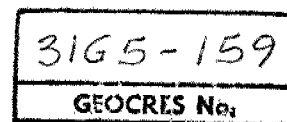


G.I.-30 SEPT. 1976

GEOCRES No. 3145-159DIST. 9 REGION W.P. No. CONT. No. W. O. No. STR. SITE No. HWY. No. 416LOCATION Hwy 416 / CEDARVIEW RD
NEAR BRUCE PITNo. of PAGES - =====OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. REMARKS:



Golder Associates Ltd.
CONSULTING ENGINEERS



REPORT TO
MINISTRY OF TRANSPORTATION ONTARIO
GEOTECHNICAL AND GROUNDWATER STUDY
PROPOSED HIGHWAY 416
BRUCE PIT
W.P. 146-74-00-2-DISTRICT 9 (OTTAWA)
NEPEAN, ONTARIO

Distribution:

- 15 copies - Ministry of Transportation Ontario
Downsview, Ontario
- 2 copies - Golder Associates Ltd.
Ottawa, Ontario

June 1989

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ABSTRACT

This report presents the results of a subsurface investigation carried out along the proposed route for Highway 416 in the vicinity of the Bruce Pit in Nepean, Ontario (Station 27+200 to 27+650). Based on present plans, this part of the proposed roadway will have a mixture of at grade, cut and fill sections. The purpose of this investigation was to determine the effects of the proposed highway on the existing groundwater flow regime and to provide recommendations for the geotechnical design of the roadway embankments.

The subsurface conditions within the study area were determined by means of two detailed boreholes supplemented with available subsurface information obtained by Conestoga-Rovers and Associates and the Ministry of Transportation Ontario. In general, the site is underlain by discontinuous deposits of earth and rubble fill, and some domestic garbage, over native deposits of sand and sand and gravel. North of about Station 27+500, the sand deposit thins and the site is underlain by deep, deposits of sensitive silty clay. The groundwater elevation across the site was found to range from about 87.8 metres in the vicinity of the Cedarview Road connection to between 87.5 and 87.6 metres north and south of this point. The groundwater level measured in the sand near the pond corresponds to the water level in the west pond (approximately elevation 87.6 metres). Previous studies indicate that groundwater flow into the pond occurs from the area west of Cedarview Drive and from the fields to the north of the pond.

Based on the results of this and previous investigations by others, the proposed highway cut should have little effect on the groundwater flow to the pond during late spring, summer and fall months. This assumes that sandy deposits encountered at depth opposite the Lynwood subdivision are not hydraulically connected to the sand deposits around the pit. Some minor loss should be expected due to surficial drainage of the highway in the recharge

area north of the pit. Some impact could occur during wet periods of the year when the flow into the pit would be highest.

Recommendations are provided for the material type and placement at the base of the embankments. Provision should be made for drains beneath the embankments and recommendations are provided for their design.

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1.0 INTRODUCTION

Golder Associates Ltd. has been retained by the Ministry of Transportation Ontario (MTO) to carry out a subsurface investigation along the proposed Highway 416 in the vicinity of the Bruce Pit (Station 27+200 to 27+650) located on Cedarview Road in Nepean, Ontario (see Key Plan, Figure 1). The purpose of the investigation was to determine the effects of the proposed highway on the existing groundwater flow regime based on a limited number of boreholes and available subsurface information obtained by others. Recommendations were to be provided for the geotechnical design of the roadway embankments through the Bruce Pit area.

As proposed, the Highway 416 alignment cuts through the Bruce Pit about 65 to 95 metres east of existing Cedarview Road. Cedarview Road is to be realigned to the east of Highway 416 and access to the subdivision will be provided by means of an overpass located opposite Bell High School. In the study area, the proposed highway will slope downward to the north at a grade of about 2 percent and will have a mixture of cut, at grade and fill sections. Embankment fill to about 5 metres height will be required in the Bruce Pit; north and south of the pit, roadway cuts of up to about 10 metres depth will be required, including an allowance for 1.5 metre deep drainage swales. Realigned Cedarview Road will require up to approximately 10 metres of grade raise fill in the Bruce Pit but will be mostly in fill section or at existing grade north and south of the pit.

2.0 SITE DESCRIPTION AND GEOLOGY

The study area is characterized by a gently sloping and rugged topography. As a result of granular material extraction during the 1940's and 50's, the average ground surface elevation across the abandoned pit floor is about 10 metres below the level of Cedarview Road. During wet periods of the year, a shallow pond forms in the lower part of the former pit. Currently, the site is used for

recreation and includes hiking pathways, cross country ski trails and a toboggan hill.

Based on geological information and from previous investigations in this area, it is known that the site is underlain by deep deposits of sand and of sand and gravel.

3.0 PREVIOUS INVESTIGATIONS

Previous investigations have been carried out at the site by Water and Earth Sciences Ltd. and by Conestoga-Rovers and Associates.

Water and Earth Sciences Associates Ltd. performed a hydrogeological assessment of the Bruce Pit to evaluate the effects of the proposed highway construction for the National Capital Commission (N.C.C.). The results of this work are presented in the "Bruce Pit Sector - Development Plan", prepared by Corush Laroque Sunderland and Partners dated February, 1984. The investigation involved the mapping of numerous natural exposures, forty (40) hand excavated shallow test pits, and sixteen (16) driven mini-piezometer points installed on the pit floor. The report describes the hydrology and hydrogeology of the pit subbasin area.

In general, the report indicates that the Bruce Pit subbasin, which has an approximate area of 1.2 square kilometres, is largely underlain by sands and gravels and drainage of the area is mostly by shallow, unconfined groundwater flow. The direction of groundwater flow is mostly to the northeast (i.e. most of the recharge is from the area west of Cedarview Road), although another minor flow divide north of the Bruce Pit separates flow moving to the north towards Baseline Road from that moving towards the pit. Low magnitude upward hydraulic gradients have also been measured in the base of the pit. The total flow from the west pond was measured as 52 cubic metres per day during a dry period of the year. The study concludes that the water table in the granular materials around the pit will not be adversely affected during the

critically dry summer months if the highway is built on 2 to 3 metres of granular material. The location of the highway north of the pit is expected to reduce the recharge area north of the pit by approximately 6 percent. Recommendations are provided for lining the roadside ditches to by-pass the pit area so that highway runoff does not impact on the quality of the water.

A detailed investigation was carried out in 1988 by Conestoga-Rovers and Associates for MTO to investigate the extent and characteristics of the fills present in the abandoned Bruce Pit Landfill site. The investigation involved numerous shallow and dry trenches, test pits, gas monitoring wells and detailed piezometer installations. Recommendations are provided for excavation, reuse and disposal of the existing earth and garbage fill materials.

4.0 PROCEDURE

The field work for this investigation was carried out on October 21 and 22, 1988. During this time, two boreholes, numbered 88-7 and 88-8, were put down at the site using a track mounted hollow stem auger machine supplied and operated by Marathon Drilling Co. Ltd. of Gloucester, Ontario. The boreholes were advanced to depths of between 8.2 and 9.8 metres below ground surface (elevation 82.8 to 85.8 metres). Standard penetration tests were carried out at regular intervals of depth and samples of the soil encountered were recovered using drive open sampling equipment. In situ vane testing was carried out to determine the shear strength characteristics of the silty clay. In situ rising head testing was carried out in the well screen in borehole 88-7 to determine the hydraulic conductivity characteristics of a sand deposit encountered at depth in the boring. The field work was supervised throughout by a member of our engineering staff who located the boreholes, directed the drilling operations, carried out the in situ testing and logged the overburden samples.

