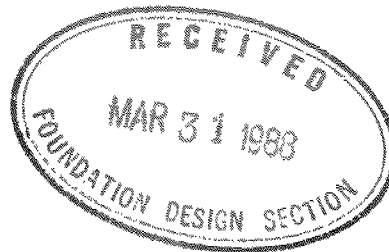


G.I.-30 SEPT. 1976

GEOCRES No. 30M12-232DIST. 6 REGION W.P. No. CONT. No. W. O. No. 87-11005STR. SITE No. HWY. No. 401LOCATION Hwy 401 at 5th line
W of MississaugaNo. of PAGES - =====OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. REMARKS:



WD 87-11005

MEADOWVALE NORTH FEEDERMAIN
M.O.E. PROJECT 5-0020-36
CONTRACT 3
TUNNEL UNDER HWY 401

Geocore: No 30M12-732

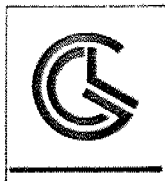
Ref. No. G-87.1203
March 1988

Prepared for:

Ministry of the Environment
c/o Marshall Macklin Monaghan Limited
Consulting Engineers
275 Duncan Mill Road
Don Mills, Ontario
M3B 2Y1

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March 9, 1988

Ref. No. G-87.1203

Ministry of the Environment
c/o Marshall Macklin Monaghan Limited
Consulting Engineers
275 Duncan Mill Road
Don Mills, Ontario
M3B 2Y1

Attention: Mr. A. Slywinskyj, P.Eng.
Associate

Re: Meadowvale North Feedermain
M.O.E. Project 5-0020-36
Contract 3
Tunnel under Hwy 401

Dear Sirs:

We have now completed the installation of the piezometers along the line of the proposed tunnel under Hwy 401, and under cover of this letter we are pleased to forward to you the factual information obtained by us during this investigation.

A total of six (6) piezometers were installed. The locations of the piezometers in relation to the tunnel alignment are shown on the individual Borehole Logs and are also depicted on Enclosure 1.

The piezometers were installed in 100 mm diameter holes drilled with a power auger machine to a depth of about 9.0 m. At four locations (within the Highway R.O.W.) the subsoil was sampled at 0.75 to 1.5 m intervals with a split barrel sampler tube to indentify the soil types present. The samples were visually examined and classified and the soil profiles encountered in the boreholes are shown on the individual Borehole Logs presented as Enclosures 2 to 7 inclusive.

The porous tip piezometers were surrounded by silica sand and bentonite clay seals were placed at one or two levels to eliminate or minimize interference from surface water. The top of each piezometer is protected with a steel casing, which was cemented into the ground, and a steel cap with a lock.



Water levels in the installations are monitored at frequent intervals, and the water level readings carried out to date are shown on the borehole logs and are summarized on Table I.

The subsurface conditions encountered in the sampled boreholes (Boreholes P2, P3, P4 and P6) are similar, yet somewhat different from the conditions found in the previous boreholes.

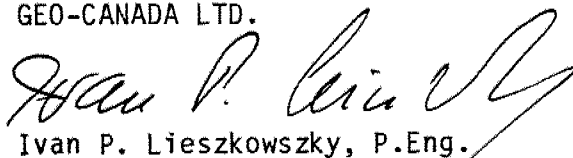
A hard to very stiff silty clay till is present in every borehole and extends from the ground surface to between Elevations 194.5 and 193.2 m. The clay till is underlain by a clayey sand and gravel layer which extends to between Elevations 192.4 and 187.9 m. The cohesionless and highly pervious sand and gravel deposit, which predominated in the previous boreholes, was encountered in Boreholes P4 and P2 at Elevations 192.4 and 190.2 m respectively.

Borehole P3 showed weathered shale (bedrock?) at Elevation 193.1 m. The shale was penetrated 2.5 m with the augers before encountering refusal at Elevation 190.6 m. Borehole P6, which was drilled about 6.0 m to the east, did not encounter shale to Elevation 188.0 m. The presence of the shale at this level in Borehole P3 is an anomaly and there is presently insufficient information available to either explain its presence or to define its extent.

In summary, generally it appears that the soil types encountered in the boreholes at or above the invert level of the tunnel are somewhat more stable and less pervious than the cohesionless sand and gravel deposits anticipated from the previous boreholes. The presence of numerous cobbles and some boulders was however confirmed by the new boreholes and the possibility of encountering shale bedrock in part of the tunnel also suggest difficult excavation conditions.

Yours very truly,

GEO-CANADA LTD.



Ivan P. Lieszkowsky, P.Eng.

IPL:bvc

WATER LEVEL RECORDS

(metres)

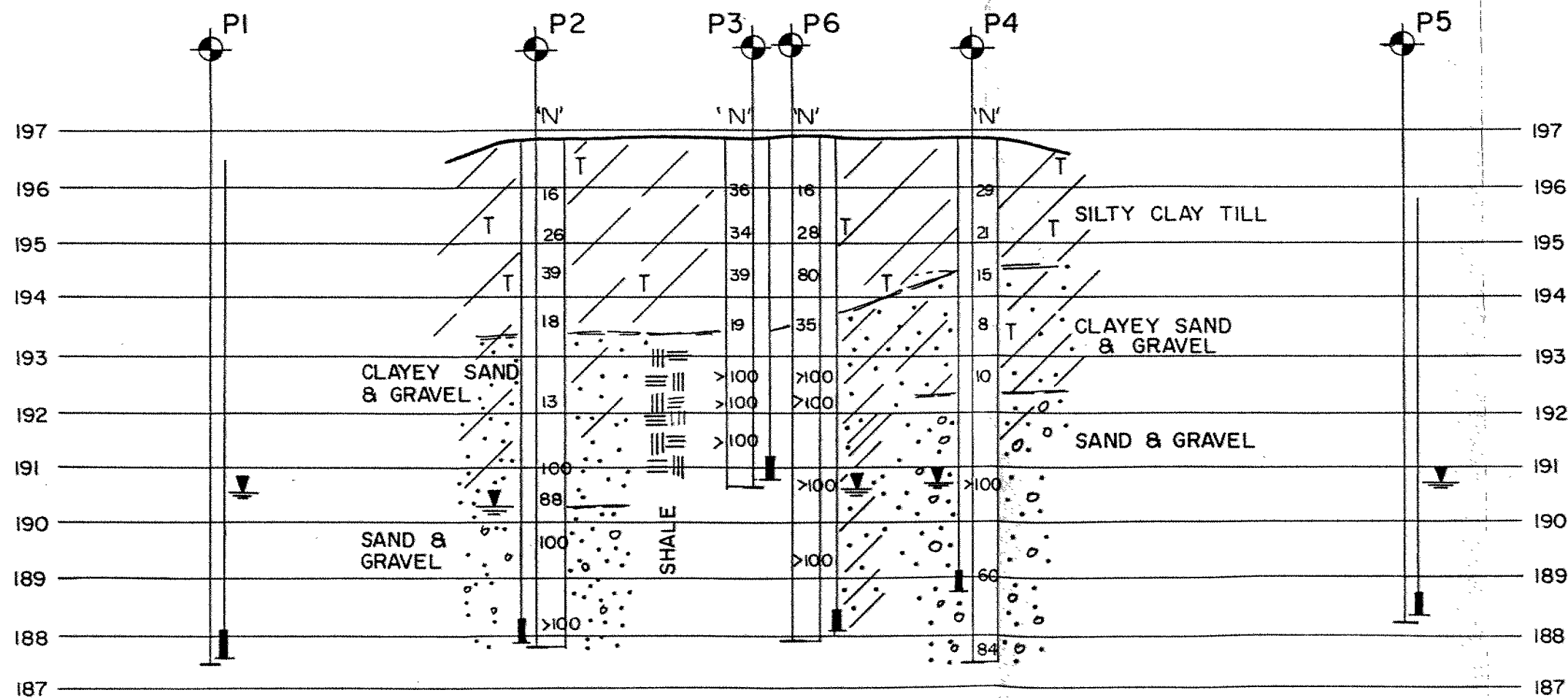
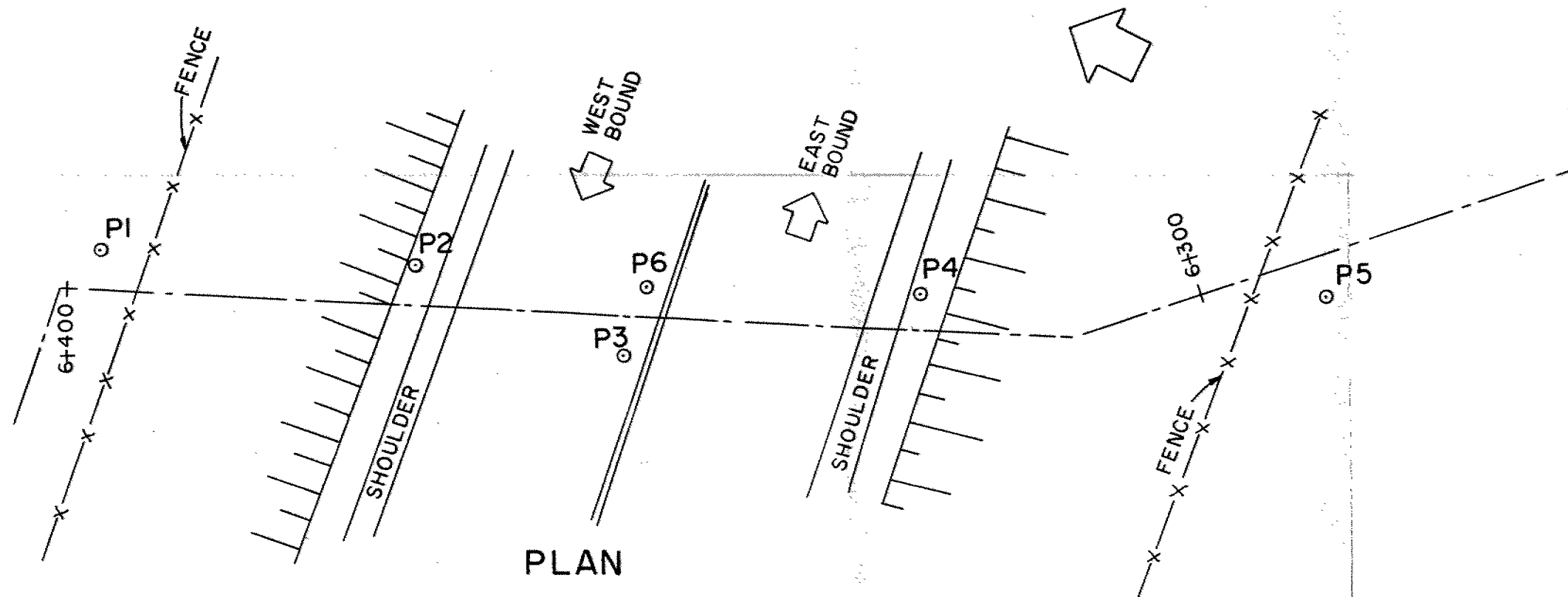
PROJECT : Meadowvale North Feedermain - Tunnel

CLIENT : M.O.E., c/o Marshall Macklin Monaghan Ltd.

REF. NO. : G-87.1203

GROUND SURFACE: 196.5 196.9 196.9 196.9 195.8 196.9

B.H. DATE 1988	P-1	P-2	P-3	P-4	P-5	P-6
	<u>ELEV.</u> <u>DEPTH</u>	<u>ELEV.</u> <u>DEPTH</u>	<u>ELEV.</u> <u>DEPTH</u>	<u>ELEV.</u> <u>DEPTH</u>	<u>ELEV.</u> <u>DEPTH</u>	<u>ELEV.</u> <u>DEPTH</u>
February 29			191.45 DRY			
March 1		188.04	191.45 DRY	189.40		
March 2	188.08	189.57	191.45 DRY	190.27	189.24	189.9
March 4	190.51	190.23	DRY	190.61	190.67	190.25
March 10	191.00	190.65	-	190.92	190.87	190.57
March 11	191.05	190.70	-	190.91	190.88	190.63
March 14	190.92	190.63	-	190.84	190.86	190.61
March 15	190.84	190.64	-	190.80	190.85	190.61
March 16	190.77	190.60	-	190.77	190.81	190.54
March 17	190.71	190.57	-	190.71	190.80	190.44
March 18	190.67	190.54	-	190.69	190.79	190.40
March 21	190.54	190.48	-	190.61	190.74	190.31
March 22	190.51	190.45	-	190.60	190.72	190.28
March 23	190.50	190.43	-	190.59	190.70	190.28
March 24	190.49	190.42	-	190.63	190.78	190.28
March 25	190.52	190.40	-	190.66	190.80	190.49



W.L. MARCH 4, 1988

(STA 6+197; o/s 3.5 m E)

DRILLING DATA

REF. NO: G-87.1203

ENCL. NO. 2

GEO-CANADA LTD.

