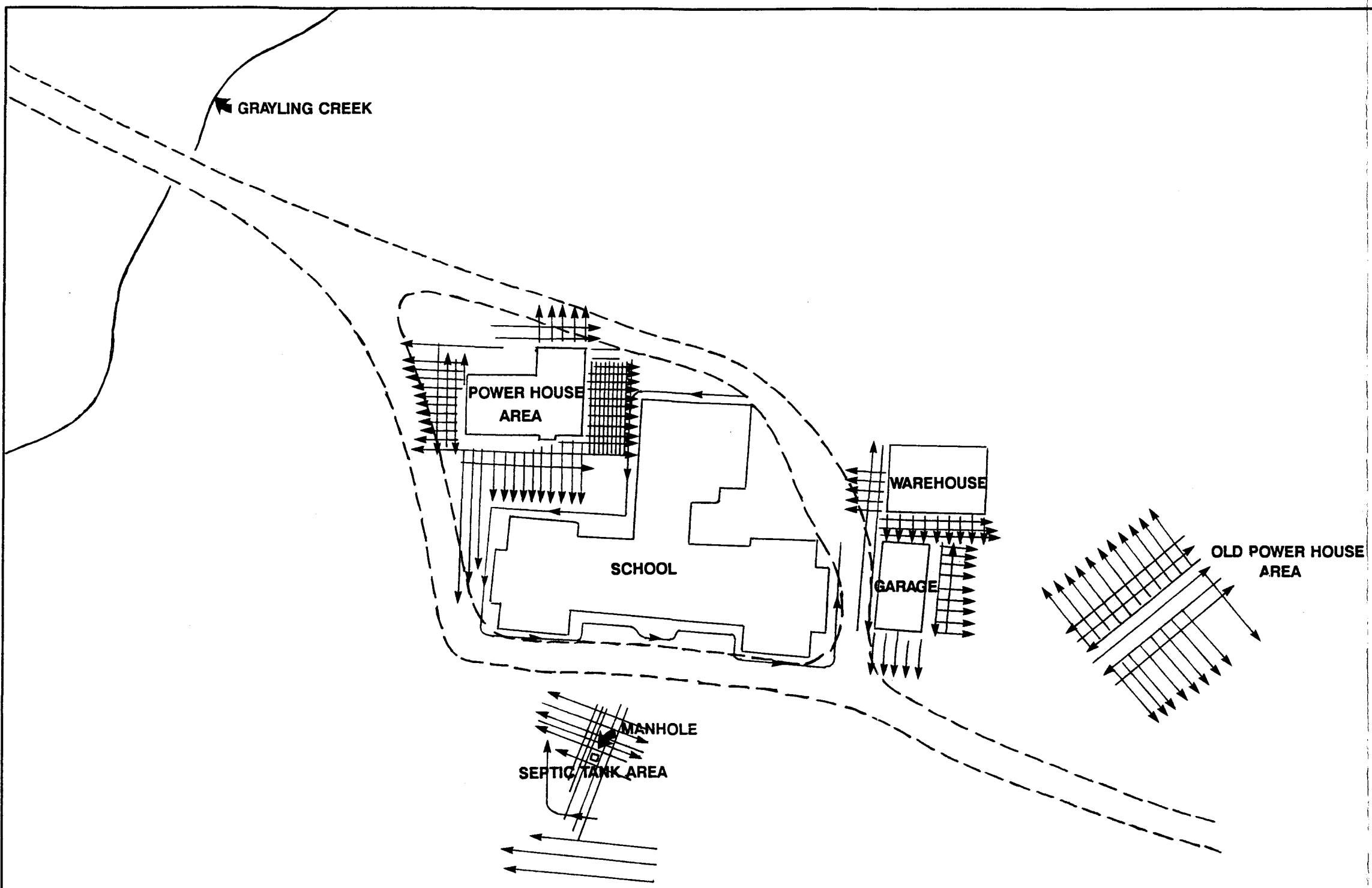
Results of the GPR survey are summarized as follows:

- Two underground fuel storage tanks were detected. One was located adjacent to the northwest corner of the power house while the second tank was found between the garage and warehouse structure just east of the school. Both tanks were found to have less than 1.0 m of soil cover.
- The concrete septic tank was delineated as being quite long and narrow. Using this information, a borehole location in close proximity to the tank was possible.
- The extent of the excavation from which two 13,620 L (3,000 gallon) tanks were previously removed was delineated in the area between the east wall of the power house and the north wing of the school. Backfill of the excavation consisted of soil as well as metal and wood debris.
- No fuel storage tanks were located in the areas where the power house structure was initially located during Phase I of the school site development.
- Significant metal debris was delineated throughout the entire surveyed location within the top 0.5 m. Some of these were obviously abandoned pipes.

Figure 1, following, shows the location, direction, and spacing of the GPR survey lines. GPR traces of the tanks identified next to the power house and between the garage/warehouse structures are presented as Figure 2.

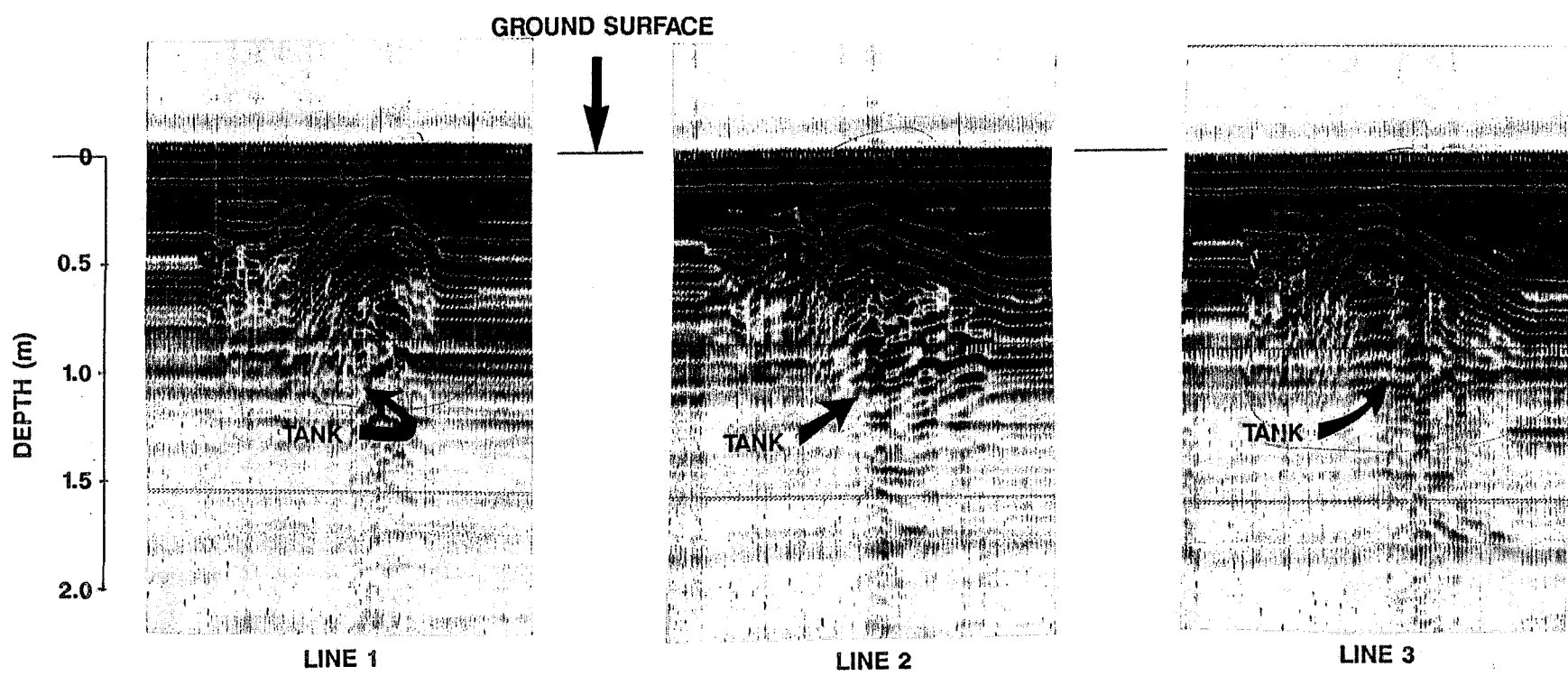
2.6 GeoEnvironmental Drilling/Sampling Program

The site was snow covered when the field work was completed. To provide site access for the GPR survey equipment and the truck mounted drill, Dickson Trucking of Carcross, Yukon was contracted to provide snow clearing services.



APPROXIMATE SCALE 1: 800

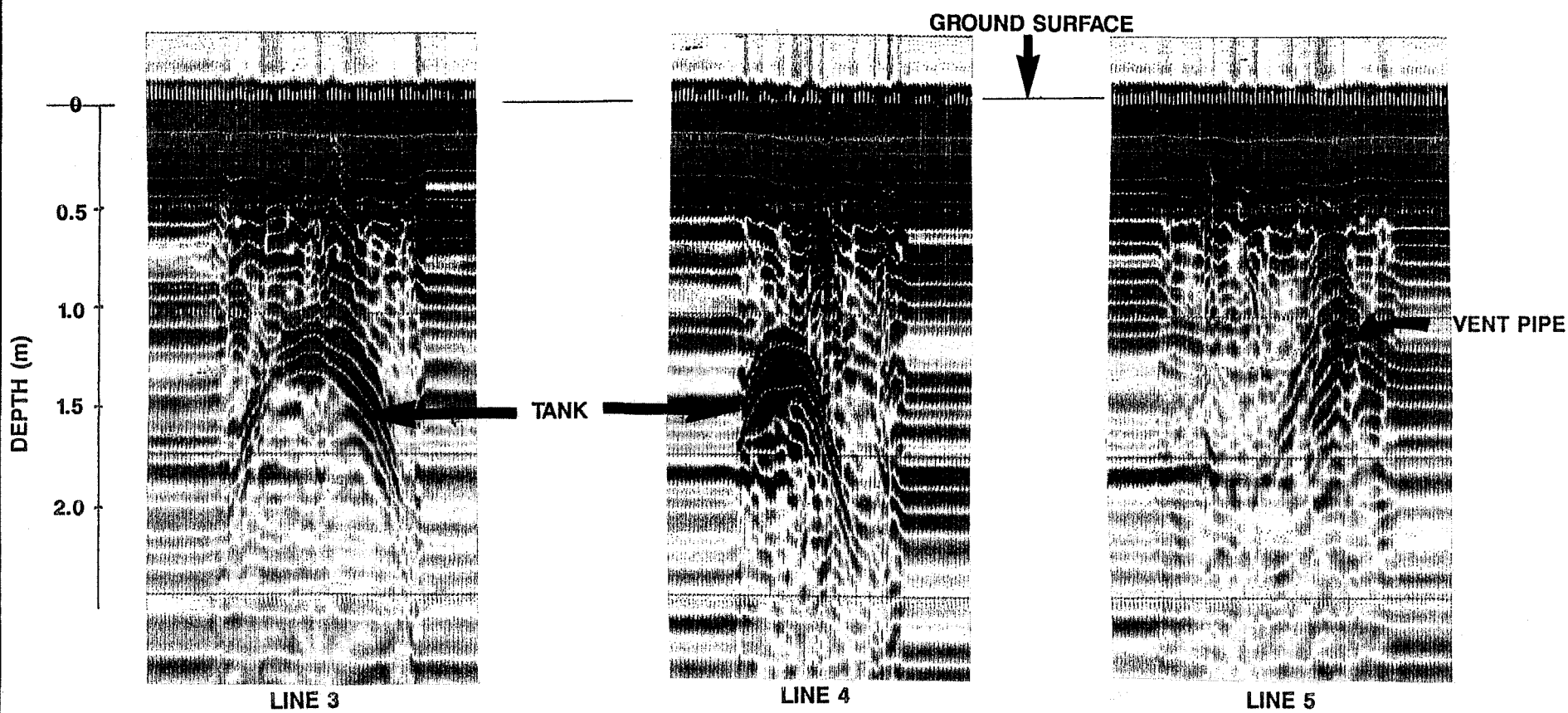
<i>EBA Engineering Consultants Ltd.</i>			PROJECT	ENVIRONMENTAL ASSESSMENT CHOUTLA SCHOOL, CARCROSS
CLIENT			TITLE	LOCATION OF GPR SURVEY LINES
DATE	DWN.	CHKD.	FILE NO.	FIGURE
93-03-26	MCP		0201-11151	1



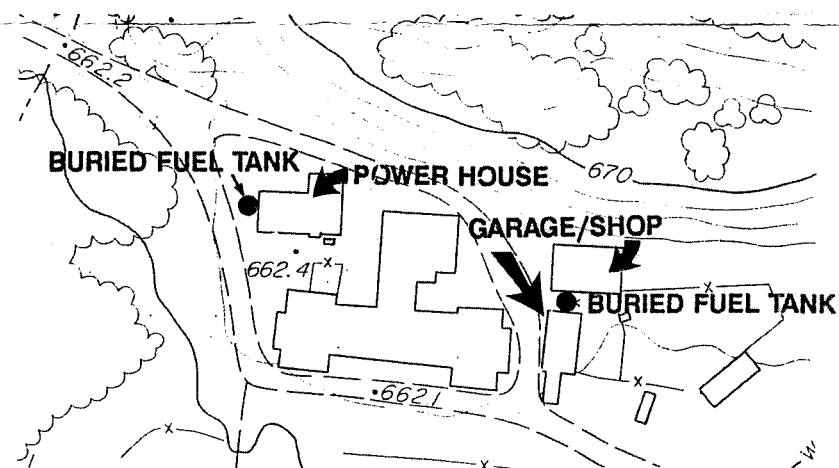
POWER HOUSE BURIED FUEL STORAGE TANK

SCALE APPROXIMATE

NOTES: DISTANCE BETWEEN LINES 2 m
EACH TRACE AS SHOWN IS 5 m LONG



UNDERGROUND FUEL STORAGE TANKS BETWEEN GARAGE AND WAREHOUSE



<i>EBA Engineering Consultants Ltd.</i>			PROJECT	ENVIRONMENTAL ASSESSMENT CHOUTLA SCHOOL, CARCROSS
CLIENT PUBLIC WORKS CANADA			TITLE	GROUND PENETRATING RADAR TRACES
DATE	93-03-26	DWN.	MCP	CHKD.
			FILE NO.	0201-11151
				FIGURE 2

Based on information gathered during the GPR survey and the initial stages of this project, potential areas of concern were identified. These areas included:

- the power house area,
- the garage/warehouse areas,
- the septic tank area in front of the school structure,
- the 150 mm diameter line from the septic tank to the edge of Grayling Bay,
- Grayling Creek upstream and downstream from the school,
- the area of distressed poplar vegetation located approximately 50 m east of the southeast corner of the school structure, and
- the greenhouse area.

The areas of concern listed above are presented on Drawing No. 11151-A-03 in Appendix A.

The drilling program was completed from March 9 to March 11, 1993 and consisted of advancing eight boreholes to below water table utilizing a truck mounted CME 75 drill equipped with hollow stem augers through which a 75 mm split spoon sampler was used to retrieve soil samples. The holes were drilled in close proximity to the areas of concern as well as one up gradient and one down gradient hole to determine background metal levels in the soil and ground water. One additional hole was advanced utilizing a hand auger (BH 11151-09) in one area that could not be accessed by the drill rig.

During drilling, monitoring wells were installed in Boreholes 11151-02 through -07 inclusive, to facilitate ground water sampling. Details of the well installations are presented on the borehole logs in Appendix B of this report.

Soil samples were collected at 1.5 m intervals throughout the depth of each borehole. Soil samples which were noted as having hydrocarbon odour based on olfactory detection were stored in glass jars and all other samples were stored in plastic bags and retained for natural moisture content determination and basic classification testing.

The soil samples collected and placed in glass jars were stored in coolers with freezer packs to ensure no loss of volatiles, and returned to EBA's Whitehorse laboratory. Samples were then split and vapour emission testing was performed in the Whitehorse lab on half the sample while the other half of the sample was forwarded to Enviro-Test Labs of Edmonton, Alberta.

Ground water sampling was conducted after all wells were purged and allowed to recover. Initially, all wells were purged dry, subsequent to a minimum 24 hour stabilization period after drilling. The wells were then allowed to recover for an additional 72 hours before actual sampling. Ground water elevations were recorded during all stages of investigation and once sampled, the water was stored in a cooler and forwarded to Enviro-Test Labs in Edmonton.

All field work and soil/water sampling was supervised by Mr. Mylès Plaunt, C.E.T. of EBA's Whitehorse office. The drill rig contracted for this project was a truck mounted CME 75 owned and operated by Midnight Sun Drilling of Whitehorse, Yukon.

The location of all boreholes is presented on Drawing No. 11151-A-01 in Appendix A. Locations can be cross-referenced to Drawing No. 11151-A-03, also in Appendix A, which presents areas of environmental concern.

2.7 Existing Soil Conditions

The Choutla School site straddles a glacial till/glaciolacustrine interface. The area in front of the school is underlain by both SAND and SILT and wet, soft silty CLAY. Along the north edge of the site, dense SAND or SILT TILL underlies the area with silts and clays above. Within the school compound varying thicknesses of granular fill were also noted.

No bedrock was encountered during drilling; however, in BH 11151-01 and -07, refusal in dense TILL was experienced.

Ground water was encountered in all holes except BH 11151-01. Groundwater was at depths ranging from 2.3 to 4.3 m. Elevations to the top of water table indicates that ground water flow is towards Grayling Bay.

Detailed soil conditions and applicable soil classification test results are presented on the borehole logs in Appendix B of this report. It should be noted that the elevations presented on the logs have been extrapolated from a 1:2000 contour map of the Carcross area prepared by McElhanney Surveying and drawn by Kenting Earth Sciences Ltd. in 1983.

3.0 SITE CONTAMINATION ASSESSMENT

3.1 Environmentally Related Field Work

For all soil samples collected during drilling, olfactory inspection was carried out to detect areas with hydrocarbon contamination. Contamination was noted in BH's 11151-04, -05, -06 and -08 during the investigation. These boreholes were located around the perimeter of the power house structure. BH 11151-04 was located where two underground storage tanks (UST's) had been removed, BH 11151-05 was drilled adjacent to the tank located by GPR at the northwest corner of the power house, BH 11151-06 was located slightly southeast of the chimney where an above ground tank was previously located and BH 11151-08 was located between the southeast corner of the power house and the school to further assess the extent of contamination. An additional soil/sludge sample for PCB testing was collected from the concrete surfaces of the transformer bases located in the southwest corner of the power house.

Borehole 11151-07 was drilled at the west end of the underground fuel storage tank located by GPR between the warehouse and garage structures. No hydrocarbon contamination was noted in this area.

Samples and cuttings from BH's 11151-02 and -03 also underwent olfactory inspection, primarily for septic tank effluent. No suspect odours were noted in these boreholes.

BH 11151-09 was hand augered in an area with distressed poplar tree vegetation. A line from the school apparently empties a reddish coloured liquid into this area after spring thaw or periods of heavy rain. An unidentifiable odour was noted in the ice over this area but it was not noted in the ground water or soil below the ice.

Ground water sampling was completed in BH's 11151-02, -03, -04, -05, -06 and -09 as well as at points in Grayling Bay upstream and downstream of the school.

3.2 Soil Testing

3.2.1 Hydrocarbon Vapour Testing

All samples noted as containing hydrocarbon contamination during drilling were subjected to hydrocarbon and gasoline vapour emission testing using a GASTEC Model 801 Pump and GASTEC 101L Analyzer Tubes. The procedure for testing was as follows. Approximately 200 grams of soil sample was put in a jar with a hole drilled in the top. Prior to testing, tape was put over the hole to properly seal the jar. The sample was allowed to recover to room temperature at which time it was shaken to release the hydrocarbon vapours contained within the soil. Vapour emission was then measured and recorded by placing the detector tube into the hole in the top of the jar. The results are presented as Table 1 in Appendix C of this report.

3.2.2 Chemical Testing of Soil and Water Samples

Selected soil and water samples were shipped in a cooler to Enviro-Test Laboratories in Edmonton, Alberta.

Tests performed on specific samples of soil and/or water are as follows:

- Heavy Metal Analysis (ICP metal scan)
 - includes aluminum, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, molybdenum, nickel, phosphorous, potassium, silicon, silver, sodium, strontium, titanium, uranium, vanadium, and zinc

- Organic Pollutants
 - PCB testing of sludge/soil sample from transformer bases

- Hydrocarbon Contamination
 - BTEX, total purgeables, total extractables by gas chromatography
 - TPH by infra-red scan

- Volatile compounds
 - Volatile target compounds (halogenated and nonhalogenated compounds)

- Organo-Chlorine Pesticides

- Coliforms
 - Total and faecal coliforms

A sample and chemical testing summary is presented as Table 2 in Appendix C of this report.

Tables 3 and 4 in Appendix C present test result summaries of the chemical tests performed along with CCME or B.C. Cleanup Criteria guidelines. Formal laboratory test results follow the test summaries.

3.3 Chemical Analysis Results Compared to Relevant Regulatory Guidelines

All chemical analysis results were compared to the CCME and/or BC remediation criteria for soil and water as well as the Canadian Drinking Water Guidelines. The remediation criteria used for soil comparisons was based on the assumption that the intended land use was to be residential. The remediation criteria used for water comparisons was based on the assumption the water is to be used for drinking water.

No soil samples exceeded the CCME soil remediation criteria (Parkland/Residential) for BTEX or other volatile hydrocarbons. Benzene in ground water from Borehole 4 (8.1 $\mu\text{g}/\text{l}$) exceeds the CCME drinking water guidelines (5 $\mu\text{g}/\text{l}$). Benzene in a composite ground water sample from Boreholes 5 and 6 (7.5 $\mu\text{g}/\text{l}$) also exceeds the CCME drinking water guideline. The ground water from borehole 5 and Borehole 6 also exceeds two aesthetic standards (for ethylbenzene and 1,2 dichlorobenzene).

Total extractable hydrocarbon levels in the soil and water samples collected from BH 11151-04 were significant, indicating the possibility of the tanks leaking prior to removal or the remaining contents of the tanks may have spilled out during removal.

A water sample from the mouth of Grayling Creek, and ground water from Borehole 11151-03 (near the septic tank) were analyzed for total and faecal coliforms. No faecal coliforms were detected in the water samples, however, the total coliforms in the water sample at Grayling Creek as 13 CFU100ml. The Canadian Drinking Water Guidelines recommend that drinking water should not contain more than 10 CFU100ml.

