Resources
HSW
Hazardous Waste
48

PITEAU ENGINEERING LTD.
HYDROGEOLOGICAL AND GEOTECHNICAL CONSULTANTS

SUITE 100, 4500 - 16th AVENUE N.W.
CALGARY, ALBERTA
CANADA T3B 0M6
TELEPHONE (403) 286-2522
TELEX 03-821172
FAX (403) 247-4811

TADEUSZ L. DABROWSKI
FREDERIC B. CLARIDGE
DENNIS C. MARTIN

March 10, 1992
OUR FILE: A91-2490

Community and Transportation Services
Municipal Engineering Branch
Yukon Territorial Government
P.O. Box 2703
Whitehorse, Yukon
Y1A 2C6

Attention: Mr. Jeff Boehmer, P.Eng., Program Engineer
Mr. Don Wilson, Waste Management Coordinator

Dear Sirs:

Subject: Phase I Hydrogeological Investigation - Copper Mine Site

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1. GENERAL

Piteau Engineering Limited of Calgary was retained by the Yukon Territorial Government to conduct an initial hydrogeological investigation of a potential site for the Special Waste Transfer Station. The area of investigation is located west of the Whitehorse Copper Mine, about 2.5 km WSW of the town of MacRae (Figure 1). The objective of the program was to conduct a hydrogeological investigation, and to assess the site's suitability for the proposed Transfer Station. Geotechnical conditions were also to be inferred from the drilling results. Aurum Geological Consultants Limited of Whitehorse was contracted by Piteau Engineering to assist in site reconnaissance and geological interpretation. Assessment of the proposed site was conducted between February 16 and 19, 1992.

2. REGIONAL GEOLOGIC SETTING

Bedrock

The region is underlain by two bedrock units, the Lewes River Group and the Whitehorse Pluton (Figure 2). The Late Triassic Lewes River Group, 200 m west of the Copper Mill Site, is a structurally-complex assemblage of calcareous and dolomitic clastic sediments. The mid-Cretaceous Whitehorse Pluton is a massive body of intrusive igneous rock trending NNW across the region. It comprises a grey, equigranular, medium to coarse grained granodiorite (Watson, 1984). The proposed Copper Mine Site is situated on the Whitehorse Pluton (Figure 2).

Contact zones between the intrusive Whitehorse Pluton and Lewes River Group often host mineral deposits. These contact zones occur as the Whitehorse Copper Belt. Since 1897, such deposits have been exploration targets (Watson, 1984). Numerous boreholes and mine workings can be expected in the Copper Belt.

Quaternary Deposits

Quaternary-age deposits include the Miles Canyon Basalt and unconsolidated glacial drift. The Miles Canyon Basalt occurs 2 km east of the area of investigation. It trends NNW in rough correspondence with the Yukon River valley and areas of population. Generally, the Miles Canyon Basalt is columnar jointed and vesicular, and varies in thickness from 2 m to over 30 m. Age of the basalt is between 2.4 and 8.8 million years before present (Ma). The basalt lies unconformably on or is interbedded with unconsolidated preglacial materials (Hart and Radloff, 1990).

Two types of glacially-derived, unconsolidated surficial deposits are recognized: sandy/gravelly tills and glaciolacustrine silts. The sandy/gravelly deposits generally occur in medium to high elevation areas, whereas the silts are found in the Yukon River valley, particularly near Whitehorse. Silt thicknesses near Whitehorse are up to 70 m (Hart and Radloff, 1990).

Faults

Two minor SE-NW striking faults, associated with Cretaceous-Tertiary movement (30 - 40 Ma) along the Tintina Fault, occur in the vicinity of the Copper Mill Site. The Polar Lake Fault lies about 1.5 km north of the site (Figure 2) while the North Star Fault is about 400 m south. Since these and other associated faults do not appear to have displaced the Miles Canyon Basalt, most recent movement along them must have occurred prior to 2.4 Ma (Doherty, pers. comm.).

3. FIELD EXPLORATION PROGRAM

Drilling at the Copper Mine Site was carried out using a Schramm T450 rotary rig supplied and operated by Midnight Sun Drilling Co. of Whitehorse. This type of rig accommodates drilling in consolidated deposits. By using air as the circulation medium, the possibility of introducing contaminants into groundwater was minimized.

Two single piezometers (92-2B and 92-3A) and one double piezometer (92-1A/1B) were installed between February 16 and 18, 1992. Borehole logs are provided in Appendix I. Details of piezometer installation are presented in Table 1 and locations are shown on Figure 3. Piezometer locations and elevations were surveyed by Yukon Engineering Services of Whitehorse.

Aquifer hydraulic conductivity tests were conducted after piezometer installation. Field-measured water level data and calculations are provided in Appendix II. Groundwater samples were collected for analysis of main ions/routine potability and DOC. Results of chemical analysis are provided in Appendix III. Selected hydrochemical parameters are presented in Table 2.

SITE HYDROGEOLOGY

Topography

The Copper Mine Site is situated on a gently sloping (<1%) terrace located between two northerly trending scarps (Figure 3). Relief of the western scarp is about 2 - 3 m whereas that of the eastern scarp is 20 - 30 m. Examination of aerial photographs and the 1:50,000 Whitehorse topographic map sheet (NTS 105D/11) suggest that surface water drainage below the site is poor. Northwesterly striking gulleys about 2 - 3 m deep and 20 m wide are incised in the terrace. The number and lateral extent of these gulleys could not be assessed due to the thick snow cover.

Geology

Hydrogeologic cross-sections across the site are presented in Figures 4 and 5. A thin (0 - 5 m) layer of medium to coarse-grained, unconsolidated sand and gravel underlays the site. Little silt or clay were apparent, but drilling operations substantially disturbed the unconsolidated sediments. Actual site and clay content could be better determined in the spring time with a hand auger or shovel. The sand and gravel overburden was dry.

Bedrock at the site consists of fine to medium grained granodiorite (Figure 4; Appendix I). Outcrops of granodiorite (i.e., zero thickness of overburden) are relatively common. At such outcrops, three suborthogonal joint sets are present. Spacing between joints is about 0.5 m. During drilling, shallow fracture zones were observed at about 5 m depth in boreholes 92-1A and 92-3A. The fracture zones were indicated by reddish-brown discoloration and brecciated material. Such fracture zones were not observed beyond 8 m depth. With increased depth, the granodiorite appears homogeneous and shows little change in grain size or coloration.

Groundwater Levels

The depth to groundwater-bearing zones is irregular (Table 1). Groundwater was encountered at about 5 m in the shallow fracture zones (92-1A, 92-3A). A deeper groundwater-bearing zone was observed at 15 m in borehole 92-1B. Confined conditions are indicated by the stabilization of piezometric levels between 3 and 7 m above the groundwater-bearing zones. At borehole 92-2B, depth of appreciable groundwater exceeds 40 m (Figure 5). Due to the different levels of groundwater, flow directions and velocities could not be calculated.

Hydraulic Conductivity Testing

During hydraulic conductivity testing at piezometer 92-1A, the stabilized piezometric level was initially 3.35 m below ground surface (Table 1). After bailing, the piezometric level stabilized to 6.79 m (Appendix II), and remained at that level for at least another 24 hours. It thus appears that the shallow fracture zone was dewatered, which suggests that the fracture set occupies only a very limited volume. Hydraulic conductivity at 92-1A could not be determined because of dewatering.

Aquifer testing at 92-1B and 92-3A yielded a hydraulic conductivity on the order of 10^{-06} m/s (Table 1; Appendix II). The calculated value represents hydraulic conductivity averaged over the screened interval, i.e., the average of matrix and fracture hydraulic conductivity. Actual hydraulic

conductivity of a specific fracture may be orders of magnitude larger. Depending on their hydraulic conductivity and distribution through the rock, fractures may strongly influence the rate and direction of groundwater flow.

On the other hand, the irregular piezometric levels and the dewatering suggest that the fracture zones may not be mutually well-connected. The groundwater may occur in fracture sets of limited volume which are hydraulically isolated. Within a hydraulically isolated fracture set, the groundwater would be essentially static. Detailed assessment of the hydraulic continuity across the site would require a pumping test and two or three additional piezometers.

Hydrochemical Characterization

Groundwater from the piezometers was collected and analyzed for main ions/potability and DOC (Table 2; Appendix III). The levels of mineralization (Total Filterable Residue or TFR) are all below maximum acceptable for drinking water (< 500 mg/L; Health and Welfare Canada, 1989). Chloride and DOC levels, two gross indicators of contamination, are within their expected background levels (< 10 mg/L). Overall, the main ion concentrations, pH, and TFR are typical of shallow bedrock groundwater in its natural state.

The following chemical types of groundwater were observed:

Piezometer	Hydrochemical Type	Mineralization TFR (mg/L)
92-1A	Ca-Na-HCO_3-SO_4	435
92-1B	Ca-Mg-HCO_3	279
92-3A	Ca-Mg-HCO_3	285

Groundwater in piezometers 92-1A and 92-3A, completed at the same depth and less than 80 m apart, are of different hydrochemical type. At the same time, the same hydrochemical types are in groundwater from shallow piezometer 92-3A and the deeper piezometer 92-1B. The higher TFR and sulphate content at 92-1A may provide additional evidence that the groundwater there is essentially static within an isolated fracture network. On the other hand, the particular chemical type and low TFR at 92-1B and 92-3A may signify that the groundwater at these locations is actively circulating through relatively well-leached bedrock.