LOG OF BOREHOLE P-2.....

(STA 6+368; o/s 3.4 m E)

CLIENT: M.O.E. c/o Marshall Macklin Monaghan
PROJECT: Meadowvale North Feedermain
LOCATION: Mississauga, Ontario
DATUM ELEVATION: Geodetic

DRILLING DATA
Method: Augering
Diameter: 100 mm
Date: March 1, 1988

REF. NO: G-87.1203
ENCL. NO: 3

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT $\frac{N}{mm^2}$					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT			UNIT WEIGHT γ	REMARKS B GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
(m) ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' BLOWS 0.3 m		20	40	60	80	100	W _p	W	W _L		
196.4	Ground Surface															
0.0	800 mm granular fill	T														
	SILTY CLAY TILL	T	1	SS	16											
	(possibly till)	T	2	SS	26											
	some sand, gravel very stiff to hard	T	3	SS	39											
		T	4	SS	18											
191.2		T														
	CLAYEY SAND AND GRAVEL compact to very dense	T	5	SS	13											
	cobbles	T	6	SS	135											
	shale fragments	T	7	SS	88											
189.2		T														
	SAND AND GRAVEL some cobbles wet very dense	T	8	SS	100											
187.8		T	9	SS	100											
	END OF BOREHOLE															

Tunnel Inv.
Auger refusal
at EL. 190.8 m
probably on
boulder,
relocated
hole 1.0 m
to the east
(5.0 m E. of
CL.)

Date W.L.
03/01 188.0
03/02 189.6
03/04 190.2

(STA 6+349; o/s 4.4 m W)

DRILLING DATA

REF. NO: C-87.1203

ENCL. NO: 4

GEO-CANADA LTD.

(STA 6+327: o/s 3.3 m E)

DRILLING DATA

Method: Augering

Diameter: 100 mm

Date: March 1, 1988

REF. NO: G-87.1203

ENCL. No: 5

GEO-CANADA LTD.

(STA 6+291: o/s 3.0 m W)

DRILLING DATA

REF. NO: G-88,1203

ENCL. NO. 6

GEO-CANADA LTD.

LOG OF BOREHOLE P-6.....

(STA 6+349; o/s 3.0 m E)




CLIENT: M.O.E. c/o Marshall Macklin Monaghan
PROJECT: Meadowvale North Feedermain
LOCATION: Mississauga, Ontario
DATUM ELEVATION: Geodetic

DRILLING DATA

Method: Augering
Diameter: 100 mm
Date: March 2, 1988

REF. No: G-88.1203

ENCL. No: 7

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	WATER CONTENT(%) γ	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
(m) ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' BLOWS 0.3 m			20	40	60	80	100						
196.9	Ground Surface																	
0.0	100 mm Asphalt 650 mm granular fill SILTY CLAY TILL (possibly fill) some sand, gravel, brown, very stiff to hard		1	SS	16		196											
			2	SS	28		194											
			3	SS	80		192											
193.9			4	SS	35		190											
3.0	CLAYEY SAND AND GRAVEL numerous cobbles, shale fragments, dense to very dense boulder		5	SS	60/0.08		188											
			6	SS	40													
			7	SS	60/0.02													
			8	SS	60/0.08													
197.0																		
9.0	END OF BOREHOLE																	

Date W.L.
03/02 189.9
03/04 190.3



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MARKHAM, ONT.
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WO 57-11005

GEOTECHNICAL INVESTIGATION
MEADOWVALE NORTH FEEDERMAIN
CONTRACT 2
M.O.E. PROJECT 5-0020-36
CITY OF MISSISSAUGA
REGION OF PEEL

Geocres NO 30M12-232

Ref. No. G-86.1102
February 1987

Prepared for:

Ministry of the Environment
c/o Marshall Macklin Monaghan Limited
Consulting Engineers
275 Duncan Mill Road
Don Mills, Ontario
M3B 2Y1

Distribution

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CONSULTING GEOTECHNICAL ENGINEERS

February 16, 1987

90 NOLAN CRT., UNIT 18
MARKHAM, ONT.
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(416) 474-9255

Ref. No. G-86.1102

Ministry of the Environment
c/o Marshall Macklin Monaghan Limited
Consulting Engineers
275 Duncan Mill Road
Don Mills, Ontario
M3B 2Y1

Attention: Mr. A. Slywinskyj, P.Eng.

Re: Geotechnical Investigation
Meadowvale North Feedermain
Contract 2
M.O.E. Project 5-0020-36
City of Mississauga
Region of Peel

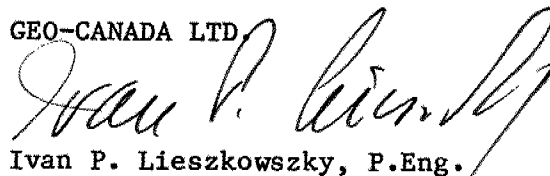
Dear Sirs:

Further to your letter of authorization dated November 4, 1986, we have carried out a subsurface investigation for the above project, and under cover of this letter, we are pleased to submit to you our report describing the subsurface conditions together with our interpretation of the test data, and recommendations for design.

We shall be pleased to discuss any questions you may have in connection with this project or to be of further service to you.

Yours very truly,

GEO-CANADA LTD.


Ivan P. Lieszkowsky, P.Eng.

IPL:esp



Ref. No. G-86.1102

EXECUTIVE SUMMARY

The geotechnical conditions encountered along the approximately 5 km long route of the feedermain are variable, but in very general terms can be described as follows. In the southern half of the project (from Britannia Road to approximately Millcreek Drive), the overburden cover is shallow, generally less than 3 m, and consists predominantly of hard silty clay till. The surface of the shale bedrock lies generally between Elevations 181 and 185 m with some local anomalies. In the northern section of the project (between Millcreek Drive and the reservoir site), the ground surface rises and the thickness of the overburden increases although the surface of the bedrock appears to be reasonably level between Elevations 186 and 181 m. Here, the till is also interbedded or is underlain by granular deposits, mainly silty fine sand or sand and gravel. These granular deposits are mostly saturated and the groundwater table was generally within these deposits.

The natural soil deposits encountered in the boreholes are competent and should provide good support to the pipes. Class "B" granular bedding can be used throughout.

The recompaction of the excavated till and shale bedrock will require considerable compaction effort and it may not be possible to achieve a degree of compaction higher than 90 to 93%. Where surface settlements cannot be tolerated, these materials may, therefore, have to be replaced by imported granular fill. The granular soil types encountered in the northern portion of the project are suitable for recompaction.

Alternative methods to resist the thrust at the pipe bends are given in the report.

.../...



Ref. No. G-86.1102

Open cut construction south of Millcreek Drive should not encounter major problems, but the granular deposits underlying the site north of Millcreek Drive are expected to be unstable below the water table. Construction in these materials will require either dewatering by well points or full support by tight sheeting.

The crossing under Erin Mills Parkway at Battleford Drive should be entirely within the shale bedrock and could probably be achieved without major problems by jacking and boring.

Tunnelling under the storm water channel will be several metres below the surface of the shale bedrock and in a zone where some fractures in the rock and water seepage from these fractures was noticed. Jacking and boring using an oversized liner is suggested for this area. Provisions will have to be made to handle water seepage.

Tunnelling under the CPR line will be through granular deposits below the groundwater level. The groundwater table will have to be depressed for the time of the construction using deep wells. Hand mining operations together with jacking an oversized liner to allow the removal of cobbles and boulders will probably be the most practical method for this crossing.

The geotechnical conditions at the Highway 401 tunnel crossing are generally unfavourable for tunnelling. Bouldery granular deposits and a high groundwater table will make tunnelling in this section difficult and will present a challenge to the contractor. Four possible alternatives are discussed in the report, consisting of a shallow tunnel above the groundwater table with some surface settlement; a deeper tunnel with groundwater lowering; soil stabilization by grouting; and tunnelling at an even deeper alignment with the use of compressed air. With the possible exception of the grouting alternative, each of these methods can be expected to cause some surface settlements. The soils through which the tunnel is driven will need continuous and immediate support.



Ref. No. G-86.1102

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.../...



A P P E N D I X

STATEMENT OF LIMITATION..... Appendix "A"

E N C L O S U R E S

KEY PLAN - BOREHOLE LOCATION PLAN...	Drawing 1
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KEY PLAN FOR SECTIONS.....	Drawing 3
LOGS OF BOREHOLES.....	Encl. 1-26 inclusive
GRAIN SIZE DISTRIBUTION CURVES.....	Fig. 1-8 inclusive



REPORT
ON
GEOTECHNICAL INVESTIGATION
MEADOWVALE NORTH FEEDERMAIN
CONTRACT 2
M.O.E. PROJECT 5-0020-36
CITY OF MISSISSAUGA
REGION OF PEEL

0.0 INTRODUCTION

Described in this report are the subsurface conditions encountered along the route of the proposed Meadowvale North Feedermain extending from Britannia Road West to the proposed reservoir site to be located north of Highway 401. The total length of this section of the feedermain is about 5.2 km.

The terms of reference and the scope of the investigation were given by the Consulting Engineers, Marshall Macklin Monaghan Limited, in a letter requesting proposals dated October 15, 1986. The terms of reference for the investigation are briefly as follows:

- The records of previous subsoil investigations adjacent to the route should be reviewed and evaluated;

.../...



- determine depth and nature of overburden, bedrock and groundwater;
- determine suitability of native excavated materials for backfilling and the chemical effects of native soils on the watermain pipe;
- provide design recommendations for pipe bedding and the resistance of thrust in the pipes;
- comment on anticipated construction conditions for open cut and tunnelling.

The scope of the investigation was defined by the Consulting Engineers and consisted of drilling twenty-one boreholes to depths ranging between 5 and 12 m.

Our report on the investigation is divided into three parts. Part I contains the factual information from the borehole investigation and the laboratory testing and includes also the procedures of the investigation. Part II consists of the interpretation and discussion of the factual information obtained, and Part III contains recommendations prepared for the use of Marshall Macklin Monaghan Limited for design purposes.

.../...



PART I

1.0 DESCRIPTION OF THE PROJECT

The project consists of the construction of an approximately 5200 m long, 900 mm diameter concrete pressure pipe watermain.

The project will commence at the termination of Contract 1, just north of Britannia Road. From here, the route will follow Erin Mills Parkway to Battleford Road, then various easements along the closed Fifth Line Right of Way to Highway 401, will pass under Highway 401, and then follow the Fifth Line West to the reservoir site. The watermain will be laid with a minimum cover of 2 m and generally open cut construction is proposed. Tunnelling or jacking is proposed at four locations: under Erin Mills Parkway at Battleford Road; under the City of Mississauga storm water channel; under the CPR line north of Derry Road; and under Highway 401.

2.0 METHOD OF INVESTIGATION

The field work for the investigation was carried out between December 18, 1986 and January 15, 1987. During this period, twenty-one boreholes were drilled at the approximate locations indicated on Drawing 1 attached. The accurate .../...



positions of the boreholes have been surveyed by Marshall Macklin Monaghan Limited, who have also provided us with ground surface elevations at these locations.

The drilling was carried out under the full time supervision of a geotechnical engineer from our office and the boreholes were advanced by augering and, in places, by diamond drilling and washboring technique. The boreholes were carried to the specified depths, but in some places the depth of the boreholes was increased to obtain sufficient information. The depth of the holes ranged between 5 and 15 m. Samples of the substrata were obtained at 0.75 m intervals of depth, using the standard penetration test method. The rock was generally penetrated by augers and identified from samples retained in the open drive split spoon samplers. At three locations, the rock was cored by diamond drilling with BXL (65 mm) size double tube core barrels.

The recovered soil samples were forwarded to our laboratory where they were re-examined and representative samples were selected for testing. The laboratory testing programme consisted of the measurement of the natural moisture contents, consistency limits, and grain size analyses.