The sludge sample collected from the concrete surfaces of the transformer bases, located in the power house, was analyzed and found to contain 130 ppm PCB's (aroclor 1260). The Canadian Environmental Protection Act prohibits the release of liquids with a PCB concentration of 50 ppm or greater into the environment.

There are, therefore, three regulatory concerns identified at the Choutla school site: the levels of benzene in the groundwater at Boreholes 4, 5 and 6 exceed the CCME drinking water guidelines; the total coliforms in the water at the mouth of Grayling Creek exceeds the Canadian Drinking Water Guideline; and the PCB concentrations in the sludge from the concrete surfaces of the transformer bases, located in the power house exceeds allowable limits according to the Canadian Environmental Protection Act.

4.0 DISCUSSION OF REMEDIAL OPTIONS

4.1 Benzene Contamination of Soil and Groundwater

Benzene is the simplest aromatic compound known. It is colourless and highly flammable. The toxic effects in humans are often attributed to combined exposure through inhalation and dermal absorption. According to a Benzene Toxicity report prepared by Janet Rzepa the toxicological effects in humans are as follows:

- When inhaled by humans benzene has no effect at 25 ppm.
- At 50 - 150 ppm benzene exposure produces headaches, lassitude and weariness.
- Concentrations of 500 ppm produce exaggerated symptoms.
- Concentrations of 3,000 ppm may be tolerated for up to one hour but 7,500 ppm may result in toxic signs within an hour.
- Exposure to concentrations of 20,000 ppm can be fatal within 10 minutes.

-
- Reproductive and prenatal toxicity has been reported as well as menstrual disturbances in women industrially exposed to benzene and other solvents.

4.1.1 Remedial Options for Benzene Contamination

Nine remedial options for the benzene contamination found at Boreholes 4, 5 and 6 were reviewed and ranked as follows:

- a) excavate and landfill
- b) excavate and selective landfill
- c) excavate and landfarm
- d) in-situ vapour extraction
- e) in-situ bio-remediation of soils
- f) ex-situ bio-remediation of soils
- g) risk assessment and monitoring
- h) passive remediation

A detailed description of these remedial methods, and their associated costs are presented in Appendix E.

4.1.2 Remediation Alternative Assessment and Ranking System

Remediation Alternative Assessment and Ranking is the process of choosing the most desirable option from among a variety of remediation alternatives. This involves preparation of a list of criteria against which each alternative is measured. This approach is particularly important where a significant number of objectives must be met.

In selecting the appropriate remediation alternative, the following parameters were considered:

- Health and Public Safety
- Ecosystem Protection
- Technical Feasibility
- Potential for Redevelopment
- Costs

The ranking methodology is based on the assumption that not all evaluation criteria used for the assessment of options are equally important in the selection of a remediation option. For example, compliance with regulatory objectives may be more important than the disruption of the site. To recognize these differences in significance, the evaluation criteria were assigned a weighting factor. The ranking multiplied by the weighting factor provides the weighted score. From the weighted score, the most desirable option may be chosen.

The assessment and ranking of remediation alternatives was completed using a remediation alternative assessment ranking methodology developed by EBA. The assessment procedure developed by EBA is based on the Kepner-Tregoe (KT) design aiding system. The methodology was developed so that, prior to the selection of a remediation alternative, the assessment of each alternative would take into account a number of criteria. This systematic evaluation of remediation alternatives is the product of a large number of small decisions, based on professional judgement. These small decisions are then organized and summarized in a table format. This systematic approach to decision making helps select the remediation alternative with the most benefits and fewest disadvantages.

Remediation alternatives were evaluated using a ranking score ranging from 1 to 5. The scoring guide for the ranking criteria is as follows:

Value	Key Words
1	least desirable, least economical
5	most desirable, most economical

Values intermediate between 1 and 5 are somewhat desirable or economical. The following is a description of the terms used in the methodology and how the methodology was used for assessing remediation alternatives.

- Health and Public Safety

Health and Public Safety refers to the human health risk associated with a particular remediation option. The most desirable alternative would involve no, or an extremely low, health risk to the surrounding community and the remediation workers. The least desirable alternative would involve either an unknown health risk or a very high health risk to the surrounding community and remediation workers.

- Ecosystem Protection

Ecosystem Protection refers to the risk of the contaminants to the surrounding ecosystem. At the Choutla School site the greatest risk to the environment is contaminants impacting on the creek or the lake. The most desirable alternatives would have no effect on the ecosystem. The least desirable alternative would have an impact on the environment or an unknown risk to the environment.

- Technical Feasibility

Technical feasibility refers to the likelihood of a remedial option to achieve its objectives. The most desirable alternatives are certain to succeed. The least desirable alternatives are those with the least chance of success.

- Potential for Redevelopment

The potential for redevelopment refers to the level of development allowable following the remedial works. The most desirable alternatives will allow unlimited development (including underground structures such as basements) of the affected site. The least desirable alternatives will be restrictive with respect to land use.

- Short Term Costs

Short term costs refer to all remediation costs except long term monitoring costs. The most desirable alternatives are defined as costing \$15,000 or less. The least desirable options are defined as costing greater than \$60,000.

- Long Term Costs

Long term costs refer to monitoring costs over several years. The most desirable options are less than \$4,000. The least desirable options are greater than \$16,000.

- Compliance with Regulatory Objectives

Compliance with regulatory objectives refers to satisfying all currently applicable laws, regulations or guidelines. The most desirable options satisfy all laws, regulations and guidelines with reservations. The least desirable options are those not in compliance.

TABLE 1
REMEDIAL ALTERNATIVE ASSESSMENT AND RANKING OF HYDROCARBON CONTAMINATED SOIL
CHOUTLA SCHOOL - CARCROSS, YUKON

Number	Remediation Alternative	Technical Criteria			Economic Criteria			Compliance with Regulatory Objectives	Total Score	Weighted Score	Ranking
		Health and Public Safety	Ecosystem Protection	Technical Feasibility	Potential for Redevelopment	Short Term Costs	Long Term Costs				
8	Risk Assessment and Monitoring	5	5	3	3	5	3	5	29	450	1
4	Excavate and Selective Landfarm	4	4	5	5	3	4	5	30	425	2
3	Excavate and Landfarm	4	4	5	5	2	5	5	30	410	3
2	Excavate and Selective Landfill	4	4	5	5	2	5	5	30	410	4
1	Excavate and Landfill	4	4	5	5	1	5	5	29	390	5
7	Ex-situ Bio-remediation	4	4	5	5	1	5	5	29	390	6
5	In-situ Vapour Extraction	4	4	3	3	4	1	4	23	365	7
6	In-situ Bio-remediation	5	5	3	3	1	1	5	23	360	8
9	Passive Remediation	1	1	1	2	5	5	1	16	205	9
	Weighting Factors	25%	5%	15%	5%	20%	5%	25%	100%		

The importance of each evaluation criteria to the selection of a remediation alternative has been set with a weighting factor as illustrated in Table 1. The higher the weighting factor, the more important the evaluation criteria.

All scored criteria are multiplied against the weighting factor and totalled to produce a score for the remediation alternative. The higher the score, the more desirable the remediation alternative.

4.1.3 Ranking of Remedial Alternatives for Benzene Contamination

Nine remediation alternatives were ranked according to the ranking system described in Section 4.1.1. Please see Table 1 for the complete assessment and ranking table. The weighted scores and rankings are also summarized below.

Alternative	Score	Rank
Risk Assessment and Monitoring	450	1
Excavation and Selective Removal and Landfarm	425	2
Excavation and Selective Removal to Landfill	410	3
Excavation and Landfarm	410	3
Excavation and Removal to a Landfill	390	5
Ex-situ Bio-remediation	390	5
In-situ Vapour Extraction	365	7
Insitu Bio-remediation	360	8
Passive Remediation (do nothing)	205	9

4.1.4 Excavation and Selective Landfarming

Although the highest ranked remedial alternative was to conduct a risk assessment and to monitor the ground water at the Choutla School site, subsequent meetings with PWC have determined that the excavation and selective landfarm of contaminated material is the most desirable form of remediation. This includes tank removal

and placing of contaminated material in the field located in the southeast corner of the site. The process is described in Section 4 of Appendix E. Associated costs are estimated at \$5,000 - \$8,000 depending upon the volume of contaminated soil removed.

4.1.5 Risk Assessment and Monitoring of Benzene in Ground Water at Choutla School Site

If, in the future, the area is considered for residential use, a risk assessment of benzene in groundwater at the Choutla School site would likely conclude that the amount and concentration of benzene in the groundwater poses little or no health risk to the surrounding population drawing their drinking water from the creek. The risk assessment would also likely conclude that commercial or residential development of the land could be undertaken with little or no risk to people dwelling or working in the area provided that any buildings built over the benzene contaminated zone have no basement structures. A limited groundwater monitoring program would need to be undertaken following the risk assessment to determine if the fate of benzene in the groundwater has been adequately predicted. Monitoring costs are estimated to be between \$8,000 to \$12,000 over approximately 5 years of annual monitoring.

4.2 Clean-Up of PCB Contamination Within the Power House

The clean-up of contamination within the power house involves removal of all PCB contaminated material in secure drums to a PCB storage area. It is estimated that 3 or 4 drums will be sufficient to secure the contaminated soil and sludge as well as rags and solvent utilized during clean-up. It is understood that YTG has space for 1 pallet of drums in their storage facility until the wastes can be legally exported to a jurisdiction where a facility capable of destroying PCB contaminated waste exists.

The clean-up of these wastes should only be conducted by qualified professionals. The costs of the clean-up, excluding long term storage and destruction costs, is estimated to

be around \$5,000. If completed concurrent to tank removal and soil farming operations, total costs for both operations are estimated to be \$10,000.

4.3 Coliforms in Creek Water

No faecal coliforms were found in water sampled from the well near the septic tank or at the mouth of the creek. It is very unlikely that the septic tank is harming the water quality of the creek. However, the total coliform count in the creek exceeds the amounts recommended by the Canadian Drinking Water guidelines. These coliforms are likely of natural origin.

5.0 RECOMMENDATIONS

EBA recommends that the PCB contamination on site be removed as soon as possible. There is a possibility that residents in the area have come into direct contact with the PCB wastes. EBA also recommends that the two existing underground fuel storage tanks and all contaminated soil noted in the three areas where tanks were located be removed to minimize the risk of further contamination by eliminating the possible sources of contamination.

EBA further recommends that a risk assessment be conducted to determine the health risks associated with benzene remaining in the soil and ground water at the Choutla School Site if residential development of the site is proposed in the future. A 5 year ground water monitoring program should be undertaken to assess ground water quality following the removal of the contaminated soils from the power house area.

EBA also recommends that residents of the area be advised of the high total coliform count in the Grayling Creek water and to either boil or chemically treat all water from the creek prior to its use as drinking water or to haul in potable water.

6.0 LIMITATION OF LIABILITY

Conclusions and recommendations presented herein are based on the contamination assessments as described in the previous sections of this report. This report has been prepared for the exclusive use of Public Works Canada for the evaluation of the subject site. It has been prepared in accordance with generally accepted geotechnical engineering practices utilizing accepted environmental sampling and testing protocols. No other warranty is made, either expressed or implied. Further information regarding the use of this report is presented in the General Conditions, preceding Appendix A.

7.0 CLOSURE

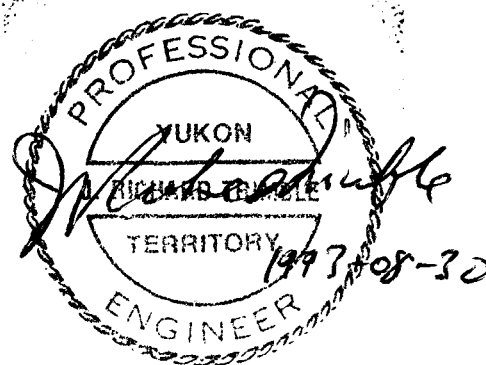
EBA Engineering looks forward to being involved with the remediation of the Choutla School site. If additional information is required regarding site clean-up or the contents of this report, do not hesitate to contact the undersigned at your convenience.

Respectfully submitted,
EBA Engineering Consultants Ltd.



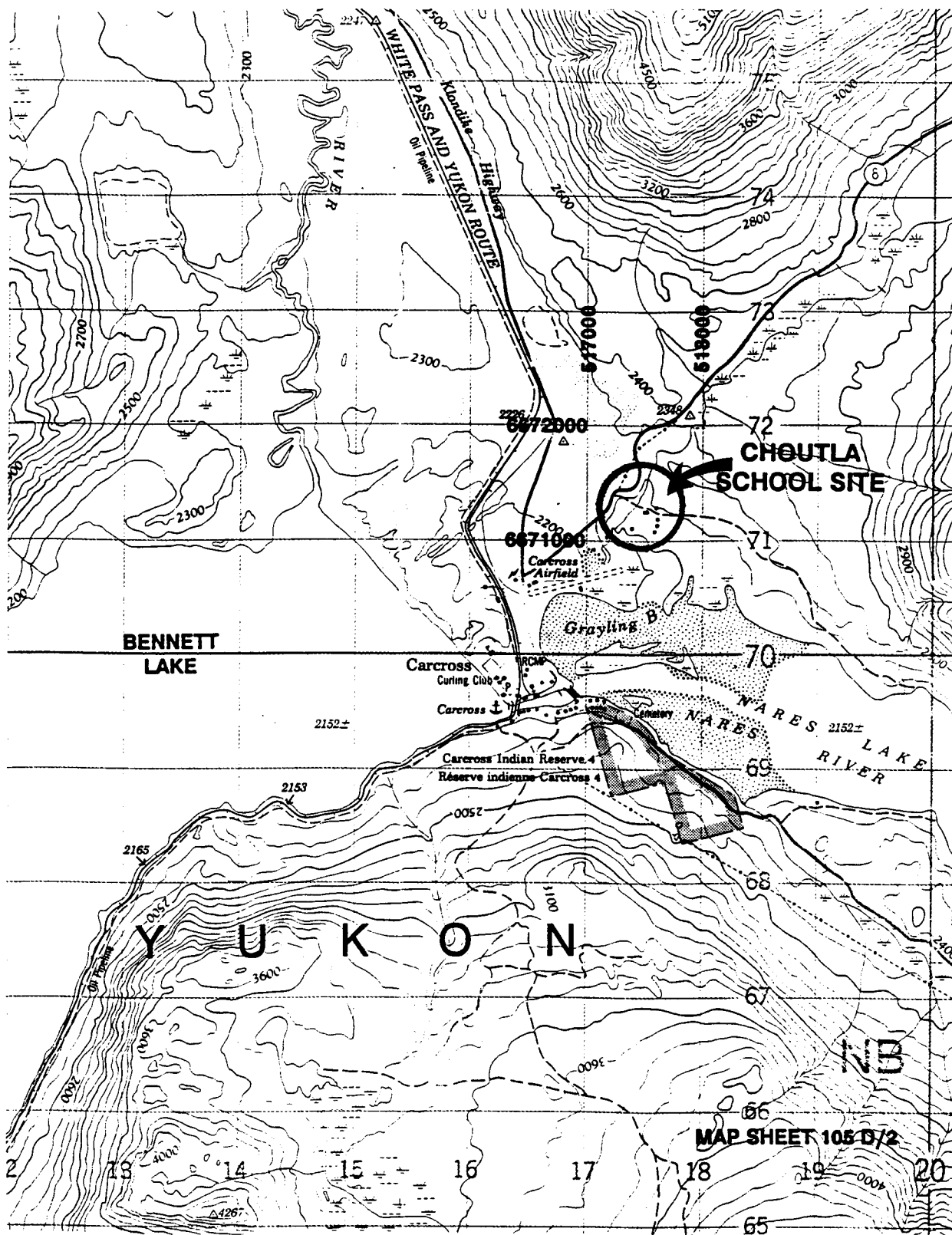
M.C. Plaunt, C.E.T.
Engineering Technologist

MCP/JRT/rsz



J.R. Trimble, P.Eng.
Project Director
Office Manager

APPENDIX A
SITE PLANS and
AREA MAPS



**BENNETT
LAKE**

**CHOULTA
SCHOOL SITE**

Carcross
Curing Club

Carcross

Carcross Indian Reserve 4
Réserve indienne-Carcross 4

NARES LAKE
RIVER

Y U K O N

MAP SHEET 105 D/2

SCALE 1:50000

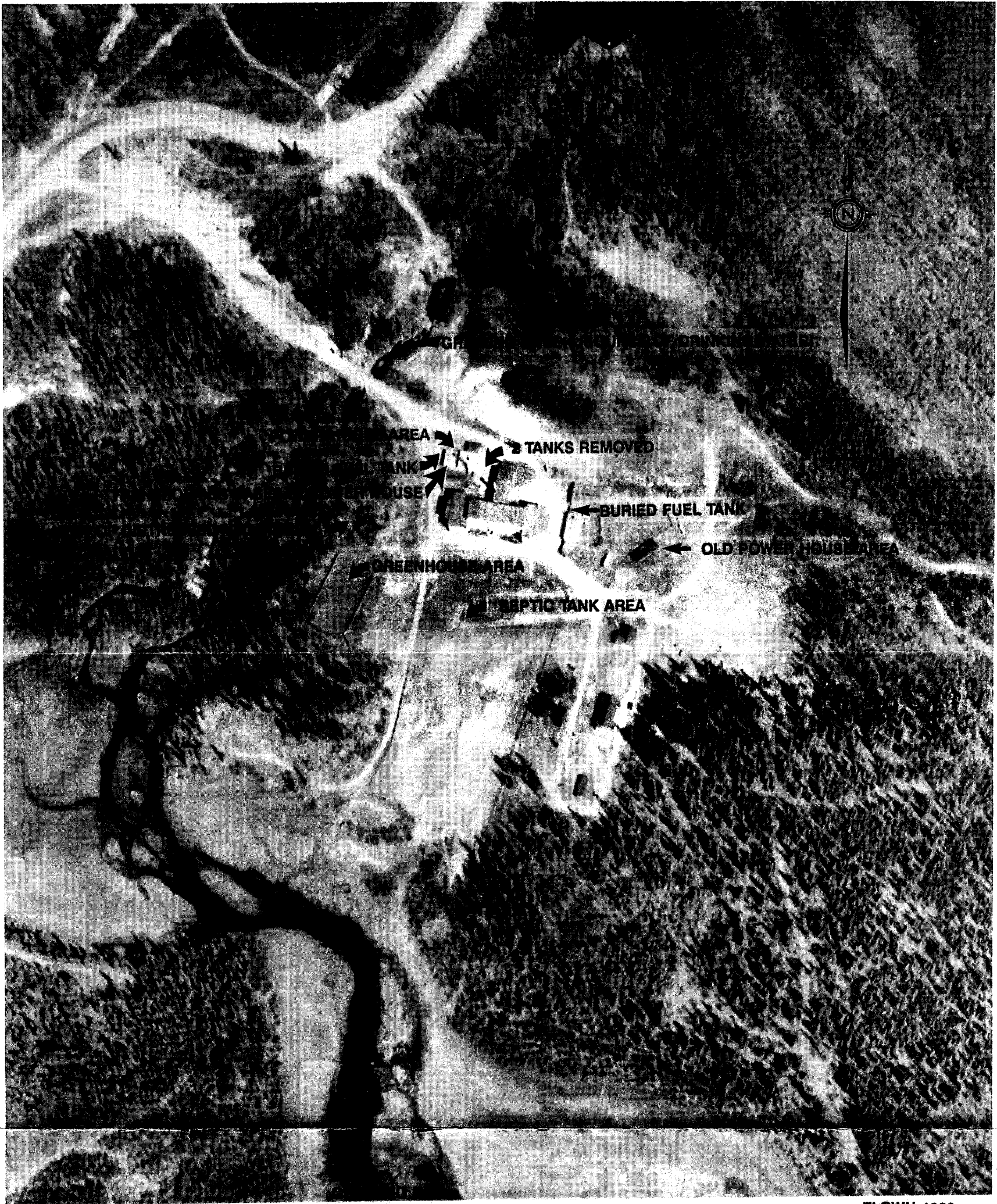
EBA Engineering Consultants Ltd.			PROJECT ENVIRONMENTAL ASSESSMENT CHOULTA SCHOOL SITE, CARCROSS	
CLIENT PUBLIC WORKS CANADA			TITLE GENERAL LOCATION MAP	
DATE 93-03-26	DWN MCP	CHKD	DWG NO. 11151-A-01	0201-11151



APPROXIMATE SCALE 1:2500
(ENLARGED FROM 1:8000 AIRPHOTO)

FLOWN 1980

<i>EBA Engineering Consultants Ltd.</i>			PROJECT	ENVIRONMENTAL ASSESSMENT CHOUTLA SCHOOL, CARCROSS
CLIENT			TITLE	SITE PLAN OF SCHOOL SITE
PUBLIC WORKS CANADA			DATE	93 03 26
DWN.	MCP	CHKD.	FILE NO.	0201-11151
				11151-A-02



FLOWN 1980

APPROXIMATE SCALE 1:2500
(ENLARGED FROM 1:8000 AIRPHOTO)

<i>EBA Engineering Consultants Ltd.</i>			PROJECT	ENVIRONMENTAL ASSESSMENT CHOUTLA SCHOOL, CARCROSS
CLIENT			TITLE	SITE PLAN IDENTIFYING AREAS OF CONCERN
DATE	93-03-26	DWN.	MCP	CHKD.
			FILE NO.	0201-11151
				11151-A-03



FLOWN 1980

APPROXIMATE SCALE 1:2500
(ENLARGED FROM 1:8000 AIRPHOTO)

<i>EBA Engineering Consultants Ltd.</i>			PROJECT	ENVIRONMENTAL ASSESSMENT CHOULTA SCHOOL, CARCROSS
CLIENT			TITLE	SITE PLAN SHOWING BOREHOLE LOCATIONS
DATE	93-03-26	DWN.	MCP	CHKD.
			FILE NO.	0201-11151
				11151-A-04

APPENDIX B
BOREHOLE LOGS AND CLASSIFICATION TEST RESULTS

ENVIRONMENTAL ASSESSMENT		CLIENT: PUBLIC WORKS CANADA		BOREHOLE No: 11151-01					
CHOUTLA INDIAN SCHOOL		DRILL: TRUCK MOUNTED CME 75		Project No: 0201-11151					
CARCROSS, YUKON		UTM ZONE: 8 N6671340.00 E517400.00		ELEVATION: 665.00 (m)					
SAMPLE TYPE		<input checked="" type="checkbox"/> GRAB SAMPLE	<input checked="" type="checkbox"/> NO RECOVERY	<input checked="" type="checkbox"/> STANDARD PEN.	<input type="checkbox"/> 75 mm SPOON	<input type="checkbox"/> CRREL BARREL			
DEPTH (m)	SAMPLE TYPE	SAMPLE NO	USC	SOIL SYMBOL	SOIL DESCRIPTION		<input checked="" type="checkbox"/> STANDARD PENETRATION 10 20 30 40	<input checked="" type="checkbox"/> PERCENT GRAVEL 20 40 60 80	DEPTH (ft)
					PLASTIC M.C. LIQUID ----- ----- ----- 10 20 30 40	<input checked="" type="checkbox"/> PERCENT SAND 20 40 60 80	<input checked="" type="checkbox"/> PERCENT SILT OR FINES 20 40 60 80	<input checked="" type="checkbox"/> PERCENT CLAY 20 40 60 80	
0.0					SILT-clayey, trace of sand, trace of organics, frozen to 0.2 m, moist below seasonal frost, firm, mottled brown and grey				0.0
1.0		1							2.0
2.0									4.0
3.0		2			-becomes wet, medium plastic, soft below 2.5 m; fine sand laminae, mottled grey with brown				6.0
4.0									8.0
5.0		3			SAND-some silt to silty, some gravel, occasional cobbles, damp, dense				10.0
6.0					-siltier with depth				12.0
7.0		4			SAND AND SILT(TILL)-gravelly, occasional cobbles and boulders, tough drilling, damp, medium brown				14.0
8.0									16.0
		5			-refusal in till at 7.5 m				18.0
									20.0
									22.0
									24.0
					END OF BOREHOLE 7.5 m				26.0

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EBA Engineering Consultants Ltd.
Whitehorse, Yukon

LOGGED BY: MCP
REVIEWED BY: JRT
Fig. No:

COMPLETION DEPTH: 7.5 m
COMPLETE: 93/03/09

EBA Engineering Consultants Ltd.