The presence of different hydrochemical types within the upper 15 m of a small area indicates very complex hydrogeologic conditions. It should be kept in mind, however, that one set of analyses is insufficient to characterize the ambient groundwater. After the effects of drilling and piezometer installation have diminished, samples should again be collected and analyzed for the same parameters.

Summary and Discussion

The hydrogeology of the site is relatively complex. The depth to groundwater-bearing zones appears fracture dependent. At the same time, piezometric levels are generally irregular and do not appear to mirror topography, which may be expected if the fracture network across the site

well-connected and the granodiorite behaves as a porous medium. Chemical evidence is mixed: data from 92-1A provide evidence for hydraulically-isolated fracture zones, whereas results from 92-1B and 93-3A suggest active groundwater flow.

5. GENERAL GEOTECHNICAL

Geotechnical conditions can be inferred from the drilling results. The site is situated on competent, relatively free-draining material which should possess sufficient bearing capacity for the proposed facility and not be susceptible to excessive settlement or subsidence. In addition, there are no evident geologic hazards near the site, such as landslide or avalanche areas. Coarse-grained construction materials should be readily available for the construction of building foundations and road subgrades. A comprehensive geotechnical evaluation will be completed as part of the final investigation, should the site be collected.

6. DISCUSSION AND RECOMMENDATIONS

As discussed in Piteau's letter dated March 12, 1992, three sites - the Copper Road Site, the Alternate Landfill Site, and the Copper Mine Site - are all geotechnically suitable for safely siting the Waste Storage Facility. Hydrogeologically, the Copper Road Site remains most highly recommended because the land surface and the groundwater-bearing zone are separated by a thick, low hydraulic conductivity basalt as well as a layer of low hydraulic conductivity clay. Depth to the groundwater zone is generally less at the Alternate Landfill and Copper Mine sites. The hydrogeology at both sites is comparatively complex.

Waste at the proposed facility is to be stored only temporarily. Any volume spilled will likely be very small, and the facility will be designed to prevent all fluid contaminant discharge to the subsurface. By importing materials and constructing multiple protective liners, both the Alternate Landfill and the Copper Mine sites could provide sufficient protection of groundwater resources. The Alternate Landfill Site is not recommended, however, since the possibility of preexisting contamination would make it impossible to evaluate the facility's performance. On the other hand, the Copper Mine Site is upgradient of possible known contaminant sources, e.g., tailings ponds, and the groundwater appears to be in its natural state.

If the committee wishes to locate the facility at the Copper Mine Site, additional hydrogeologic investigation is recommended. Additional investigation would optimize facility location and design of its groundwater quality monitoring network. It is recommended that such investigation include:

(1) a geophysical survey to determine distribution and thickness of overburden, and possible existence of major fracture zones;

(2) additional monitoring wells, installed based on geophysical results, to allow more detailed hydraulic characterization, and,

(3) a pumping test to determine the degree of hydraulic continuity across the site, as well as the transmissivity of fracture zones.

Details of implementing the above recommendations can be established when it is known whether

e Copper Mine site is acceptable to committee members.

We trust that this report is suitable for your present needs. If you require further information, please contact the undersigned at your convenience.

Report Prepared By:
PITEAU ENGINEERING LTD.

Morris Maccagno, M.Sc., Geol. I.T.

Dr. Tad Dabrowski, P.Eng.

Gordon J. Johnson, M.S., P.Eng.

7. REFERENCES

Hart, C.J.R., and J.K. Radloff, 1990. Geology of Whitehorse, Alligator Lake, Fenwick Creek, Carcross and part of Robinson Map Areas (105D/11,6,3,2,&7). Indian and Northern Affairs: Yukon Region Open File 1990-4. Exploration and Geological Services Division, Whitehorse, Yukon.

National Health and Welfare, 1989. Guidelines for Canadian Drinking Water Quality, Fourth Edition. Minister of National Health and Welfare Canada. Ottawa.

Watson, P.H., 1984. The Whitehorse Copper Belt - A Compilation. Indian and Northern Affairs, Exploration and Geological Services Division, Whitehorse, Yukon.

TABLE 1

Details of Piezometer Installation, Depth to Groundwater Zone and Hydraulic Conductivity

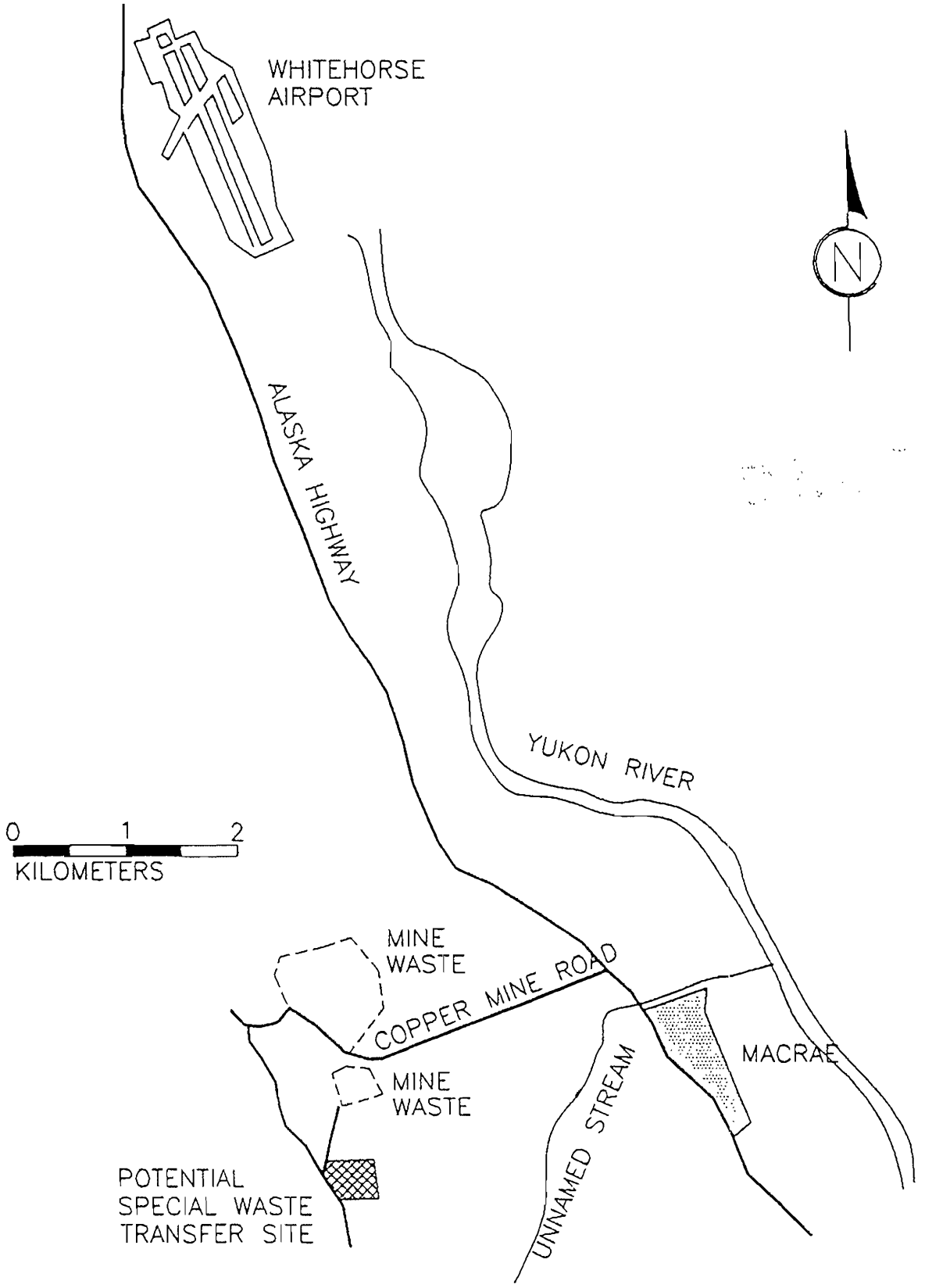
PIEZO. NO.	GROUND ELEVATION (geodetic) (m)	PVC STICK-UP (m)	DATUM ELEVATION (geodetic) (m)	DEPTH INTERVAL OF SAND (below PVC top) (m)	DEPTH TO GROUNDWATER ZONE (below PVC top) (m)	DEPTH TO PIEZOMETRIC SURFACE (below PVC top) (m)	PIEZOMETRIC SURFACE ELEVATION (geodetic) (m)	DATE (d/m/y)	HYDRAULIC CONDUCTIVITY (m/s)	LITHOLOGY OF COMPLETION
92-1A	841.9	0.57	842.5	7.0-8.5	7.32	3.92	838.55	19/02/92	-	fractured granodiorite
92-1B	842.0	0.61	842.6	13.7-15.7	14.94	7.35	835.26	18/02/92	2.4E-06	granodiorite (fractured ?)
92-2B	842.5	0.51	843.0	13.4-15.7	>40	dry	-	20/02/92	-	granodiorite (fractured ?)
92-3A	843.3	0.52	843.3	4.2-6.0	5.02	3.31	839.99	20/02/92	3.3E-06	fractured granodiorite