The field and laboratory test results are presented on the borehole logs, attached as Enclosures 1 to 26 inclusive, and .../...



the grading curves, showing the particle size distribution of the various soil types, are attached as Figures 1 to 9 inclusive.

3.0 PREVIOUS STUDIES

In interpreting the data and preparing the report, reference was also made to previous subsurface investigations and studies carried out in the vicinity of the feedermain routes. In total, the results of seven investigations were used and the approximate locations of these study sites in relation to this project are shown on the Reference Key Plan, attached as Drawing 2. A list of these projects and references are briefly as follows:

1.) Geo-Canada Ltd.

"Soil Investigation, Proposed Swiss Chalet, Erin Mills Parkway", 1985, Ref. No. G-86.0303.

2.) Peto MacCallum Limited

"Geotechnical Investigation, Proposed Residential Subdivision, Meadowvale West, Mississauga", 1983, Ref. No. 83F132.

.../...



3.) Geo-Canada Ltd.

"Soil Investigation, Proposed Re/Max Office Building, Millcreek Drive, Mississauga, Ontario", 1985, Ref. No. G-85.0208.

4.) Golder Associates

"Geotechnical Investigation, Proposed Grade Separation, CPR-Derry Road West, Mississauga, Ontario", 1982, Ref. No. 821-1240.

5.) Peto MacCallum Limited

"Geotechnical Investigation, Meadowvale North Business Park, Mississauga, Ontario", 1981, Ref. No. 81F227.

6.) Associated Geotechnical Services Ltd.

"Soil Investigation, Daniels Business Park, Mississauga, Ontario", 1986, Ref. No. 86-81.

7.) Golder Associates

"Geotechnical Investigation, Water Tank Reservoir and Pump Station, Mississauga, Ontario", 1986, Ref. No. 861-1254.

4.0 SITE AND GEOLOGY

The project site is located in the north-western quadrant of
.../...



the City of Mississauga, extending from Britannia Road West to the northern City limit. It is an approximately 5 km long section and follows closely the present and previous alignment of the Fifth Line West.

In the southern half of the project, that is south of the storm water channel draining Lake Aquitaine, the topography is relatively flat and ground surface elevations range between about 183 and 187 m. From here, the groundwater level gradually rises and reaches about Elevation 206 m near the reservoir site. Between the CPR main line and Highway 401, the line of the feedermain will cross a small creek, a tributary to the Credit River.

Geologically, the site is located on a till plain which extends between the Oakridges Moraine to the north and the old shoreline of post-glacial Lake Iroquois to the south. The glacial drift (till) found in this area is typically clayey silt (Halton Till) which was deposited towards the final stages of the last Ice Age. Drift thickness is generally shallow, generally less than 10 m, and is in places interbedded with granular glacio-fluvial deposits. Bedrock in the region is red shale of the Queenstone Formation which is interbedded with bands of harder silt stone. The boundary between the overburden and the underlying shale bedrock is generally poorly defined as the base of the till is shaley .../...



which blends in gradually with the underlying highly weathered shale.

The position of the groundwater table is generally erratic and varies with local changes in the composition and permeability of the till. There are several small lakes or "kettle" ponds in the area which were formed during the ablation of the till sheet. The macro drainage in the area is generally towards the south-east to Lake Ontario via the Credit River.

5.0 SUBSURFACE CONDITIONS

5.1 General

The subsurface conditions were explored at twenty-one locations along the route of the feedermain and additional information on the anticipated conditions was also obtained from previous studies carried out at nearby sites. From these, the general subsurface conditions can be described briefly as follows.

Three major soil deposits were identified. A glacial till, which consists predominantly of silty clay or clayey silt and has a generally hard consistency; granular deposits, consisting of silty fine sand or sand and gravel; and shale bedrock.
.../...



In the southern half of the site (Boreholes 1 to 9), the overburden cover is shallow, generally less than 3 m, and consists predominantly of hard silty clay till. The surface of the shale bedrock lies generally between Elevations 181 and 185 m with some local anomalies. In the northern section of the project, as the ground surface rises, the thickness of the overburden increases although the surface of the bedrock appears to be reasonably consistent between Elevations 186 and 181 m. Also, interbedded in the till or underlying it are thick deposits of granular soil types, mainly silty fine sand or sand and gravel with numerous cobbles and boulders. These granular deposits are generally saturated and the groundwater table was mostly within these deposits.

5.2 Detailed Description of Subsurface Conditions

For the purpose of discussion and to facilitate the description of the geotechnical and construction conditions, we have divided the length of the feedermain into ten arbitrary sections. A key plan showing the approximate extent of these sections is attached as Drawing 3, and the general conditions encountered within these sections will be discussed briefly below.

.../...



5.2.1 Section 1

Erin Mills Parkway from Britannia Road to Battleford Road

The subsurface conditions in this area were explored by Boreholes 1 to 4 inclusive, and additional information at the south end of the project is provided by Borehole 10 put down by Peto MacCallum Limited in 1984 for Contract 1.

Based on this, the subsurface profile is described as consisting of a surficial layer of mixed fill, followed by hard silty clay to clayey silt till and shale bedrock.

Fill was encountered in every borehole, except Borehole 1, and ranged in thickness between 0.8 and 1.4 m. Deeper fill was encountered in Borehole 10 put down by Peto MacCallum Limited (2.8 m) and in our Borehole 2, where the depth of fill over the culvert is 7.9 m thick. The composition of the fill is quite heterogeneous and its compactness condition ranges from loose to compact or firm to very stiff.

Silty clay till was encountered in every borehole, except in Borehole 3, and the thickness of the till varied from 1.6 to 3.5 m. It is a predominantly clayey material of very stiff to hard consistency.

.../...



The surface of the shale bedrock was encountered at depths ranging between 0.8 and 3.5 m, except in Borehole 2, where the surface of the shale lies 10.4 m below the grade of the road. The surface elevation of the rock in this section is quite irregular and ranges between 189.8 and 177.5 m. The rock was generally penetrated with the augers and was cored only in Borehole 4, where core recovery ranged between 90 and 100%. The examination of the recovered cores indicates that it is a red shale of the Queenstone Formation with occasional thin grey bands of hard siltstone.

Free standing water levels were recorded only in Boreholes 2 and 3, at Elevations 177.2 and 187.8 m respectively.

5.2.2 Section 2

Erin Mills Parkway at Battleford Road

The subsurface conditions at the proposed tunnel crossing of Erin Mills Parkway are shown on the Logs of Boreholes 4 and 4A.

The subsurface profile consists of a 1.2 to 1.4 m thick surficial fill, followed by a 1.1 to 1.6 m thick hard silty clay till, and shale bedrock between Elevations 184.8 and 185.5 m.

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The fill consists predominantly of silt and sand and penetration resistances of 15 to 16 blows per 0.3 m indicate a compact condition.

The underlying silty clay till contains some sand and a trace of gravel, and penetration resistances of 30 to 65 blows per 0.3 m indicate hard consistency.

The surface of the shale bedrock was encountered at depths between 2.3 and 3 m, that is between Elevations 185.5 and 184.8 m. The rock was cored in both boreholes and core recovery ranged from 83 to 100%. The rock is a fine to very fine grained fissile shale with thin, 15 to 100 mm thick silt stone bands. The surface of the shale is highly to moderately weathered, but at greater depths the degree of weathering is only slight. Rock quality designation values (RQD) measured on BXL (41 mm) size cores ranged from 20 to 65%, indicating a rock of poor to fair quality.

Before coring both boreholes were dry, and after completing the coring a piezometer was installed in Borehole 4. Unfortunately, the installation was destroyed, probably by a snow plough, and later readings in the piezometers, therefore, could not be taken.

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5.2.3 Section 3

Closed Road Allowance For Fifth Line
From Battleford Road to Stormwater Channel

Subsurface conditions in this area are shown on Boreholes 5, 5A, 6, 7 and 8, and also by the boreholes put down by Peto MacCallum Limited in 1983 for the adjacent residential subdivision to the west of the feedermain line (Reference 2).

The subsurface conditions in this section are fairly uniform and consist of silty clay to clayey silt till underlain by shale bedrock at depths ranging between 2 and 3.7 m, that is between Elevations 183.3 and 180.3 m. The boreholes put down on the adjacent subdivision showed similar conditions consisting of 1 to 2.7 m of heterogeneous earth fill overlying a reddish brown silt till to the full depth of the boreholes, that is 4.6 m.

The till has a very stiff to hard consistency with penetration indices of 13 to greater than 100 blows per 0.3 m. In places, the till contains thin, wet sand seams.

The shale bedrock was penetrated with the augers to depths ranging between 1 and 6 m without encountering major difficulty or refusal.

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Free standing water levels were recorded in Boreholes 7 and 8 between Elevations 181 and 179.8 m. In the adjacent subdivision, no groundwater was recorded in the boreholes by Peto MacCallum Limited.

5.2.4 Section 4

City of Mississauga Storm Water Channel

The subsurface conditions at the crossing of the storm water channel are shown on the Log of Borehole 8, indicating a surficial layer of compact silty sand, which is described as possible fill material, followed by hard clayey silt till to a depth of 3.7 m and shale bedrock at Elevation 181.2 m.

The borehole, through the shale was extended by augering to a depth of 6.2 m (Elevation 175 m) without encountering major difficulties or refusal. During augering, samples of the shale were recovered by the standard penetration test method and the recovered samples indicate a moderately weathered fine grained red shale with thin bands of hard siltstone. During augering, below Elevation 177 ± m, free water was recorded suggesting fracture zones within the shale bedrock.

The water level in a piezometer installed at Elevation 175 m showed the water head at Elevation 178.1 m on the day of the

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drilling and at Elevation 179.8 m approximately seven weeks later.

5.2.5 Section 5

Closed Road Allowance of Fifth Line From Storm Water Drain to Millcreek Drive

Borehole 9 shows the anticipated subsurface conditions in this area. It consists of hard clayey silt till underlain by shale bedrock at relatively shallow depth. At the borehole location, the surface of the bedrock was 1.5 m below ground surface at Elevation 183.9 m. The borehole bored dry and remained dry for a period of twenty-four hours.

5.2.6 Section 6

Millcreek Drive, Derry Road West, and Easement Along CPR Line

Boreholes 10 to 14 inclusive show the subsurface conditions in this area. The typical subsurface profile can be described as follows:

The overburden in this area consists of a surficial layer of fill underlain by stiff to hard silty clay or clayey silt till which is interbedded or is overlain by granular deposits consisting of silty sand, fine sand or gravelly sand. The

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surface of the shale bedrock was encountered at depths between 3 and 5.8 m, that is generally between Elevations 186.8 and 184.7 m.

Groundwater was generally encountered in the granular deposits and free standing water levels in the boreholes were recorded between Elevations 190.7 and 187.7 m.

Similar subsurface conditions were encountered and reported by Golder Associates at the Derry Road/CPR grade separation (Reference 4), where the thickness of the clayey silt till overburden was generally shallow and the surface of the rock was between Elevations 187.5 and 186.2 m. Water levels observed in piezometers over a longer period of time indicate a gradient from west to east, sloping from Elevation 188.6 to 184.5 m.

5.2.7 Section 7

Old Road Allowance of Fifth Line at CPR Line

Borehole 14, which was drilled at the proposed tunnel crossing under the CPR line indicates that underlying 1 m of silty clay the subsoil is predominantly sand. The composition of the deposit ranges from silty sand with occasional cobbles and boulders to a uniform fine sand with

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some silt. The full depth of the sand deposit is unknown but based on the two adjacent boreholes (Boreholes 13 and 15) it may extend to the surface of the shale bedrock which is expected to be at about Elevation 185 m.

The groundwater level was monitored and observed in a piezometer and at the time of the investigation it was recorded at Elevation 190.8 m.

The silty sand stratum, which extends from Elevation 192.6 m to 189.8 m, is a well graded mixture of gravel to clay size particles with occasional cobbles and boulders. Penetration resistances range from 26 to greater than 100 blows per 0.3 m, indicating compact to very dense but generally very dense conditions. The underlying fine sand is uniformly graded and contains only 10% of soil fines. Penetration resistances greater than 80 blows per 0.3 m indicate that the sand is very dense.

5.2.8 Section 8

Old Road Allowance of Fifth Line West
From CPR Line to Highway 401

Boreholes 15 to 17A inclusive provide information on the subsurface conditions in this section.