Samples of the soils encountered were taken to our laboratory for detailed examination and classification testing. Samples of the soils encountered were tested for moisture content, liquid and plastic limits and grain size distribution.

Detailed logs of the soil and groundwater conditions encountered in boreholes 88-7 and 88-8 are given on the Record of Borehole sheets following the text of this report. Logs from previous boreholes put down by MTO and Conestoga-Rovers and Associates in the study area and from work carried out by Golder Associates in and adjacent to the Lynwood subdivision are also provided for reference purposes. The approximate locations of the boreholes with respect to existing and proposed site features are given on the site plan and profile, Drawing 1467400-A2. The results of the laboratory testing are given on Figures 2 and 3 and on the Record of Borehole sheets.

The borehole locations were determined by our staff and are referenced to existing site features. The ground surface elevations at the borehole locations were referenced to the fire hydrant located at the northwest corner of the intersection of Dante Street and Cedarview Road. The elevation of the arrowhead on the hydrant was provided by the City of Nepean as 87.73 metres, Geodetic datum.

5.0 SUBSURFACE CONDITIONS

As previously indicated, the detailed soil and groundwater conditions determined from the boreholes are given on the Record of Borehole sheets following the text of this report. The following presents a brief description of the conditions across the site, followed by a detailed description of the soil and groundwater conditions encountered in the boreholes.

5.1 General

The subsurface conditions in the vicinity of the Bruce Pit west pond were previously shown to consist of discontinuous deposits of earth, rubble and garbage fill over deep deposits of native sand and sand and gravel; the sand becomes silty at depth (elevation 84.6 to 88.2 metres) in some of the boreholes. North of about Station 18+500, the sand deposit thins, and the site is underlain by deep, deposits of grey and grey brown sensitive silty clay. The groundwater elevation across the study area was found to range from a maximum of about 87.8 to 88.0 metres in boreholes 3 and 4 put down by Conestoga-Rovers and Associates near the proposed Cedarview Road connection. North and south of this area, the groundwater elevation drops and generally ranges between elevation 87.5 and 87.6 metres. The groundwater level measured in previous Conestoga-Rovers borehole 5 was 87.6 metres, which is approximately the reported static water level in the adjacent west pond.

5.2 Topsoil, Fill, Surficial Sand

Both of the boreholes put down during this study encountered surficial deposits of topsoil or fill and sand. The combined thickness of the topsoil and native fine to medium sand at borehole 88-7 was found to be about 0.8 metres.

At borehole 88-8, a deposit of fill having a thickness of 1.5 metres and composed of dark brown and red brown sandy silt containing some organic matter was encountered above a thin deposit of native sand.

5.3 Silty Clay

The fill, surficial sand and topsoil deposits were found to be underlain at both of the borehole locations by a deep deposit of sensitive silty clay. At borehole 88-7, the upper 2.9 metres of the deposit is weathered to a very stiff grey brown crust. The

standard penetration resistance N values measured within the grey brown silty clay ranged from 1 to 6 blows per 0.3 metres. The weathered silty clay has measured liquid limit values of 43 and 51 and plastic limit values of 17 and 23, which reflect medium to high plasticity. The water content was generally found to be about midway between the liquid and plastic limits, ranging from 25 to 34 percent (average 30 percent).

Beneath the upper weathered zone at borehole 88-7 and at borehole 88-8, the silty clay is grey in colour and has stiff consistency. The shear strength of the silty clay, as determined by in situ vane tests, varies from 52 to over 100 kilopascals. Atterberg limit tests carried out on samples of the grey silty clay gave liquid limit values of 38 to 53 and plastic limit values of 15 to 21, which also reflect medium to high plasticity. The measured water contents range from 27 to 52, which approach or exceed the measured liquid limit.

The results of the Atterberg limit tests are given on the Plasticity Chart, Figure 2.

5.4 Layered Sand and Silty Sand

A layered sand and silty sand deposit was encountered at borehole 88-7 within the grey silty clay at a depth of 6.3 metres (elevation 84.7 metres). Grain size distribution curves for samples of the sand and silty sand encountered are given on Figure 3. These results show that the fine to coarse sand layers contain about 7 percent silt whereas the silty sand contains about 28 percent silt and clay by weight. Standard penetration tests carried out in the layered sand gave N values of 7 and 21 blows per 0.3 metre which reflect a loose to compact density.

A rising head test was carried out within a sealed well screen to determine the hydraulic conductivity of the layered sand. The testing showed little or no water take after 30 minutes, possibly

due to smearing of the sides of the borehole with silty clay during augering.

5.5 Groundwater

Standpipes and well screens were sealed into the boreholes and water levels were determined from these devices on November 10, 1988. At that time, the groundwater elevation measured in boreholes 88-8 and within the deep sand deposit in borehole 88-7 was found to be 87.5 metres. At shallow depth in borehole 88-7, the groundwater level is at 2.0 metres below ground surface (elevation 89.0), which reflects a downward hydraulic gradient at this location.

It should be noted that the groundwater levels could be higher during wet periods of the year such as the early spring.

6.0 DISCUSSION AND RECOMMENDATIONS

6.1 Effect of the Highway Cut on Groundwater Flow

As mentioned previously, the water flow through the west pond has previously been estimated to be around 52 cubic metres per day. Most of the flow is derived from shallow groundwater flow from the fields and forested areas west of Cedarview Road and from the fields to the north of the pond.

Based on the groundwater levels obtained during the investigation by Conestoga-Rovers and Associates (May 1988) and the current investigation (November 1988), the proposed highway cut between about Stations 27+330 and 27+500 will be above the measured groundwater level. Where the cut dips below the measured groundwater level north of about Station 27+500, the overburden deposits were shown to consist of silty clay. Therefore, it is expected that the proposed highway cut will have little effect on the groundwater levels around the pond during late spring, summer and fall months unless the sandy deposits encountered beneath the silty clay at boreholes 88-7 and to the north at borehole 88-4 are hydraulically connected to the sandy deposits around the pit. The effect of underdrainage of the sand from the highway cut section opposite the Lynwood subdivision will be studied in an additional subsurface investigation. If the groundwater levels show a significant rise during wet periods of the year such as the early spring, the proposed roadway cut through the native sand north of the Bruce Pit may intersect the groundwater table. Some impact on the groundwater flow into the pond could occur in such as case due to drainage along the highway cut but would be limited to periods when the flow into the pond is highest. It is therefore recommended that monitoring be carried out using both the existing boreholes and future route borings to obtain seasonal groundwater level data north of the pond. This groundwater information will also be necessary for the design of the roadway base and swales.

Since the proposed highway will be constructed within the current recharge area to the north of the pond, there could be a small decrease in groundwater flow from this area due to reduced rainwater infiltration, particularly if the highway swales are lined to reduce contaminant loading on the pond.

6.2 Design of Highway 416 and Cedarview Road Embankments

The proposed Highway 416 and proposed realigned Cedarview Road embankments will be constructed over the west pond and will have heights of up to 5 and 10 metres, respectively. To ensure that the embankments do not affect groundwater flow either into the pond or surface drainage through the pond to the east, it is recommended that the lower part of the embankments (from subgrade level to about 1 metre above the maximum static water level in the pond) be constructed with free draining sand or sand and gravel. The native sand or sand and gravel obtained from the cut areas or imported fill, such as that conforming to MTO grading specifications for Granular B Type I, could be used provided that the materials contain less than about 7 percent silt by weight. Prior to placement of the granular material, all wet and disturbed material and garbage fill should be removed from the subgrade areas. The subexcavated areas such as the garbage and rubble fill areas on the west and north sides of the west pond should be backfilled with sand or sand and gravel.