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Environmental Assessment
 Choutla School, Carcross, YT

Project Number: 0201-11151

Date Tested: 1993 03 24

Borehole Number: 11151-01

Depth: 4.0 - 4.5 m and 5.0 - 6.0 m

Soil Description: SILT AND SAND (SM) (TILL) - gravelly,
 trace of clay

Cu: _____

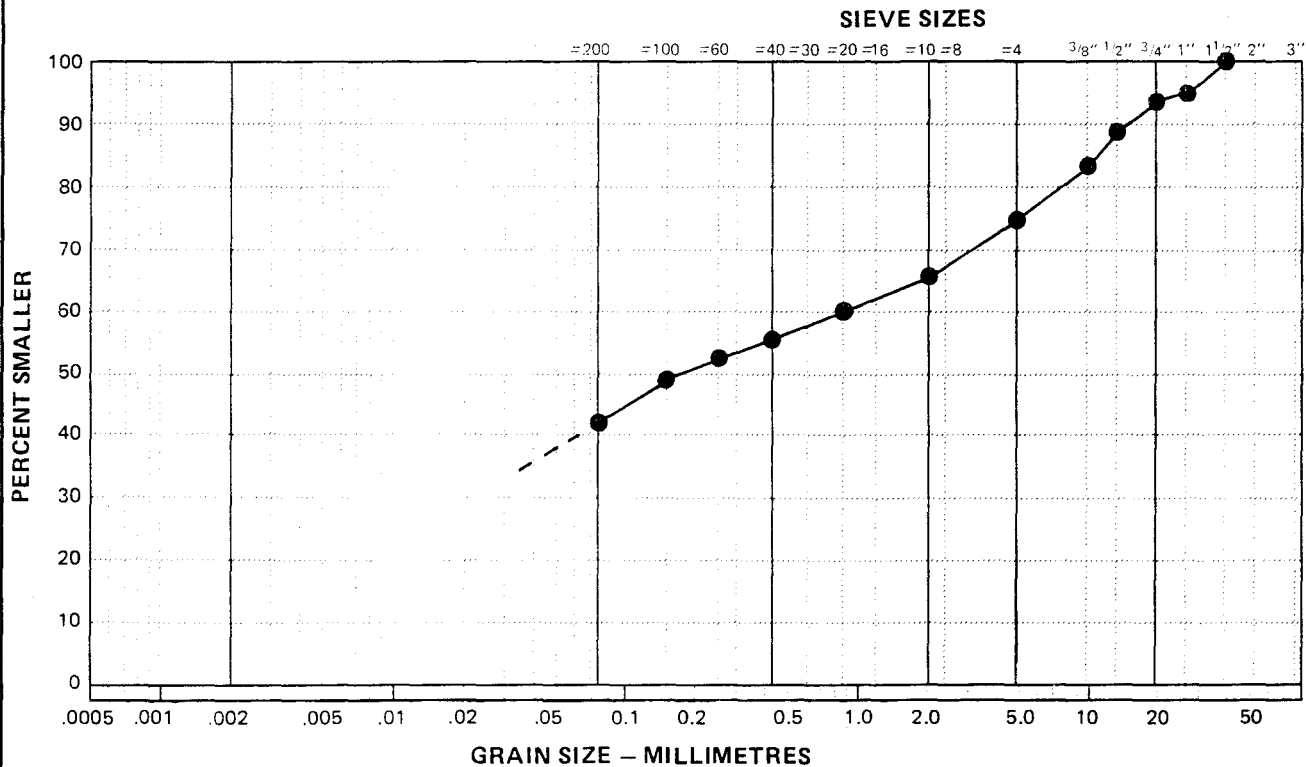
Cc: _____

Natural Moisture Content: 6.8 %

Remarks: Gravel 25.1%
 Sand 32.6%
 Silt 42.3%

SIEVE	PERCENTAGE PASSING
3"	
2"	
1 1/2"	100.0
1"	95.5
3/4"	93.9
3/8"	84.5
No. 4	74.9
No. 10	66.4
No. 20	60.1
No. 40	56.3
No. 60	52.7
No. 100	49.3
No. 200	42.3

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE

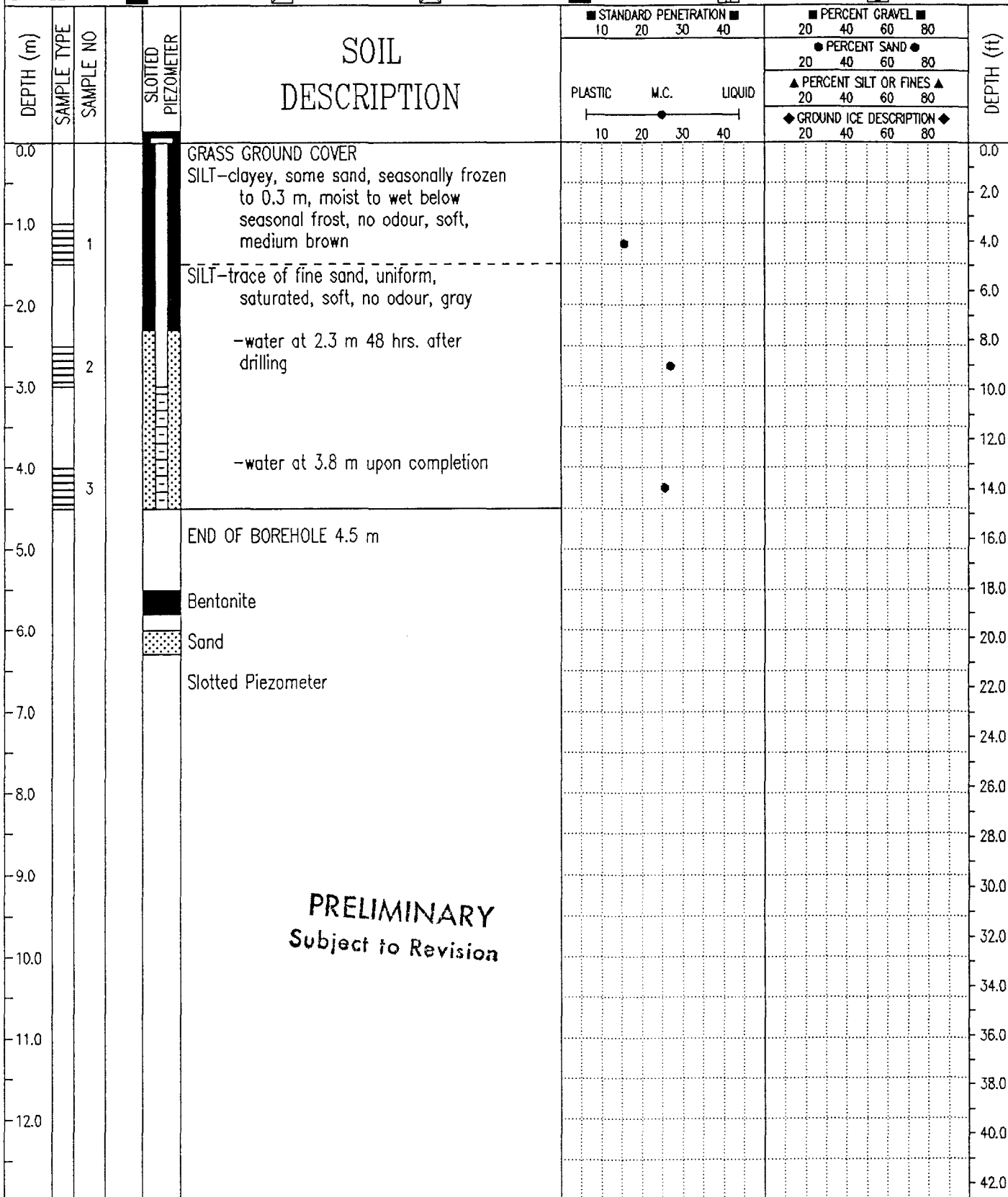


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The testing services reported herein have been performed by an EBA technician to recognized industry standards, unless otherwise noted. No other warranty is made. These data do not include or represent any interpretation or opinion of specification compliance or material suitability. Should engineering interpretation be required, EBA will provide it upon written request.



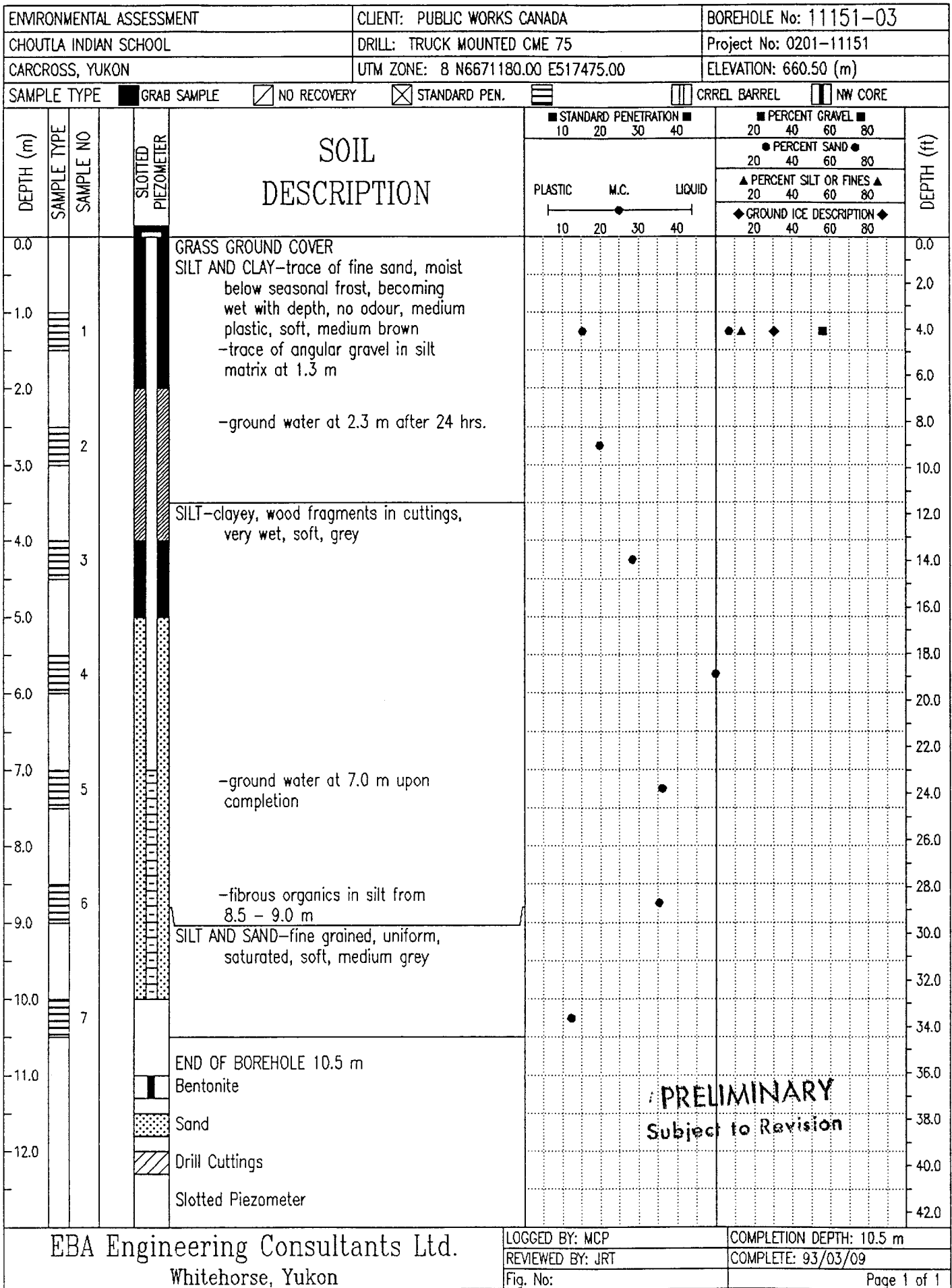
ENVIRONMENTAL ASSESSMENT	CLIENT: PUBLIC WORKS CANADA	BOREHOLE No: 11151-02
CHOUTLA INDIAN SCHOOL	DRILL: TRUCK MOUNTED CME 75	Project No: 0201-11151
CARCROSS, YUKON	UTM ZONE: 8 N6671100.00 E517475.00	ELEVATION: 659.00 (m)
SAMPLE TYPE	<input checked="" type="checkbox"/> GRAB SAMPLE <input type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> STANDARD PEN.	<input type="checkbox"/> CRREL BARREL <input type="checkbox"/> NW CORE



EBA Engineering Consultants Ltd.
Whitehorse, Yukon

LOGGED BY: MCP
REVIEWED BY: JRT
Fig. No:

COMPLETION DEPTH: 4.5 m
COMPLETE: 93/03/09



EBA Engineering Consultants Ltd.

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Environmental Assessment
Choutla School, Carcross YT

Project Number: 0201-11151

Date Tested: 93-03-24

Borehole Number: 11151-03

Depth: 1.0 - 1.5 m

Soil Description: SILT (ML) - gravelly, some sand,
trace of clay

Cu: 9.7

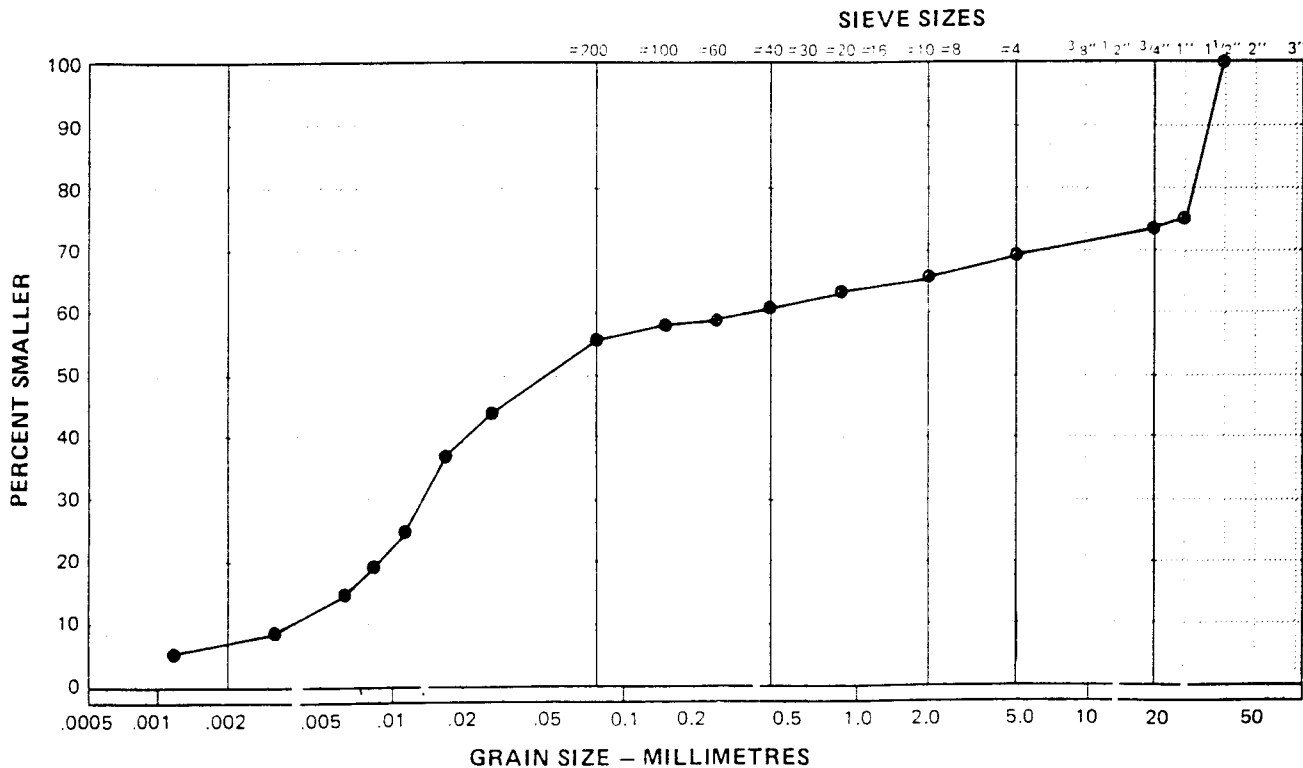
Cc: 18.9

Natural Moisture Content: _____ %

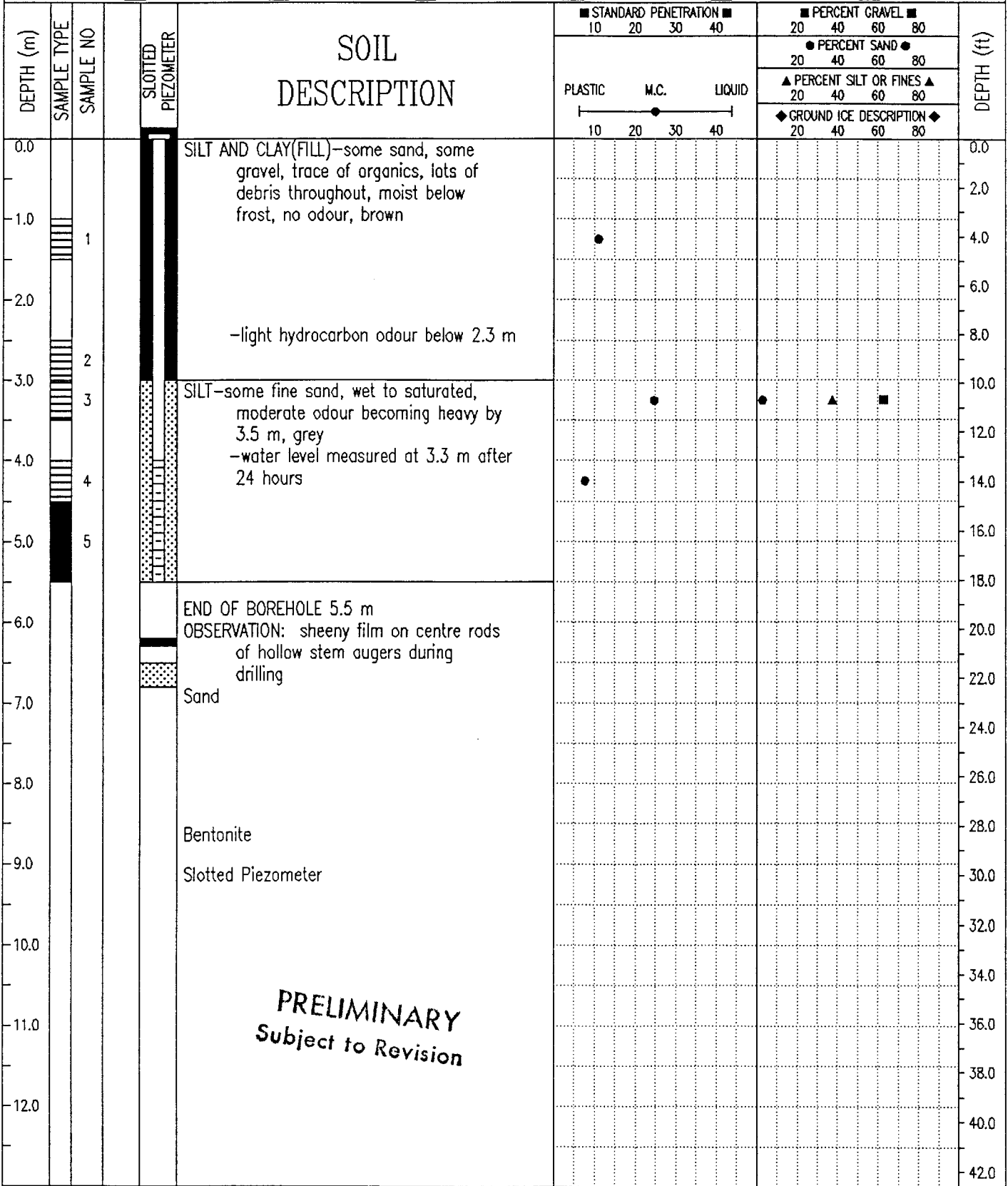
Remarks: Gravel 30.5
Sand 13.4
Silt 49.1
Clay 7.0

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	100.0
1"	75.3
3/4"	73.2
1/2"	73.2
3/8"	73.2
No. 4	69.5
No. 10	66.7
No. 20	63.1
No. 40	60.7
No. 60	59.7
No. 100	58.9
No. 200	56.1

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



ENVIRONMENTAL ASSESSMENT	CLIENT: PUBLIC WORKS CANADA	BOREHOLE No: 11151-04
CHOUTLA INDIAN SCHOOL	DRILL: TRUCK MOUNTED CME 75	Project No: 0201-11151
CARCROSS, YUKON	UTM ZONE: 8 N6671310.00 E517520.00	ELEVATION: 662.40 (m)
SAMPLE TYPE	<input checked="" type="checkbox"/> GRAB SAMPLE <input checked="" type="checkbox"/> NO RECOVERY <input checked="" type="checkbox"/> STANDARD PEN. <input type="checkbox"/> CRREL BARREL <input type="checkbox"/> NW CORE	



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EBA Engineering Consultants Ltd. Whitehorse, Yukon	LOGGED BY: MCP	COMPLETION DEPTH: 5.5 m
	REVIEWED BY: JRT	COMPLETE: 93/03/10
	Fig. No:	Page 1 of 1

EBA Engineering Consultants Ltd.