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As indicated, predominantly granular deposits are expected. These extend from the ground surface ($195 \pm \text{m}$) to the surface of the shale bedrock, which in Boreholes 15 and 17A was encountered at Elevation $185.5 \pm \text{m}$.

The composition of the granular overburden varies from silty sand till, silty sand and fine sand to well graded bouldery sand and gravel with some silt. The deposits are generally dense to very dense with occasional compact zones.

The groundwater level in Boreholes 16 and 17 was at about Elevation $191 \pm \text{m}$, dropping to Elevation 188.8 m at Borehole 15 located near the creek.

5.2.9 Section 9

Crossing Under Highway 401

Boreholes 17 and 17A and 18 were drilled on the south and north side of the Highway respectively. They indicate that from the ground surface to about Elevation $194 \pm \text{m}$, that is to a depth of about 2 m, the subsoil is stiff to hard silty clay or clayey silt underlain by sand and gravel with occasional boulders and cobbles. In Borehole 18, that is on the north side of the Highway, an approximately 2 m thick layer of silty sand till is sandwiched between the silty clay

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till and the sand and gravel deposits. The lateral extent of this layer is unknown. The sand and gravel stratum extends to depths between 10 and 15 m and is underlain by the shale bedrock.

The thin surficial silty clay till, which appears to be present on both sides of the Highway, consists of 8% gravel, 31% sand, 41% silt, and 20% clay. Penetration indices range from 13 to 31 blows per 0.3 m, indicating a stiff to hard consistency.

The silty sand till was encountered only in Borehole 18. The composition of this till is typically about 40% gravel, 20% sand, 30% silt, and 10% clay. The deposit is compact as indicated by penetration resistances of 16 and 21 blows per 0.3 m. The till also contains boulders.

The principal soil deposit underlying the site is a sand and gravel stratum which extends to depths between 10 and 15 m. Typically, it consists of 30 to 50% gravel, 30 to 50% sand, and 8 to 17% soil fines, mainly silt, with less than 4% clay size particles. The deposit also contains occasional to frequent cobbles and boulders. It is generally dense to very dense and penetration indices were generally in excess of 100 blows per 0.3 m.

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The bedrock was cored in Borehole 17A, where it was penetrated for a depth of 4 m. Core recovery ranged from 92 to 100% and RQD values from 50 to 100%, indicating sound conditions. The rock is a red coloured shale belonging to the Queenstone Formation, is very fine grained and contains bands of hard siltstone. There were no fractures observed.

Piezometers were installed in Boreholes 17A and 18, and water level readings carried out one month after the field work was completed indicated water levels between Elevations 191.1 and 191.6 m showing a slight gradient from north to south.

5.2.10 Section 10

Fifth Line West From Highway 401 to Reservoir Site

The subsurface conditions in this area were explored by Boreholes 19, 20 and 21, put down during the present investigation. Additional information was also obtained from previous investigations carried out by Peto MacCallum Limited, Associated Geotechnical Services Limited, and Golder Associates (References 5, 6 and 7).

These various investigations indicate that to a depth of about 4 m the subsoil is predominantly cohesive silty clay or clayey silt till followed at depth by coarser textured

.../...



materials such as silt, silty sand or sand. The clayey tills are generally very stiff to hard and the coarser textured deposits are generally dense to very dense. Bedrock was encountered only in Borehole 8 drilled by Associated Geotechnical Services near the south-east corner of the proposed reservoir site. At this location, the surface of the rock was at 4.1 m, that is at about Elevation 202 m. At the other locations, even where the boreholes extended to a considerable depth, the surface of the bedrock was not contacted to about Elevation 189 m.

The boreholes drilled during the present investigation were dry and remained dry for the duration of the field work, and piezometers installed at the reservoir site indicate groundwater levels at about Elevation 201 m. From here, the water level is expected to drop to the south.

6.0 SOIL PROPERTIES

In this section, the properties of the main soil types are described.

6.1 Silty Clay Till

A cohesive till consisting of silty clay or clayey silt is the predominant soil type which forms the overburden

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throughout most of the site. It was encountered in every borehole except Boreholes 12 and 16.

The thickness of the deposit ranges from 0.6 to greater than 4 m, but is typically 2 to 3 m thick.

Its composition ranges from gravel to clay size particles. The results of grain size analyses are shown on Figure 1, indicating 0 to 10% gravel, 19 to 37% sand, 36 to 68% silt, and 12 to 24% clay.

Atterberg tests performed on the soil fines gave liquid limits between 24 and 27%, a plastic limit of 12 to 16%, and plasticity indices of 8 to 15. Natural moisture contents ranged from 8 to 14%, but were typically around 10%. These tests indicate a silty clay of low plasticity and hard consistency.

The hard consistency of the till was confirmed by the standard penetration tests which gave values between 13 and greater than 100 blows per 0.3 m, but typically greater than 50.

6.2 Silty Sand Till

A coarse textured sandy till was encountered in Boreholes 16
.../...



and 18, where its thickness ranged from 2 to 2.3 m.

Grain size analyses performed indicate a gravel content of 38%, 22% sand, 27% silt, and 13% clay. Occasional cobbles and boulders are also present in this deposit. The matrix of the till is weakly to moderately cemented.

Natural moisture contents were measured between 20 and 30%, and penetration resistances ranged from 16 to greater than 100 blows per 0.3 m. From the penetration indices, the compactness condition of the till in Borehole 16 is inferred to be dense to very dense and compact in Borehole 18.

6.3 Sand

Granular deposits ranging in composition from silty fine sand to bouldery sand and gravel were found in Boreholes 10 to 18 inclusive, that is generally in the boreholes located in the northern half of the project. These deposits were found at various depths and elevations as either overlying or underlying the till or, in many places, interbedded in the till strata. The thickness of the deposit appears to increase in the northerly direction and ranges from less than 1 m at the south end (Borehole 10B) to greater than 10 m just north of Highway 401 (Borehole 18).

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A large number of grain size analyses were performed on the granular soil types and the results of these are presented on Figures 2 to 8 inclusive. The composition of the deposit varies considerably and the percentage of gravel, sand, silt and clay size particles range between the following values: Gravel 0 to 67%; sand 32 to 90%; silt 5 to 32%; clay 0 to 7%.

In addition, the deposit in many places contains cobbles and boulders and also pockets or lenses of silt till.

Natural moisture contents range between 5 and 21%, but were typically between 15 to 19%. These values indicate generally saturated conditions.

The deposits are generally dense to very dense, as indicated by penetration indices of 40 to greater than 100. Compact conditions were recorded only in Boreholes 15 and 11, where penetration resistances of 16 to 29 blows per 0.3 m were recorded.

6.4 Shale Bedrock

Shale bedrock was contacted and penetrated at most borehole locations, except in Boreholes 14, 16 and 19 to 21 inclusive. At the other borehole locations, the surface of the rock was contacted at depths ranging between 0.8 and 14.9 m, but .../...



generally between 2 and 4 m. The surface of the bedrock lies between Elevations 189.8 and 177.5 m, but with the exception of two boreholes (Boreholes 2 and 3) the surface elevation of the rock was between Elevations 185.7 and 180.3 m.

The rock was cored in Boreholes 4, 4A and 17A to depths ranging between 3 and 4 m. Core recovery was 80 to 100% and the examination of the recovered cores indicates red shale of the Queenstone Formation which is interbedded with thin, 15 to 100 mm thick bands of hard siltstone. The percentage of siltstone in the cores ranged from 8 to 32%. The shale is very closely bedded, is fine to very fine grained, and is fissile. Near the surface, the shale is weathered and the degree of weathering ranges from high to moderate. With depth, the degree of weathering decreases and the rock is only slightly weathered or is unweathered.

RQD values (Rock Quality Designation), as measured on 41 mm diameter cores (BXL), range between 20 and 65%. Generally, near the surface, the RQD values are low and increase with depth. In places, the rock is fractured and in Borehole 8 increased groundwater flow was noticed from these zones.

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PART II

7.0 DISCUSSION OF THE RESULTS

In this section of the report, the subsurface conditions are briefly reviewed and the field and laboratory test data presented in Part I of the report is interpreted as relevant for the design of the project. Brief comments on the anticipated construction conditions are also provided. These comments, however, are intended only for the guidance of the design engineer and are probably insufficient or incomplete for the contractors bidding on the project, or may not fully evaluate all the problems that will be encountered.

To facilitate the discussion, the project was divided into ten sections, the approximate locations and extent of which are shown on Drawing 3.

7.1.1 Section 1

Erin Mills Parkway from Britannia Road to Battleford Road

This section extends along Erin Mills Parkway from Britannia Road to Battleford Road. Open cut construction is envisaged and Boreholes 1 to 4 indicate the anticipated subsurface conditions.

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The overburden in this section is shallow, generally less than 3 m thick, and is underlain by shale bedrock. The overburden is very stiff to hard silty clay or clayey silt till except in Borehole 2, where fill extends to a depth of about 8 m, i.e. to the invert of the culvert. Groundwater was encountered in Boreholes 2 and 3, and the other boreholes were dry at the time of the investigation. Due to the nearly impervious nature of the till and the shale, perched groundwater conditions can develop either within the overlying fill material or the upper weathered and fissured zone of the subsoil.

At the nominal foundation depth of about 3 m below grade, the pipe will be laid on either the hard till or the shale bedrock. Only in the vicinity of Borehole 2, where Erin Mills Parkway is on a high embankment, will the pipe be laid in fill. All these deposits, including the fill, will provide adequate to excellent support to the pipes, and Class "B" granular bedding in accordance with OPSD-1102.01 can be used. Where the subgrade is rock, the minimum thickness of the granular bedding material should be 150 mm and on the fill the thickness of the bedding material should be increased to 300 mm and the degree of compaction should be 100% of the standard Proctor maximum dry density.

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We do not anticipate unusual or major construction problems in this section. The removal of the hard till and especially the shale bedrock will be difficult and slow, but based on our previous experience with the shale, we do not anticipate that blasting would be required. The removal of the rock will require powerful equipment, narrow buckets, and special hardened cutting teeth. The sides of the excavations are expected to be generally stable at steep angles and less stable conditions are expected only in the surficial granular fill materials. Unsupported or unprotected excavations in the overburden must be cut back to a temporarily stable angle of at least 45 degrees, and to 60 degrees in the shale. Vertical cuts should be supported by braced skeleton sheeting or protection to the workmen should be provided by a trench box. As both the till and the shale are relatively impervious, no dewatering problems are expected. Seepage into the excavation even below the water table will be minimal and could be handled by gravity drainage and pumping from temporary sumps established inside the trench. The shale is known to disintegrate quickly when exposed to air or surface water. The base of the excavation should, therefore, not be left open for periods of more than a few hours or else should be protected with a working mat of weak concrete or granular fill.

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The recompaction of the hard and dry excavated materials will require considerable compaction effort, that is thin (150 mm) layers, heavy compactors (sheepsfoot roller) and many passes of the compaction equipment. If a high degree (95%) of compaction cannot be achieved with the contractor's plant and equipment, then it may be necessary to replace the excavated material with imported granular fill which can be more easily compacted to a higher degree of compaction.

To maintain the stability of the excavation through the existing embankment in the vicinity of Borehole 2, it is suggested that the excavation be carried out in short, not more than 8 m long sections, and that the completed section of the trench be backfilled before the next section is opened. The excavated material should not be stockpiled on the top or on the face of the slope as this may cause instability of the embankment.

7.1.2 Section 2

Erin Mills Parkway at Battleford Road

The crossing of the watermain under Erin Mills Parkway at Battleford Road will be by tunnelling or jacking and boring.

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The subsurface conditions at this location were investigated on both sides of Erin Mills Parkway and are shown on the Logs of Boreholes 4 and 4A. As shown, below an approximately 1.4 m thick layer of sandy and silty fill material, the natural subsoil is hard silty clay till which extends to between 2.3 and 3 m below the ground surface, that is to Elevations 185.5 and 184.8 m. At this level, the surface of the shale bedrock was encountered. The rock is a moderately to slightly weathered fine grained fissile shale belonging to the Queenstone Formation. It is interbedded with thin seams of hard siltstone. The thickness of the siltstone bands is 15 to 100 mm. Due to a damaged piezometer, the groundwater conditions are not known, but could be at a depth of about 3 m. Perched groundwater conditions could also exist in the overlying fill or in the fissures of the silty clay till.