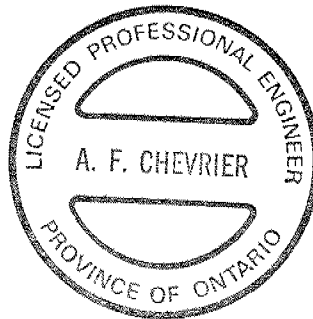
To facilitate drainage through the sandy embankment fill, drains should be installed beneath the embankments. The drains should consist of 150 millimetre perforated pipe surrounded by 19 millimetre diameter clear stone fully wrapped in a non-woven filter fabric. The clear stone should extend from subgrade level to above the expected high water level and should have a minimum width of about 0.6 metres. A minimum of three drains would be required; two drains should be located approximately 5 metres from the edges of the existing pond and the third should cross the mid-point of the embankment or at the location of any existing drainage channels.

For the proposed Cedarview embankment, a small pipe or culvert drain should also be installed.

To prevent erosion due to surface water flow down the embankment and sloughing of the sand or sand and gravel fill due to groundwater flow through the fill, the embankment fill below the high water level could be protected with rip rap underlain by a filter fabric or by soil of suitable grading to act as a filter. Topsoil and grass cover is not considered suitable protection below the high water level since groundwater flow through the embankment could be inhibited.

Yours truly,

GOLDER ASSOCIATES LTD.



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for A.F. Chevrier, P. Eng.

F. J. Heffernan
for F.J. Heffernan, P. Eng.

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Disk 1

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_a	1	RATE OF SECONDARY CONSOLIDATION
c_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_l	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m ³	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m ³	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m ³	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m ³	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m ³ /s	RATE OF DISCHARGE
γ_d	kN/m ³	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m ³	UNIT WEIGHT OF SATURATED SOIL	I_c	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m ³	SEEPAGE FORCE
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						



Ministry
of
Transportation
Ontario

RECORD OF BOREHOLE No 88-4

METRIC

W P 146-74-00 LOCATION Co-ords N 5 021 150; E 358 904 ORIGINATED BY PH
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AC
DATUM Geodetic DATE October 20, 1988 CHECKED BY AC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa						
87.3	Ground Surface							20 40 60 80 100						GR SA SI CL
0.0	Topsoil													
0.2	Silty clay, some silty fine sand seams. (Weathered Crust)													
	Very Stiff Grey Brown		1	SS	8									
85.3			2	SS	4									
2.0	Silty clay, some silty fine sand seams.													
	Firm Grey		3	SS	1									
			4	SS	PM									
83.0														
4.3	Silty sand & gravel, trace clay.													
82.1	Loose Grey		5	SS	5									24 39 (38)
5.2	Sand, layered. Fine to coarse sand, some gravel & silt, fine sand with some silt, medium to coarse sand, trace gravel, silty sand, some gravel.		6	SS	3									12 53 (35)
			7	SS	14/15mm									
			8	SS	26									1 94 (3)
	Loose to Compact Grey Brown and Grey		9	SS	23									21 60 (19)
78.2														
9.1	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 88-5

METRIC

W P 146-74-00 LOCATION Co-ords N 5 021 082; E 358 806 ORIGINATED BY PH
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AC
DATUM Geodetic DATE October 17, 1988 CHECKED BY AC

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100				
88.2	Road Surface														
0.1	Asphalt.					88									
	Fill-sand, some gravel; trace to some silt.		1	AS	-										
87.3	Brown														
0.9	Silty clay, some silty fine sand seams. (weathered crust) Very Stiff Grey Brown to Stiff		2	SS	10										
			3	SS	6										
			4	SS	2										
85.3															
2.9	Silty clay, some silty fine sand seams. Firm Grey		5	SS	WH										
83.7															
4.5	Silty sand & gravel.		6	SS	6										
83.0	Loose Grey														
5.2	End of Borehole														

RECORD OF BOREHOLE No 88-6

METRIC

W P 146-74-00 LOCATION Co-ords N 5 020 852; E 358 895 ORIGINATED BY PH
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AC
DATUM Geodetic DATE October 17, 1988 CHECKED BY AC

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA S: CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20 40 60 80 100	20 40 60 80 100					
89.2	Road Surface												
0.1	Asphalt.												
88.6	Fill-sand & gravel, trace silt, occasional cobble. Brown												
0.6	Silty clay, some silty fine sand seams. (Weathered Crust)		1	SS	5								
	Very Stiff Grey Brown		2	SS	5								
86.4			3	SS	2								
2.8	Silty clay, some silty fine sand seams.												
	Stiff Grey		4	SS	1								
			5	SS	WH								
84.0													
5.2	End of Borehole												

RECORD OF BOREHOLE No 88-7

METRIC

W.P. 146-74-00 LOCATION Co-ords N 5 020 864; E 359 027
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger
DATUM Geodetic DATE October 21, 1988
ORIGINATED BY PH
COMPILED BY AC
CHECKED BY AC

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
91.0	Ground Surface												
0.1	Topsoil												
90.2	Sand, fine to medium trace gravel, some silt; Red Brown												
0.8	Silty clay, some silty sand & sand seams. (Weathered Crust)	1	SS	6		90							
	Very Stiff Grey Brown	2	SS	6									
		3	SS	4									
		4	SS	1									
87.3	Silty clay, some silty sand & sand seams.												
	Stiff Grey	5	SS	1									
84.7	Sand, layered. Fine to coarse sand, trace silt and silty sand, trace gravel.	6	SS	7									
		7	SS	21									
83.5	Loose to Compact												
7.5	Silty clay, some sand seams.	8	SS	2									
82.8	Grey												
8.2	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 88-8

METRIC

W P 146-74-00 LOCATION Co-ords N 5020 785: E 359 069 ORIGINATED BY PH
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AC
DATUM Geodetic DATE October 21 and 22, 1988 CHECKED BY AC

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20 40 60 80 100	20 40 60 80 100	Wp	W	Wl		
95.6	Ground Surface												
0.0	Fill-sandy silt, some organic matter.												
	Very Loose Dark Brown & Red Brown		1	SS	3								
94.1													
1.5	Sand, trace silt. Brown.												
1.7	Clayey silt, some sand seams, trace shells.		2	SS	14								
1.8	Grey Brown												
	Silty clay, some silty sand & sand seams.		3	SS	WH								
	Stiff Grey		4	SS	WH								
			5	SS	WH								
			6	SS	WH								
			7	SS	WH								
			8	SS	1								
85.8													
9.8	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLES FROM
PREVIOUS INVESTIGATIONS