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Environmental Assessment
Choutla School, Carcross YT

Project Number: 0201-11151

Date Tested: 93-03-24

Borehole Number: 11151-04

Depth: 3.0 m

Soil Description: SILT (ML) AND SAND - trace of clay

Cu: 7.8

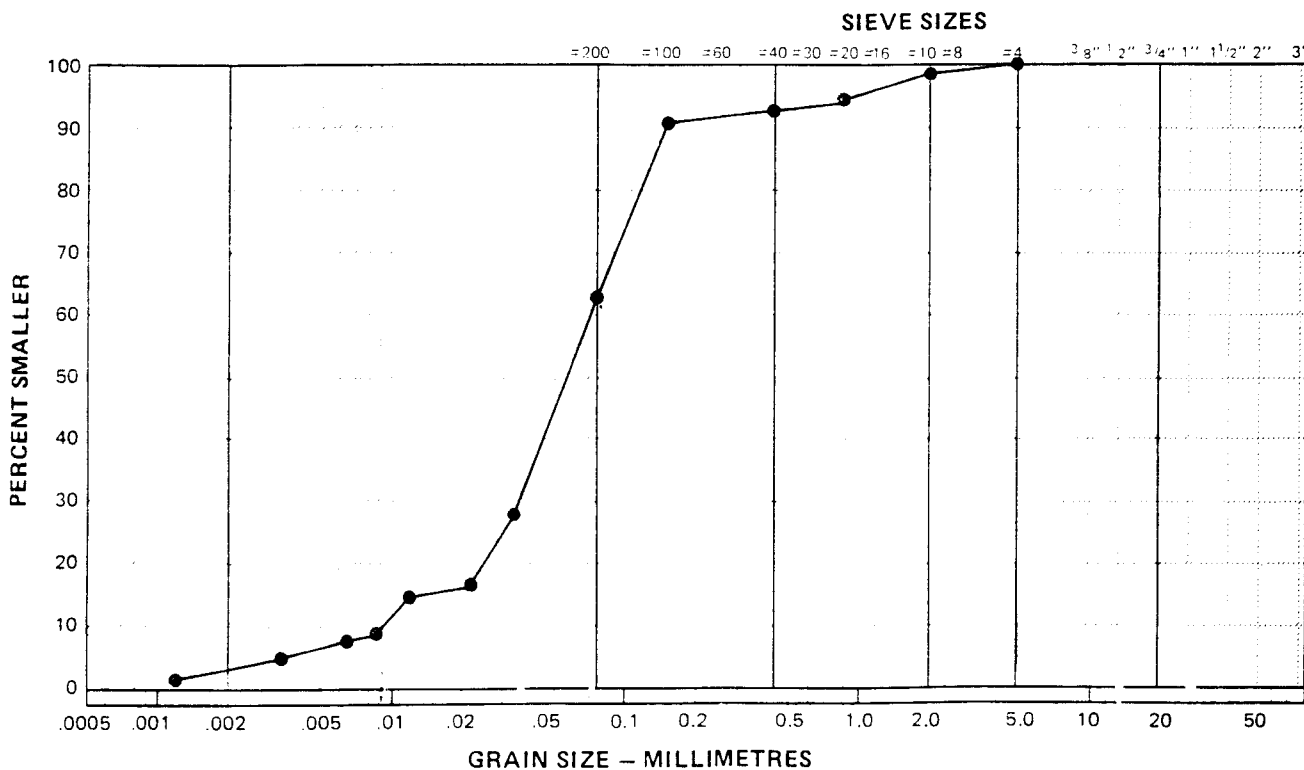
Cc: 2.1

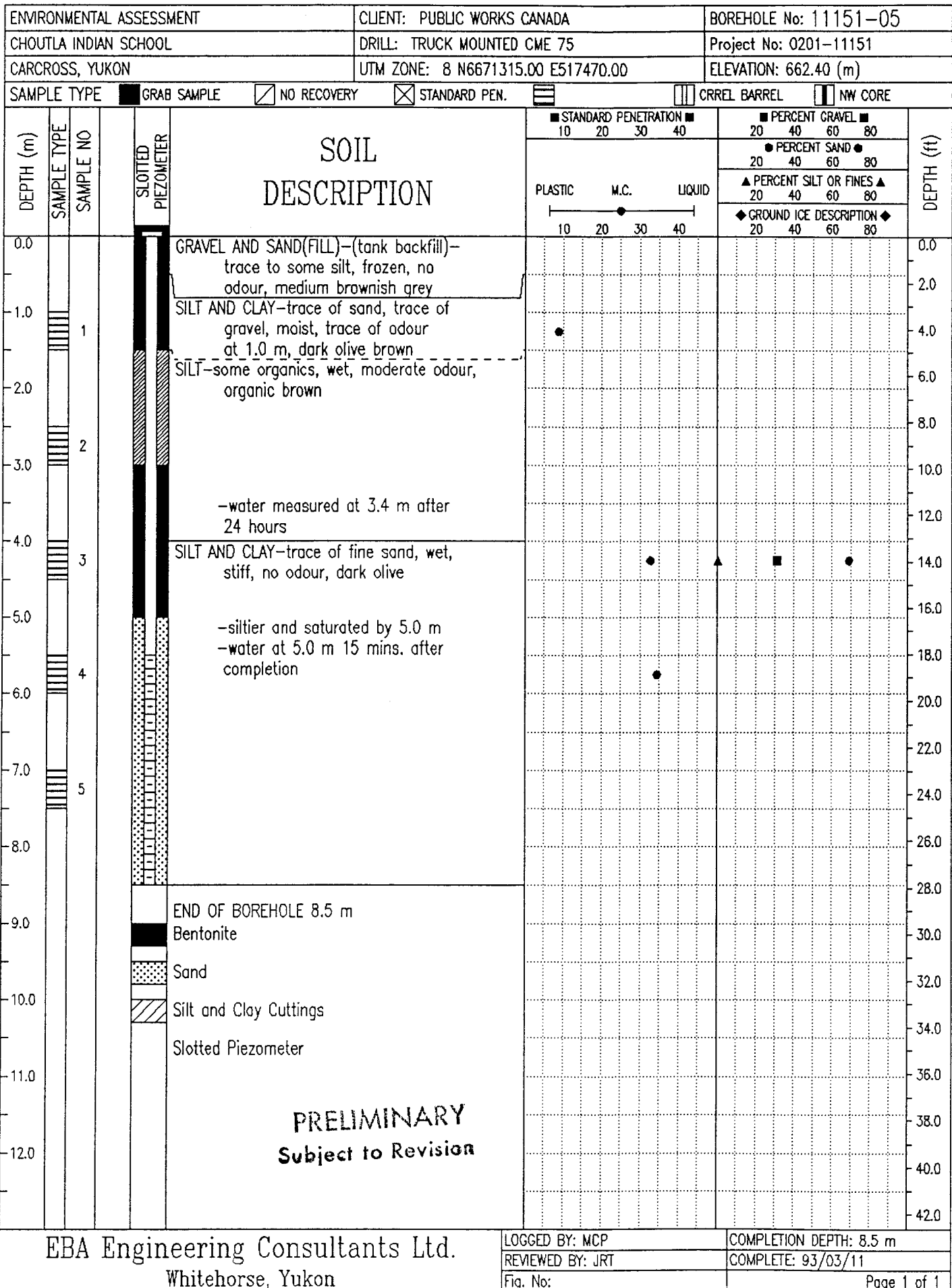
Natural Moisture Content: _____ %

Remarks: Sand 37.4%
Silt 62.6%
Clay 3.0%

SIEVE	PERCENTAGE PASSING
3"	
1 1/2"	
1"	
3/4"	
1/2"	
3/8"	
No. 4	100.0
No. 10	98.2
No. 20	95.4
No. 40	93.4
No. 60	93.4
No. 100	90.8
No. 200	62.6

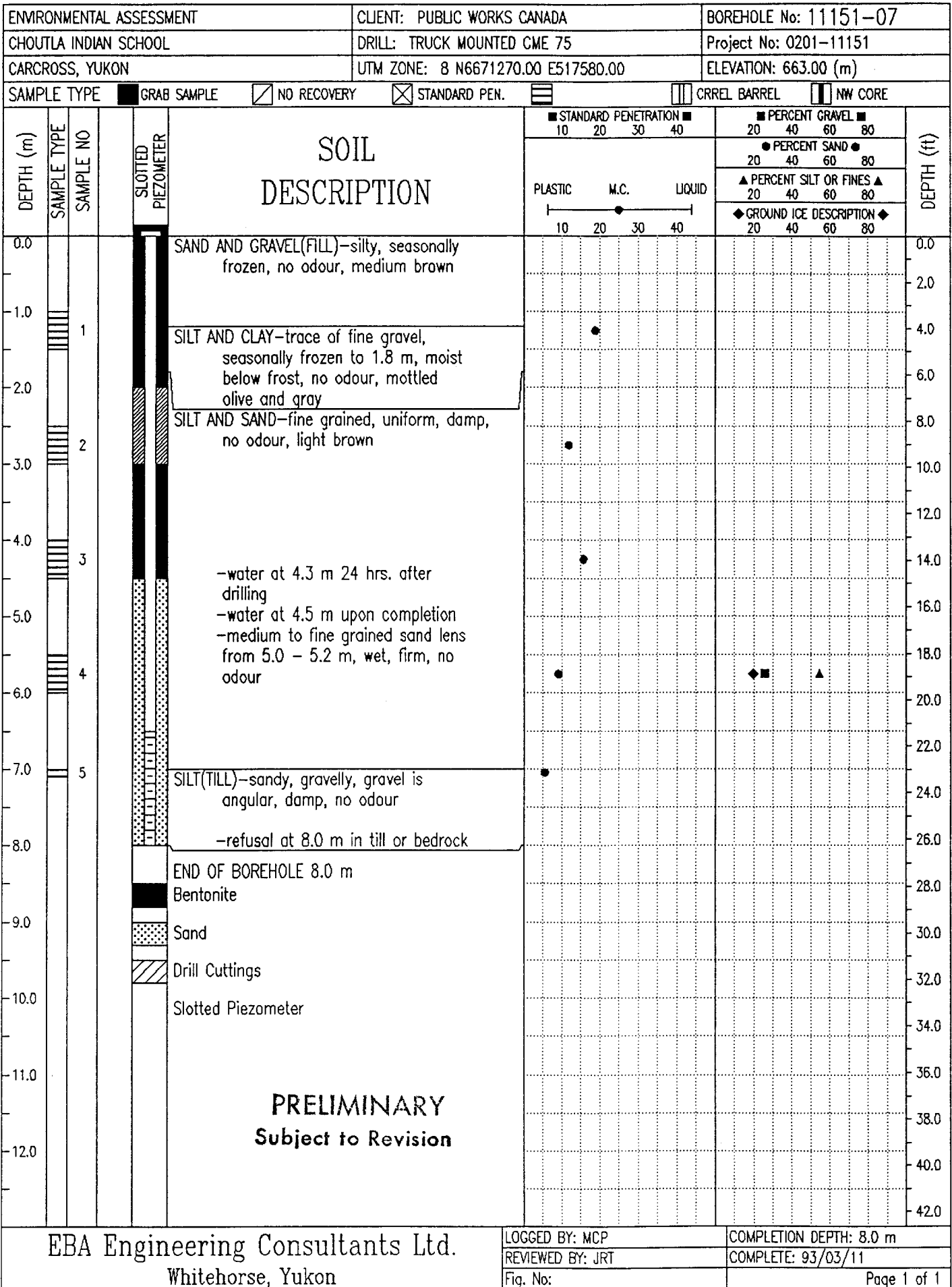
CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE





ENVIRONMENTAL ASSESSMENT		CLIENT: PUBLIC WORKS CANADA		BOREHOLE No: 11151-06				
CHOUTLA INDIAN SCHOOL		DRILL: TRUCK MOUNTED CME 75		Project No: 0201-11151				
CARCROSS, YUKON		UTM ZONE: 8 N6671280.00 E517480.00		ELEVATION: 662.40 (m)				
SAMPLE TYPE		<input checked="" type="checkbox"/> GRAB SAMPLE	<input type="checkbox"/> NO RECOVERY	<input checked="" type="checkbox"/> STANDARD PEN.	<input type="checkbox"/> CRREL BARREL	<input type="checkbox"/> NW CORE		
DEPTH (m)	SAMPLE TYPE	SAMPLE NO	SLOTTED PIEZOMETER	SOIL DESCRIPTION		<input checked="" type="checkbox"/> STANDARD PENETRATION 10 20 30 40	<input checked="" type="checkbox"/> PERCENT GRAVEL 20 40 60 80	DEPTH (ft)
						PLASTIC M.C. LIQUID 10 20 30 40	<input checked="" type="checkbox"/> PERCENT SAND 20 40 60 80	
0.0				GRAVEL AND SAND—surfacing				0.0
1.0		1		SILT—sandy, some clay, trace of gravel, frozen to 0.3 m, moist below, firm, no odour, medium brown				2.0
2.0		2		SILT AND CLAY—moist, very stiff, no odour, mottled olive and grey				4.0
3.0		3		SAND—silty, trace of fine gravel, damp, loose, medium brown (no odour)				6.0
4.0		4		SILT AND CLAY—trace of fine sand, wet and soft by 2.8 m, no odour, mottled olive and grey —water table at 3.3 m after 24 hours				8.0
5.0				SILT—sandy, sand is fine grained, uniform, saturated, trace of odour below water table, olive brown				10.0
6.0				END OF BOREHOLE 5.5 m				12.0
7.0				Bentonite				14.0
8.0				Sand				16.0
9.0				Drill Cuttings				18.0
10.0				Slotted Piezometer				20.0
11.0								22.0
12.0								24.0
								26.0
								28.0
								30.0
								32.0
								34.0
								36.0
								38.0
								40.0
								42.0
EBA Engineering Consultants Ltd. Whitehorse, Yukon				LOGGED BY: MCP	REVIEWED BY: JRT	Fig. No:	COMPLETION DEPTH: 5.5 m	COMPLETE: 93/03/11
							Page 1 of 1	

PRELIMINARY
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EBA Engineering Consultants Ltd.

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Environmental Assessment
Choutla School, Carcross, YT

Project Number: 0201-11151

Date Tested: 1993 03 24

Borehole Number: 11151 - 07

Depth: 7.0 - 7.5 m

Soil Description: SAND (TILL) (SM) - silty, some gravel

Cu: _____

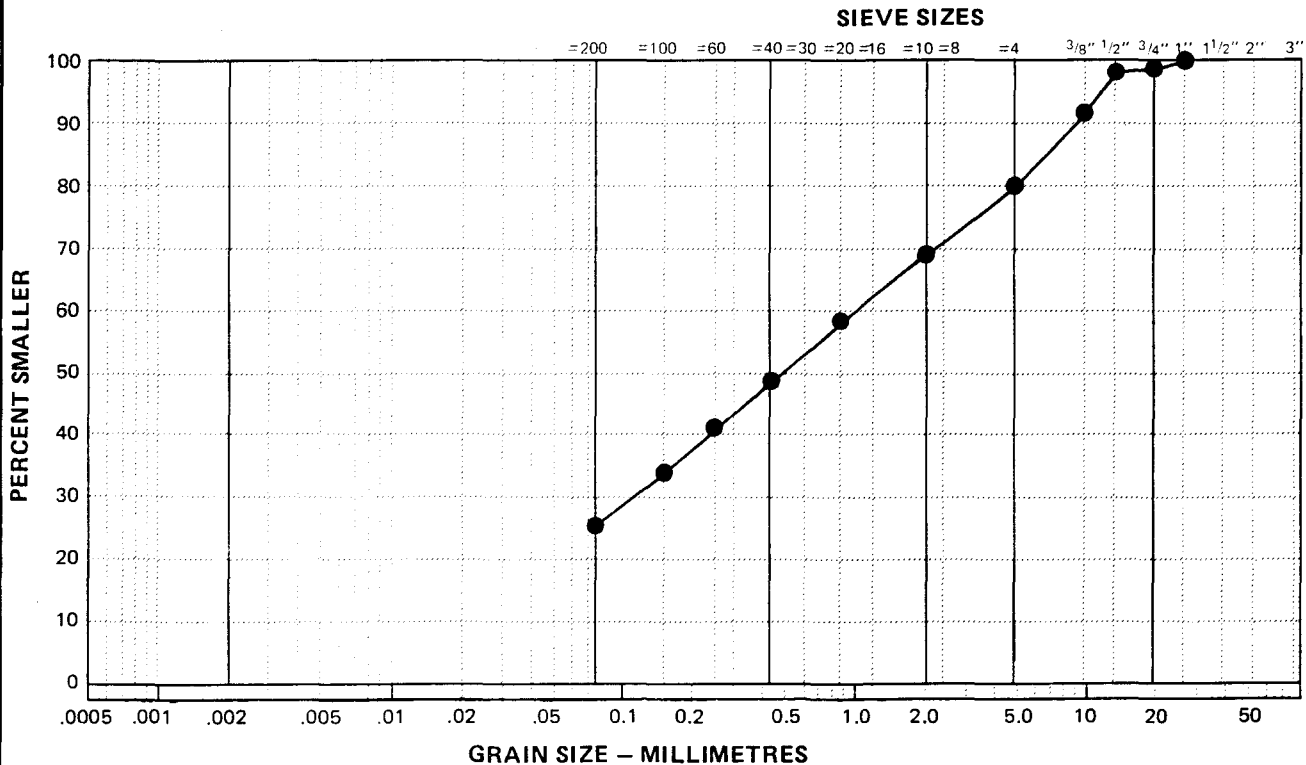
Cc: _____

Natural Moisture Content: 9.1 %

Remarks: Gravel 19.7%
Sand 54.5%
Silt 25.8%

SIEVE	PERCENTAGE PASSING
3"	
2"	
1 1/2"	
1"	100.0
3/4"	98.5
3/8"	91.9
No. 4	80.3
No. 10	68.6
No. 20	57.6
No. 40	48.3
No. 60	40.7
No. 100	34.0
No. 200	25.8

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



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The testing services reported herein have been performed by an EBA technician to recognized industry standards, unless otherwise noted. No other warranty is made. These data do not include or represent any interpretation or opinion of specification compliance or material suitability. Should engineering interpretation be required, EBA will provide it upon written request.

ENVIRONMENTAL ASSESSMENT			CLIENT: PUBLIC WORKS CANADA			BOREHOLE No: 11151-08								
CHOUTLA INDIAN SCHOOL			DRILL: TRUCK MOUNTED CME 75			Project No: 0201-11151								
CARCROSS, YUKON			UTM ZONE: 8 N6671270.00 E517520.00			ELEVATION: 662.40 (m)								
SAMPLE TYPE			<input type="checkbox"/> GRAB SAMPLE	<input checked="" type="checkbox"/> NO RECOVERY	<input checked="" type="checkbox"/> STANDARD PEN.	<input type="checkbox"/> 75 mm SPOON	<input type="checkbox"/> CRREL BARREL	<input type="checkbox"/>						
DEPTH (m)	SAMPLE TYPE	SAMPLE NO	USC	SOIL SYMBOL	SOIL DESCRIPTION	STANDARD PENETRATION				PERCENT GRAVEL				DEPTH (ft)
						10	20	30	40	20	40	60	80	
						PLASTIC M.C. LIQUID ----- ----- ----- 10 20 30 40				● PERCENT SAND ● 20 40 60 80 ▲ PERCENT SILT OR FINES ▲ 20 40 60 80 ◆ PERCENT CLAY ◆ 20 40 60 80				
0.0					GRAVEL AND SAND-silty, trace of clay, wood and other debris in top 1.0 m, moist below seasonal frost, no odour, medium brown									0.0
1.0														2.0
2.0					SILT AND CLAY-wet, firm to soft with depth, trace to light odour, brown becoming olive and gray at 2.5 m									4.0
3.0		1			-becomes grey and very soft at 3.0 m, light colour									6.0
4.0		2												8.0
5.0														10.0
6.0		3												12.0
7.0														14.0
														16.0
														18.0
														20.0
														22.0
END OF BOREHOLE 6.0 m NOTE: Borehole drilled with solid shaft augers to delineate soil interfaces -No well installed														
EBA Engineering Consultants Ltd. Whitehorse, Yukon						LOGGED BY: MCP			COMPLETION DEPTH: 6.0 m					
						REVIEWED BY: JRT			COMPLETE: 93/03/11					
						Fig. No:			Page 1 of 1					

ENVIRONMENTAL ASSESSMENT				CLIENT: PUBLIC WORKS CANADA				BOREHOLE No: 11151-09						
CHOUTLA INDIAN SCHOOL				DRILL: HAND AUGER				Project No: 0201-11151						
CARCROSS, YUKON				UTM ZONE: 8 N6671240.00 E517440.00				ELEVATION: 659.40 (m)						
SAMPLE TYPE				<input type="checkbox"/> GRAB SAMPLE		<input checked="" type="checkbox"/> NO RECOVERY		<input checked="" type="checkbox"/> STANDARD PEN.		<input type="checkbox"/> CRREL BARREL				
DEPTH (m)	SAMPLE TYPE	SAMPLE NO	USC	SOIL SYMBOL	SOIL DESCRIPTION	STANDARD PENETRATION				PERCENT GRAVEL				DEPTH (ft)
						10	20	30	40	20	40	60	80	
						PLASTIC M.C. LIQUID -----●----- 10 20 30 40				● PERCENT SAND ● 20 40 60 80 ▲ PERCENT SILT OR FINES ▲ 20 40 60 80 ◆ PERCENT CLAY ◆ 20 40 60 80				
0.0					ICE—surface water frozen to ground level, ice has organic odour ORGANICS—peat, saturated, black, no odour									0.0
					SILT—sandy, gravelly, gravel is angular, saturated, no odour, medium brown									2.0
-1.0		1			END OF BOREHOLE 0.9 m									4.0
														6.0
2.0														
PRELIMINARY <i>Subject to Revision</i>						LOGGED BY: MCP				COMPLETION DEPTH: 0.9 m				
						REVIEWED BY: JRT				COMPLETE: 93/03/11				
						Fig. No:				Page 1 of 1				
EBA Engineering Consultants Ltd.						Whitehorse, Yukon								