To avoid a mixed face in the tunnel, we recommend that the invert of the tunnel be lowered so that the top of the pipe or a temporary liner is at or below Elevation 184 m. This should provide adequate cover for the tunnel and should minimize ground movements at the surface.

The liner or the pipe could be advanced by jacking and the material at the face could be removed either by hand mining

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or boring. Experience with the Queenstone shale suggests that the rock can be removed by horizontal boring and augering although the presence of the harder siltstone bands will tend to slow down the operation and may cause some problems in keeping the alignment of the bored tunnel. At the location of Borehole 4, the percentage of siltstone in the shale increases from 12% above Elevation 183 m to 32% below Elevation 183 m. In Borehole 4A, the percentage of siltstone is only about 8% and the thickness of the siltstone bands is also less. In anticipation of possible problems with these hard siltstone bands, it may be advisable to increase the size of the temporary liner so that workers can enter the opening, if necessary, and remove any obstructions by hand.

Groundwater seepage into the tunnel opening is expected to be small and could be handled by gravity drainage.

7.1.3 Section 3

Closed Road Allowance For Fifth Line From Battleford Road to Storm Water Channel

This section, which stretches along the old road allowance of Fifth Line West, extends from Battleford Road to the storm water channel. The subsurface conditions in the area are

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shown on Boreholes 5, 5A, 6, 7 and 8.

The overburden is between 2 and 3.7 m thick and consists of stiff to hard silty clay or clayey silt till with occasional thin wet sand seams. The surface of the shale bedrock lies between Elevations 183.3 and 180.3 m, and the boreholes were dry to Elevation 181 m. Groundwater was measured only in Borehole 8 at Elevation 179.8 m.

The bedding of the watermain should present no problems and granular Class "B" bedding in accordance with OPSD-1102.01 can be used.

No unusual construction problems are anticipated and the construction conditions in this section are similar to those discussed for Section 1 (7.1.1). Little to moderate seepage, mainly through the sand seams, is expected and it should be possible to handle this by gravity drainage and/or pumping from inside the excavation.

As this section is located along an easement outside paved areas, probably some minor surface settlements can be tolerated. In this case, the on-site excavated materials could be used for backfilling. The recompaction of the

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on-site excavated till or shale will be difficult and will require considerable compaction effort. We expect that the degree of compaction with these materials will unlikely exceed 90 to 93%. With this degree of compaction, some minor surface settlements can be expected. If these are not acceptable or if the contractor cannot demonstrate that the native materials can be compacted to higher densities, then they should be replaced with imported granular fill.

7.1.4 Section 4

City of Mississauga Storm Water Channel

The crossing of the feedermain under the City of Mississauga storm water channel will be by tunneling or jacking and boring.

The geotechnical conditions at the location of the crossing are shown on the Log of Borehole 8. The overburden cover is shallow, 3.7 m thick, and consists of 1.8 m of compact silty sand underlain by hard clayey silt till which extends to Elevation 181.2 m. At this level, the surface of the shale bedrock was encountered. The rock was penetrated with the augers to a depth of 9.9 m (Elevation 175 m) without encountering major difficulties or obstructions. During

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augering, it was noticed that thin bands of hard siltstone are present and below about Elevation 177 m the inflow of water indicates occasional fracture zones. A piezometer was installed to monitor the groundwater level and water level readings ranged between Elevations 178.1 and 179.8 m.

It is understood that the invert of the storm sewer pipes below which the feedermain will have to pass is at about Elevation 179.3 m. Depending on the method of construction used during the construction of the storm sewer channel, the shale below the invert level may have been fractured by overexcavation or overbreak. In order to provide sufficient separation between the storm sewer and the watermain and to provide a sufficiently thick cover of undisturbed rock above the tunnel, we recommend that the crown of the pipe or tunnel liner should be at or below Elevation 177.5 m. At this elevation, the entire cross section of the tunnel will be within the shale bedrock which may contain some fracture zones below Elevation 177 m. As regionally high lateral stresses are known to exist in the shale bedrock, which may exert high swelling pressures on the tunnel, it is suggested that the pipe be laid in a larger diameter primary liner and the void between the two be filled with compressible material such as sand.

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The liner could be advanced by jacking and material at the face of the liner could be removed either by hand mining or boring. It is suggested that the diameter of the liner be large enough to permit the entry of workers to remove any obstructions that may be encountered. It is believed that the shale could be bored without major difficulties, but depending on the amount and thickness of the siltstone bands, due to the mixed face conditions, it may be difficult to maintain the proper alignment of the liner.

Although the shale is generally tight and nearly impervious, water seepage from fracture zones known to be present in the shale can be expected. The amount of seepage, however, should not be excessive and could probably be handled by gravity drainage.

7.1.5 Section 5

Closed Road Allowance of Fifth Line From Storm Water Drain to Millcreek Drive

The geotechnical conditions in this section are shown on the Log of Borehole 9, indicating 1.5 m deep hard clayey silt till overburden underlain by shale bedrock at Elevation 183.9 m. Free groundwater accumulation in the borehole was not recorded at this location.

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The pipe will probably be laid on the shale bedrock and Class "B" granular bedding of a minimum thickness of 150 mm will be sufficient.

Excavation in the till should not present problems, but the removal of the shale bedrock may be slow and difficult. Since no major difficulties were encountered when penetrating the shale with the augers, we expect that the rock could be removed without blasting. Powerful equipment will, however, be required. Both the till and the shale will be self-supporting and the excavations could be carried out with nearly vertical sides using a trench box as protection. Groundwater seepage into the trench is expected to be minimal.

The backfilling of the trench with the on-site excavated materials will be difficult and will require considerable compaction effort. Even then, it is unlikely that the excavated materials could be placed at densities higher than 90 to 93%, and if a higher degree of compaction is required, they may have to be substituted with granular material. However, since this section is an untravelled easement, some minor surface settlements can probably be tolerated.

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7.1.6 Section 6

Millcreek Drive, Derry Road West, and
Easement along CPR Line

Boreholes 10 to 14 inclusive show the geotechnical conditions in this area. The thickness of the overburden in this section ranges between 3 and 5.8 m, increasing in the northerly direction. It consists of clayey silt or silty clay till which is interbedded or is overlain or underlain by wet sand layers. The thickness of these granular deposits is between 1 and 5 m. The surface of the shale was encountered in Boreholes 10, 11, 12 and 13, between Elevations 186.8 and 184.7 m. The groundwater level was recorded at depths between 2 and 3 m, but in places (e.g. Borehole 10A) a higher, possibly perched water table was observed.

A variety of materials is expected at the proposed construction depth, but all natural soil deposits are expected to provide fair to good support for the pipes. Class "B" granular bedding will be sufficient.

The construction conditions will likely vary in this section. The silty clay and the clayey silt till are expected to be stable in the excavations even below the water table. Unsupported cuts, however, should be sloped at an angle of 45

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degrees and vertical trench walls can be supported with braced skeleton sheeting or a trench box. Above the groundwater table, the sand deposits will be temporarily stable at an angle of 35 degrees (1.4 : 1), but below the water table these materials are expected to be unstable. The flow of groundwater into the excavation will cause caving conditions and the sand would have to be supported either by tight braced sheeting or the sand will have to be stabilized by dewatering (e.g. well points). Due to the limited thickness of the sand deposit and the presence of an impervious layer (e.g. till or shale), the use of tight sheeting, which is extended to the surface of the underlying impervious layers, appears to be a more practical alternative. Where the excavation in the sand extends less than 0.6 m below the water table, pumping from temporary filtered sumps may also be sufficient.

The on-site excavated granular materials are suitable for backfilling although in places they may be too wet for optimum compaction and will, therefore, have to be dried or mixed with dry granular material. Both the till and the shale would be difficult materials to recompact and would require considerable compaction effort. Where surface settlement cannot be tolerated, these materials may have to be replaced by imported granular fill.

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7.1.7 Section 7

Old Road Allowance of Fifth Line at CPR Line

As the north side of the track was inaccessible, only one borehole (Borehole 14) was drilled on the south side of the tracks. This borehole indicates that underlying a 1 m thick layer of silty clay the subsoil is silty sand and fine sand. These cohesionless granular deposits extend to a depth at least 5 m, and judging from the two nearby boreholes, Boreholes 13 and 15, they probably extend as far as the surface of the shale bedrock, i.e. to about Elevation 185 + m. The groundwater level over a period of seven weeks appears to be reasonably steady at about Elevation 190.8 m, that is approximately 2.8 m below ground surface.

The entire cross section of the tunnel at this location will be in cohesionless granular deposits and will also be partly below the groundwater table. Above the groundwater table, the sand will have a very short stand-up time and, therefore, the full cross section of the tunnel will need immediate and full support. Due to some apparent cohesion imparted to the sand by the low moisture content (7 to 10%), the face of the tunnel, however, is expected to be stable for a somewhat longer period of time. Below the groundwater table, however,

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the sand will tend to ravel or flow into the tunnel opening causing unstable conditions and probable loss of ground. For the duration of the construction, therefore, the water table will have to be locally depressed. This could probably be achieved by one or two deep wells installed on both sides of the track. The wells, which should be equipped with submersible pumps, should extend to near the surface of an impervious layer such as the clayey silt till or shale bedrock. The dewatering system should ensure that the water level during construction is depressed at least 1 m below the invert of the tunnel. The effectiveness of the dewatering system should be monitored in suitably located piezometers.

To minimize surface settlements, it is recommended that the earth cover on top of the tunnel be at least twice the tunnel diameter. Due to anticipated obstructions on boulders and cobbles, it is recommended that an oversized tunnel liner be used which allows the entry of workers into the tunnel opening to break up and remove the boulders. The liner, in this case, could be advanced by jacking and the material at the face removed by hand mining. If the jacking and mining is interrupted, a temporary bulk head should be immediately installed at the face to prevent loss of ground.

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7.1.8 Section 8

Old Road Allowance of Fifth Line West
From CPR Line to Highway 401

This section will be installed as open cut and involves the crossing of a minor creek.

The geotechnical conditions are indicated by Boreholes 15, 16, 17 and 17A. With the exception of a thin stratum of glacial till (clayey silt or silty sand), granular deposits predominate in this section. These granular deposits range in composition from silty sand to uniform fine sand or sand and gravel with cobbles and boulders. The surface of the shale bedrock was encountered in Boreholes 15 and 17A at about Elevation 185 \pm m. The groundwater table slopes from north to south, that is towards the creek, and ranges between Elevations 191.3 and 188.8 m.

The substrata encountered in this section will provide excellent to good support to the pipes and Class "B" granular bedding will be adequate.

Borehole 15, drilled at the creek crossing, indicates that the fine sand extends to a depth of 2.6 m where it is followed by hard clayey silt till and shale bedrock at

.../...



Elevation 185.4 m. At the proposed construction depth of 3 m, the pipe will be laid on the hard clayey silt till and the construction could be carried out inside tight interlocking sheeting which should be driven about 0.5 m into the impervious clayey silt till. The excavation could be backfilled with the on-site excavated fine sand. After backfilling, the sheeting can be withdrawn.

Construction in the northern portion of this section will likely be above the groundwater table and, therefore, no major construction problems are anticipated. Above the water table, the granular deposits are expected to be temporarily stable at an angle of about 35 degrees or else the trench walls could be supported by braced close sheeting.

The granular deposits excavated in this section can be used for backfilling.

7.1.9 Section 9

Crossing under Highway 401

The subsurface conditions along this approximately 120 m long tunnel crossing under Highway 401 were investigated at the two ends of the tunnel. At the south end, Boreholes 17 and

.../...



17A were drilled, and on the north side Borehole 18 was put down. The boreholes indicate that underlying an approximately 2 m thick layer of clayey silt till the subsoil is a thick deposit of sand and gravel with numerous cobbles and boulders. The sand is relatively clean and contains between 8 and 17% soil fines of which approximately 4% is clay size. The gravel content, that is particles larger than 4.75 mm, is quite high and varies between 24 and 58%. Cobble and boulder size particles, that is particles larger than 60 mm, are not included in these percentages although they are present throughout the deposit. Embedded in the deposit are also pockets or lenses of fine textured silt till. The sand and gravel deposit extends to the surface of the shale bedrock which on the south side lies at about Elevation 185.7 m, that is about 10 m below ground surface, and on the north side at Elevation 181 m, that is approximately 15 m below ground surface.