TABLE 2

SELECTED HYDROCHEMICAL PARAMETERS

PIEZO. NO.	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	CHLORIDE (mg/L)	SULPHATE (mg/L)	pH	BICARBONATE (mg/L)	DOC (mg/L)
92-1A	71.00	11.50	73.50	5.30	137.0	7.40	265.7	7.4
92-1B	86.00	14.50	3.87	1.00	29.2	7.60	286.5	4.5
92-2B	-	-	-	-	-	-	-	-
92-3A	85.00	14.00	7.80	0.70	32.6	7.40	286.5	5.4

NOTE: PIEZOMETER 92-2B DRY AT TIME OF SAMPLING

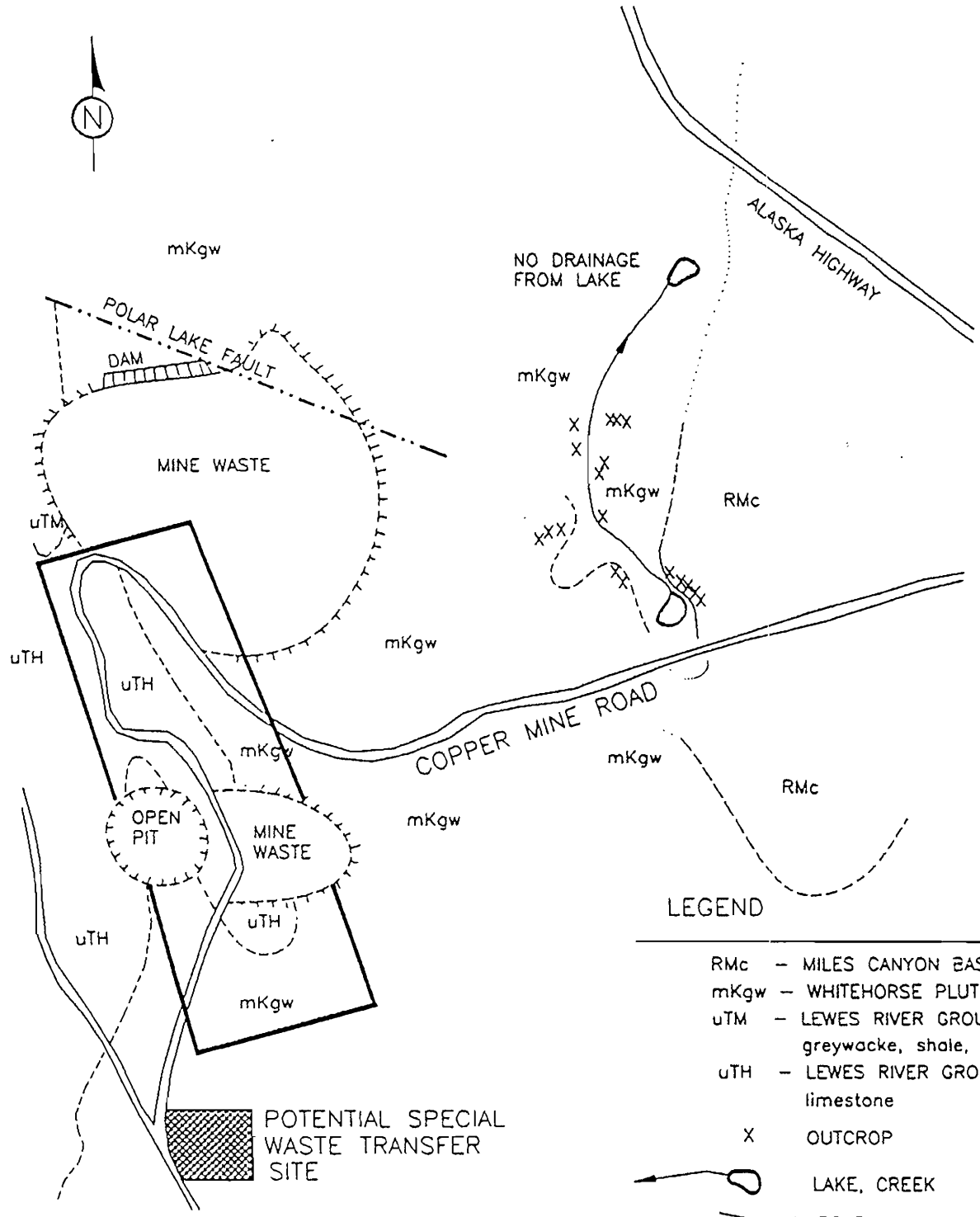


YUKON TERRITORIAL GOVERNMENT
WASTE CONTAINMENT SITES INVESTIGATION

PITEAU ENGINEERING LTD.
GEOTECHNICAL AND
HYDROGEOLOGICAL CONSULTANTS
VANCOUVER CALGARY

LOCATION OF STUDY AREA AND DRAINAGE

BY:	DATE:
M.T.	MAR./92
APPROVED:	FIGURE:
	1



NOTE: PREPARED BY AL DOHERTY, AGCI

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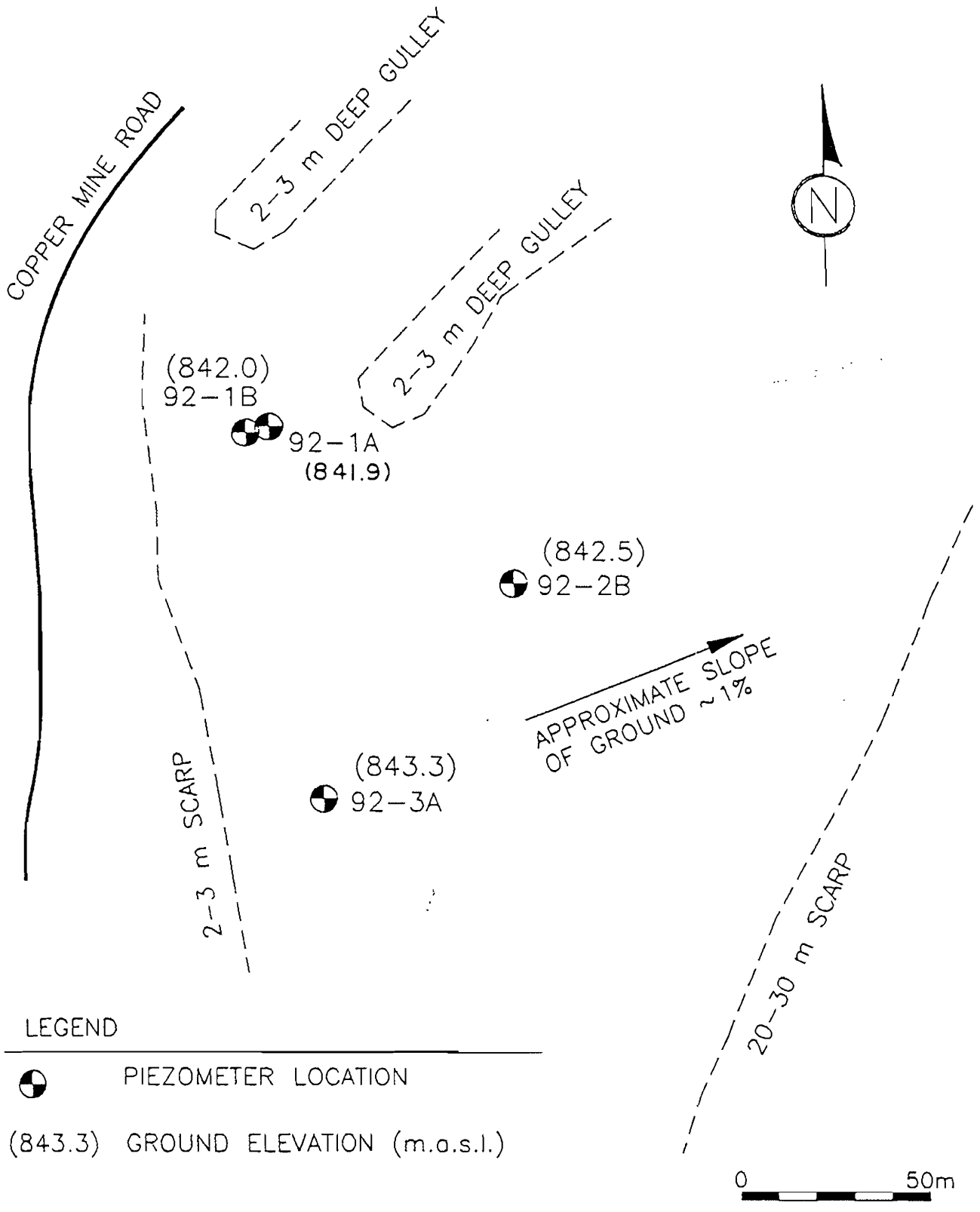
VANCOUVER CALGARY