APPENDIX C
ENVIRONMENTAL TEST RESULTS,
SUMMARY TABLES,
FORMAL TEST RESULTS

TABLE 1

HYDROCARBON VAPOUR EMISSION TEST RESULTS
CHOUTLA SCHOOL - CARCROSS , YUKON

Jar No.	Borehole No.	Depth (m)	Vapour Readings P.P.M.	Remarks
1	11151-04	4.0 - 4.3	30	Moderate Odour
2	11151-04	4.3 - 5.0	30	Moderate Odour
3	11151-05	2.5 - 3.0	85	Moderate Odour
4	11151-06	4.0 - 4.5	0	Trace of Odour
5	11151-08	5.8 - 6.0	0	Light Odour
6	11151-08	4.0 - 4.5	0	Light Odour
7	11151-08	2.5 - 2.7	0	Light Odour

- All samples from vicinity of power house structure
- Tests performed with GASTEC Model 801 Pump using GASTEC 101L Analyzer Tubes

TABLE 2

SAMPLE SUMMARY AND CHEMICAL TESTING PROGRAM
CHOUTLA SCHOOL SITE - CARCROSS, YUKON

Test Performed	Soil Samples	Water Samples
Total Metals	<ul style="list-style-type: none"> ● Composite of BH 11151-01 samples ● Composite of BH;s 11151-04, -05, -06 soil samples ● BH 11151-09 -- 0.8 m depth 	<ul style="list-style-type: none"> ● Composite water sample from BH's 11151-04, -05, -06 ● BH 11151-09 -- composite of melted ice and ground water ● Upstream water sample from Grayling Creek
BTEX, Total Extractables, Total Purgeables	<ul style="list-style-type: none"> ● BH 11151-04 at 4.0 - 4.5 m ● BH 11151-06 at 4.0 - 4.5 m ● BH 11151-08 at 5.8 - 6.0 m 	<ul style="list-style-type: none"> ● BH 11151-04 ● Composite water from BH's 11151-05 & -06
Volatile Target Compounds	<ul style="list-style-type: none"> ● BH 11151-05 at 2.5 - 3.0 m 	<ul style="list-style-type: none"> ● Composite from BH's 11151-04,-05, and -06
Mineral Oil and Grease		<ul style="list-style-type: none"> ● Mouth of Grayling Creek
PCB	<ul style="list-style-type: none"> ● Soil/Sludge from transformer bases in power house 	
Total and Faecal Coliforms		<ul style="list-style-type: none"> ● Mouth of Grayling Creek ● BH 11151-03
O.C. Pesticides		<ul style="list-style-type: none"> ● BH 11151-02 (Down Gradient Hole)

Notes: BTEX refers to Benzene, Toluene, Ethylbenzene and Xylenes
 OC Pesticides refers to Organo-Chlorine Pesticides
 PCB refers to Polychlorinated Biphenyls
 Volatile Target Compounds will include halogenated and nonhalogenated compounds

TABLE 3

INORGANIC PARAMETERS (METALS)
CHOUTLA SCHOOL - CARCROSS, YUKON

ICP Metals	Water Samples (values in mg/L)			BC Cleanup Criteria (Water)			Soil Samples (values in µg/gm)			BC Cleanup Criteria (Soil)		
	Composite BH 4,5,6	Composite BH 9	Upstream Grayling Creek	A*	B _{dw} *	B _{as} *	Composite BH 4,5,6	BH 9 0.8 m	Composite BH 1	A**	B**	C**
Aluminum	13.8	0.7	0.08				12 800	16 100	16 500			
Barium	0.295	0.028	0.016	.005	0.05	0.05	153	82	179	200	500	2 000
Beryllium	<0.001	<0.001	<0.001				0.8	0.7	1.0			
Boron	0.14	0.21	0.07									
Cadmium	<0.003	<0.003	<0.003	.001	0.005	0.005	0.3	<0.3	0.3	1.0	5.0	20.0
Calcium	150	31.7	51.7				28 800	5 920	26 300			
Chromium	<0.01	<0.01	<0.01	0.015	0.05	0.05	27.8	23.9	27.5			
Cobalt	<0.01	<0.01	<0.01	0.01		0.05	10.0	12.0	13.0	15	50	300
Copper	0.02	<0.01	<0.01	0.025	1.00	0.10	26.1	58.5	43.8	30	100	500
Iron	16.8	1.38	0.07				21 000	37 200	28 200			
Lead	<0.04	<0.04	<0.04	0.01	0.05	0.05	8.0	7.0	13.0	50	500	1 000
Magnesium	42.3	4.90	7.26				8 480	11 600	10 300			
Manganese	1.57	0.150	0.008				442	628	602			
Molybdenum	<0.02	<0.02	<0.02	0.005		0.5	<2.0	<2.0	<2.0	4.0	10.0	40.0
Nickel	0.03	0.03	0.03	0.01		0.5	20	32	24			
Phosphorous	0.8	<0.1	<0.1				649	888	713			
Potassium	6.0	<1.0	<1.0				1 710	1 240	1 910			
Silicon	17.9	3.46	4.58									
Silver	<0.05	<0.05	<0.05	0.005	0.05	0.05				2.0	20.0	40.0
Sodium	33.0	3.0	4.0				500	210	485			
Titanium	0.936	0.022	<0.003									
Thallium	<0.10	<0.10	<0.10									
Vanadium	0.044	0.004	0.007									
Zinc	0.090	0.058	0.019	0.05	5.00	0.20	60.9	98.6	77.9	80	500	1 500

* Water: A - Remediation not required B_{dw} - Drinking water remediation criteria B_{as} - Aquatic life remediation criteria

** Soil: A - Remediation not required B - Residential recreational or agricultural remediation levels C - Industrial Remediation Levels

TABLE 4

**ORGANIC PARAMETERS
CHOUTLA SCHOOL - CARCROSS, YUKON**

	Water Samples (values in μL unless otherwise noted)					BC Clean-Up Criteria Water ($\mu\text{g/L}$)			Soil Samples (values in $\mu\text{g/g}$) unless otherwise noted					CCME Clean-up Criteria Soil ($\mu\text{g/g}$)		
	Mouth of Grayling Creek	BH 3 Near Septic Tank	BH 2 Down Gradient	BH 4	Composite BH's 5 & 6	A*	B _{DW} *	B _{DS} *	BH 4 4.0 - 4.5 m	BH 6 4.0 - 4.5 m	BH 8 5.8 - 6.0 m	BH 5 2.5 - 3.0 m	Power House Transformer Bases	Agric.	Res./ Parkland	Comm./ Inst.
Mineral Oil and Grease	<0.2 mg/L					100										
Total Purgeables				N.D.	N.D.				N.D.	N.D.	0.41					
Total Extractables				13000	290				2300	N.D.	N.D.					
Benzene				8.1	7.5	0.5	5.0†	0.5	N.D.	0.019	N.D.			0.05	0.5	5.0
Toluene				1.9	0.3	0.5	2.4†		0.007	0.026	0.007			0.1	3.0	30
Ethyl Benzene				1.1	9.2	0.5	2.4†		0.091	0.045	0.091			0.1	5.0	50
Xylenes				72.0	2.3	0.5	300†		0.29	0.22	0.29			0.1	5.0	50
Polychlorinated Biphenyl Analysis												130 ppm Aroclor 1260	0.5	5.0	50	
Organo Chlorine Pesticides			Not Detected (see formal test results)													
Fecal Coliforms	<2 CFU100mL	<2 CFU100mL				10 CFU100mL (Cdn. Drinking Water)										
Total Coliforms	13 CFU100mL	<2 CFU100mL														
Volatiles Target Compounds in Water and Soil				Composite of BH's 4, 5, & 6 (see formal test results)								(see formal test results)				

* Water Clean-up Criteria: A - Remediation not required
 B_{DW} - Drinking water remediation levels
 B_{DS} - Aquatic life remediation levels

† C.C.M.E. Drinking Water Remediation Criteria

EBA Engineering
Consultants Ltd.
WHITEHORSE
APR 30 1993



RECEIVED

CHEMICAL ANALYSIS REPORT

EBA ENGINEERING CONSULTANTS
3167 - 3 AVENUE
WHITEHORSE, YUKON
Y1A 1G4

DATE: April 21, 1993

ATTN: MYLES PLAUNT

Lab Sample #: E3-03-216 (Revision) Sampled By: Client

Customer #: 0201-11151 Date Received: March 16, 1993

Analysis Date: March 20, 1993

Sample Description: 2 water and 3 soil samples for benzene, toluene, ethylbenzene, xylenes, total purgeables and total extractables analysis; 1 soil for PCB analysis; 1 soil and 1 water sample for volatiles analysis; 1 water for organochlorine analysis; and 3 soils and 6 waters for inorganics analysis.

PART 1A: UNDERGROUND STORAGE TANK WATER RESULTS:

LAB SAMPLE #	SAMPLE I.D.	RESULTS ($\mu\text{g/L}$ or ppb)				Total Purgeables	Total Extractables
		Benzene	Toluene	Ethyl Benzene	Xylenes		
E3-03-216-17	BH4	8.1	1.9	1.1	72	N.D.	13000 ¹
E3-03-216-18	BH#5-6	7.5	0.3	9.2	2.3	N.D.	290 ²
Detection Limits -		0.5	0.5	0.5	0.5	100	50

N.D. - None Detected, less than detection limit.

E3-03-216 (cont'd.)

PART 1B: UNDERGROUND STORAGE TANK SOIL RESULTS:

LAB SAMPLE #	SAMPLE I.D.	RESULTS ($\mu\text{g/g}$ or ppm)*					
		Benzene	Toluene	Ethyl Benzene	Xylenes	Total Purgeables	Total Extractables
E3-03-216-04	BH4 @ 4-4.5M	N.D.	0.007	0.091	0.29	N.D.	2300 ¹
E3-03-216-05	BH6 @ 4-4.5M	0.019	0.026	0.045	0.22	N.D.	N.D.
E3-03-216-03	BH8 @ 5.8-6M	N.D.	0.007	0.091	0.29	0.41	N.D.
Detection Limits -		0.005	0.005	0.005	0.005	0.10	5.0

* Results are reported on a dry weight basis.

N.D.- Not Detected; less than detection limit.

1.GC/FID analysis of extractables showed components in the $\text{C}_9\text{-C}_{20}$ carbon range indicative of diesel.

2.GC/FID analysis of extractables showed components in the $\text{C}_7\text{-C}_{12}$ carbon range with no discernible pattern.

Total Extractables: This result is a summation of the hydrocarbon concentration from the C_7 to C_{30} carbon range (including toluene, ethylbenzene, xylenes) and is calculated against a calibrated diesel or gasoline standard.

E3-03-216 (cont'd.)

PART 2: TOTAL PURGEABLES:

This semi-quantitative result is a summation from the C₃ to C₆ carbon range (including benzene) and is calculated against a calibrated gasoline standard.

BTEX METHOD REFERENCE: EPA SW 846 METHOD-5030/8015 AND 8020

TOTAL EXTRACTABLE METHOD REFERENCE: EPA SW 846 METHOD-3550 OR 3580/8000

<u>LAB SAMPLE #</u>	<u>SAMPLE I.D.</u>	<u>% MOISTURE</u>
E3-03-216-01	BH4 @4-4.5	7.7
E3-03-216-02	BH6 @4-4.5	21.5
E3-03-216-03	BH8 @5.8-6	25.2

Note: Percent moisture is expressed as a percentage of the total wet weight as received.

QA/QC:

<u>TEST</u>	<u>ACCURACY</u>	<u>PRECISION</u>
BTEX (SOIL)	86%	± 18%
BTEX (WATER)	98%	± 10%
TOTAL EXTRACTABLES (WATER)	87%	± 19%
TOTAL EXTRACTABLES (SOIL)	95%	± 21%

Note: Accuracy is expressed as the average % recovery and Precision as the relative standard deviation (RSD) of fortifications made using certified reference standards (B.T.E.X.) and in-house standards (total extractables).

E3-03-216 (cont'd.)

PART 3: POLYCHLORINATED BIPHENYL ANALYSIS**METHOD OVERVIEW:**

The submitted material was weighed into culture tubes and 25 mL of extraction solvent was added to each. The tubes were sealed, shaken and sonicated for a total time of 1 hour. An aliquot was removed from each and cleaned up with concentrated H₂SO₄ prior to analysis. All extracts were spiked with an internal standard prior to analysis by gas chromatography/electron capture detection (GC/ECD). This was a total Aroclor analysis.

RESULTS:

TABLE 1. Polychlorinated biphenyl analysis (PCB) by GC/ECD

<u>LAB SAMPLE #</u>	<u>SAMPLE I.D.</u>	<u>RESULTS ($\mu\text{g/g}$ or ppm)</u>
E3-03-216-08A	POWER HOUSE FLOOR	130 ppm Aroclor 1260
METHOD BLANK		N.D.

N.D. - Not Detected, less than the MDL.

Minimum Quantifiable Level (MQL) - 0.10 ppm for all Aroclors.

Minimum Detection Limit (MDL) - 0.030 ppm for all Aroclors.

QA/QC STATEMENT:

Accuracy is 99% (expressed as the average % recovery of PCB in soil at a 5 ppm level).

Precision is $\pm 15\%$ (expressed as the relative standard deviation or RSD).

EXTRACTION METHOD: EPA 3550 (Modified)

ANALYTICAL METHOD: EPA 8080 (Modified)

E3-03-216 (cont'd.)

PART 4: ORGANOCHLORINE ANALYSIS

LAB SAMPLE #: E3-03-216-14A

SAMPLE I.D.: BH #2 DOWNGRADIENT WELL

	RESULTS $\mu\text{g/L}$	DETECTION LIMIT	QA/QC:
			% SPIKE RECOVERY
HCB	N.D.	0.050 ppb	108
α BHC	N.D.	0.050 ppb	104
β BHC	N.D.	0.050 ppb	104
γ BHC	N.D.	0.050 ppb	120
RONNEL	N.D.	0.050 ppb	119
Heptachlor Epoxide	N.D.	0.050 ppb	103
DDE	N.D.	0.050 ppb	91
DIELDRIN	N.D.	0.050 ppb	98
DDD	N.D.	0.050 ppb	105
DDT	N.D.	0.050 ppb	93
Methoxychlor	N.D.	0.050 ppb	85

N.D. - Not Detected

METHOD OVERVIEW:

The water sample was extracted with Dichloromethane, concentrated, and analyzed by GC/ECD.

NOTE: A peak at the retention time of DDT was found but DDT could not be confirmed at this level. (0.2 ppb)

PART 5A: EPA 624 VOLATILES IN WATER**OVERVIEW:**

A 15 mL portion of the sample was poured into a 20 mL headspace vial and sealed with a teflon-lined septum. The sample was spiked with three surrogate compounds and three internal standard compounds to monitor the headspace extraction efficiency and system performance. A method blank was prepared along with the sample to account for any background contamination. Analysis was performed using an automated headspace extractor interfaced to a capillary gas chromatograph equipped with a mass selective detector (GC/MSD) in selected ion monitoring (SIM) mode. The sample was quantitated using a multi-point calibration curve and an internal standards method of calculation.

E3-03-216 (cont'd.)

RESULTS:

Enviro-Test Sample Number: E3-03-216-15A Customer Sample Identifier: BH4 (BH5-BH6 COMPOSITE)

<u>COMPOUND IDENTIFIED:</u>	<u>CONCENTRATION:(μg/L-ppb)</u>	<u>DETECTION LIMIT:(μg/L-ppb)</u>
Benzene	6.9	1
Bromodichloromethane	N.D.	1
Bromoform	N.D.	1
Bromomethane	N.D.	10
Carbon tetrachloride	N.D.	1
Chlorobenzene	N.D.	1
Chloroethane	N.D.	10
2-Chloroethyl vinyl ether	N.D.	5
Chloroform	N.D.	1
Dibromochloromethane	N.D.	1
1,2-Dichlorobenzene	3.2	1
1,3-Dichlorobenzene	N.D.	1
1,4-Dichlorobenzene	N.D.	1
1,1-Dichloroethane	N.D.	1
1,2-Dichloroethane	N.D.	1
1,1-Dichloroethene	N.D.	1
trans-1,2-Dichloroethene	N.D.	1
1,2-Dichloropropane	N.D.	1
cis-1,3-Dichloropropene	N.D.	1
trans-1,3-Dichloropropene	N.D.	1
Ethylbenzene	18	1
Methylene Chloride	N.D.	1
Styrene	N.D.	1
1,1,2,2-Tetrachloroethane	N.D.	5
Tetrachloroethene	N.D.	1
Toluene	N.D.	1
1,1,1-Trichloroethane	1.6	1
1,1,2-Trichloroethane	N.D.	1
Trichloroethene	N.D.	1
Trichlorofluoromethane	N.D.	1
Vinyl chloride	N.D.	10
m+p-Xylenes	19	1
o-Xylene	N.D.	1

N.D.- Not detected, less than detection limit.

E3-03-216 (cont'd.)

QA/QC:

VOC SPIKE COMPOUND:	ACCURACY:	PRECISION:
1,2-Dichloroethane-d4	102%	± 8.02%
Toluene-d8	97%	± 8.77%
4-Bromofluorobenzene	91%	± 1.51%

Note: Accuracy is expressed as the average % recovery, and precision as ± the relative standard deviation (RSD), of standard reference materials or in-house spikes.

METHOD REFERENCE:

ETL MSOP# 50.01 (modified method EPA8240 with automated headspace and GC/MSD/SIM analysis).

PART 5B: EPA 624 VOLATILES IN SOIL

OVERVIEW:

Approximately 2g of the soil sample was weighed out into a 20 mL headspace vial, adjusted to a 15.0 mL final volume and sealed with a teflon-lined septum. The sample was spiked with three surrogate compounds and three internal standard compounds to monitor the headspace extraction efficiency and system performance. A method blank was prepared along with the sample to account for any background contamination. Analysis was performed using an automated headspace extractor interfaced to a capillary gas chromatograph equipped with a mass selective detector (GC/MSD) in selected ion monitoring (SIM) mode. The sample was quantitated using a multi-point calibration curve and an internal standards method of calculation.

E3-03-216 (cont'd.)

RESULTS:

Enviro-Test Sample Number: E3-03-216-07A Customer Sample Identifier: BH5 2.5-3.0 M

<u>COMPOUND IDENTIFIED:</u>	<u>CONCENTRATION:(μg/kg-ppb)</u>	<u>DETECTION LIMIT:(μg/kg-ppb)</u>
Benzene	N.D.	10
Bromodichloromethane	N.D.	10
Bromoform	N.D.	10
Bromomethane	N.D.	100
Carbon tetrachloride	N.D.	10
Chlorobenzene	N.D.	10
Chloroethane	N.D.	100
2-Chloroethyl vinyl ether	N.D.	50
Chloroform	N.D.	10
Dibromochloromethane	N.D.	10
1,2-Dichlorobenzene	240	10
1,3-Dichlorobenzene	N.D.	10
1,4-Dichlorobenzene	21	10
1,1-Dichloroethane	N.D.	10
1,2-Dichloroethane	N.D.	10
1,1-Dichloroethene	N.D.	10
trans-1,2-Dichloroethene	N.D.	10
1,2-Dichloropropane	N.D.	10
cis-1,3-Dichloropropene	N.D.	10
trans-1,3-Dichloropropene	N.D.	10
Ethylbenzene	96	10
Methylene Chloride	N.D.	10
Styrene	N.D.	10
1,1,2,2-Tetrachloroethane	N.D.	50
Tetrachloroethene	N.D.	10
Toluene	N.D.	10
1,1,1-Trichloroethane	23	10
1,1,2-Trichloroethane	N.D.	10
Trichloroethene	N.D.	10
Trichlorofluoromethane	N.D.	10
Vinyl chloride	N.D.	100
m+p-Xylenes	270	10
o-Xylene	110	10

N.D.- Not detected, less than detection limit.

E3-03-216 (cont'd.)

QA/QC:

<u>VOC SPIKE COMPOUND:</u>	<u>ACCURACY:</u>	<u>PRECISION:</u>
1,2-Dichloroethane-d4	102%	± 8.17%
Toluene-d8	97%	± 9.06%
4-Bromofluorobenzene	89%	± 4.63%

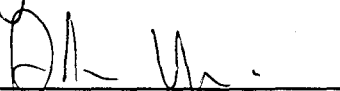
Note: Accuracy is expressed as the average % recovery, and precision as ± the relative standard deviation (RSD), of standard reference materials or in-house spikes.

METHOD REFERENCE:

ETL MSOP# 50.01 (modified method EPA8240 with automated headspace and GC/MSD/SIM analysis).

CERTIFIED BY: 
Sean Johnston, Trace Residue Analyst

APPROVED BY: 
Doug Johnson, Project Manager

APPROVED BY: 
Gordon Nelson, Manager, Environmental Services,
Industrial Chemicals Division

ALL SAMPLES WILL BE DISPOSED OF AFTER 30 DAYS FOLLOWING ANALYSIS. PLEASE CONTACT THE LAB IF YOU REQUIRE ADDITIONAL SAMPLE STORAGE TIME.