The groundwater level in the boreholes was monitored over a period of approximately one month and was relatively stable at about Elevation $191.5 \pm$ m, that is approximately 4.5 m below ground surface.

.../...



The geotechnical conditions described above are not favourable for tunnelling. The granular deposit which underlies the thin veneer of till is a cohesionless deposit which above the water table would have some stand-up time but will generally need immediate and full support. Below the water table, this deposit will be fast ravelling and would tend to flow into the tunnel opening with the groundwater. This could be prevented only if the groundwater level would be depressed for the duration of the construction or the ground is stabilized by grouting.

To minimize ground surface settlements, the thickness of soil cover above the crown of the tunnel should be preferably three tunnel diameters. Assuming that a 1.5 m diameter liner will be installed, the invert of the liner should, therefore, be about 6 m below ground surface, that is at about Elevation 190 m. This would put the tunnel approximately 1.3 to 1.6 m below the groundwater table. Under no circumstances should the cover be less than 2 diameters.

In view of the anticipated problems, the following alternatives could be considered.

.../...



- a) The invert of the tunnel could be raised to about Elevation 191.5 m, that is to the water level, in which case problems due to groundwater could be minimized or eliminated, but the potential risk of a major loss of ground occurring and causing excessive settlement is increased. The tunnelling, in this case, would have to be carried out with extreme care. A smooth steel liner equipped with a short roof shield could be advanced by jacking. It is estimated that with good workmanship and great care surface settlements could be kept to a minimum of 75 to 100 mm. The width of the settlement trough is estimated to be about 6 m centering over the tunnel. When jacking and tunnelling operations stop, the face must be immediately protected with a full bulk head.
- b) In order to minimize ground surface settlements, the depth of cover on the tunnel should preferably be increased to 3 or more tunnel diameters. This, however, would be possible only if the water level could be depressed. There is a possibility that a number of large diameter deep wells located along the north and south edges of the Highway and extending to near the surface of the shale bedrock may be able to depress the water level to a sufficient depth that will allow the lowering of the

.../...



tunnel and working in the dry. The feasibility of this, however, should be established prior to starting the construction with a full scale pumping test in which both the pumping rate and the draw-down that can be achieved by deep wells is established.

- c) Consideration could also be given to stabilize the deposits by grouting. Colloidal chemical grouts could be used which could be introduced from inside the tunnel, grouting ahead of the tunnel face, and then carrying out the tunnelling in the grout stabilized zone. Although this method is expensive, ground surface settlements could be virtually eliminated. Before adopting this method, however, the suitability of the soil for grouting, i.e. depth of penetration, grout-soil interaction, etc. should be determined in the field.
- d) The use of compressed air to stabilize the ground could also be considered, although due to the high permeability of the soil and the presence of only a thin layer of less pervious material at ground surface air losses from the tunnel could be significant. In addition to the risk of a blow-out, there is also the danger that the air pressure will build up at the underside of the impervious

.../...



stratum resulting in a pressure greater than the hydrostatic head which then may result in increased pressure and water flow at the working face. It is important, therefore, that the air pressure be kept to a minimum, just sufficient to balance the water head.

The removal of obstructions that impede the advancement of the liner should be done with great care. Large boulders should preferably be broken up rather than removed, and any void left after the removal of cobbles and boulders should immediately be filled with concrete, cement grout, or pea gravel. To reduce the friction on the liner, it may also be necessary to use Bentonite grout as lubricant.

7.1.10 Section 10

Fifth Line West from Highway 401 to Reservoir Site

Boreholes 19, 20 and 21 show the geotechnical conditions along this section indicating predominantly cohesive silty clay or clayey silt till. The till has a hard consistency. From previous studies carried out in the area, the till is known to be interbedded or to be underlain by sand deposits of various thickness and elevation. The possibility of

.../...



encountering sand layers which may be waterbearing should, therefore, not be excluded. Bedrock was not encountered and only a borehole drilled by Associated Geotechnical Services near the reservoir site indicated rock at Elevation 202 m. Boreholes put down during the present investigation did not encounter groundwater and long term observations carried out at the reservoir site by Golder Associates indicate that the groundwater level at that site is at Elevation 201.5 ± m.

Bedding conditions in this section are considered to be excellent, and Class "B" granular bedding can be used.

No major or unusual construction problems are envisaged. Excavations in the hard and occasionally bouldery till may be slow, but the sides of the excavations are expected to be stable at a vertical face and, therefore, only nominal support consisting of braced skeleton sheeting or a trench box will be required. If these are not used, the sides of the excavations should be cut back to 45 degrees. Little or no groundwater seepage is expected.

The recompaction of the hard till will require considerable compaction effort and it is doubtful that the excavated material could be replaced at densities higher than about 90

.../...



to 93%. At this density, some minor surface settlements can be expected and, therefore, if long term settlements over the trench cannot be tolerated, then imported granular materials may have to be used.

7.2 Thrust Resistance

The thrust at the bends in the feedermain could be resisted either by thrust blocks or by friction along the pipe and the use of restraint mechanical joints extending to some distance beyond the bend. These alternatives will be discussed briefly below.

Thrust blocks which are poured tightly against the undisturbed subsoil or rock could be designed for a safe passive earth pressure of 200 KPa in the clayey till overburden and 500 KPa in the shale bedrock. It is recommended that no passive resistance should be assumed in the top 1.2 m of the trench as resistance in this zone could be weakened by the seasonal freeze and thaw cycles and weathering. If there is a danger that at some time in the future the soil in the area of the thrust block will be removed, then thrust blocks should not be used.

.../...



As an alternative, the thrust could be taken up by restraint joints in the pipe and considering friction along certain lengths on either side of the elbow. In this case, again two alternatives could be considered. The pipe could be encased in concrete in which case the force in the pipe would be resisted by friction between the concrete encasement and the surrounding subsoil; or the forces could be resisted by the friction developed between the pipe and the backfill surrounding it.

In the event that the pipe is encased in concrete, the angle of friction (δ) between the concrete and the surrounding soil can be assumed to be 26 degrees in the silty clay till, 29 degrees in the shale bedrock, and 31 degrees in the granular deposits. The ultimate unit frictional resistance (s) can be evaluated by the following expression:

$$s = N \tan \delta \text{ (kN/sq.m)}$$

In the above equation, N is the unit normal stress on the contact plain between the concrete and subsoil. When calculating the vertical stresses, the unit weight of the backfill material can be assumed to be 20.5 kN per cubic metre. The horizontal normal stress can be taken as 40% of

.../...



the vertical stress in the overburden. The adhesion between the concrete and the rough surface of the shale bedrock can be taken as 100 kN/square metre.

The unbalanced forces in the pipe can also be resisted by the frictional resistance between the pipe and the granular backfill surrounding the pipe. The angle of friction between the concrete pipe and the surrounding granular fill can be assumed to be 24 degrees. The calculations for the unit frictional resistance and normal stresses are as above with the exception that the horizontal normal stress should be taken only as 30% of the vertical stress because of the anticipated poorer degree of compaction on the sides of the pipe.

The above calculated resisting forces are ultimate and the safety factor should not be less than 1.75 for normal working pressure and 1.3 under test or surge pressure.

When calculating the unit normal stresses below the groundwater table, the submerged unit weight of the soil should be used. It is also customary to assume that within a certain length of the pipe on each side of an elbow the soil may be removed from the top and the side of the pipe or that

.../...



the grade in the future may be reduced. Possible fluctuations in the water level should also be considered.

Other methods such as installing shear keys below the pipe or using rock anchors could also be considered.

7.3 Soil Corrosiveness

To determine the potential of a possible chemical attack on the concrete pipe, two samples of the silty clay till and one sample of the granular deposits were tested for sulphate (SO₄) content.

The tests show that the total sulphate (SO₄) in the soil samples was between 0.09 and 0.12% for the silty clay, and 0.075% in the sand.

Percentages less than 0.10% represent a negligible potential degree of sulphate attack, and percentages between 0.10 and 0.20 represent a mild degree of sulphate attack. In the present case, the potential for sulphate attack on the concrete pipe is considered to be negligible to mild. For both cases, Type 20 Portland cement mixed with a maximum water : cement ratio of 0.5 is considered to be suitable.

.../...



PART III

8.0 RECOMMENDATIONS

In this section, design recommendations which have been discussed and outlined in Part II of the report will be summarized in a condensed form for an easy review by the design engineer.

8.1 Bedding

Generally, Class "B" granular bedding in accordance with the Ontario Provincial Standard Drawing OPSD-1102.01 will be adequate. The minimum thickness of the granular bedding material below the pipe should be as follows.

Subgrade	Bedding Thickness
Sand	75 mm
Silty Clay or Clayey Silt Till	75 mm
Shale	150 mm
Fill (Borehole 2)	300 mm

.../...



Generally, 19 mm size clear stone can be used for bedding where the subgrade is shale, silty clay or clayey silt till, or well graded sand and gravel. On the silty sand or fine sand subgrade, only well graded granular material meeting the grading requirements of Granular "B" material should be used, OPS Form 1010.

The degree of compaction of the bedding material below the pipe and to the spring line of the pipe should be 95%, and 100% where the pipe is laid on fill (Borehole 2).

8.2 Soil Parameters

Various soil parameters to be used in the design of thrust resistance or the evaluation of lateral pressures on temporary trench supports are given in Table I on the following page.

.../...



TABLE I
DESIGN SOIL PARAMETERS

Soil Parameter	Soil Type			
	Clay Till	Sand	Shale	Granular Fill
Unit Wt. γ kN/cu.m	20.5	19.5	24.0	20.5
Submerged Unit Wt. γ' kN/cu.m	10.5	9.5	14.0	10.5
Angle of Shearing Resistance ϕ (degrees)	28	35	N/A	32
Coefficient of Earth Pressure				
active, K_a	0.36	0.27	N/A	0.31
at rest, K_o	0.48	0.43	N/A	0.47
passive, K_p	2.8	3.7	N/A	3.3
Passive Resistance KPa	200	N/A	500	N/A
Friction Angle, δ , (degrees)				
soil-concrete	26	31	29	30
soil-pipe	N/A	N/A	N/A	24

.../...

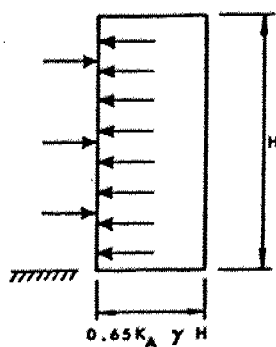


8.3 Trench Support

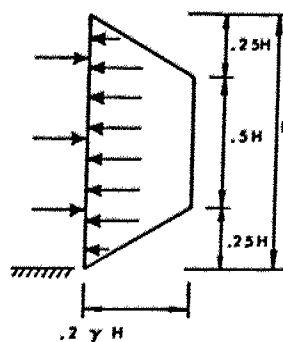
The sides of the excavations above the water table are expected to be temporarily stable without support at the following slope angles:

Soil Type	Angle (degrees)	Slope (H:V)
Silt-Clay Till	45	1:1
Shale	60	0.6:1
Sand	35	1.4:1

Vertical cuts should be supported with braced sheeting and the earth pressure distribution on the sheeting can be assumed to be as shown on Figures a) and b) below.



a) Sand



b) Clay Till



Design parameters for the values shown on the above Figures can be taken from Table I in Section 8.2.

The design of all members must include the effects of loads of street traffic, construction equipment, adjacent structures and, where applicable, water pressure.

8.4 Backfilling

The degree of compaction of the backfill under travelled roadways and other areas where surface settlements cannot be tolerated, should be not less than 95%.

Where surface settlements can be tolerated, such as in easements or outside paved areas, the degree of compaction could be between 90 and 92%.

To achieve the above degrees of compaction, the backfill material should be placed in layer thicknesses between 150 and 300 mm maximum. The type of compaction equipment used should be compatible with the type of backfill material (e.g. vibratory equipment for granular soils and heavy sheepfoot rollers for clay soils).