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

CRA - 1

PROJECT NAME: BRUCE PIT

HOLE DESIGNATION: OW1-88

PROJECT NO.: 2396

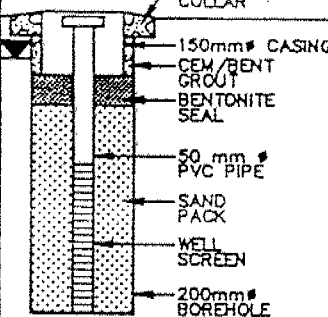
DATE COMPLETED: 27 APR 1988

CLIENT: MTO

DRILLING METHOD: 108 mm ID HSA

LOCATION: AS PER PLAN

CRA SUPERVISOR: S. CROSSMAN

DEPTH m BG	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION m AMSL	MONITOR INSTALLATION	SAMPLE		
				NUMBER	STATE	VALUE
	REFERENCE POINT (Top Of Casing) GROUND SURFACE	87.311 87.31	 <p>CONCRETE PROTECTIVE COLLAR 150mm# CASING CEM/BENT GROUT BENTONITE SEAL 50 mm # PVC PIPE SAND PACK WELL SCREEN 200mm# BOREHOLE</p>			
1.0	PT PEAT: amorphous, fibrous in a slightly woody structure, compact, brown, very moist.	87.11				
2.0	SM SAND: little silt, compact, fine to medium grained, poorly graded, massive, brown, moist. - wet - grey	86.87		1SS	X	13
3.0	END OF HOLE @ 3.05 m BGS.	84.26		2SS	X	16
4.0			<p>SCREEN DETAILS: Screened Interval: 84.26 to 85.79 AMSL Length -1.52m Diameter -50mm Slot # 10 Material- PVC</p>			
5.0						
6.0						
7.0						
8.0						
9.0						
10.0						
11.0						
12.0						
13.0						

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

GRAIN SIZE ANALYSIS



WATER FOUND



STATIC WATER LEVEL



2/05/88

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

CRA - 2

PROJECT NAME: BRUCE PIT

PROJECT NO.: 2396

CLIENT: MTO

LOCATION: AS PER PLAN

HOLE DESIGNATION: OW2-88

DATE COMPLETED: 25 APR 1988

DRILLING METHOD: 108 mm ID HSA

CRA SUPERVISOR: S. CROSSMAN

DEPTH m BG	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION m AMSL	MONITOR INSTALLATION	SAMPLE		
				NUMBER	STATE	VALUE
	REFERENCE POINT (Top Of Casing) GROUND SURFACE	96.903 96.90				
1.0	TOPSOIL: sandy, silty loam, compact, brown, slightly moist. SW SAND: trace silt, trace fine gravel, dense, well graded, medium to coarse grained, brown, slightly moist.	96.83		1SS	X	34
2.0						
3.0	- little gravel			2SS	X	40
4.0						
5.0				3SS	X	38
6.0	- very dense, moist					
7.0				4SS	X	72
8.0	- dense					
9.0	- very moist, slight plasticity, some silt			5SS	X	28
10.0						
11.0	- very dense, occasional silt seam, angular gravel, wet			6SS	X	54
12.0						
13.0	SM SAND: some silt, very dense, fine grained, poorly graded, massive, grey, wet. END OF HOLE @ 12.80 m BGS.	84.62 84.10		7SS	X	37
				8SS	X	53

SCREEN DETAILS:

Screened Interval:
84.80 to 86.33 AMSL
Length - 1.52m

Diameter - 50mm
Slot # 10
Material - PVC

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

GRAIN SIZE ANALYSIS



WATER FOUND



STATIC WATER LEVEL



4/05/88

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

CRA - 3

PROJECT NAME: BRUCE PIT
PROJECT NO.: 2396
CLIENT: MTO
LOCATION: AS PER PLAN

HOLE DESIGNATION: OW3-88
DATE COMPLETED: 26 APR 1988
DRILLING METHOD: 108 mm ID HSA
CRA SUPERVISOR: S. CROSSMAN

DEPTH m BG	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION m AMSL	MONITOR INSTALLATION	SAMPLE		
				NUMBER	STATE	VALUE
	REFERENCE POINT (Top Of Casing) GROUND SURFACE	98.262 98.26 98.21	CONCRETE PROTECTIVE COLLAR			
1.0	TOPSOIL: sandy loam, brown, moist.		150mm# CASING			
2.0	SP SAND: trace silt, compact, poorly graded, medium grained, layered, light brown, slightly moist.		200mm# BOREHOLE	1SS	⊗	7
3.0			CEMENT/BENTONITE GROUT			
4.0	CL CLAY (Till): little silt, little fine gravel, trace sand, stiff, low plastic, green-grey, silt seams, moist, occasional wet lenses of coarse sand.	94.66		2SS	⊗	11
5.0			50 mm # PVC PIPE			
6.0				3SS	⊗	5
7.0	SW SAND: some silt, some fine gravel, very dense, well graded, fine to coarse grained, layered, slightly moist.	91.61				
8.0				4SS	⊗	11
9.0			BENTONITE SEAL			
10.0			SAND PACK	5SS	⊗	85
11.0	- little gravel, massive, wet, grey-brown	87.97		6SS	⊗	>100
12.0	- siltier, very moist		WELL SCREEN			
13.0	END OF HOLE @ 12.80 m BGS.	85.45	SCREEN DETAILS: Screened Interval: 86.59 to 88.11 AMSL Length -1.52m	7SS	⊗	57
				8SS	⊗	58

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

GRAIN SIZE ANALYSIS



WATER FOUND



STATIC WATER LEVEL



4/05/88

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

CRA - 4

PROJECT NAME: BRUCE PIT

HOLE DESIGNATION: OW4-88

PROJECT NO.: 2396

DATE COMPLETED: 27 APR 1988

CLIENT: MTO

DRILLING METHOD: 108 mm ID HSA

LOCATION: AS PER PLAN

CRA SUPERVISOR: S. CROSSMAN

DEPTH m BG	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION m AMSL	MONITOR INSTALLATION	SAMPLE			
				NUMBER	STATE	VALUE	* HNU (ppm)
	REFERENCE POINT (Top Of Casing) GROUND SURFACE	95.707 95.71	CONCRETE PROTECTIVE COLLAR				
1.0	REFUSE: decayed domestic garbage, plastic, wood, black, moist, compact.		150mm# CASING				
2.0			200mm# BOREHOLE				
3.0			CEMENT/BENTONITE GROUT				
4.0			50 mm # PVC PIPE				
5.0							
6.0							
7.0	SP SAND: trace silt, compact, medium grained, uniform, massive, light grey-brown, moist, garbage odour.	89.46	BENTONITE SEAL	1SS	X	32	3
8.0	- occasional thin seam of coarse sand	87.87		2SS	X	32	2
9.0							
10.0	SM SAND: little silt, dense, fine grained, poorly graded, grey-brown, massive, very moist, garbage odour.	86.56	SAND PACK	3SS	X	29	
11.0			WELL SCREEN	4SS	X	27	
12.0	ML SILT: some sand, compact, layered, thin laminations of fine sand, wet, grey, slight garbage odour.	84.67					
13.0	SM SAND: little silt, fine grained, poorly graded, massive, compact, grey, wet, odourless.	83.15 82.91		5SS	X	17	
	END OF HOLE @ 12.80 m BGS.		SCREEN DETAILS: Screened Interval: 84.73 to 87.78 AMSL Length -3.05m				Diameter -50mm Slot # 10 Material -PVC
	* - HNU READING FROM SAMPLE HEAD SPACE						