ACCREDITED BY THE: AMERICAN INDUSTRIAL HYGIENE ASSOCIATION (AIHA) - Industrial Hygiene analysis as registered by AIHA
STANDARDS COUNCIL OF CANADA - Organic & Industrial Hygiene analysis as registered with the Council
AGRICULTURE CANADA - Pesticide in Fruits and Vegetables, pesticides and PCP in meat

CERTIFIED BY THE: CANADIAN ASSOCIATION OF ENVIRONMENTAL ANALYTICAL LABORATORIES - All pesticides (as registered by CAEAL) and total PCBs in water

938-67 Avenue
Edmonton, AB
T6E 0P5



NORWEST LABS

(403) 438-5522 or 1-800-661-7645
(403) 438-0396 fax

DATE 23 MAR 93 11:56

P.O. NO. E3-03-216

W.O. NO. 2 60979

E.T.L. CHEMSPEC
EDMONTON, AB

EBA

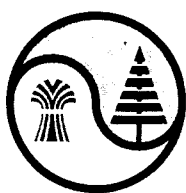
SAMPLE	1	2	3
	E303216-02A	E303216-03A	E303216-19A
	BH4 5-6 COMP.	BH 9 QSM	BH1 COMPOSITE

ICP METALS, 3050

	1	2	3
ALUMINUM ug/gm	12800	16100	16500
BARIUM ug/gm	153	82.0	179
BERYLLIUM ug/gm	0.8	0.7	1.0
CADMIUM ug/gm	0.3	<0.3	0.3
CALCIUM ug/gm	28800	5920	26300
CHROMIUM ug/gm	27.8	23.9	27.5
COPPER ug/gm	26.1	58.5	43.8
IRON ug/gm	21000	37200	28200
LEAD ug/gm	8	7	13
MAGNESIUM ug/gm	8480	11600	10300
MANGANESE ug/gm	442	628	602
MOLYBDENUM ug/gm	<2	<2	<2
NICKEL ug/gm	20	32	24
PHOSPHORUS ug/gm	649	888	713
POTASSIUM ug/gm	1710	1240	1910
SODIUM ug/gm	500	210	485
VANADIUM ug/gm	44.8	49.1	60.9
ZINC ug/gm	60.9	98.6	77.9
COBALT ug/gm	10	12	13

Lab Manager: JA

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NORWEST LABS

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DATE 24 MAR 93 16:05

P.O. NO. E303216

W.O. NO. 2 60980

E.T.L. CHEMSPEC
EDMONTON, AB

EBA

SAMPLE	1	2	3	4
	E303216-09A	E303216-10A	E303216-11A	E303216-12A
	BH4-5-6 COMP.	BH9 COMPOSITE	UPSTREAM GRAYLING CREEK	MOUTH/GRAYLING CREEK

MICROBIOLOGICAL

FECAL COLIFORMS	CFU100mL			<2
TOTAL COLIFORMS	CFU100mL			13

ICP METALS, TOTAL

BARIUM	mg/L	0.295	0.028	0.016
BERYLLIUM	mg/L	<0.001	<0.001	<0.001
BORON	mg/L	0.14	0.21	0.07
CADMIUM	mg/L	<0.003	<0.003	<0.003
CALCIUM	mg/L	150	31.7	51.7
CHROMIUM	mg/L	<0.01	<0.01	<0.01
ALUMINUM	mg/L	13.8	0.70	0.08
COBALT	mg/L	<0.01	<0.01	<0.01
COPPER	mg/L	0.02	<0.01	<0.01
IRON	mg/L	16.8	1.38	0.07
LEAD	mg/L	<0.04	<0.04	<0.04
MAGNESIUM	mg/L	42.3	4.90	7.26
MANGANESE	mg/L	1.57	0.150	0.008
MOLYBDENUM	mg/L	<0.02	<0.02	<0.02
NICKEL	mg/L	0.03	0.03	0.03
PHOSPHORUS	mg/L	0.8	<0.1	<0.1
POTASSIUM	mg/L	6	<1	<1
SILVER	mg/L	<0.05	<0.05	<0.05
SILICON	mg/L	17.9	3.46	4.58
SODIUM	mg/L	33	3	4
TITANIUM	mg/L	0.936	0.022	<0.003
THALLIUM	mg/L	<0.10	<0.10	<0.10
VANADIUM	mg/L	0.044	0.004	0.007
ZINC	mg/L	0.090	0.058	0.019

Lab Manager: E. Collins

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DATE 24 MAR 93 16:05

P.O. NO. E303216

W.O. NO. 2 60980

E.T.L. CHEMSPEC
EDMONTON, AB

EBA

SAMPLE	5	6
	E303216-13A	E303216-16A
	BH3 SEPTIC TANK AREA	MOUTH/GRAYLING CREEK

MICROBIOLOGICAL

FECAL COLIFORMS	CFU100mL	<2
TOTAL COLIFORMS	CFU100mL	<2

ORGANICS

HYDROCARBONS	mg/L	<0.2
--------------	------	------

note TOTAL COLIFORMS CFU = Colony Forming Units
TC = Total Coliforms

note HYDROCARBONS HYDROCARBON IS MINERAL O&G.

1.-TWO SAMPLES(NO.60980-4 AND 5) WERE ANALYZED FOR TOTAL COLIFORMS (TC) AND

FECAL (FC) USING THE MOST PROBABLE NUMBER (MPN) PROCEDURE (FDA, BACTERIOLO-) 1 col 7
FILTRATION (MF) PROCEDURE BECAUSE OF THE TURBIDITY OF SAMPLE 60980-5.

2.-NO FC WERE DETECTED IN SAMPLES 60980-4 AND 5, HOWEVER, THE RESULTS WERE
EXPRESSED AS <2 CFU/100ML BASED ON THE LOWEST DILUTION ANALYZED.

3.-NO TC WERE DETECTED IN SAMPLES 60980-5, HOWEVER, THE SAMPLE 60980-4
PRODUCED A LOW COUNT OF 13 MPN/100M.

Lab Manager: _____

938-67 Avenue
Edmonton, AB
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(403) 438-0396 fax

DATE 24 MAR 93 16:05

P.O. NO. E303216

W.O. NO. 2 60980

E.T.L. CHEMSPEC
EDMONTON, AB

EBA

PARAMETER	DATE OF APPROVAL	ANALYZED BY	PARAMETER	DATE OF APPROVAL	ANALYZED BY
TOTAL COLIFORMS	24Mar93	SABINA PIETUCHA	TOTAL COLIFORMS	24Mar93	SABINA PIETUCHA
HYDROCARBONS	22Mar93	NICHOLAS CHEONG	BARIIUM	24Mar93	ERIC THOMSEN
BERYLLIUM	24Mar93	ERIC THOMSEN	BORON	24Mar93	ERIC THOMSEN
CADMIUM	24Mar93	ERIC THOMSEN	CALCIUM	24Mar93	ERIC THOMSEN
CHROMIUM	24Mar93	ERIC THOMSEN	COBALT	24Mar93	ERIC THOMSEN
ALUMINIUM	24Mar93	ERIC THOMSEN	COPPER	24Mar93	ERIC THOMSEN
IRON	24Mar93	ERIC THOMSEN	LEAD	24Mar93	ERIC THOMSEN
MAGNESIUM	24Mar93	ERIC THOMSEN	MANGANESE	24Mar93	ERIC THOMSEN
MOLYBDENUM	24Mar93	ERIC THOMSEN	NICKEL	24Mar93	ERIC THOMSEN
PHOSPHORUS	24Mar93	ERIC THOMSEN	POTASSIUM	24Mar93	ERIC THOMSEN
SILVER	24Mar93	ERIC THOMSEN	SILICON	24Mar93	ERIC THOMSEN
SODIUM	24Mar93	ERIC THOMSEN	TITANIUM	24Mar93	ERIC THOMSEN
THALLIUM	24Mar93	ERIC THOMSEN	VANADIUM	24Mar93	ERIC THOMSEN
ZINC	24Mar93	ERIC THOMSEN			

Lab Manager: _____

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(403) 438-0396 fax

DATE 23 MAR 93 11:56

P.O. NO. E3-03-216

W.O. NO. 2 60979

E.T.L. CHEMSPEC
EDMONTON, AB

EBA

Quality Assurance Analysis

Standard Reference Material Analysis

METHOD ANALYSIS	UNITS	STANDARD			QC WITH THIS ORDER			HISTORICAL PRECISION		CONTROL LIMITS		
		DESCRIPTION	D.L.	TARGET	#	MEAN	% Y	#	MEAN	LOW	HIGH	
6800	Al	mg/kg	NBS	5	14500	1	12674	87.4	540	15263	10582	18418
6801	Ba	mg/kg	NBS	.2	104.9	1	91.84	87.5	577	98.07	76.1	133.7
6802	Be	mg/kg	NBS	.1	0.9	1	0.7943	88.3	570	0.8987		
6804	Cd	mg/kg	NBS	.3	3.45	1	3.326	96.4	612	3.159	2.50	3.82
6805	Ca	mg/kg	NBS	5	27095	1	24846	91.7	545	24793	19748	34442
6806	Cr	mg/kg	NBS	.5	93.3	1	76.95	82.5	596	82.41	76.9	109.7
6807	Cu	mg/kg	NBS	.5	93.9	1	84.39	89.9	582	87.94	84.5	103.3
6808	Fe	mg/kg	NBS	1	31500	1	29840	94.7	545	30533	27100	35900
6809	Pb	mg/kg	NBS	2	147.5	1	142.0	96.3	611	137.7	120.3	174.7
6810	Mg	mg/kg	NBS	2	10352	1	9234	89.2	544	9427	7494	13210
6811	Mn	mg/kg	NBS	.3	462	1	462.2	100.0	541	463.9	403	521
6812	Mo	mg/kg	NBS	2	0.0	1	0.8439		529	-0.5000	-3	2.5
6813	Ni	mg/kg	NBS	2	35.47	1	34.90	98.4	616	34.65	25.75	45.12
6814	P	mg/kg	NBS	10	869	1	708.4	81.5	540	739.9	638	1101
6815	K	mg/kg	NBS	50	1990	1	1477	74.2	539	2186	820	3160
6816	Na	mg/kg	NBS	50	200	1	156.4	78.2	532	186.5	150	250
6817	V	mg/kg	NBS	.3	30	1	28.59	95.3	575	18.29	25	35
6818	Zn	mg/kg	NBS	.5	438	1	392.2	89.5	583	393.3	372	504
6823	Co	mg/kg	NBS	1	14	1	10.92	78.0	525	10.98	9	19
6800	Al	mg/kg	REAGENT BLANK	5	0.0	1	0.0		541	4.408	-20	20
6801	Ba	mg/kg	REAGENT BLANK	.2	0.0	1	0.1500		579	0.2311	-5	5
6802	Be	mg/kg	REAGENT BLANK	.1	0.0	1	0.0		572	-0.01101	-0.1	0.1
6804	Cd	mg/kg	REAGENT BLANK	.3	0.0	1	0.0		614	0.000103	-.3	0.3
6805	Ca	mg/kg	REAGENT BLANK	5	0.0	1	0.0		546	13.55	-13	35

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EDMONTON, AB

EBA

Quality Assurance Analysis

Standard Reference Material Analysis

METHOD ANALYSIS	UNITS	STANDARD			QC WITH THIS ORDER			HISTORICAL PRECISION		CONTROL LIMITS	
		DESCRIPTION	D.L.	TARGET	#	MEAN	% Y	#	MEAN	LOW	HIGH
6806	Cr	mg/kg	REAGENT BLANK	.5	0.0	1	0.2500	598	0.1482	-1.0	1.0
6807	Cu	mg/kg	REAGENT BLANK	.5	0.0	1	0.0	584	0.1071	-0.6	0.6
6808	Fe	mg/kg	REAGENT BLANK	1	0.0	1	0.0	546	7.817	-16	25
6809	Pb	mg/kg	REAGENT BLANK	2	0.0	1	0.0	613	0.01837	-2	2
6810	Mg	mg/kg	REAGENT BLANK	2	0.0	1	0.0	545	3.681	-26	35
6811	Mn	mg/kg	REAGENT BLANK	.3	0.0	1	0.0	542	0.3469	-0.3	0.3
6812	Mo	mg/kg	REAGENT BLANK	2	0.0	1	0.0	535	-0.02738	-2	2
6813	Ni	mg/kg	REAGENT BLANK	2	0.0	1	0.0	622	0.1416	-2	2
6814	P	mg/kg	REAGENT BLANK	10	0.0	1	0.0	541	2.479	-8	12
6815	K	mg/kg	REAGENT BLANK	50	0.0	1	0.0	540	1.221	-70	70
6816	Na	mg/kg	REAGENT BLANK	50	0.0	1	0.0	543	34.45	-57	126
6817	V	mg/kg	REAGENT BLANK	.3	0.0	1	0.0	581	0.02808	-1.8	1.8
6818	Zn	mg/kg	REAGENT BLANK	.5	0.0	1	0.8500	585	0.6803	-2	2
6823	Co	mg/kg	REAGENT BLANK	1	0.0	1	0.0	532	0.000087	-0.5	0.5

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EDMONTON, AB

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Quality Assurance Analysis

Standard Reference Material Analysis

METHOD ANALYSIS	UNITS	STANDARD			QC WITH THIS ORDER			HISTORICAL PRECISION		CONTROL LIMITS		
		DESCRIPTION	D.L.	TARGET	#	MEAN	% Y	#	MEAN	LOW	HIGH	
4615	Mn	mg/L	METAL STD.	.001	0.6	1	0.6013	100.2	209	0.6239	0.54	0.66
4615	Mn	mg/L	METAL STD.	.001	0.06	1	0.06403	106.7	209	0.06383	0.048	0.072
4617	Mo	mg/L	METAL STD.	.02	1.0	1	1.007	100.7	206	1.043	0.9	1.1
4617	Mo	mg/L	METAL STD.	.02	0.1	1	0.1039	103.9	206	0.1036	0.08	0.12
4618	Ni	mg/L	METAL STD.	.02	2.0	1	2.048	102.4	254	2.062	1.8	2.2
4618	Ni	mg/L	METAL STD.	.02	0.2	1	0.2224	111.2	254	0.2170	0.16	0.24
4619	P	mg/L	METAL STD.	0.1	5.0	1	5.061	101.2	185	5.163	4.5	5.5
4619	P	mg/L	METAL STD.	0.1	0.5	1	0.5128	102.6	185	0.5107	0.4	0.6
4620	K	mg/L	METAL STD.	1	100	1	97.51	97.5	175	98.89	90	110
4620	K	mg/L	METAL STD.	1	10	1	9.919	99.2	175	9.958	8	12
4624	Na	mg/L	METAL STD.	1	100	1	98.93	98.9	178	101.9	90	110
4624	Na	mg/L	METAL STD.	1	10	1	10.36	103.6	178	10.51	8	12
4626	Ti	mg/L	METAL STD.	.003	.30	1	0.3128	104.3	189	0.3448	.27	.33
4626	Ti	mg/L	METAL STD.	.003	0.03	1	0.03214	107.1	189	0.03158	0.024	0.036
4627	Tl	mg/L	METAL STD.	.1	3.0	1	3.316	110.5	203	3.117	2.7	3.3
4627	Tl	mg/L	METAL STD.	.1	0.30	1	0.3544	118.1	205	0.3185	0.24	0.36
4629	V	mg/L	METAL STD.	.003	0.30	1	0.3217	107.2	206	0.2594	0.23	0.27
4629	V	mg/L	METAL STD.	.003	0.03	1	0.03056	101.9	206	0.02616	0.024	0.036
4630	Zn	mg/L	METAL STD.	.002	0.60	1	0.6083	101.4	264	0.6367	0.54	0.66
4630	Zn	mg/L	METAL STD.	.002	0.06	1	0.06623	110.4	264	0.06517	0.048	0.072

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Quality Assurance Analysis

Standard Reference Material Analysis

METHOD ANALYSIS	UNITS	STANDARD			QC WITH THIS ORDER			HISTORICAL PRECISION		CONTROL LIMITS		
		DESCRIPTION	D.L.	TARGET	#	MEAN	% Y	#	MEAN	LOW	HIGH	
5094	HYDRO-CARBONS	mg/L	HIGH CHEMICAL	0.2	50	1	52.00	104.0		45	55	
5094	HYDRO-CARBONS	mg/L	LOW CHEMICAL	0.2	5	1	5.000	100.0		4	6	
4603	Ba	mg/L	METAL STD.	.001	.30	1	0.2936	97.9	183	0.3022	.27	.33
4603	Ba	mg/L	METAL STD.	.001	0.03	1	0.03056	101.9	183	0.03115	0.024	0.036
4604	Be	mg/L	METAL STD.	.001	0.12	1	0.1033	86.1	204	0.1114	0.07	0.17
4604	Be	mg/L	METAL STD.	.001	0.01	1	0.01102	110.2	204	0.01111	0.008	0.012
4606	Cd	mg/L	METAL STD.	.003	0.30	1	0.3073	102.4	256	0.3132	0.27	0.33
4606	Cd	mg/L	METAL STD.	.003	0.03	1	0.03174	105.8	256	0.03167	0.024	0.036
4607	Ca	mg/L	METAL STD.	.05	5.66	1	5.508	97.3	188	5.634	5.26	6.06
4607	Ca	mg/L	METAL STD.	.05	0.5	1	0.6054	121.1	188	0.5793	0.4	0.6
4608	Cr	mg/L	METAL STD.	.01	0.60	1	0.6180	103.0	239	0.6221	0.54	0.66
4608	Cr	mg/L	METAL STD.	.01	0.06	1	0.06437	107.3	239	0.06565	0.048	0.072
4600	Al	mg/L	METAL STD.	.02	5.0	1	5.677	113.5	234	5.538	4.2	6.7
4609	Co	mg/L	METAL STD.	0.01	1.0	1	1.012	101.2	206	1.038	0.90	1.10
4600	Al	mg/L	METAL STD.	.02	0.5	1	0.5932	118.6	234	0.5665	0.4	0.6
4609	Co	mg/L	METAL STD.	0.01	0.1	1	0.1077	107.7	206	0.1077	0.08	0.12
4610	Cu	mg/L	METAL STD.	.01	1.0	1	1.036	103.6	253	1.064	0.9	1.1
4610	Cu	mg/L	METAL STD.	.01	0.1	1	0.1147	114.7	253	0.1112	0.08	0.12
4611	Fe	mg/L	METAL STD.	.02	2.0	1	2.040	102.0	191	2.146	1.80	2.20
4611	Fe	mg/L	METAL STD.	.02	0.2	1	0.2156	107.8	191	0.2136	0.16	0.24
4612	Pb	mg/L	METAL STD.	.04	4.0	1	3.901	97.5	250	4.071	3.6	4.4
4612	Pb	mg/L	METAL STD.	.04	0.4	1	0.4111	102.8	250	0.4124	0.32	0.48
4614	Mg	mg/L	METAL STD.	.05	50	1	54.31	108.6	179	54.76	45	55
4614	Mg	mg/L	METAL STD.	.05	5.0	1	5.779	115.6	179	5.749	4.0	6.0

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The following published METHODS OF ANALYSIS were used:

EPA6010	ALUMINUM	ICP Spectroscopy. Ref. EPA 6010 (SW-846)	EPA6010	VANADIUM	ICP Spectroscopy. Ref. EPA 6010 (SW-846)
EPA6010	BARIUM	ICP Spectroscopy. Ref. EPA 6010 (SW-846)	EPA6010	ZINC	ICP Spectroscopy. Ref. EPA 6010 (SW-846)
EPA6010	BERYLLIUM	ICP Spectroscopy. Ref. EPA 6010 (SW-846)	EPA6010	COBALT	ICP Spectroscopy. Ref. EPA 6010 (SW-846)
EPA6010	CADMIUM	ICP Spectroscopy. Ref. EPA 6010 (SW-846)	EPA 3050	EPA DIGEST 3050	Acid digestion of sediments, soils, and sludges using nitric acid/hydrogen peroxide. Reported on dry weight (mg/kg). Ref. EPA 3050 (SW-846)
EPA6010	CALCIUM	ICP Spectroscopy. Ref. EPA 6010 (SW-846)			
EPA6010	CHROMIUM	ICP Spectroscopy. Ref. EPA 6010 (SW-846)			
EPA6010	COPPER	ICP Spectroscopy. Ref. EPA 6010 (SW-846)			
EPA6010	IRON	ICP Spectroscopy. Ref. EPA 6010 (SW-846)			
EPA6010	LEAD	ICP Spectroscopy. Ref. EPA 6010 (SW-846)			
EPA6010	MAGNESIUM	ICP Spectroscopy. Ref. EPA 6010 (SW-846)			
EPA6010	MANGANESE	ICP Spectroscopy. Ref. EPA 6010 (SW-846)			
EPA6010	MOLYBDENUM	ICP Spectroscopy. Ref. EPA 6010 (SW-846)			
EPA6010	NICKEL	ICP Spectroscopy. Ref. EPA 6010 (SW-846)			
EPA6010	PHOSPHORUS	ICP Spectroscopy. Ref. EPA 6010 (SW-846)			
EPA6010	POTASSIUM	ICP Spectroscopy. Ref. EPA 6010 (SW-846)			
EPA6010	SODIUM	ICP Spectroscopy. Ref. EPA 6010 (SW-846)			

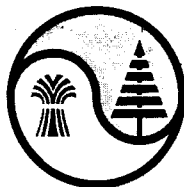
Method References:

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

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EBA

The following published METHODS OF ANALYSIS were used:

EPA418.1	HYDROCARBONS	25010P	MANGANESE
	Separatory funnel extraction with Freon, add silica gel, analyze by Infrared spectroscopy @ 2930 cm ⁻¹ Ref. US EPA 418.1; APHA 5520 F		Total by ICP spectroscopy @ 257.6 nm Ref. EPA 200.2 / APHA 3120 B
6009P	BARIUM	42009	MOLYBDENUM
	Total by ICP spectroscopy @ 455.4 nm Ref. EPA 200.2 / APHA 3120 B	28009P	Total, ICP spectroscopy. Ref APHA 3120 B
4009	BERYLLIUM	19005	NICKEL
	Total, ICP spectroscopy. Ref APHA 3120 B		Total, ICP spectroscopy. Ref APHA 3120 B
48009P	CADMIUM	47001	POTASSIUM
	Total, ICP spectroscopy. Ref. APHA 3120 B		Total by ICP spectroscopy @ 769.8 nm Ref. EPA 200.2 / APHA 3120 B
0005	CALCIUM	11005	SILVER
	Total by ICP spectroscopy @ 317.9 nm Ref. EPA 200.2 / APHA 3120 B		Total, ICP spectroscopy. Ref APHA 3120 B
4009	CHROMIUM	22009	SODIUM
	Total, ICP spectroscopy. Ref APHA 3120 B		Total by ICP spectroscopy @ 589.5 nm Ref. EPA 200.2 / APHA 3120 B
27009P	COBALT	23009P	TITANIUM
	Total, ICP spectroscopy. Ref APHA 3120 B		Total by ICP spectroscopy @ 334.9 nm Ref. EPA 200.2 / APHA 3120 B
3009	ALUMINUM	30009	VANADIUM
	Total, ICP spectroscopy. Ref APHA 3120 B		Total, ICP spectroscopy. Ref APHA 3120 B
29009P	COPPER		ZINC
	Total by ICP spectroscopy @ 308.2 nm Ref. EPA 200.2 / APHA 3120 B		Total, ICP spectroscopy. Ref APHA 3120 B
26009P	IRON		
	Total by ICP spectroscopy @ 259.9 nm Ref. EPA 200.2 / APHA 3120 B		
82009P	LEAD		
	Total, ICP spectroscopy. Ref APHA 3120 B		
2005	MAGNESIUM		
	Total by ICP spectroscopy @ 285.2 nm Ref. EPA 200.2 / APHA 3120 B		

Method References:

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

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APPENDIX D

**LEVEL ONE ENVIRONMENTAL ASSESSMENT
AND SITE HISTORY
CHOUTLA SCHOOL, CARCROSS YUKON**

LEVEL ONE ENVIRONMENTAL ASSESSMENT
AND SITE HISTORY
CHOUTLA SCHOOL, CARCROSS, YUKON

submitted to:

PUBLIC WORKS CANADA

prepared by:

EBA ENGINEERING CONSULTANTS LTD.
WHITEHORSE, YUKON

0201-11151

March, 1993

TABLE OF CONTENTS

1.0	INTRODUCTION	1
2.0	DATA COLLECTION AND REVIEW	1
2.1	Existing Information	1
2.2	Title Search	1
2.3	Airphoto Review	2
2.4	Observations	2
2.5	Interviews	3
3.0	SUMMARY	4

1.0 INTRODUCTION

To complete a level one environmental assessment and provide site history information for the Choutla School site, the following tasks were performed:

- Existing plans for the construction and development of the site were studied.
- A title search was conducted at the YTG Land Titles office.
- 1980 Airphotos of the area were borrowed from YTG and studied.
- Contractors and personnel familiar with the site were contacted and interviewed to help in identifying potential concerns after visual reconnaissance during the field investigation was completed.