WHITEHORSE COPPER MINE AREA GEOLOGICAL MAP

BY:	DATE:
M.T.	MAR./92
APPROVED:	FIGURE:
	2



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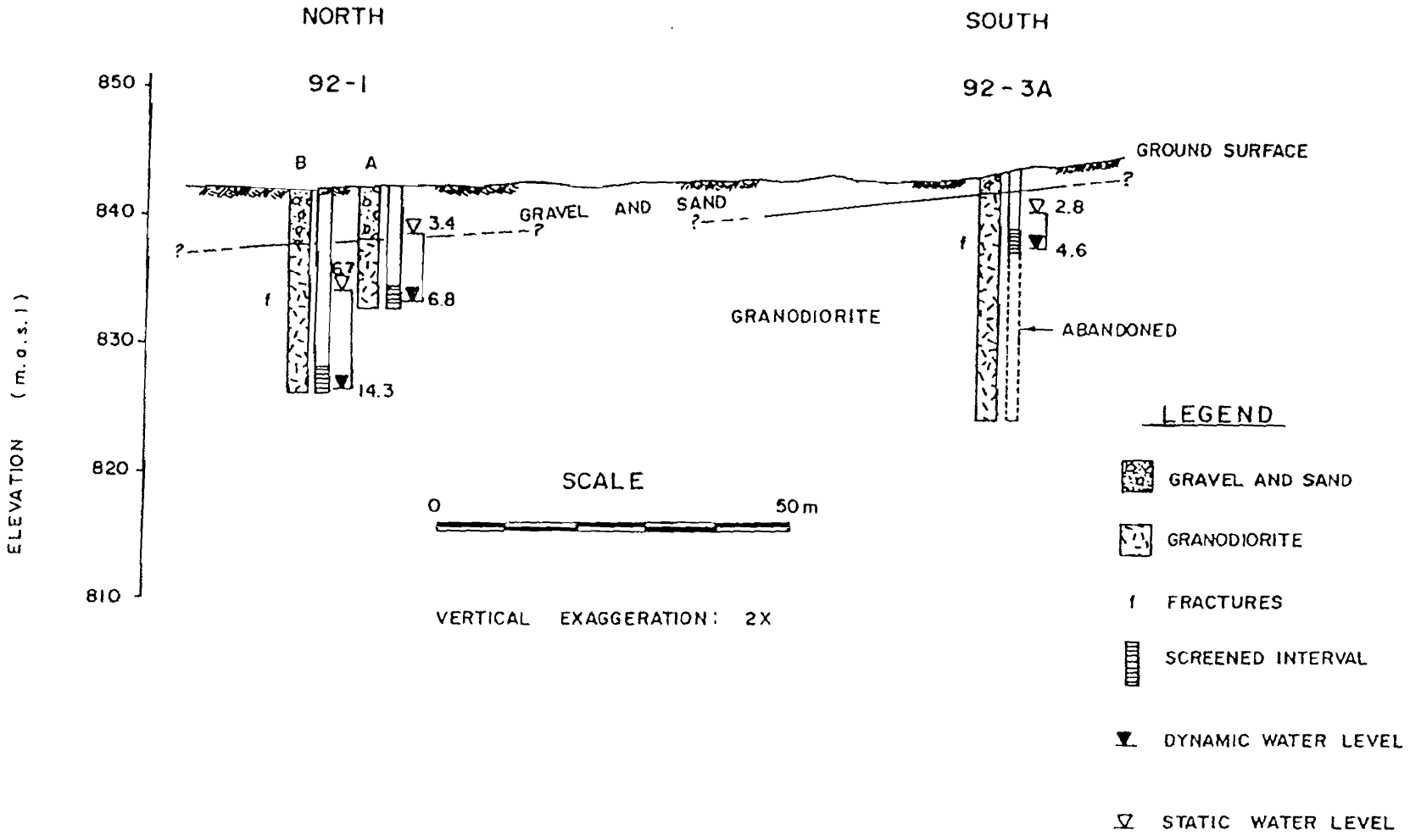
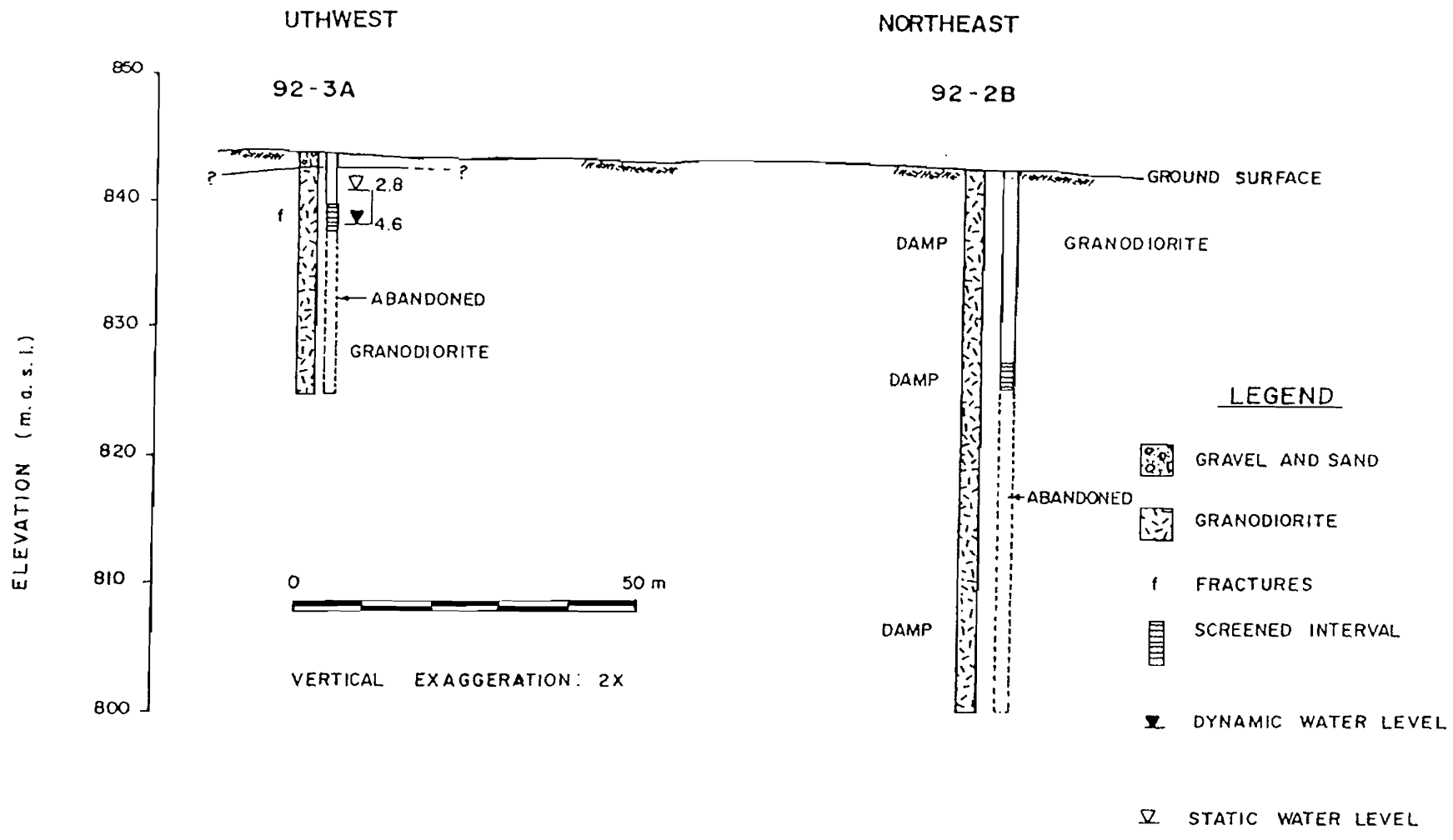
VANCOUVER CALGARY

APPROXIMATE PIEZOMETER LOCATIONS AND GROUND ELEVATIONS

BY:	DATE:
M.T.	MAR./92
APPROVED:	FIGURE:
	3



YUKON TERRITORIAL GOVERNMENT WASTE CONTAINMENT SITES INVESTIGATION	PITEAU ENGINEERING LTD. GEOTECHNICAL AND HYDROGEOLOGICAL CONSULTANTS VANCOUVER CALGARY	
NORTH - SOUTH HYDROGEOLOGICAL CROSS-SECTION	BY: E.L.	DATE: MARCH/92
	APPROVED:	FIGURE: 4



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VANCOUVER CALGARY

SOUTHWEST - NORTHEAST HYDROGEOLOGICAL CROSS - SECTION

BY: E.L.
DATE: MARCH/92
APPROVED:
FIGURE: 5

APPENDIX I

BOREHOLE LOGS AND DETAILS OF PIEZOMETER CONSTRUCTION

PITEAU ENGINEERING LTD. OFFICE REPORT ON SITE INVESTIGATION SHEET 1 OF 2

CONTRACT NO.: A91-2490
BORING NO.: 92-1A/1B
NORTHING: 6721408.682
COMPILED BY: M. Maccagno
LOCATION: Coppermine Mill
EASTING: 496987.509
BORING DATE: February 18, 1992
CONTRACTOR: Midnight Sun Drilling
ELEVATION: 841.934

DRILLING NOTES:
Coordinates are UTM.
152mm steel casing to 4.5m (92-1a) and 6.7m (92-1b).