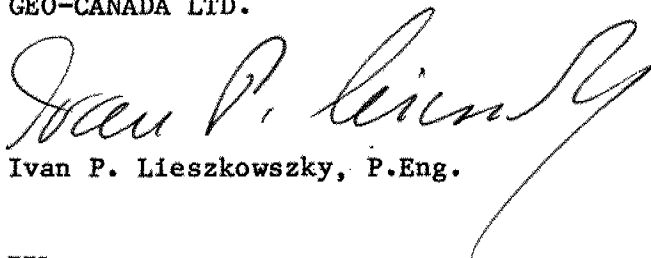
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9.0 STATEMENT OF LIMITATION

The Statement of Limitation, as quoted in Appendix "A", is an integral part of this report.

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Ivan P. Lieszkowszky, P.Eng.

IPL:esp



A P P E N D I X



APPENDIX
"A"
Statement of Limitation

The conclusions and recommendations in this report are based on information determined at the borehole locations. Soil and groundwater conditions between and beyond the boreholes may differ from those encountered at the borehole locations, and conditions may become apparent during construction which could not be detected or anticipated at the time of the soil investigation.

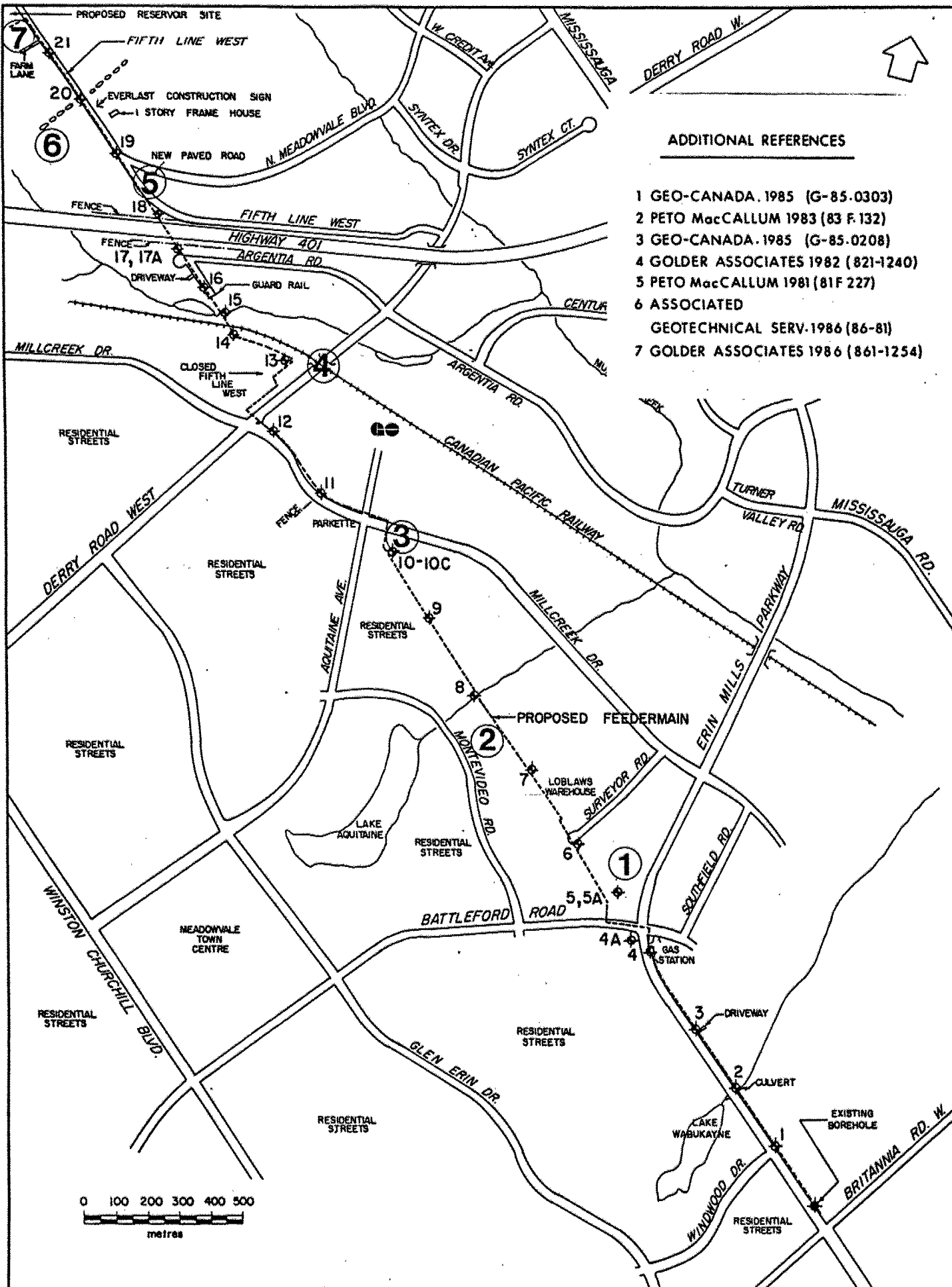
The design recommendations given in this report are applicable only to the project described in the text, and then only if constructed substantially in accordance with details of alignment and elevations stated in the report. Since all details of the design may not be known to us, in our analysis certain assumptions had to be made. The actual conditions may, however, vary from those assumed, in which case changes and modifications may be required to our recommendations.

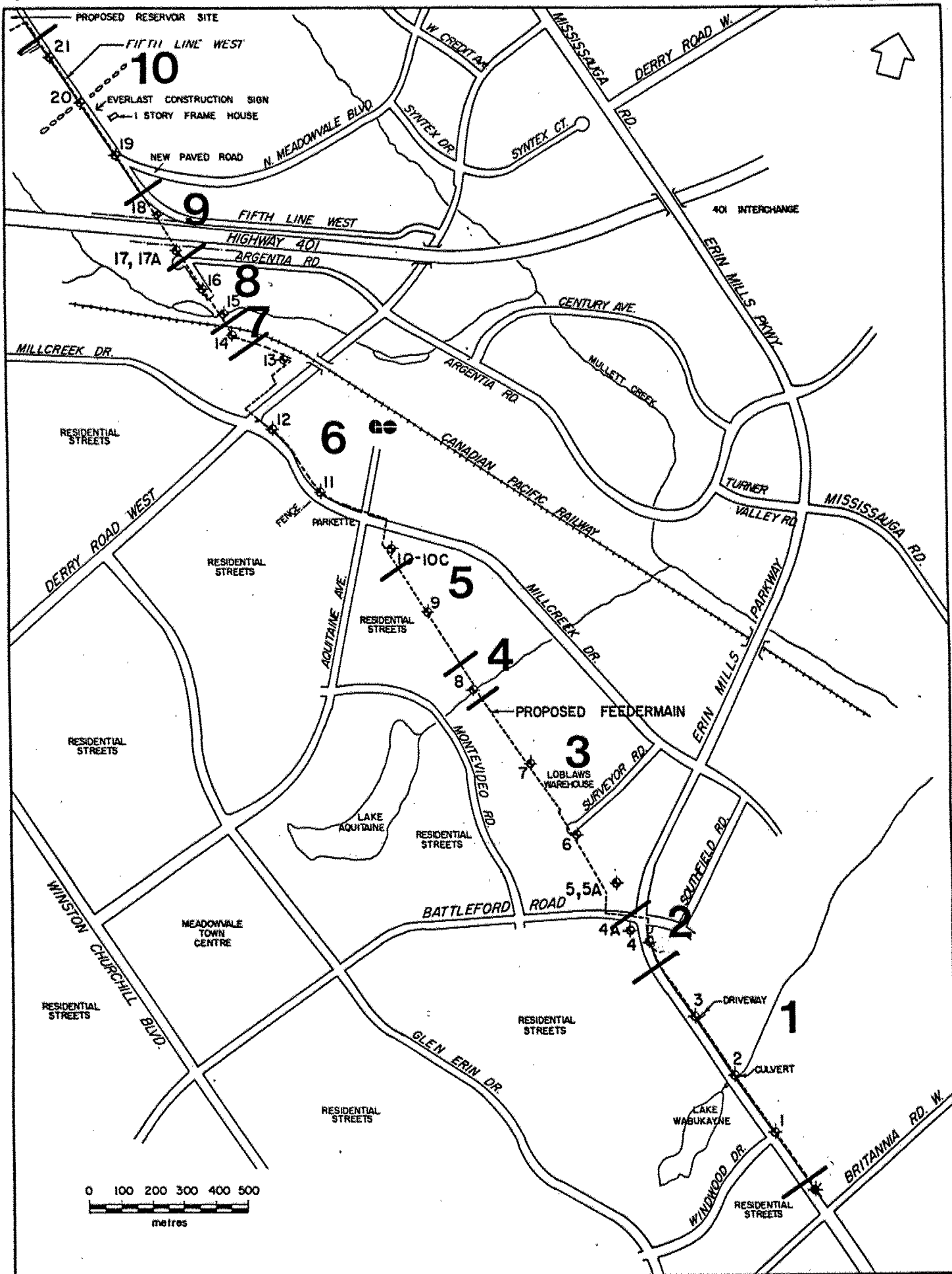
We recommend, therefore, that we be retained during the final design stage to review the design drawings and to verify that they are consistent with our recommendations or the assumptions made in our analysis. We recommend also that we be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in the boreholes. In cases where these recommendations are not followed, the company's responsibility is limited to interpreting accurately the information encountered at the boreholes.

The comments given in this report on potential construction problems and possible methods are intended only for the guidance of the design engineer. The number of boreholes may not be sufficient to determine all the factors that may affect construction methods and costs. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work.



E N C L O S U R E S





KEY PLAN FOR SECTIONS

G-86.1102

DWG.3

LOG OF BOREHOLEI.....																	
CLIENT: M.O.E. c/o Marshall Macklin Monaghan PROJECT: Meadowvale North Feedermain LOCATION: Mississauga, Ontario DATUM ELEVATION: Geodetic					DRILLING DATA Method: Augering Diameter: 100 mm Date: December 23, 1986					REF. NO: G-86.1102 ENCL. NO: 1							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' BLOWS 0.3 m			SHEAR STRENGTH					WATER CONTENT(%)				
								UNCONFINED + FIELD VANE QUICK TRIAXIAL & LAB VANE					W _p — W — W _L 10 20 30				
184.8	Ground Surface																
0.0	500 mm sand and gravel FILL	T															
	SILTY CLAY TILL some sand gravel brown very stiff to hard	T	1	SS	26												
		T	2	SS	40												
		T	3	SS	46												
		T	4	SS	36												
181.3	SHALE BEDROCK weathered red		5	SS	50 0.1												
180.1			6	SS	50 0.08												
4.7	END OF BOREHOLE															HOLE DRY ON COMPLETION GR = Gravel SA = Sand SI = Silt CL = Clay	

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LOG OF BOREHOLE2.....

CLIENT: M.O.E. c/o Marshall Macklin Monaghan
 PROJECT: Meadowvale North Feedermain
 LOCATION: Mississauga, Ontario
 DATUM ELEVATION: Geodetic

DRILLING DATA
 Method: Augering
 Diameter: 100mm
 Date: December 23, 1986

REF. NO: G-86.1102
 ENCL. No. 2

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 SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' BLOWS 0.3m		20	40	60	80	100					
187.9	Ground Surface															
0.0	500mm sand and gravel fill	X														
		X	1	SS	15											
	FILL	X														
	mixture of silt clay, sand, some gravel, trace of organic matter	X	2	SS	19	186										
		X	3	SS	28											
	Reddish brown, moist,	X	4	SS	28											
	Compact to very stiff.	X	5	SS	31	184										
		X	6	SS	21											
		X	7	SS	16	182										
180.0		X	8	SS	29	180										
7.9	SILTY CLAY TILL Dark grey, very stiff	T														
		T	9	SS	15											
178.3																
9.6	(Continued)															

LOG OF BOREHOLE ..2.(CONT.)

CLIENT: M.O.E. c/o Marshall Macklin Monaghan
 PROJECT: Meadowvale North Feedermain
 LOCATION: Mississauga, Ontario
 DATUM ELEVATION: Geodetic

DRILLING DATA
 Method: Augering
 Diameter: 100 mm
 Date: December 23, 1986

REF. NO: G-86.1102
 ENCL. NO: 2A

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT Σ					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ	REMARKS a GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' BLOWS 0.3 m			20	40	60	80	100	W _p	W	W _L		
178.3	CONTINUATION																
9.6	SILTY CLAY TILL very stiff	T															
177.5		T															
10.4	SHALE BEDROCK weathered, red		10	SS	50 0.1												
175.6			11	SS	50 0.08												
12.3	END OF BOREHOLE																

LOG OF BOREHOLE3.....