2.0 DATA COLLECTION AND REVIEW

2.1 Existing Information

No site specific geotechnical reports were uncovered during a cursory search. However, the set of plans supplied by P.W.C. for this project was valuable for determining the development sequence of the school site through the initial and final phases of construction. The plans also identified the location of the first school structure, the Phase I power house location, the location of the septic tanks and the outlet line from the septic tank to Grayling Bay.

2.2 Title Search

A title search at the YTG Land Titles office determined that Lot 449, Group 804 was never titled. Therefore, the search was not useful in determining past site use.

2.3 Airphoto Review

The following airphotos were borrowed from YTG - Lands Branch:

Roll	Number	Scale	Date
6 1678	128633	1:8000	1980
6 1678	128634	1:8000	1980

Observations made from airphoto review are presented below:

- Photos were taken prior to the partial demolition of the school
- The skating rink area was still intact and the greenhouses had not yet been constructed.
- The well established access road to the septic tank area indicates that both ends of the tank had been accessed and possibly pumped out on a regular basis.
- No significant surface staining was noted on the airphotos indicating that no significant surface spills were evident at that time.
- The parcel resurveyed as Lot 448, Group 804 on the west side of the Tagish Road had not yet been cleared or utilized.

2.4 Observations

During the site investigation, photos were taken to illustrate present site conditions and features. The photos are presented following this text.

Other observations made are as follows:

- The school and power house structures are presently in ruins. Access in and around both buildings is hazardous.
- The garage and warehouse buildings are being utilized as workshops by area residents. As well, vehicles are scattered throughout the site.
- The greenhouses and garden appear to be utilized during the growing season. No evidence of any fertilizers exists on site.
- Water for the site was directed from Grayling Creek just upstream of the school access road. The concrete structure built to facilitate water supply is structurally unsound.

2.5 Interviews

To conduct the interviews, Patsy Baker, who is the environmental auditor for the Carcross and Tagish First Nation, assisted in collecting information from Carcross area residents who are familiar with the site.

The following information was gathered:

- Patrick James (Chief of Carcross and Tagish First Nation) attended the school. He has no recollection of any fuel spills or problems with the septic system while attending the school. The original school structure which burned down was heated by a wood fired boiler.
- Mr. Lawrence Dickson of Carcross removed two 3,000 gallon tanks from between the power house and the north wing of the school. One tank was

damaged. Both tanks may be in use as sewage holding tanks in the Carcross area. Tank removal took place approximately 5 years ago. Mr. Dickson also recalls the location of a large above ground tank located in front of the power house chimney. He was not familiar with its contents or when it was removed from site.

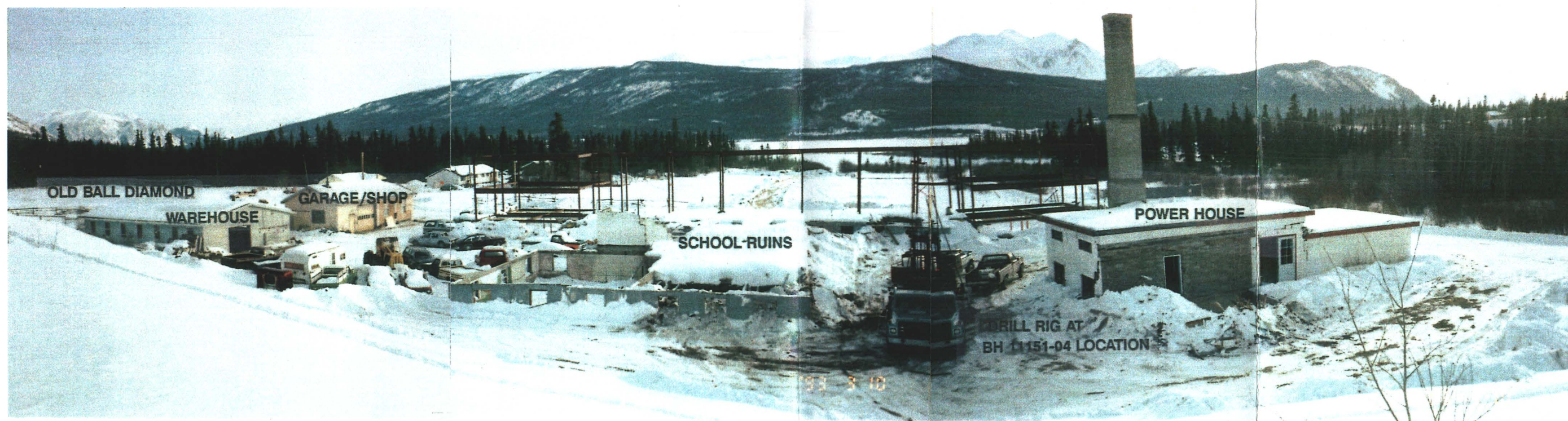
- Mr. Harold Gatensby thought, but could not confirm, that the removal of the transformers from the power house was by government personnel. Mr Gatensby lives at the mouth of Grayling Creek and he stated that grayling numbers in the creek have dropped significantly. He also identified the area with distressed poplar trees and stated that a reddish liquid washes into the area from a line which comes from either the power house or the school. BH 11151-09 was subsequently hand augered in this area after our conversations with Mr. Gatensby.
- The greenhouse operation has been in place for about 8 years. The operation has never utilized chemical fertilizers.
- The main concern of the residents in the area is the water quality of Grayling Creek which is utilized as a potable water source for the four families living at the site.

3.0 SUMMARY

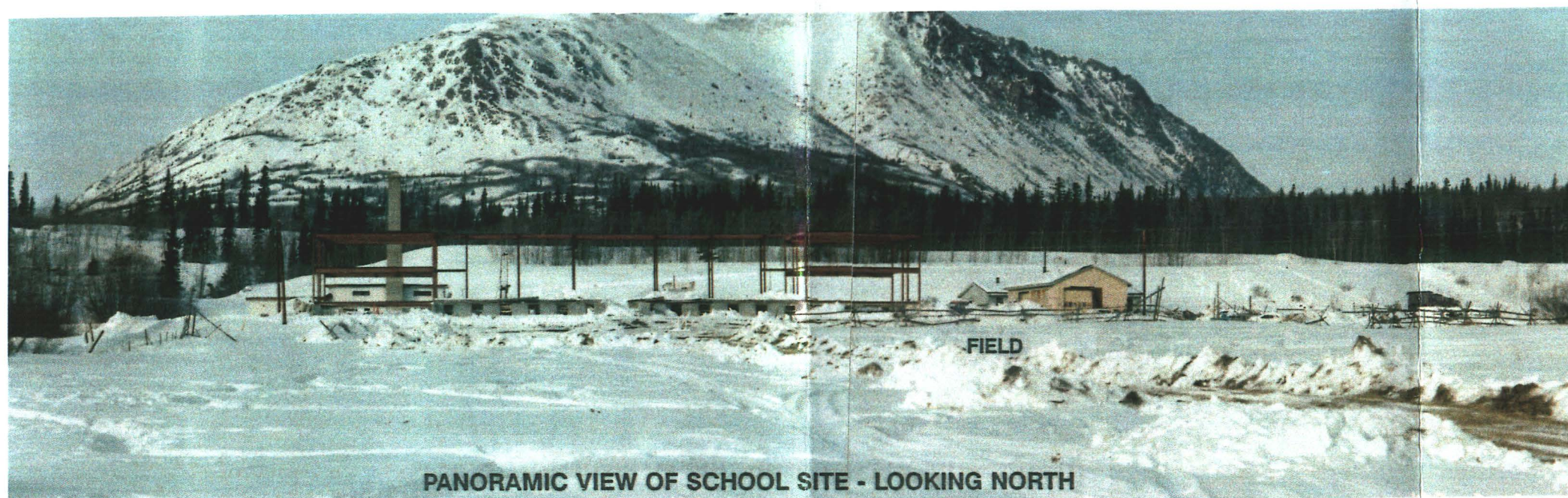
- The main environmental concerns at the site are the presence of the two underground fuel storage tanks which were detected by GPR and the location where the two other tanks were removed.
- The possible presence of PCB's in the power house is a definite concern. Children who live in the area likely view the ruins with interest and have

probably played in the basements of both the school and the power house structures.

- Past history of site use prior to school site development is sketchy. The site may have been utilized as a highway camp during the Alaska Highway construction but this could not be verified.
- The Carcross and Tagish First Nation would like to utilize the site as a ceremonial or healing site with some residential development being an option.

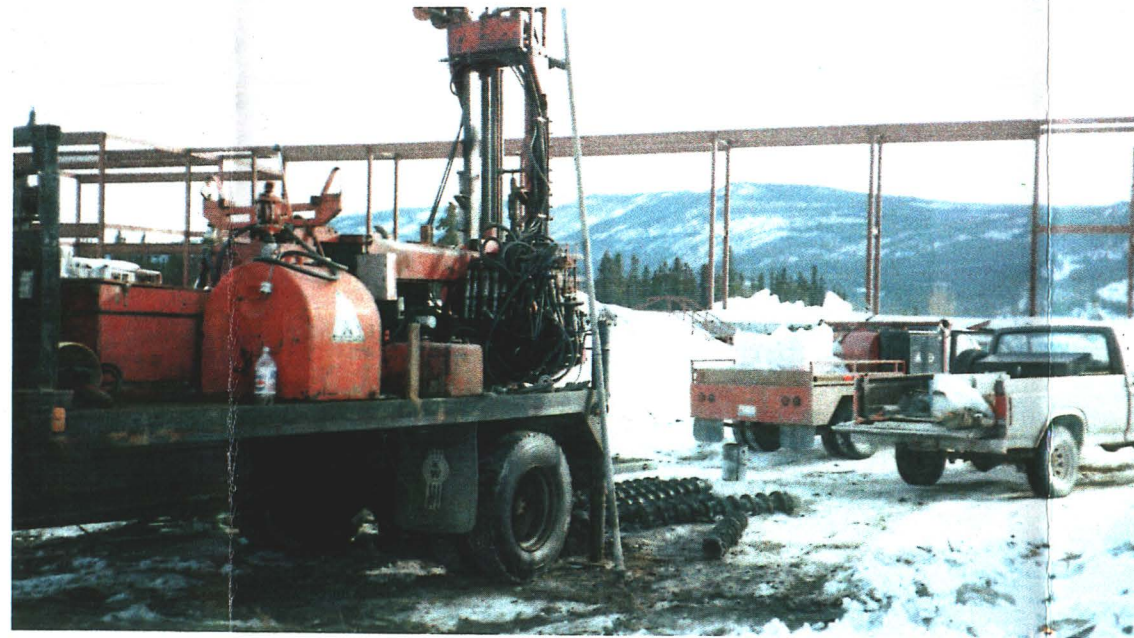
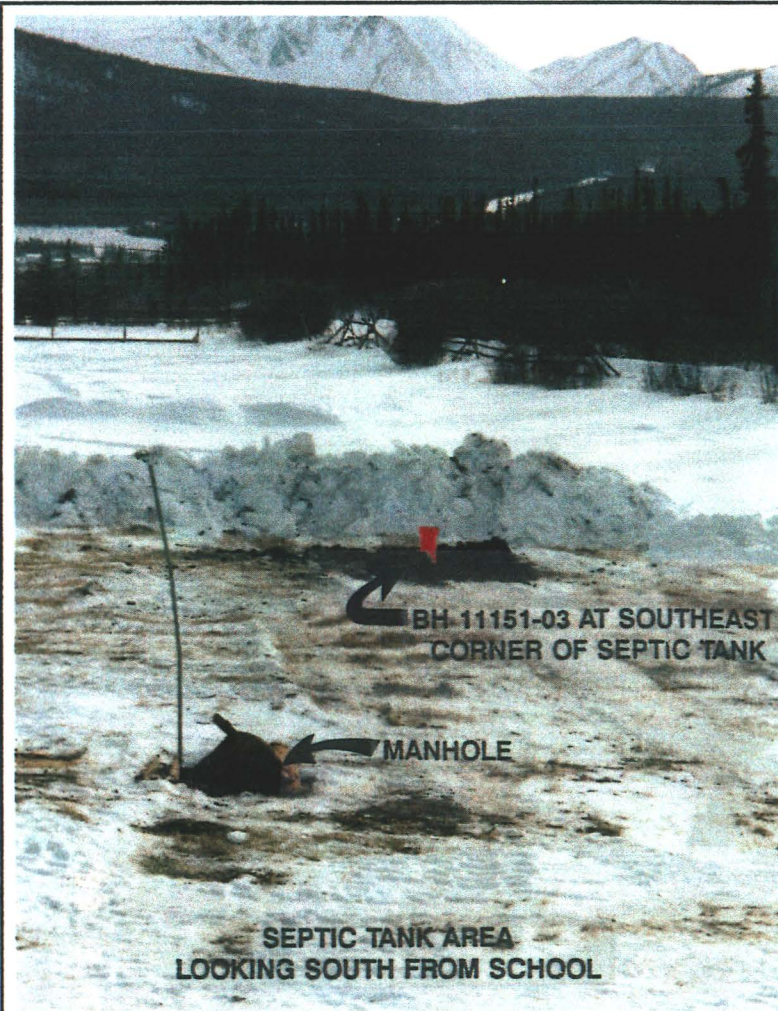


PANORAMIC VIEW OF SCHOOL SITE - LOOKING SOUTH TOWARDS GRAYLING BAY



PANORAMIC VIEW OF SCHOOL SITE - LOOKING NORTH

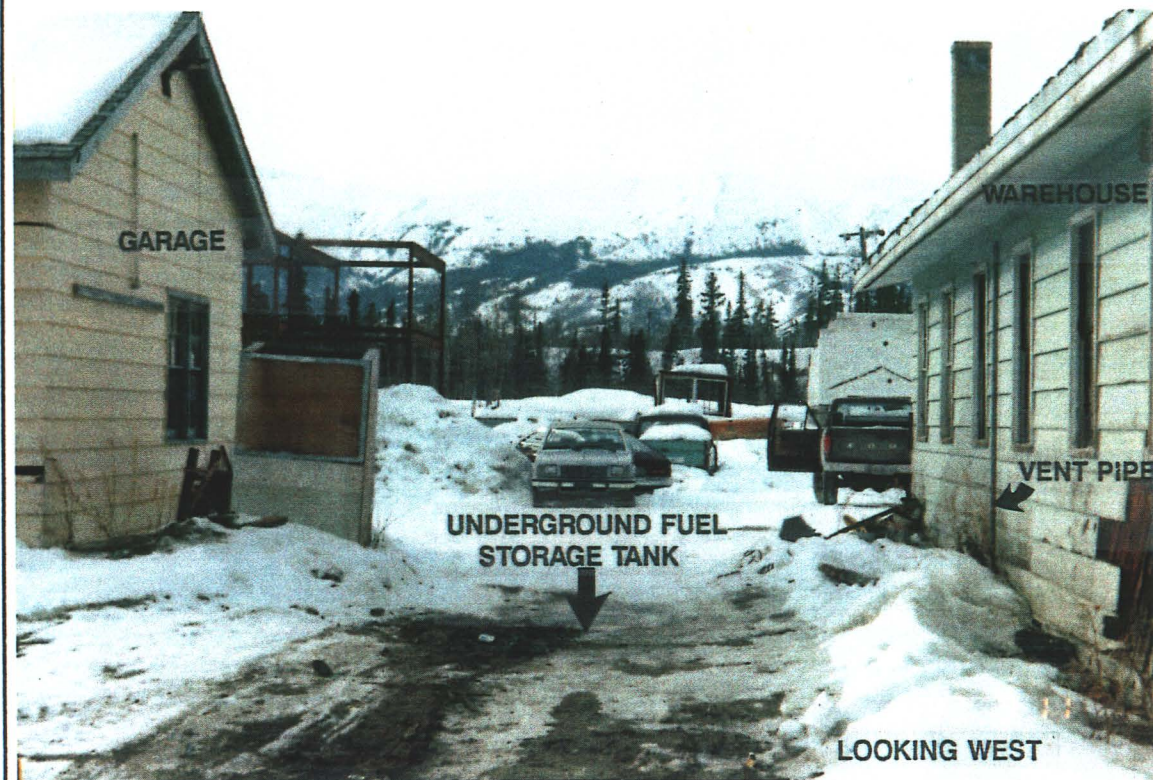
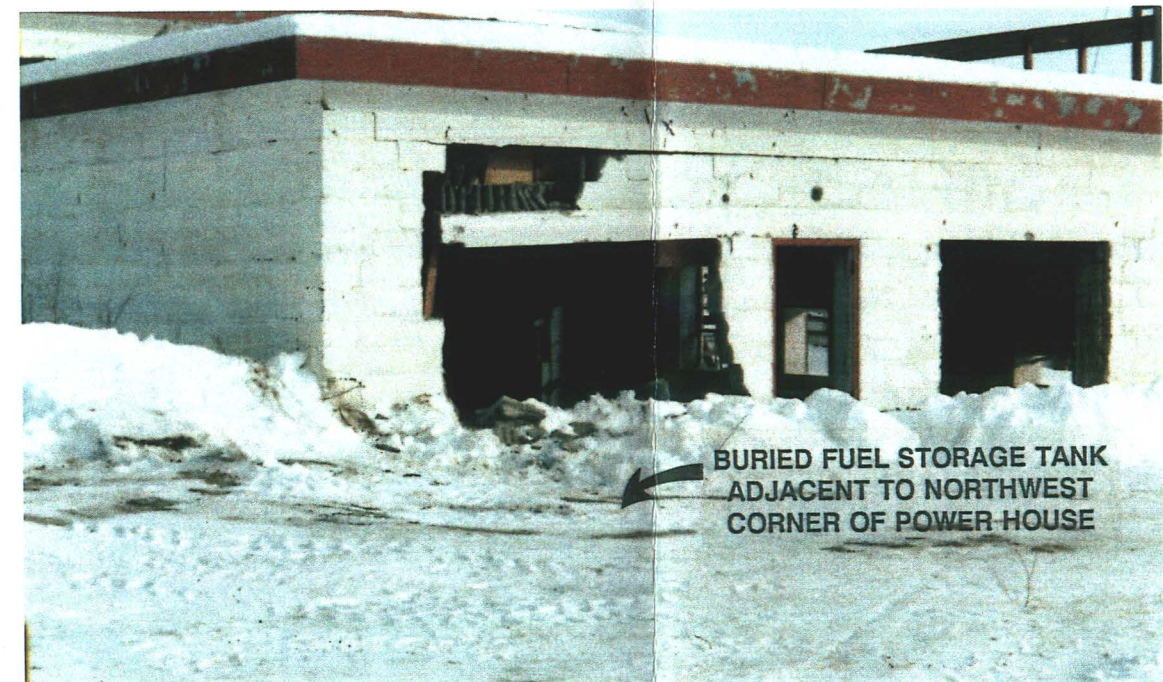
<i>EBA Engineering Consultants Ltd.</i>			PROJECT	ENVIRONMENTAL ASSESSMENT CHOUTLA SCHOOL, CARCROSS
CLIENT			TITLE	PHOTOGRAPHIC PRESENTATION OF SUBJECT SITE
PUBLIC WORKS CANADA			DATE	93-03-26
			DWN.	MCP
			CHKD.	
			FILE NO.	0201-11151



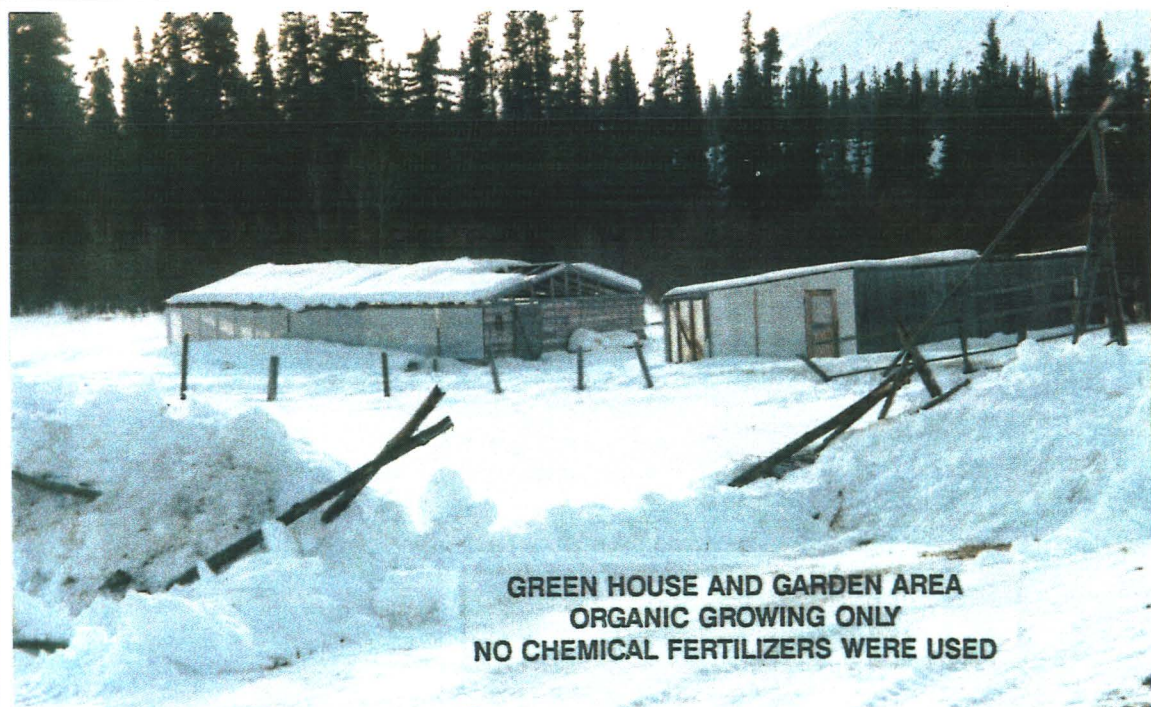
**DRILL RIG AT BH 11151-04
LOCATION WHERE TWO FUEL
STORAGE TANKS HAD
BEEN LOCATED**