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

GRAIN SIZE ANALYSIS



WATER FOUND



STATIC WATER LEVEL



5/05/88

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

CRA - 5

PROJECT NAME: BRUCE PIT

HOLE DESIGNATION: OW5-88

PROJECT NO.: 2396

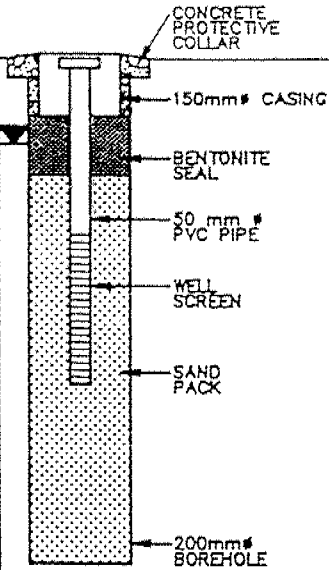
DATE COMPLETED: 26 APR 1988

CLIENT: MTO

DRILLING METHOD: 108 mm ID HSA

LOCATION: AS PER PLAN

CRA SUPERVISOR: S. CROSSMAN

DEPTH m BG	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEVATION m AMSL	MONITOR INSTALLATION	SAMPLE		
				NUMBER	STATE	VALUE
	REFERENCE POINT (Top Of Casing) GROUND SURFACE	88.534 88.53	 <p>CONCRETE PROTECTIVE COLLAR</p> <p>150mm# CASING</p> <p>BENTONITE SEAL</p> <p>50 mm # PVC PIPE</p> <p>WELL SCREEN</p> <p>SAND PACK</p> <p>200mm# BOREHOLE</p>			
1.0	SP SAND: little silt, compact, uniform, medium grained, massive, brown, moist.	87.63				
2.0	- wet			1SS	X	17
3.0	SM SAND: some silt, compact, fine grained, layered with occasional 3 cm seams of coarse sand, wet, grey, thin silt seams.	85.64		2SS	X	20
4.0	- siltier, not as dense			3SS	X	15
5.0	END OF HOLE @ 5.18 m BGS.	83.35				
6.0			<p>SCREEN DETAILS: Screened Interval: 85.18 to 86.71 AMSL Length -1.52m Diameter -50mm Slot # 10 Material-PVC</p>			
7.0						
8.0						
9.0						
10.0						
11.0						
12.0						
13.0						

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

GRAIN SIZE ANALYSIS



WATER FOUND



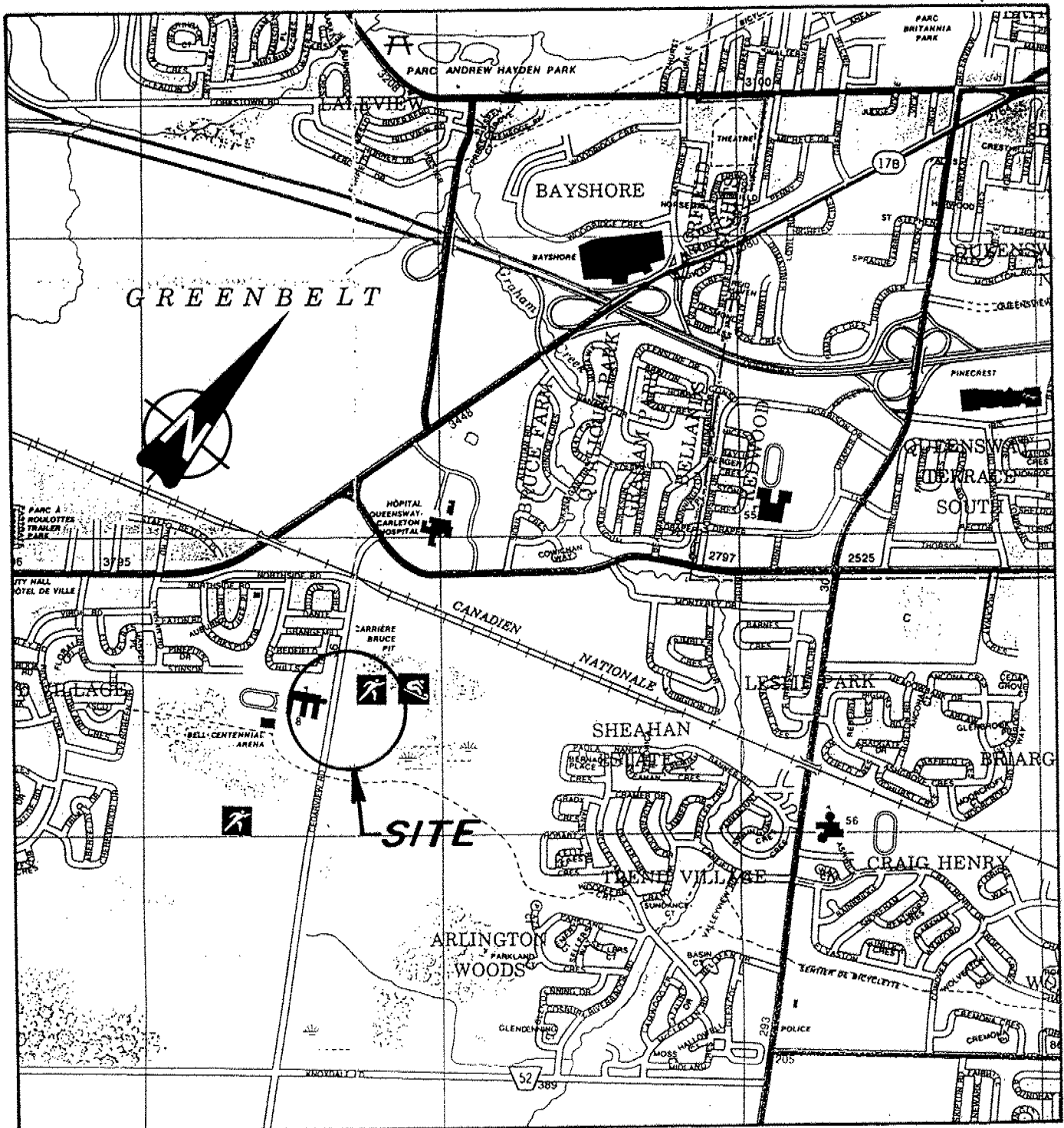
STATIC WATER LEVEL



2/05/88

KEY PLAN

FIGURE 1



SCALE 1: 25000

SPECIAL NOTE

THIS DRAWING IS TO BE READ IN CONJUNCTION
WITH ACCOMPANYING REPORT.