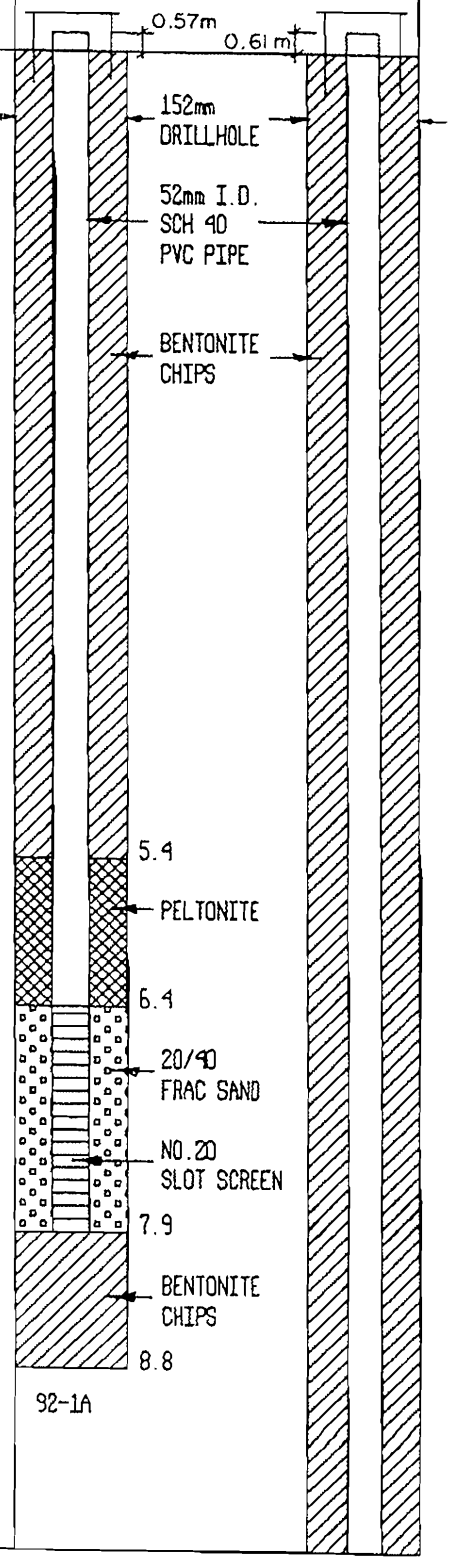
TYPE OF RIG: Schramm Rotary Top-drive
SAMPLE HAMMER: wt.: 63.6 kg drop: 76 cm

▽ STATIC WATER LEVEL
▼ DYNAMIC WATER LEVEL

DEPTH m	SYMBOL	DESCRIPTION	HYDROGEOLOGIC INFORMATION: WATER LEVEL	HYDROGEOLOGIC INFORMATION: AIR-LIFT TEST	HYDROGEOLOGIC INFORMATION: JOINTS AND FRACTURES	HYDRAULIC CONDUCTIVITY
0.0		SOIL/ROCK				
		SAND AND GRAVEL: medium to coarse, 1-2 cm pebbles, black microcrystalline basalt fragments, coarse to medium crystalline granite fragments, dry				
			1A 19/02/92 3.35m ▽			
4.3						
		GRANODIORITE: light greenish grey, fine to medium crystalline				
5.8		alteration zone, greenish-brown to red, brecciated zone				
6.2		damp to wet	20/02/92 1B 6.73m ▽	6.2m steady <1Igpm		
			1A 18/02/92 7.31m ▼			
7.9		reddish brown				

WELL INFORMATION

DRILLING AND INSTRUMENTATION



PITEAU ENGINEERING LTD. OFFICE REPORT ON SITE INVESTIGATION SHEET 2 OF 2

CONTRACT NO.: A91-2490
BORING NO.: 92-1A/1B
NORTHING:

COMPILED BY: M. Macaggno
LOCATION: Coppermine Mill
EASTING:

BORING DATE: February 16, 1992
CONTRACTOR: Midnight Sun Drilling
ELEVATION:

DRILLING NOTES:

TYPE OF RIG:

SAMPLE HAMMER- wt.: 63.6 kg drop: 76 cm

▽ STATIC WATER LEVEL
▼ DYNAMIC WATER LEVEL

DEPTH m	SYMBOL	DESCRIPTION (SOIL/ROCK)	HYDROGEOLOGIC INFORMATION: WATER LEVEL	HYDROGEOLOGIC INFORMATION: AIR-LIFT TEST	HYDROGEOLOGIC INFORMATION: JOINTS AND FRACTURES	HYDRAULIC CONDUCTIVITY	WELL INFORMATION: DRILLING AND INSTRUMENTATION
10.0		GRANODIORITE: light greenish grey, fine to medium crystolline					
11.0							BENTONITE
12.0							12.3 PELTONITE
13.0							13.1
							13.6 20/40 FRAC SAND NO.20 SLOT SCREEN
14.0		14.3 free-water, stronger flow (approx. 1 Igpm)	▼ 14.3 16/02/92				
15.0							15.1
							92-1B
16.0							
17.0							
18.0							
19.0							
20.0							

PITEAU ENGINEERING LTD. OFFICE REPORT ON SITE INVESTIGATION SHEET 1 OF 1

CONTRACT NO.: A91-2490
BORING NO.: 92-28 3A
NORTHING: 6721376.089
COMPILED BY: M. Maccagno
LOCATION: Coppermine Mill
EASTING: 497052.602
BORING DATE: February 17, 1992
CONTRACTOR: Midnight Sun Drilling
ELEVATION: 842.554 (Ground)

DRILLING NOTES:
Coordinates are in UTM.
152mm steel casing to 6.7m.

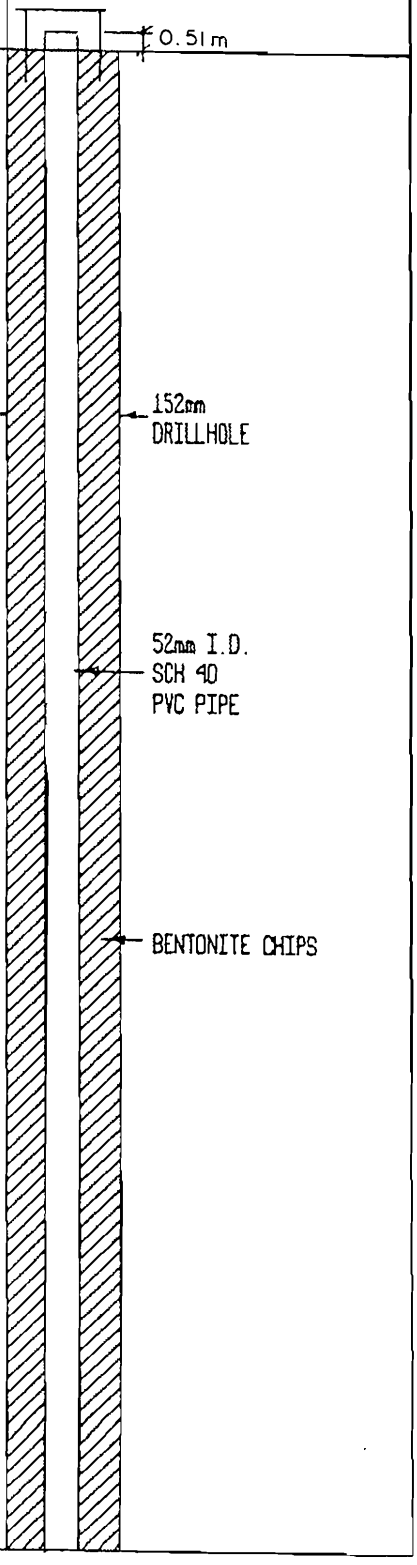
TYPE OF RIG: Schramm Rotary Top-drive
SAMPLE HAMMER: wt.: 63.6 kg drop: 76 cm

▽ STATIC WATER LEVEL
▼ DYNAMIC WATER LEVEL

DEPTH m	SYMBOL	DESCRIPTION (SOIL/ROCK)	HYDROGEOLOGIC INFORMATION: WATER LEVEL	AIR-LIFT TEST	JOINTS AND FRACTURES	HYDRAULIC CONDUCTIVITY
0.0		GRANODIORITE: light greenish grey, fine to medium crystalline, some calcite veins				
6.7		calcite veining, slightly damp				

WELL INFORMATION

DRILLING AND INSTRUMENTATION



PITEAU ENGINEERING LTD. OFFICE REPORT ON SITE INVESTIGATION SHEET .2. OF 9..