**(BETWEEN NORTH WING OF
SCHOOL AND NORTHEAST
CORNER OF POWER HOUSE)**

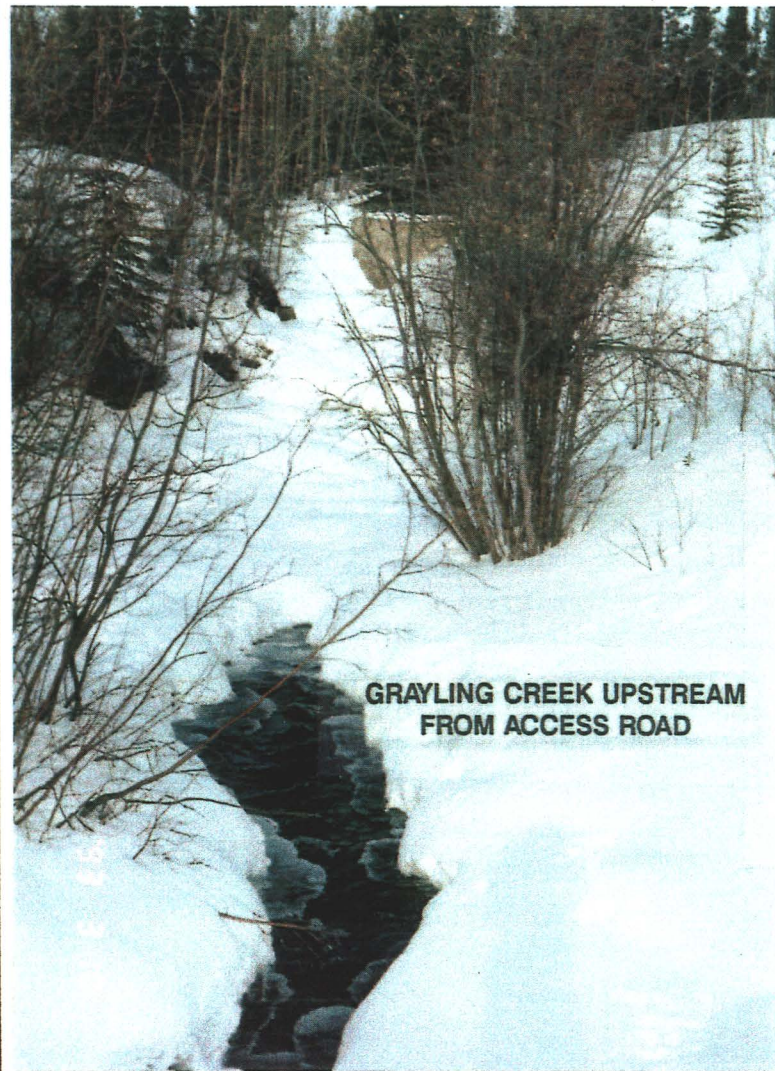
**UNDERGROUND TANK
LOCATIONS**



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GREEN HOUSE AND GARDEN AREA
ORGANIC GROWING ONLY
NO CHEMICAL FERTILIZERS WERE USED



GRAYLING CREEK UPSTREAM
FROM ACCESS ROAD

NOTE CONCRETE INTAKE STRUCTURE
IN PHOTO WHERE THE WATER FOR
THE SCHOOL SITE WAS DRAWN



WEST SIDE OF
POWER HOUSE



TWO PHOTOS SHOWING
THE TRANSFORMER BASES.

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APPENDIX E

**REMEDIALTION ALTERNATIVES FOR
HYDROCARBON CONTAMINATED SOILS**

TABLE OF CONTENTS

1.0	GENERAL	1
2.0	EXCAVATION AND REMOVAL TO LANDFILL SITE	2
2.1	General Description	2
2.2	Applicability	2
2.3	Advantages and Limitations	3
2.4	Costs	3
2.5	Equipment and Manpower Requirements	3
2.6	Data Required for Evaluation	4
3.0	EXCAVATION AND SELECTIVE REMOVAL OF SOIL TO LANDFILL	4
3.1	General	4
3.2	Applicability	4
3.3	Advantages and Limitations	5
3.4	Costs	5
3.5	Equipment and Manpower Requirements	5
3.6	Data Required for Evaluation	6
4.0	EXCAVATION AND SELECTIVE LAND FARMING OF CONTAMINATED SOIL	6
4.1	General Description	6
4.2	Applicability	7
4.3	Advantages and Limitations	7
4.4	Costs	7
4.5	Equipment and Manpower Requirements	8
4.6	Data Requirements for Evaluation	8
5.0	IN-SITU TREATMENT VAPOUR EXTRACTION	9
5.1	General Description	9
5.2	Applicability	9
5.3	Advantages and Limitations	9
5.4	Costs	10
5.5	Equipment and Manpower Requirements	10
5.6	Data Requirements for Evaluation	10
5.7	Other Related Information	11
6.0	EXCAVATION AND EX-SITU BIO-REMEDIATION OF SOILS	11
6.1	General	11
6.2	Applicability	11

6.3	Advantages and Limitations	12
6.4	Data Required for Evaluation	12
7.0	IN- SITU BIO-REMEDICATION	12
7.1	General	12
7.2	Applicability	13
7.3	Advantages and Limitations	13
7.4	Costs	13
7.5	Equipment and Manpower Requirements	13
7.6	Data Requirements for Evaluation	14
8.0	RISK ASSESSMENT	14
8.1	General Description	14
8.2	Applicability	15
8.3	Advantages and Disadvantages	15
8.4	Costs	15
8.5	Manpower Requirements	16
8.6	Data Requirements for Evaluation	16
9.0	PASSIVE REMEDIATION (DO NOTHING)	16

1.0 GENERAL

The main objectives of the remediation program are as follows:

- minimize the risks to human health and the environment
- ensure compliance with all applicable laws and regulations
- allow for future residential and/or commercial development of the site

With a view to meeting these objectives, EBA reviewed available alternatives on a site-specific basis that optimizes the following criteria:

- the results of the remediation program must adequately protect the present and any future residents of the land
- the results must adequately protect the environment
- the work must meet regulatory approval
- the work must be undertaken as economically as possible

To accomplish these goals, only proven remediation alternatives were considered. The following eight alternatives were evaluated:

- excavation and removal to landfill
- excavation and selective removal to landfill
- excavation and removal of soils on-site
- excavation and selective removal of soils on-site
- in-situ vapour extraction
- pump and treat ground water
- risk assessment with ground and surface water monitoring
- passive remediation

A description of each remediation alternative is described in the following sections.

2.0 EXCAVATION AND REMOVAL TO LANDFILL SITE

2.1 General Description

Excavation of contaminated soil and disposal off-site is a simple and effective method for dealing with small quantities of gasoline contaminated soil. Generally the method involves defining the vertical and areal extent of the contaminated area through drilling and chemical analysis excavating the area defined as exceeding regulatory guidelines, and disposing the contaminated soil at a suitable nearby landfill. The criteria for accepting contaminated soil varies between jurisdictions and landfills. The landfill at Whitehorse may accept hydrocarbon contaminated soil in small quantities but that would require significant haul costs.

Following removal of all contaminated soil from the site, additional soil on site is sampled and tested to confirm that any soil remaining on site is within regulatory limits. The excavation is then backfilled with clean engineered fill.

2.2 Applicability

Landfilling off-site is applicable for the following conditions:

- when the size of the contaminated area is small
- when immediate action is required due to immediate threat to public safety
- when the contamination cannot be remediated by ground water treatment or long-term treatment is too costly or undesirable

Highly toxic wastes are unsuitable for landfill disposal.

2.3 Advantages and Limitations

Off-site disposal has several advantages. It is an immediate and permanent remediation option and is generally the most cost effective alternative when small volumes of wastes are involved. Immediate health and safety threat to nearby residents and remediation workers. It is simple methodology utilizing readily available equipment such as backhoes and dumptrucks. The main disadvantages are that volatilization of certain contaminants such as gasoline may pose an immediate health and safety threat to workers involved in excavations and it is not cost effective for large scale contamination or when distances to a suitable landfill are large (or if no landfill is available). In addition, recent increases in landfill charges have affected the economics of its use.

2.4 Costs

The costs for delineation of the areal and vertical extent of a contaminated area is approximately \$15,000 to \$20,000. Soil excavation and hauling costs are estimated to be in the range of \$25 per tonne. Confirmatory chemical analysis of soil remaining in place and other associated engineering costs following excavation is approximately \$8,000. Costs of fill and compaction is approximately \$25 per tonne. Landfill costs are to be extra.

2.5 Equipment and Manpower Requirements

The equipment required for the excavation and transportation of contaminated soils, such as front-end loaders, backhoes and dumptrucks are generally readily available.

Manpower requirements may include additional field technical staff to part-time monitor the excavation and to collect soil samples for confirmation analysis following excavation.

2.6 Data Required for Evaluation

Site specific information necessary for excavation of contaminated soil and off-site disposal are:

- soil stratigraphy
- soil physical and chemical properties
- depth to ground water
- availability of suitable landfill site
- availability of equipment
- availability and site size

3.0 EXCAVATION AND SELECTIVE REMOVAL OF SOIL TO LANDFILL

3.1 General

Excavation and selective removal of soil to a landfill off-site is similar to the previously mentioned remediation alternative with the exception that engineering judgement and continuous sampling and testing of soil is conducted during removal. On-going testing of soils determines the degree of contamination present. Only soils which exceed applicable regulatory limits is landfilled and excavated clean soils are returned to the excavation as backfill.

3.2 Applicability

Excavation and selective removal of soils to landfills is applicable for moderate to large scale contaminated sites when immediate action is required or long term treatment is too costly. Hazardous wastes (i.e., highly flammable wastes or soils very high in BTEX) are not suitable for selective removal to a landfill off-site.

3.3 Advantages and Limitations

Selective removal and landfilling has several advantages. It is an immediate and permanent option and is generally the most cost effective method for medium to large scale contamination of fine-grained soils. It also uses readily available equipment such as backhoes and dumptrucks. The main advantage is minimizing the quantity of fill to be brought to site, but more significantly, it minimizes landfill and trucking costs. The main disadvantages are that volatilization of certain contaminants may pose an immediate health and safety threat to workers involved in excavations.

3.4 Costs

Costs for delineation, soil excavation, hauling, backfilling and landfilling charges are the same as for excavation and removal of all soils to the landfill; however, significant cost savings are realized with even a small proportion of soil being diverted from the landfill. Additional costs, however, are involved in monitoring, sampling and testing soils. Costs vary for monitoring and testing soils depending on the amount and type of testing conducted on site. Supervisory costs are approximately \$500/day.

3.5 Equipment and Manpower Requirements

The equipment required for the excavation and transportation of contaminated soils such as front-end loaders, backhoes and dumptrucks are readily available.

Manpower requirements include field technical staff to conduct full-time monitoring of the excavation, sampling and testing of soil samples during excavation and final sampling of soil remaining following excavation.

3.6 Data Required for Evaluation

Site specific information necessary for excavation of contaminated soil and off-site disposal are:

- soil stratigraphy
- soil physical and chemical properties
- delineation of contamination plume
- depth to ground water
- availability of suitable landfill site
- availability of equipment
- accessibility and site size

4.0 EXCAVATION AND SELECTIVE LAND FARMING OF CONTAMINATED SOIL

4.1 General Description

Land farming involves spreading selected excavated contaminated soil onto a prepared surface and may involve mixing wastes with the top layer of the soil. Degradation and immobilization of certain chemicals occur when applied to the surface soil. Organic chemicals undergo biodegradation, volatilization and photolysis at a much faster rate than in the case of passive remediation, particularly if additional soil nutrients or microorganisms are added and the waste is tilled occasionally. Inorganic chemicals such as lead, which may be present in some gasolines, will accumulate in soils and cannot be degraded.

4.2 Applicability

Soil farming of contaminated soils is applicable if the wastes are primarily organic chemicals which degrade readily, and if a suitable area is available for spreading large volumes of soil.

Temperature influences the rate of degradation. Warmer temperatures are conducive to faster degradation rates.

4.3 Advantages and Limitations

The main advantages of soil farming are that it may be the cheapest remediation option if a suitable area can be found, it only requires readily available equipment and it can completely remediate certain contaminants such as gasoline-range organics. The main disadvantages are: it is completely unsuitable for inorganics such as lead, it requires a large area away from populated areas in order to implement, it poses a health threat to workers involved in excavating and tilling the soil through exposure to volatile chemicals, and there may be difficulties obtaining regulatory approval to operate a soil farming operation.

4.4 Costs

The costs for them contaminated soils are similar to landfilling off-site. Savings may be realized because there are no costs associated with disposal of contaminated soils, the treated soil can be re-used, and there may be cost savings associated with placement of treated soil in excavations rather than importing engineered fill. There can be additional costs involved in soil nutrients, tilling the landfarmed soil and in monitoring.

4.5 Equipment and Manpower Requirements

Areas designated for on-site them operations are usually temporary treatment areas. Special site preparation such as liners and leachate collection systems are generally not required. Stormwater diversion (eg. a shallow earthen dyke, or ditches) around the treatment area would be necessary.

A crew is initially needed to set up the treatment area. Once established, a contractor is usually needed to disc the soil area, apply nutrients and monitor the progress of the process.

Equipment requirements include: earthmoving equipment for the initial establishment of the treatment area and the placement of the contaminated soil, soil discing equipment, a mix tank for nutrients and a sprinkler system to maintain desired moisture levels.

4.6 Data Requirements for Evaluation

Site specific information necessary for them contaminated soil are:

- soil stratigraphy
- soil physical and chemical properties
- quality of contaminated soil necessary for landfill
- depth to ground water
- aquifer physical properties and characteristics
- ground water flow rate and direction
- precipitation, temperature and wind direction
- topography
- accessibility and site size
- proximity to surface water
- current surface water drainage patterns
- current land use patterns

5.0 IN-SITU TREATMENT VAPOUR EXTRACTION

5.1 General Description

Vapour extraction involves forcing air throughout the soil medium to remove low molecular weight hydrocarbons from the vadose zone and the phreatic surface of the ground water (the surface of the water table). A system of wells is placed in the contaminated area and connected to a blower/burner facility via vapour collection headers. Circulating air within the vadose zone removes hydrocarbons that are partitioned into the vapour phase. These are brought to the surface and either treated or vented to the atmosphere.

5.2 Applicability

Vapour extraction is applicable for gasoline range organics within granular soils. It is inapplicable for higher end hydrocarbons or for fine-grained soils. Venting is difficult to control for areas with a high water table.

5.3 Advantages and Limitations

The main advantages of vapour extraction systems are that capital costs are generally low and compare favourably with other remediation options, it is an in-situ method that is non-disruptive to activities on site and it involves few of the health hazards associated with excavation, hauling, or them. Disadvantages include an inability to remove heavier end hydrocarbons, ineffectiveness in fine-grained soils and residual levels of hydrocarbons that may be left in treated soils. Also, if the vapour collected from the soil is only vented and not treated, the emissions can be a health hazard. Vapour extraction is not effective below the water table.

5.4 Costs

The costs of implementing vapour extraction can vary from approximately \$25,000 for a simple system to \$150,000 for more elaborate and effective systems. Operation and maintenance of a system can vary from \$5,000 to \$20,000 a year. Vapour extraction systems in optimum circumstances (i.e., gasoline range organics in coarse-grained soils) can remediate soils to acceptable levels within 3-10 years.

5.5 Equipment and Manpower Requirements

Equipment required for the extraction of volatiles includes:

- extraction wells
- vent ducts
- vacuum pump or air blower
- airflow monitoring equipment and control system
- exhaust emission control system (eg. carbon absorption system or flare gas burner)
- surface monitoring system

Once the system is in operation one person would generally be required for monthly monitoring to ensure proper equipment operation and to monitor exhaust gas quality.

5.6 Data Requirements for Evaluation

Site specific information necessary for using vapour extraction systems includes:

- contaminant characteristics
- soil stratigraphy
- soil physical and chemical properties

-
- depth to ground water
 - precipitation
 - topography
 - accessibility and site size
 - current land use

5.7 Other Related Information

Hydrocarbon production rates range from 0.1 to 0.2 kilograms per day to more than 50 kilograms per day depending on site conditions. Production rates decrease as concentrations of contaminants decrease. No permits are generally required for the installation and operation of volatile organic carbon venting equipment.

6.0 EXCAVATION AND EX-SITU BIO-REMEDIATION OF SOILS

6.1 General

Excavation and ex-situ bio-remediation of contaminated soil involves excavating contaminated soil and treating the soil inside a bio-reactor. Natural or genetically engineered soil micro-organisms are used to detoxify the contaminant of interest. The environmental conditions inside the bio-reactor are enhanced for ideal microbial catabolism or cometabolism of organic contaminants.

6.2 Applicability

Ex-situ bio-remediation is applicable for moderate to large scale organically contaminated sites where landfills are unavailable or costs of disposal are high.

Inorganic chemicals such as lead are inapplicable for ex-situ bio-remediation.

6.3 Advantages and Limitations

The main advantages of ex-situ bio-remediation is all soil is treated on-site and it is generally cost effective for sites where no suitable landfills are nearby. Organic chemicals in soil concentrations too high to be acceptable at landfill sites are ideally remediated with this methodology.

The disadvantages of ex-situ bio-remediation is it involves a health threat to workers involved in excavating the soil through exposure to volatile chemicals and is generally not cost-effective compared to other excavation alternatives until disposal costs reach approximately \$50/tonne.

6.4 Data Required for Evaluation

Site-specific information necessary for ex-situ bio-remediation of contaminated soil is:

- soil physical and chemical properties
- amount and nature of contaminated soil
- availability of equipment and appropriately trained personnel
- space limitations on site

7.0 IN- SITU BIO-REMEDICATION

7.1 General

In-situ bio-remediation is similar in principal to ex-situ bio-remediation except it involves no excavation or disruption of site activities and enhancement of the soil environment of microbial degradation is done in-situ.

7.2 Applicability

In-situ bio-remediation is applicable for moderate to large scale contaminated sites where disruption of the site is considered an important factor. It is generally more applicable for coarse-grained as opposed to fine-grained soils and works best with organic chemicals such as gasoline. As is the case for ex-situ bio-remediation, in-situ bio-remediation is ineffective for lead.

7.3 Advantages and Limitations

Advantages of in-situ bio-remediation include little disruption to the site and low health threat to remediation workers. Disadvantages include generally higher costs to remediate sites and the inability to clean up the site to the most stringent standards (i.e., CCME Criteria for Soils). It is also ineffective for certain site conditions such as tightly packed clays and for certain chemical classes such as inorganics. Acceptable levels of remediation are also not immediate and may take several years. This is an important function in this instance.

7.4 Costs

The cost of in-situ bio-remediation of a site can vary from as little as \$80,000 for a very small scale contamination problem to approximately \$500,000 for a moderate scale contamination problem. Costs are very highly site and contaminant dependent.

7.5 Equipment and Manpower Requirements

In-situ bio-remediation requires a ground water injection and extraction well network blowers, oxygenation system and a small shed to house this equipment.

Field technical staff are usually required to maintain the system.

7.6 Data Requirements for Evaluation

Site-specific information necessary for in-situ bio-remediation of contaminated soils are:

- soil stratigraphy
- soil physical and chemical properties
- contamination fully characterized
- depth to ground water
- aquifer physical properties and characteristics
- ground water flow rate and characteristics
- accessibility and site size
- proximity to surface water

8.0 RISK ASSESSMENT

8.1 General Description

Risk assessment involves contaminant fate transport modelling (i.e. where a contaminant travels, what form the contaminant takes and when it arrives at a particular location) together with toxicology information of a particular contaminant, and determines the risks involved to potential receptors (human, animal or an ecosystem). If the risk is determined to be low (i.e. 1 in 1,000,000 chance of death due to cancer), no further action at a site may be recommended. For the Choutla School site, the benzene transport in ground water would be modelled and the benzene concentration in the creek and lake predicted. If the predicted levels in the lake or creek were found not to exceed the Canadian Drinking Water Guidelines (which are risk based standards) no further remedial works would be necessary. If the predicted concentrations were found to exceed the Canadian Drinking Water Guidelines, further remedial actions would be necessary.

8.2 Applicability

A risk assessment is applicable in situations where the concentration of a particular contaminant exceeds a regulatory limit, and where there may be a benefit (either on economic, technical or health grounds) gained in determining a site specific risk based standards. The concentration of benzene in the soil at the Choutla School site was found to be just over the regulatory limit. There is likely a health benefit in not exposing nearby residents and remedial workers to benzene released during a remedial program, as well as an economic benefit. A risk assessment may be applicable in a situation such as the Choutla School site.

8.3 Advantages and Disadvantages

The main advantage of a risk assessment are economics and health. A risk assessment will normally allow, with justification, no remediation of the site or a reduced remediation program. As most remedial programs involve a large (but of short duration) release of contaminants, there is lower health risk to both the surrounding population and remedial workers. Also a reduced remedial program is more economical. The main disadvantage to a risk assessment is the future fate, and therefore risk, of a contaminant is being predicted, and there is some uncertainty involved in the predictions. A very conservative risk assessment is often necessary to protect the public. There is, therefore, a decrease in benefits if a too conservative approach is taken.

8.4 Costs

The cost of a risk assessment is dependant on the complexity of the problem. A very detailed risk assessment of a complex and highly hazardous site (i.e. a leaking landfill) can be several hundred thousand dollars. The Choutla School site is relatively uncomplicated and the costs should be between \$10,000 to \$15,000.

8.5 Manpower Requirements

Provided that site specific data has already been obtained, a risk assessment is primarily a modelling exercise and there are no equipment costs. Only appropriately qualified professionals should undertake risk assessments.

8.6 Data Requirements for Evaluation

Site specific information necessary for a risk assessment are:

- soil stratigraphy
- soil physical and chemical properties
- ground water characteristics
- topography
- precipitation, temperature and wind direction
- proximity to surface water and wells
- population of surrounding area
- current and future land use patterns
- chemical properties of contaminant
- toxicological properties of contaminant

9.0 PASSIVE REMEDIATION (DO NOTHING)

Passive remediation is not a viable alternative. It's main use as an alternative is as a contrast to the other alternatives. It is used as minimum baseline in ranking schemes.