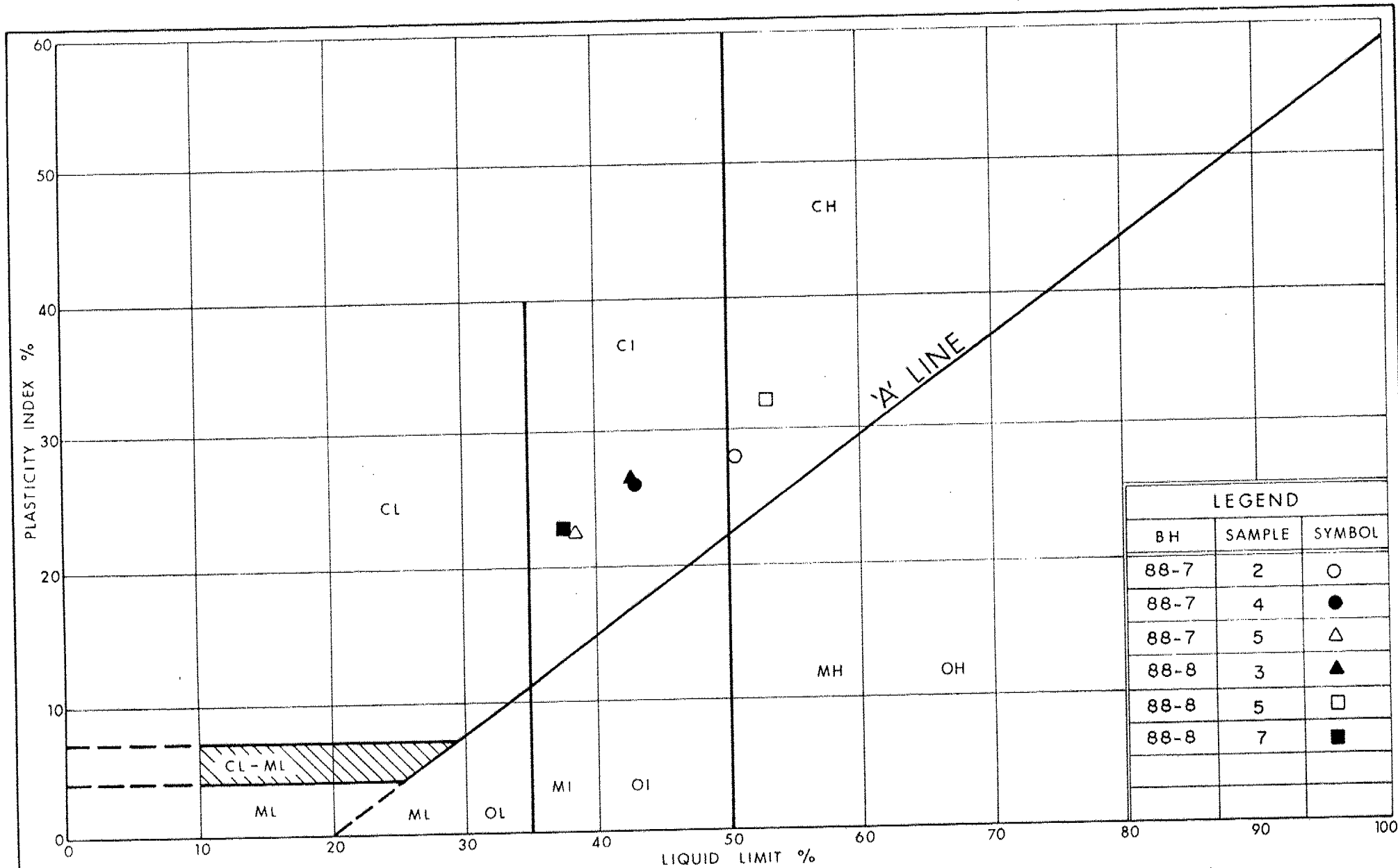
Date JAN. 24, 1989

Project 881-2294-2

Golder Associates

Drawn JC

Chkd AC



Ministry of
Transportation

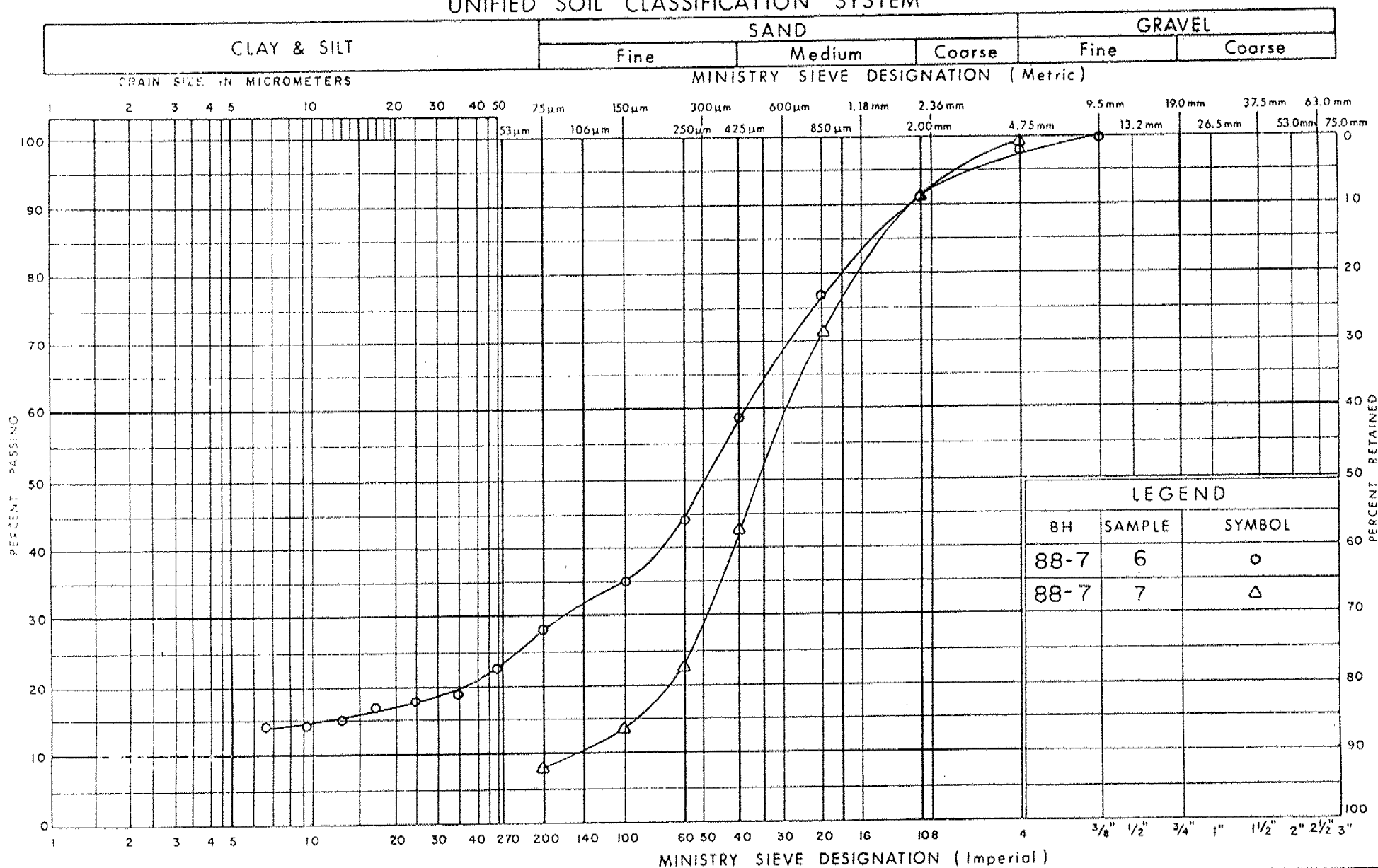
PLASTICITY CHART

SILTY CLAY, SOME SILTY SAND & SAND SEAMS

FIG No 2

W P 146-74-00

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
LAYERED SAND AND SILTY SAND

FIG No 3

W P 146-74-00

OVERSIZE DRAWING

DRAFT

October 27, 1988

Our Ref: 881-2294

Ministry of Transportation Ontario
Foundation Design Section
1201 Wilson Avenue
Room 315, Central Building
Downsview, Ontario
M3M 1J8

ATTENTION: Mr. M.S. Devata, P.Eng.

**RE: INTERIM REPORT, GROUNDWATER AND GEOTECHNICAL INVESTIGATIONS,
PROPOSED HIGHWAY 416, CINDARVIEW CORRIDOR, NEPEAN, ONTARIO**

Dear Sirs:

This interim report provides general information of the findings of the above investigation to date and a preliminary opinion of their implication on design and construction of sections of Highway 416. The following discussions are divided into the four separate sections of the alignment which are being investigated.

a) Silver Springs Farm

Two water well rig boreholes are yet to be constructed to 20 metre depth as described in our proposal; this work is scheduled to be carried out on November 1 and 2, 1988. Since this work has not yet been carried out, and since the available subsurface information is inconclusive, it is not possible to predict at this time what effect the Highway 416 bedrock cut may have on the quality and quantity of the Silver Springs Farm well.

b) Lynwood Subdivision

The proposed boreholes for this section have been recently completed and reviewed in conjunction with the previous data and proposed roadway profile. Our borehole 88-4 put down to the south of the CN rail line between the Highway 416 cut and the Lynwood subdivision indicates that a portion of the cut in this area will extend some 2 to 3 metres into a saturated sand deposit which has a piezometric head about 7 metres above the proposed bottom of excavation level. The deposit was not previously detected in the deep boreholes advanced by the

October 27, 1988

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881-2294

Ministry of Transportation Ontario (MTO) along the CN rail line, nor in the borehole advanced along Cedarview Road about 370 metres south of the CN rail line. If this deposit is extensive, there are several major concerns that have to be addressed.