CONTRACT NO.: A91-2490
BORING NO.: 92-28 3A
NORTHING:

COMPILED BY: M. Maccagno
LOCATION: Coppermine Mill
EASTING:

BORING DATE: February 17, 1992
CONTRACTOR: Midnight Sun Drilling
ELEVATION:

DRILLING NOTES:

TYPE OF RIG: Schramm Rotary Top-drive
SAMPLE HAMMER: wt.: 63.6 kg drop: 76 cm

▽ STATIC WATER LEVEL
▼ DYNAMIC WATER LEVEL

DEPTH m	SYMBOL	DESCRIPTION SOIL/ROCK	HYDROGEOLOGIC INFORMATION WATER LEVEL	AIR-LIFT TEST	JOINTS AND FRACTURES	HYDRAULIC CONDUCTIVITY	WELL INFORMATION DRILLING AND INSTRUMENTATION
10.0		GRANODIORITE: as above, light greenish grey, fine to medium crystalline, some calcite veins					BENTONITE
11.0							
12.0							11.9 PELTONITE
13.0							12.9 20/40 FRAC SAND
14.0			DRY 20/02/92				13.7
		14.8 slightly damp					NO.20 SLOT SCREEN
15.0							15.2
16.0							
17.0							
18.0							
19.0							
20.0							

PITEAU ENGINEERING LTD. OFFICE REPORT ON SITE INVESTIGATION SHEET 3 OF 9

CONTRACT NO.: A91-2490
BORING NO.: 92-28 3A
NORTHING:

COMPILED BY: M. Maccagno
LOCATION: Coppermine Mill
EASTING:

BORING DATE: February 17, 1992
CONTRACTOR: Midnight Sun Drilling
ELEVATION:

DRILLING NOTES:

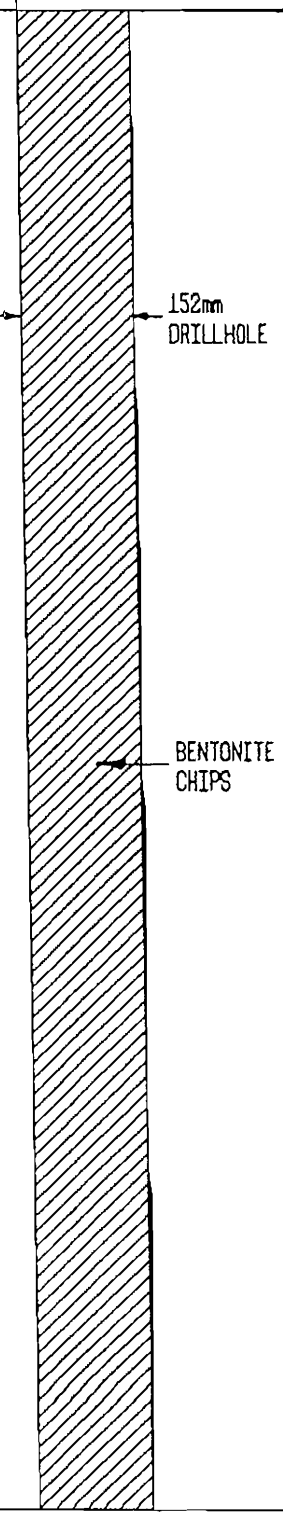
TYPE OF RIG: Schramm Rotary Top-drive
SAMPLE HAMMER: wt.: 63.6 kg drop: 76 cm

▽ STATIC WATER LEVEL
▼ DYNAMIC WATER LEVEL

DEPTH m	SYMBOL	DESCRIPTION SOIL/ROCK	HYDROGEOLOGIC INFORMATION: WATER LEVEL	HYDROGEOLOGIC INFORMATION: AIR-LIFT TEST	HYDROGEOLOGIC INFORMATION: JOINTS AND FRACTURES	HYDRAULIC CONDUCTIVITY
20.0		GRANODIORITE: as above, light greenish grey, fine to medium crystalline, some calcite veins				
21.0						
22.0						
23.0						
24.0						
25.0						
26.0						
27.0						
28.0						
29.0						
30.0						

WELL INFORMATION

DRILLING AND INSTRUMENTATION



PITEAU ENGINEERING LTD. OFFICE REPORT ON SITE INVESTIGATION SHEET 4 OF 4

CONTRACT NO.: A91-2490
BORING NO.: 92-28 ~~34~~
NORTHING:

COMPILED BY: M. Maccagno
LOCATION: Coppermine Mill
EASTING:

BORING DATE: February 17, 1992
CONTRACTOR: Midnight Sun Drilling
ELEVATION:

DRILLING NOTES:

TYPE OF RIG: Schramm Rotary Top-drive
SAMPLE HAMMER: wt.: 63.6 kg drop: 76 cm

▽ STATIC WATER LEVEL
▼ DYNAMIC WATER LEVEL

DEPTH m	SYMBOL	DESCRIPTION (SOIL/ROCK)	HYDROGEOLOGIC INFORMATION: WATER LEVEL	HYDROGEOLOGIC INFORMATION: AIR-LIFT TEST	HYDROGEOLOGIC INFORMATION: JOINTS AND FRACTURES	HYDRAULIC CONDUCTIVITY	WELL INFORMATION: DRILLING AND INSTRUMENTATION
30.0		GRANODIORITE: as above, light greenish grey, fine to medium crystalline, some calcite veins					
31.0							
		31.6 becoming yellow-green					
32.0							
33.0							
		33.8					BENTONITE CHIPS
34.0							
35.0		slightly damp interval					
36.0		36.3					
		slightly damp, decreasing with depth					
37.0							
38.0							
39.0							
		39.6 dry					
40.0		TOTAL DEPTH 40m					

PITEAU ENGINEERING LTD. OFFICE REPORT ON SITE INVESTIGATION SHEET 1 OF 2

CONTRACT NO.: A91-2490
BORING NO.: 92-3A / 2B
NORTHING: 6721308.923

COMPILED BY: M. Moccagno
LOCATION: Coppermine Mill
EASTING: 497009.141

BORING DATE: February 18, 1992
CONTRACTOR: Midnight Sun Drilling
ELEVATION: 843.328 (Ground)

DRILLING NOTES:
Coordinates are in UTM.
152mm steel casing to 1.83m.

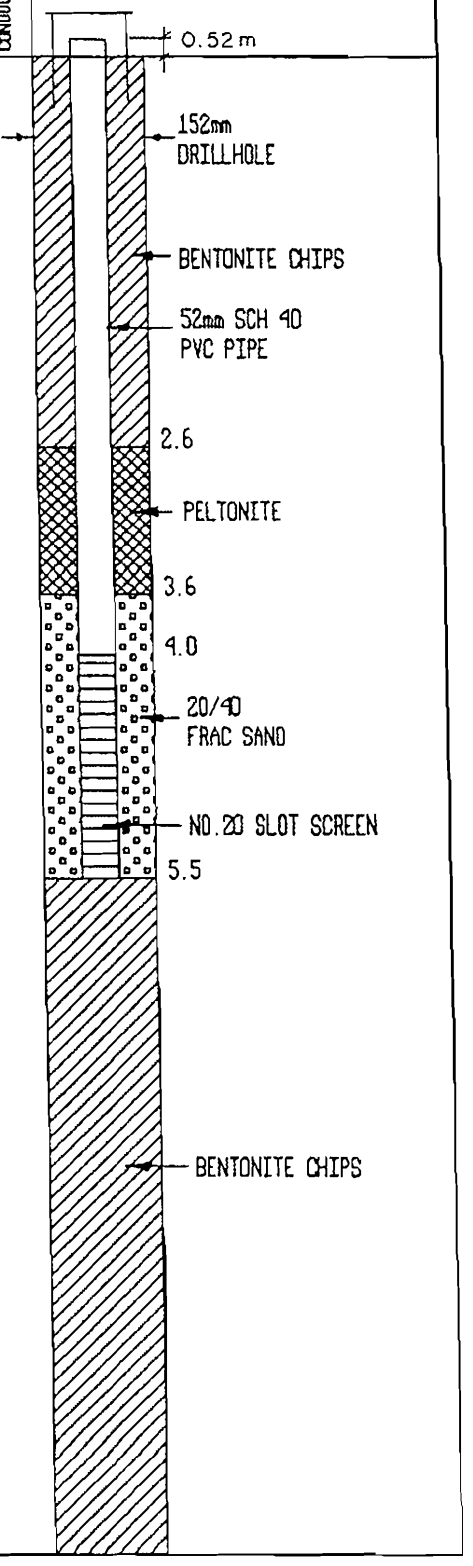
TYPE OF RIG: Schramm Rotary Top-drive
SAMPLE HAMMER: wt.: 63.6 kg drop: 76 cm