- i) In terms of temporary groundwater control for the excavation, and based on the relatively high hydraulic conductivity of the sand encountered, groundwater control is expected to affect the groundwater level in the subdivision if the sands along the alignment are connected to sandy deposits underlying the silty clay in the subdivision. Depending on the extent and continuity of the sand deposit, temporary (and permanent) groundwater control may influence the groundwater level in the Bruce pit.
- ii) With respect to permanent groundwater control, if the deposit is found to be extensive, permanent groundwater lowering for the highway cut may have to be achieved by using such techniques as a system of deep permanent wells or by isolating the cut using a low permeability cut-off wall through the sands.

To provide sufficient information to address these concerns, the areal extent of the deposit must be determined. In addition, a pump test in the sand deposit should be considered in order to determine the hydraulic characteristics of the sand deposit and to then assess the effect of groundwater control measures on the local groundwater regime.

Another aspect to be addressed in this section is the potential drawdown of the groundwater level in the silty clay soils due to "under-drainage" from the proposed cut in the bedrock. Borehole 88-3 was recently advanced in the area between the CN tracks and Baseline Road to determine the permeability of the bedrock in this area where the bottom portion of the highway cut will transition into bedrock. Rising head permeability testing has not been carried out to date on the completed borehole nor has the analysis been carried out to evaluate the possible influence of the drawdown in the bedrock.

c) Bruce Pit

Based on available data, it is not considered that the proposed highway cut will result in a decrease in groundwater flow from west to east. The measured groundwater level in the sand is below the level of the cut for the roadway and drainage ditches. Filling of the Bruce pit should be carried out using sand or sand and gravel to allow continued west-east water flow; a fabric wrapped French drain design might be considered for this purpose to prevent piping of the sand where groundwater will exit at the toe of the fill slope.

Boreholes advanced north of the Bruce pit along the highway alignment showed extensive deposits of silty clay with some clayey silt, silt and silty sand layers. These deposits extend to below the level of

October 27, 1988

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881-2294

the proposed cut and therefore, groundwater flow along the highway cut from sand deposits is not expected to be of concern.

d) Stoney Swamp

Three boreholes have been recently completed (October 26, 1988) into bedrock to a maximum depth of 10 metres in this section, which is some 3 to 4 metres below the bottom of the proposed cut. Pump testing and hydraulic conductivity determinations have not yet been carried out.

However, groundwater inflow into the open boreholes from fracture zones in the rock above the base level of the proposed cut were estimated at about 0.035 to 0.07 L/S (0.5 to 1 lpm); consequently, inflow to the rock cut could be significant.

The groundwater level in boreholes 88-10 and 88-11 located on both sides of the groundwater divide described in the Water and Earth Sciences report are similar, and approximately the same as the water level in Stoney Swamp. This water level is some 4 metres above the base of the proposed cut. The effect of the cut on the groundwater regime in the Swamp has not been determined as yet, nor has an estimate of potential groundwater inflow from the bedrock into the excavation.

We trust that this letter provides sufficient information for your present purposes. We are proceeding with the remaining aspects of the field program as originally proposed, and will keep you advised of the findings and their implications on design and any additional investigation requirements. Should there be any questions in the meantime, please contact us.

Yours truly

GOLDER ASSOCIATES (EASTERN CANADA) LTD.


P.A. Smolkin, P.Eng.


F.J. Haffernan, P.Eng.

AFC:PAS:FJH:cn
2018/002



Golder Associates

CONSULTING GEOTECHNICAL AND MINING ENGINEERS



September 13, 1988

Our ref: 881-2294

MINISTRY OF TRANSPORTATION
Foundation Design Section
1201 Wilson Avenue
Room 315, Central Building
Downsview, Ontario
M3M 1J8

ATTENTION: Mr. M. S. Devata, P.Eng.

RE: GROUNDWATER AND FOUNDATION INVESTIGATIONS
PROPOSED HIGHWAY 416
CEDARVIEW CORRIDOR
NEPEAN, ONTARIO

Dear Sirs:

Further to the letter from the Minister dated August 23, 1988 and our meeting of August 29, 1988, we are pleased to submit our proposal for the above investigations.

PROPOSED FIELD PROGRAM

The investigations are comprised of four separate areas near the northern end of the Highway 416 alignment where it joins Highway 417 at the west end of Ottawa.

In order to achieve the objective of the study, we propose to first collect and collate all of the available data on the subsurface conditions for the study areas. A preliminary analysis of this data would then be carried out using this information to attempt to quantify the effects of the highway cuts on the existing groundwater regime, and to identify areas where additional field investigation is required.

Based on our knowledge of the soil conditions in the four areas, the proposed field program is as follows:

A. Silver Springs Farm

This farm on Richmond Road, near the built-up area of Nepean, sells bottled spring water to the public. The owner has a concern that the roadway cut for Highway 416 will affect the quality or quantity of the well. We intend to test his well to get baseline data for the groundwater at his location. We would then put down two holes, using a well drilling rig to 60 foot depth which will take us well into the bedrock aquifer. One test hole would be in the Silver Springs Farm area and the other test hole would be adjacent to the cut. Well screens would be placed in the test holes and rising head tests would be carried out to determine the permeability of the bedrock. This would allow us to make some determination of the water flow that is expected into the cut. From comparison of the static water levels in the two test holes and the Silver Spring Farm well, we could determine the groundwater flow pattern at the site and what effect the flow into the cut will have on the Silver Spring Farm well.

B. Lynwood Subdivision

The highway will be in cut within a clay stratum adjacent to the Lynwood subdivision. We propose to put down two detailed boreholes within the cut to determine the properties of the clay stratum as it effects the stability of the sideslopes and to determine the groundwater level in this area. The borehole nearest the railway track would be taken to about 10 feet into the bedrock (about 40 foot depth borehole) and a well screen would be put in to determine the permeability of the bedrock as it effects possible drawdown in the clay stratum.

We intend to put down two detailed boreholes along the first street back from the Highway to determine the soil and groundwater conditions. Piezometers would be sealed in these boreholes to allow monitoring of the groundwater levels within the clay stratum before construction begins and following construction.

C. Bruce Pit

We intend to put down two boreholes at the Bruce Pit to augment information obtained in the investigation by Conestoga-Rovers. The boreholes would be taken to about 30 foot depth. One borehole will be on the edge of the pit area and will determine the depth of the fill and the nature of the underlying sand. A piezometer will be sealed in the sand to determine the groundwater level. The field personnel will be outfitted with protective gear while drilling this borehole. Another borehole to the north of this will be within the natural soil. The properties of the soil at the transition between the sand and clay will be determined and a piezometer will be installed in the borehole to determine the groundwater level. Information on the groundwater in this area is needed for an assessment of the effect of the roadway cut on the groundwater resources in the forest area adjacent to Bell High School and Bell Arena.

D. Stony Swamp

Three boreholes will be drilled some 30 feet in the bedrock in the Stony Swamp area to determine the permeability of the bedrock.

A pumping test will be carried out in one of the test holes and the effect of this pumping will be monitored in the other two boreholes. Based on these results, an assessment of the water inflow into the rock cut would be made.

EQUIPMENT AND SUPERVISION

We will carry out the field work using two CME drill rigs, Bombardier mounted, and fully equipped for overburden sampling and rock core drilling. The equipment will be supplied by F.E. Johnson Drilling Company and if unavailable from them, by Marathon Drilling Company, Ottawa. The water well rig would be supplied by Henry Main Well Drilling, Richmond, Ontario. The field work will be carried out by Mr. D.J. Samotowka, assisted by W. Kris Marentette.

REPORTING

Upon completion of the field work, Mr. Andrew Chevrier, under the direction of Mr. F.J. Heffernan, will prepare and submit a detailed engineering report to MTO standards on each of the sites giving all the factual information obtained during the investigation, together with geotechnical recommendations for design. Input would also be given to the report by Mr. Paul Smolkin and Mr. Bruce Wilson on the groundwater aspects of the study.

COMPENSATION

Compensation for our services will be in accordance with MTO rates for geotechnical projects. In this regard, the payroll costs for the engineers on this project are:

Mr. A. Chevrier	(\$24.65)
Mr. Paul Smolkin	(\$32.22)
Mr. Bruce Wilson	(\$27.09)

On field supervision the rates are:

Mr. D.J. Samotowka	(\$26.56)
Mr. K. Marantette	(\$19.72)

The draftsmen and clerical rates are:

Mr. J. Cobisa	(\$14.46)
Mr. S. Leighton	(\$11.83)
Ms. D. Charron	\$13.61)

The standard cost is detailed on the attached "Project Cost and Performance Report". We estimate the cost of the investigation to be \$44,520.

We trust that this letter provides sufficient information on our proposed office study, field work and reporting. Should you have any questions regarding this letter, please contact us.

Yours truly,

GOLDER ASSOCIATES (EASTERN CANADA) LTD.

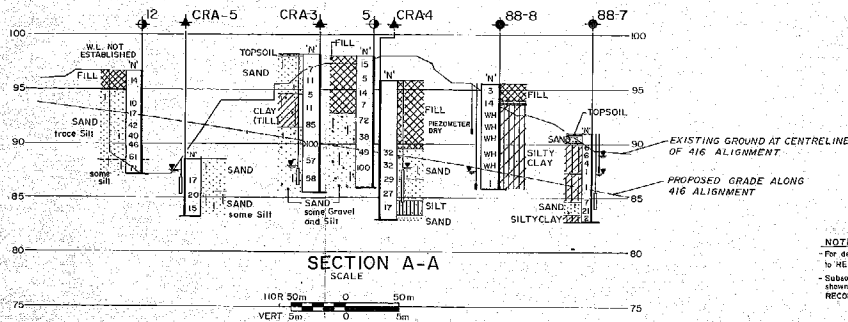
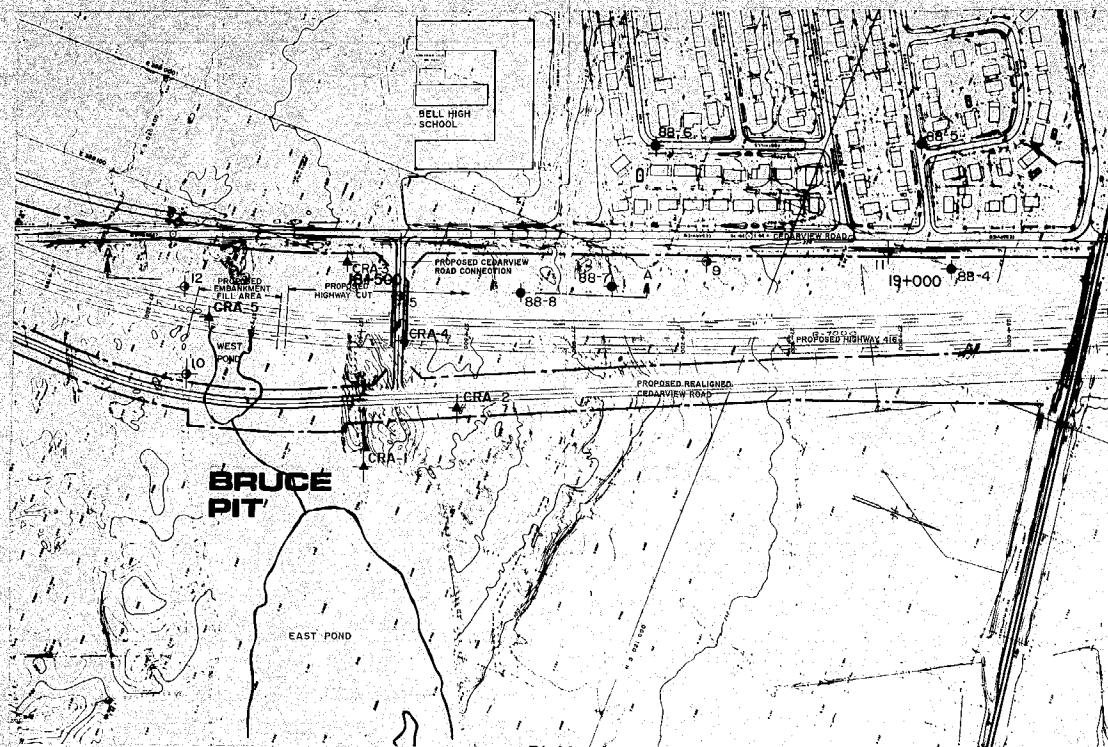


F. J. Heffernan, P.Eng.

FJH/cg

Atts: as noted above.

*Confirmed by telephone - Total hrs. for
Principal (F. Heffernan)
= 15 HOURS.*



NOTE

- For detailed soil descriptions refer to RECORD OF BOREHOLE SHEETS.
- Subsoil information for boreholes not shown on section A-A, refer to RECORD OF BOREHOLE SHEETS.

METRIC

DIMENSIONS ARE IN METRES
 AND/OR MILLIMETRES UNLESS
 OTHERWISE SHOWN. STATIONS
 IN KILOMETRES - METRES.

CONT No
 WP No 146-74-00

HIGHWAY 416

BRUCE PIT
 BORE HOLE LOCATIONS & SOIL STRATA



SHEET

REF. TO FIG. 1

KEY PLAN SCALE

LEGEND

- ◆ Bore Hole by Golder Associates
- ◆ Dynamic Cone Penetration Test (Cone)
- ◆ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CON Blows/0.3m (60° Cone, 475 J/blow)
- W.I. at time of investigation April and Nov, 1998
- ◆ Previous borehole by MTO Geocres (no. 315-1-139)
- ◆ Previous borehole by CRA report no. 2395
- Piezometer
- Well Screen

No.	ELEVATION	NORTH	EAST
88-4	87.80	5 021 180	358 804
88-5	88.20	5 021 002	358 806
88-6	88.20	5 020 852	358 855
88-7	91.00	5 020 864	358 027
88-8	95.00	5 020 785	358 169
5	98.10	5 020 688	358 103
9	88.60	5 020 925	358 976.7
10	97.60	5 020 521	358 252.3
11	87.70	5 021 061	358 962.2
12	96.70	5 020 486	358 175.3
CRA-1	87.31	5 020 710	358 209
CRA-2	96.30	5 020 771	358 185
CRA-3	96.26	5 020 822	358 081
CRA-4	95.71	5 020 638	358 145
CRA-5	88.53	5 020 520	358 133

NOTE

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

NOTE: The complete foundation investigation and design report for this project and other related documents may be executed at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 10-2.2 of Form 100.

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