▽ STATIC WATER LEVEL
▼ DYNAMIC WATER LEVEL

DEPTH m	SYMBOL	DESCRIPTION (SOIL/ROCK)	HYDROGEOLOGIC INFORMATION: WATER LEVEL	HYDROGEOLOGIC INFORMATION: AIR-LIFT TEST	HYDROGEOLOGIC INFORMATION: JOINTS AND FRACTURES	HYDRAULIC CONDUCTIVITY
0.0		SAND AND GRAVEL: rounded pebbles, 0.5-2 cm, black microcrystalline basalt and coarse to medium crystalline granodiorite fragments, dry				
1.2		GRANODIORITE: light greenish grey, fine to medium crystalline, dry				
			20/02/92 2.73 ▽			
4.5		damp to wet, brown-green, brecciated, medium to coarse-grained	▼ 18/02/92	4.5m very weak blow		

WELL INFORMATION

DRILLING AND INSTRUMENTATION



PITEAU ENGINEERING LTD. OFFICE REPORT ON SITE INVESTIGATION SHEET 2 OF 2

CONTRACT NO.: A91-2490
BORING NO.: 92-3A 2-13
NORTHING:

COMPILED BY: M. Maccagno
LOCATION: Coppermine Mill
EASTING:

BORING DATE: February 18, 1992
CONTRACTOR: Midnight Sun Drilling
ELEVATION:

DRILLING NOTES:

TYPE OF RIG: Schramm Rotary Top-drive
SAMPLE HAMMER: wt.: 63.6 kg drop: 76 cm

▽ STATIC WATER LEVEL
▼ DYNAMIC WATER LEVEL

DEPTH m	SYMBOL	DESCRIPTION (SOIL/ROCK)	HYDROGEOLOGIC INFORMATION: WATER LEVEL	HYDROGEOLOGIC INFORMATION: AIR-LIFT TEST	HYDROGEOLOGIC INFORMATION: JOINTS AND FRACTURES	HYDRAULIC CONDUCTIVITY	WELL INFORMATION / DRILLING AND INSTRUMENTATION
10.0		GRANODIORITE: as above, light greenish grey, fine to medium crystalline, dry					
11.0		11.3 dry					
12.0							
13.0							
14.0							← BENTONITE CHIPS
15.0							
16.0							
17.0							
18.0		TOTAL DEPTH 18.3m					18.3
19.0							
20.0							

APPENDIX II

TIME VERSUS DRAWDOWN DATA
AND HYDRAULIC CONDUCTIVITY CALCULATIONS

PROPOSED SPECIAL WASTE STORAGE STATION - COPPER MINE SITE
FIELD MEASURED VALUES - TIME VERSUS DRAWDOWN

92-1A

Time (min)	Water Level (m)	Drawdown (m)
0.5	-	-
1	8	4.08
1.5	7.9	3.98
2	7.85	3.93
3	7.81	3.89
4	7.77	3.85
5	7.73	3.81
7	7.71	3.79
10	-	-
12	-	-
20	7.64	3.72
30	7.44	3.52
50	7.39	3.47
60	7.36	3.44

Static water level = 3.92 m (19/02/92)
PVC stick-up = 0.57 m

92-1B

Time (min)	Water Level (m)	Drawdown (m)
0.5	8.82	1.47
1	8.60	1.25
1.5	8.43	1.08
2	8.32	0.97
3	8.12	0.77
4	8.00	0.65
5	7.89	0.54
7	7.75	0.40
10	7.62	0.27
20	7.44	0.09
30	7.39	0.04
50	7.37	0.02
60	7.36	0.01

Static water level = 7.35 m (19/02/92)
PVC stick-up = 0.61 m

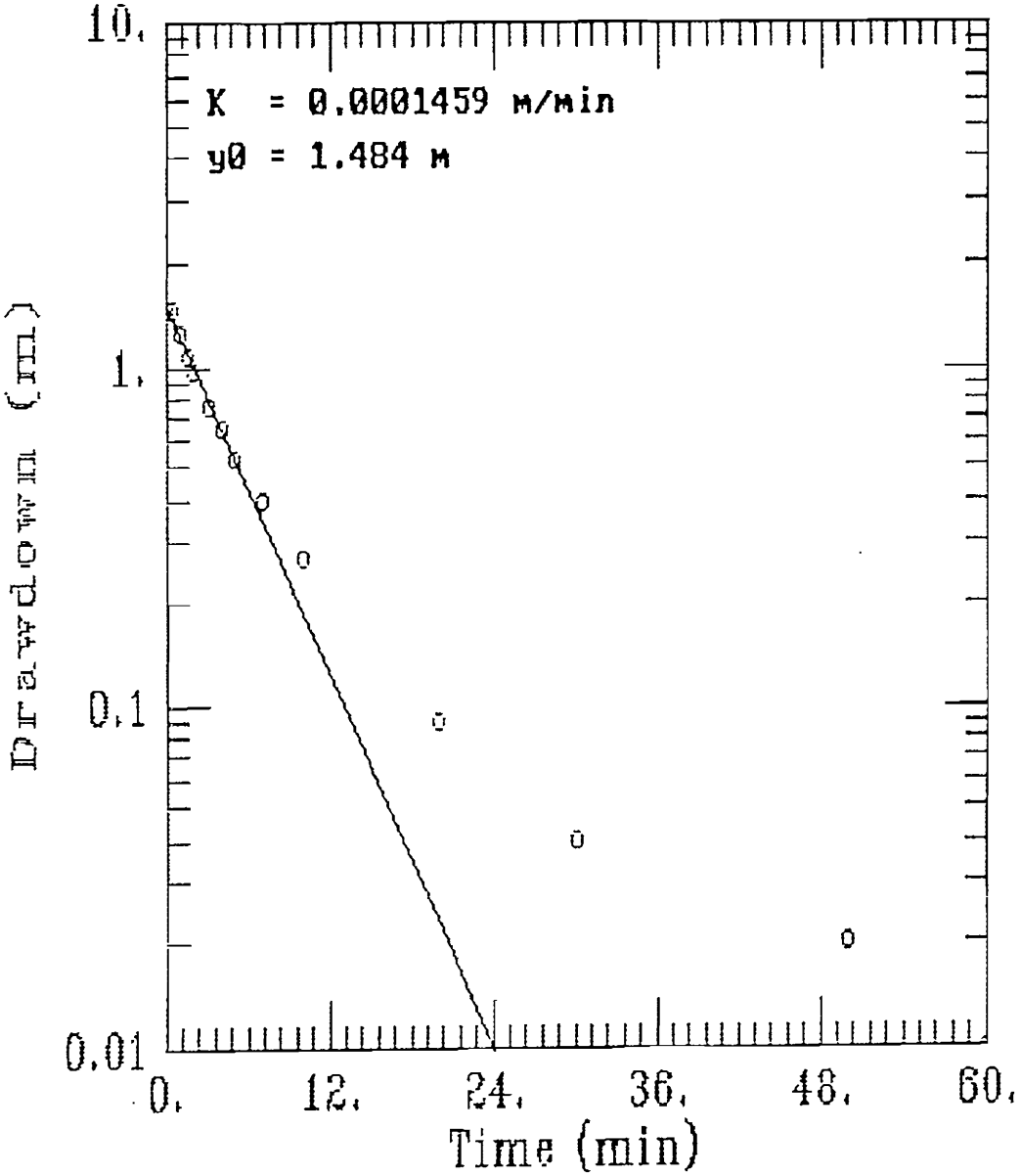
92-3A

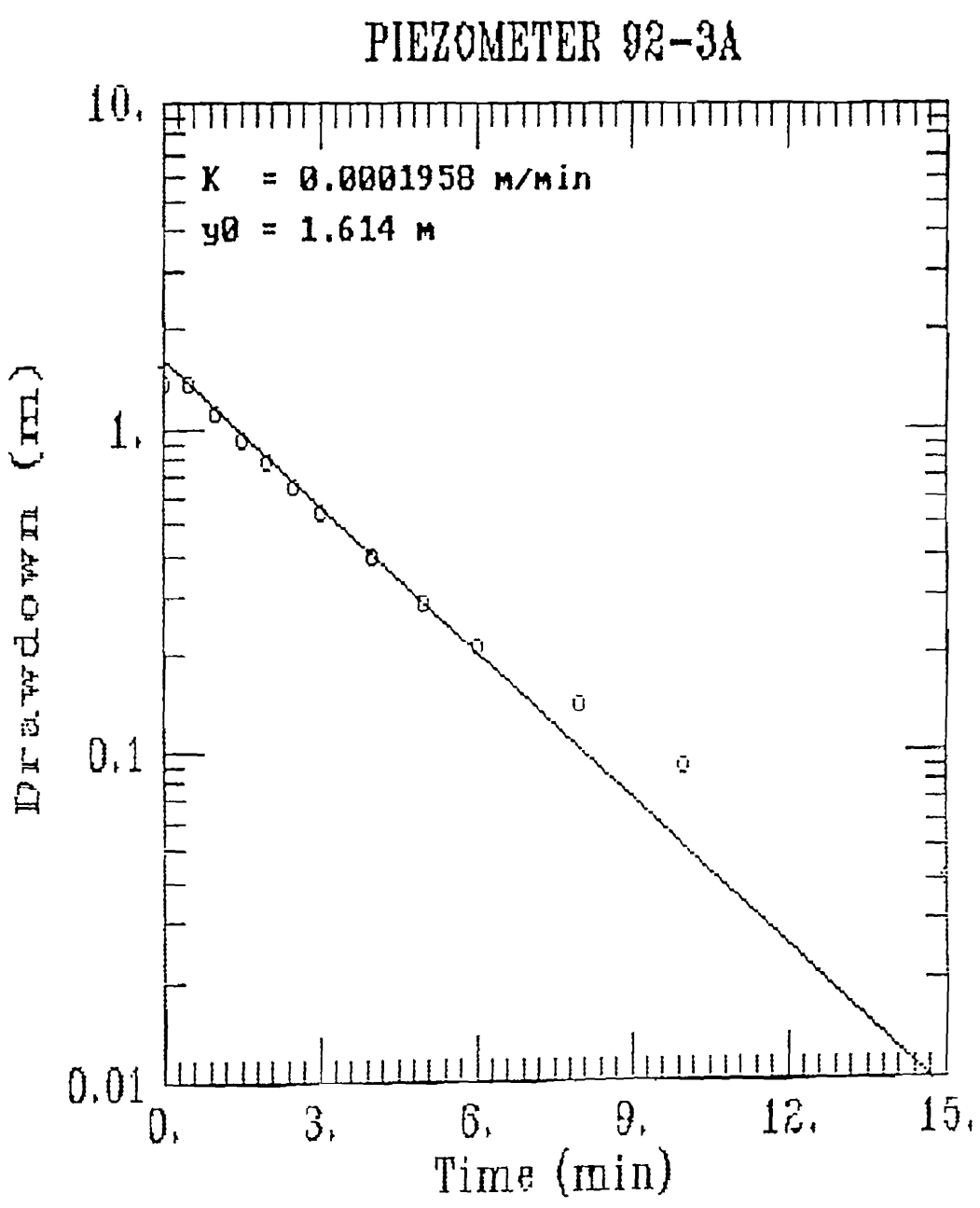
Time (min)	Water Level (m)	Drawdown (m)
0.5	4.68	1.37
1	4.40	1.09
1.5	4.24	0.93
2	4.09	0.78
2.5	3.97	0.66
3	3.86	0.55
4	3.71	0.40
5	3.60	0.29
6	3.52	0.21
8	3.45	0.14
10	3.40	0.09
15	3.35	0.04
90	3.31	0.00

Static water level = 3.31 m (19/02/92)
PVC stick-up = 0.52 m

Note: all water levels are relative to top of PVC

PIEZOMETER 92-1B




PIEZOMETER 92-3A
K = 0.0001958 m/min
y0 = 1.614 m
10.
1.
0.1
0.01
0.
3.
6.
9.
12.
15.
Time (min)

APPENDIX III

RESULTS OF LABORATORY CHEMICAL ANALYSIS

CHEMEX Labs Alberta Inc.

2021 - 41 AVE. N.E., CALGARY, ALBERTA T2E 6P2
TELEPHONE (403) 291-3077 FAX (403) 291-9468
9331 - 48 STREET, EDMONTON, ALBERTA T6B 2R4
TELEPHONE (403) 465-9877 FAX (403) 466-3332

PITEAU ENGINEERING LIMITED
ATTENTION: TAD DABROWSKI
JOB# A91-2490
WATER ANALYSIS

Sample Description : 92-1A
Sampled By : M.H.
Sample Station Code :

Sample Date & Time :
Sample Access :
Sample Type :

Chemex Worksheet Number : 4061-1
Chemex Project Number : PITE192-0501-04061
Report Date : March 5, 1992

PARAMETER DESCRIPTION	NAQUADAT CODE	UNITS	R E S U L T S	MEQ/L
Calcium	20103L	mg/L	71.00	3.5429
Magnesium	12102L	mg/L	11.50	0.9453
Sodium	11103L	mg/L	73.50	3.1973
Potassium	19103L	mg/L	3.99	0.1021
Chloride	17206L	mg/L	5.30	0.1495
Sulphate	16306L	mg/L	137.0	2.8496
PP Alkalinity as CaCO3	10151L	mg/L	< 0.1	
Total Alkalinity as CaCO3	10111L	mg/L	218.00	
pH	10301L	Units	7.40	
Carbonate	06301L	mg/L	< 0.5	
Bicarbonate	06201L	mg/L	265.7	4.3582
Total Hardness as CaCO3	10602L	mg/L	224.8	
Hydroxide	08501L	mg/L	< 0.5	
Fluoride	09105L	mg/L	0.36	
Specific Conductance	02041L	umhos/Cm	820.00	
Dissolved Organic Carbon	06104L	mg/L	7.4	
Nitrite Nitrate Nitrogen as N	07110L	mg/L	2.740	0.1959
Total Filterable Residue	10451L	mg/L	435.	
Iron	26104L	mg/L	0.07	
Manganese	25104L	mg/L	0.040	
Ion Balance	00103L	Balance	1.03	

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CHEMEX Labs Alberta Inc.

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9331 - 48 STREET, EDMONTON, ALBERTA T6B 2R4
TELEPHONE (403) 465-9877 FAX (403) 466-3332

PITEAU ENGINEERING LIMITED
ATTENTION: TAD DABROWSKI
JOB# A91-2490
WATER ANALYSIS

Sample Description : 92-1B
Sampled By : M.M.
Sample Station Code :

Sample Date & Time :
Sample Access :
Sample Type :

Chemex Worksheet Number : 4061-2
Chemex Project Number : PITE192-0501-04061
Report Date : March 5, 1992

PARAMETER DESCRIPTION	NAQUADAT CODE	UNITS	R E S U L T S	MEQ/L
Calcium	20103L	mg/L	86.00	4.2914
Magnesium	12102L	mg/L	14.50	1.1919
Sodium	11103L	mg/L	3.87	0.1683
Potassium	19103L	mg/L	1.09	0.0279
Chloride	17206L	mg/L	1.00	0.0282
Sulphate	16306L	mg/L	29.2	0.6074
PP Alkalinity as CaCO3	10151L	mg/L	< 0.1	
Total Alkalinity as CaCO3	10111L	mg/L	235.00	
pH	10301L	Units	7.60	
Carbonate	06301L	mg/L	< 0.5	
Bicarbonate	06201L	mg/L	286.5	4.6980
Total Hardness as CaCO3	10602L	mg/L	274.7	
Hydroxide	08501L	mg/L	< 0.5	
Fluoride	09105L	mg/L	0.14	
Specific Conductance	02041L	umhos/Cm	516.00	
Dissolved Organic Carbon	06104L	mg/L	4.5	
Nitrite Nitrate Nitrogen as N	07110L	mg/L	0.354	0.0253
Total Filterable Residue	10451L	mg/L	279.	
Iron	26104L	mg/L	< 0.01	
Manganese	25104L	mg/L	0.037	
Ion Balance	00103L	Balance	1.06	

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CHEMEX Labs Alberta Inc.

2021 - 41 AVE N.E., CALGARY, ALBERTA T2E 6P2
TELEPHONE (403) 291-3077 FAX (403) 291-9468
9331 - 48 STREET, EDMONTON, ALBERTA T6B 2R4
TELEPHONE (403) 465-9877 FAX (403) 466-3332

PITEAU ENGINEERING LIMITED
ATTENTION: TAD DABROWSKI
JOB# A91-2490
WATER ANALYSIS

Sample Description : 92-3A
Sampled By : M.M.
Sample Station Code :

Sample Date & Time :
Sample Access :
Sample Type :

Chemex Worksheet Number : 4061-3
Chemex Project Number : PITE192-0501-04061
Report Date : March 5, 1992

PARAMETER DESCRIPTION	NAQUADAT CODE	UNITS	RESULTS	MEQ/L
Calcium	20103L	mg/L	85.00	4.2415
Magnesium	12102L	mg/L	14.00	1.1508
Sodium	11103L	mg/L	7.80	0.3393
Potassium	19103L	mg/L	1.43	0.0366
Chloride	17206L	mg/L	0.70	0.0197
Sulphate	16306L	mg/L	32.6	0.6781
PP Alkalinity as CaCO3	10151L	mg/L	< 0.1	
Total Alkalinity as CaCO3	10111L	mg/L	235.00	
pH	10301L	Units	7.40	
Carbonate	06301L	mg/L	< 0.5	
Bicarbonate	06201L	mg/L	286.5	4.6980
Total Hardness as CaCO3	10602L	mg/L	270.1	
Hydroxide	08501L	mg/L	< 0.5	
Fluoride	09105L	mg/L	0.12	
Specific Conductance	02041L	umhos/Cm	533.00	
Dissolved Organic Carbon	06104L	mg/L	5.4	
Nitrite Nitrate Nitrogen as N	07110L	mg/L	0.356	0.0255
Total Filterable Residue	10451L	mg/L	285.	
Iron	26104L	mg/L	0.08	
Manganese	25104L	mg/L	0.011	
Ion Balance	00103L	Balance	1.06	

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