CLIENT: M.O.E. c/o Marshall Macklin Monaghan
 PROJECT: Meadowvale North Feedermain
 LOCATION: Mississauga, Ontario
 DATUM ELEVATION: Geodetic

DRILLING DATA
 Method: Augering
 Diameter: 100 mm
 Date: December 23, 1986

REF. NO: G- 86.1102
 ENCL. NO: 3

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 B GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
m ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' BLOWS 0.3 m			20	40	60	80	100					
190.6	Ground Surface																
0.0	FILL sand and gravel	⊗					190										
189.8		⊗															
0.8	SHALE BEDROCK weathered red	⊗	1	SS	50 0.1												
		⊗	2	SS	50 0.13												
		⊗	3	SS	50 0.08		188										
		⊗	4	SS	50 0.08	W.L. 187.8											
		⊗	5	SS	50 0.08												
185.9		⊗	6	SS	50 0.05		186										
4.7	END OF BOREHOLE																

LOG OF BOREHOLE4.....

CLIENT: M.O.E. c/o Marshall Macklin Monaghan
PROJECT: Meadowvale North Feedermain
LOCATION: Mississauga, Ontario
DATUM ELEVATION: Geodetic

DRILLING DATA
Method: Augering & Diamond Drilling ENCL. No. 4
Diameter: 100 mm (65 mm)
Date: January 12, 1987

REF. No. G-86.1102

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT Σ					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS B GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
m ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' BLOWS 0.3 m			20	40	60	80	100					
187.8	Ground Surface																
0.0	FILL																
	sandy silt																
187.0																	
1.4	FILL		1	SS	15												
186.4	silty sand																
1.4		T															
	SILTY CLAY TILL	T	2	SS	30		186										
	some sand	T															
	trace gravel	T															
	reddish brown	T	3	SS	35												
	hard	T															
184.8																	
3.0	highly weathered		4	SS	160 0.15												
	moderately weathered																
	SHALE BEDROCK		5	RC (BXL)	90% RQD. 21%		184										
	fine to very fine grained, with some hard silt stone bands (40-100mm) red with grey and green seams		6	RC (BXL)	100% RQD. 35%												
							PIEZOMETER										
181.8							182										
5.9	END OF BOREHOLE																NO GAS VAPOUR DETECTED IN BOREHOLE

LOG OF BOREHOLE ...4A....

CLIENT: M.O.E. c/o Marshall Macklin Monaghan
PROJECT: Meadowvale North Feedermain
LOCATION: Mississauga, Ontario
DATUM ELEVATION: Geodetic

DRILLING DATA

Method: Augering & Diamond Drilling ENCL. No. 5
Diameter: 100 mm (65 mm)
Date: January 12, 1987

REF. No: G-86.1102

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100	W _p	W	W _L		
187.8	Ground Surface															
0.0	300 mm Granular "B" FILL silty sand some gravel															
186.6			1	SS	16											
1.2	SILTY CLAY TILL reddish brown hard		2	SS	65	186										
185.5																
2.3	SHALE BEDROCK weathered		3	SS	100 0.1											
	slightly weathered		4	SS	100 0.0											
	fine grained fissile very closely bedded with occasional thin (15 to 50 mm) hard siltstone bands with frequent fractures red, grey seams		5	RC (BXL) Rec. 83% RQD. 20%		184										
			6	RC (BXL) Rec. 100% RQD. 65%		182										
181.9																
5.9	END OF BOREHOLE															HOLE DRY AFTER AUGERING



PROJECT No. G-85.0303 LOG OF BOREHOLE(5)..... 35 m. E. of Centreline
 (G-861102)
 CLIENT: Foodcorp Limited
 PROJECT: Restaurant
 LOCATION: Erin Mills Parkway, Mississauga, Ont.
 DATUM ELEVATION: G.S.C.

DRILLING DATA

Method: Augering

Diameter: March 29, 1985

Date:

m ELEV. DEPTH.	SOIL PROFILE		SAMPLE			GROUND WATER	REMARKS
	DESCRIPTION	SYMBOL	NUMBER	TYPE	N' BLS / 0.3		
186.3	Ground Surface						
0.0	FILL Silty Clay Wood, Glass, Rags, Paper, Asphalt Dark						
185.4			1	SS	23		
0.9	Silty CLAY Multi-Coloured Very Stiff to Hard						
	Weathered Traces of Organics		2	SS	34		
184.1							
2.2	Silty CLAY Embedded Gravel Shaley (Glacial Till) Red-Brown Mottled Hard		3	SS	$\frac{100}{0.28}$		
183.3			4	SS	$\frac{100}{0.25}$	DRY	
3.0	REFUSAL						

PROJECT No. G-85.0303

LOG OF BOREHOLE.....(5A).....80.m E. of Centre-line

(G-861102)

CLIENT: Foodcorp Limited

DRILLING DATA

PROJECT: Restaurant




Method: Augering

LOCATION: Erin Mills Parkway, Mississauga, Ont.

Diameter: 100 mm

DATUM ELEVATION: G.S.C.

Date: March 29, 1985










m ELEV. DEPTH.	SOIL PROFILE		SAMPLE			GROUND WATER	REMARKS
	DESCRIPTION	SYMBOL	NUMBER	TYPE	N' BLS/0.3		
183.4	Ground Surface						
0.0	Silty CLAY Multi-Coloured Hard Weathered Organic -----						
			1	SS	53		
182.0							
1.4	Silty CLAY Shaley (Glacial Till) Red-Green Mottled Hard						
			2	SS	66		
181.4							
2.0	SHALE Weathered Red						
			3	SS	100 0.23	DRY	
181.1							
2.3	REFUSAL						

LOG OF BOREHOLE6.....

CLIENT: M.O.E. c/o Marshall Macklin Monaghan
PROJECT: Meadowvale North Feedermain
LOCATION: Mississauga, Ontario
DATUM ELEVATION: Geodetic

DRILLING DATA
Method: Augering
Diameter: 100 mm
Date: December 23, 1986

REF. NO: G-86.1102
ENCL. NO: 8


SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ	REMARKS B GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
in ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' BLOWS 0.3 m		SHEAR STRENGTH					W _p	W	W _L		
185.6	Ground Surface															
0.0	250 mm Topsoil															
	CLAYEY SILT TILL sandy, trace of gravel reddish brown, moist to damp stiff to hard		1	SS	17											
			2	SS	22	184							0			10 36 37 17
			3	SS	13											
			4	SS	43											4 37 47 12
181.9						182										
3.7	SHALE BEDROCK weathered red		5	SS	50 0.1											
180.9			6	SS	50 0.08	DRY										
4.7	END OF BOREHOLE															HOLE DRY

LOG OF BOREHOLE7.....

CLIENT: M.O.E. Marshall Macklin Monaghan
 PROJECT: Meadowvale North Feedermain
 LOCATION: Mississauga, Ontario
 DATUM ELEVATION: Geodetic

DRILLING DATA
 Method: Augering
 Diameter: 100 mm
 Date: December 22, 1986

REF. NO: G-86.1102
 ENCL. NO: 9

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS B GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' BLOWS 0.3 m			SHEAR STRENGTH					WATER CONTENT(%)				
								UNCONFINED QUICK TRIAXIAL + FIELD VANE & LAB VANE									
183.3	Ground Surface																
0.0	250 mm Topsoil																

LOG OF BOREHOLE8.....

CLIENT: M.O.E. c/o Marshall Macklin Monghan
PROJECT: Meadowvale North Feedermain
LOCATION: Mississauga, Ontario
DATUM ELEVATION: Geodetic

DRILLING DATA
Method: Augering
Diameter: 100 mm
Date: December 22, 1986

REF. No: G-86.1102
ENCL. No: 10


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 SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' BLOWS 0.3 m		20	40	60	80	100				
184.9	Ground Surface														
0.0	300 mm Topsoil														
	SILTY SAND some gravel (possibly fill) brown, damp, compact		1	SS	17										
183.1			2	SS	15										
1.8	CLAYEY SILT TILL														
	some sand gravel shale fragments reddish brown hard		3	SS	36										0 19 68 13
			4	SS	50 0.1										
181.2			5	SS	50 0.1										
3.7	SHALE BEDROCK														
	moderately weathered fine grained very closely bedded with thin bands of hard siltstone red with grey bands		6	SS	50 0.1										
			7	SS	50 0.03										
			8	SS	50 0.03										
	fracture zones wet		9	SS	50 0.03										
			10	SS	50 0.03										
175.0															
9.9	END OF BOREHOLE														

LOG OF BOREHOLE9.....

CLIENT: M.O.E. c/o Marshall Macklin Monaghan
PROJECT: Meadowvale North Feedermain
LOCATION: Mississauga, Ontario
DATUM ELEVATION: Geodetic

DRILLING DATA
Method: Augering
Diameter: 100 mm
Date: December 22, 1986

REF. NO: C-86.1102
ENCL. NO: 11

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
m ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	N° BLOWS 0.3 m		20	40	60	80	100				
185.4	Ground Surface														
0.0	250 mm Gravel 150 mm Topsoil CLAYEY SILT TILL sandy, some gravel reddish brown, hard		1	SS	35										
181.9	1.5	SHALE BEDROCK moderately weathered very closely bedded red	2	SS	50 0.1										
			3	SS	50 0.05										
			4	SS	50 0.08										
			5	SS	50 0.02										
			6	SS	50 0.05										150 mm hard band at EL. 181.7 m
180.8	4.6	END OF BOREHOLE													HOLE DRY

PROJECT No. G-85.0208 .. LOG OF BOREHOLE (10)
 (G-86.1102) STA 4 + 896; 9 m Rt.

CLIENT: E.S. Mitchell, Architect

DRILLING DATA

PROJECT: Re/Max Office Building

Method: Augering

LOCATION: Millcreek Drive, Mississauga, Ont.

Diameter: 125 mm

DATUM ELEVATION: Local

Date: Feb. 22, 1985

m ELEV. DEPTH.	SOIL PROFILE		SAMPLE			GROUND WATER	REMARKS
	DESCRIPTION	SYMBOL	NUMBER	TYPE	N' BLS / 0.3		
99.4	Ground Surface						
0.0	200 mm Topsoil Multi-Coloured Mixture of Clayey Silt, Sand, Organic Matter FILL Loose						
98.2			1	SS	9		
1.2	Fine SAND Grey, Dense						
			2	SS	40		
97.0	Moist						
2.4	Silty Clay TILL Some Embedded Gravel, Shale		3	SS	85		Wet Cave at Elevation 96.9 m
96.3	Red. Hard		4	SS	55/0.08		
3.1	REFUSAL, PROBABLY BEDROCK						

PROJECT No. G-85.0208
(G-86.1102)

LOG OF BOREHOLE.....(10 A).....

STA 4 + 918; 17 m Rt.

CLIENT: E.S. Mitchell, Architect
PROJECT: Re/Max Office Building
LOCATION: Millcreek Drive, Mississauga, Ont.






DRILLING DATA

Method: Augering

Diameter: 125 mm

DATUM ELEVATION: Local

Date: Feb. 22, 1985

m ELEV. DEPTH.	SOIL PROFILE		SAMPLE			GROUND WATER	REMARKS
	DESCRIPTION	SYMBOL	NUMBER	TYPE	N' BLS/0.3		
99.6	Ground Surface						
0.0	125 mm Topsoil Multi-Coloured Mixture of Clayey Silt, Weathered Shale, Sand FILL Compact						W.L. 99.0 m
98.4			1	SS	18		
1.2	Fine SAND to Sandy Silt Brown-Grey Dense						
			2	SS	34		
97.1			3	SS	100		
2.5	Red Silty Clay TILL to						
96.5	Weathered Shale		4	SS	70	0.08	
3.1	REFUSAL, PROBABLY BEDROCK						

PROJECT No. G-85.0208 LOG OF BOREHOLE(10. B)
 (G-86.1102) STA 4 + 867; 20 m Rt.

CLIENT: E.S. Mitchell, Architect

DRILLING DATA

PROJECT: Re/Max Office Building

Method: Augering

LOCATION: Millcreek Drive, Mississauga, Ont.

Diameter: 125 mm

DATUM ELEVATION: Local

Date: Feb. 22, 1985

m ELEV. DEPTH.	SOIL PROFILE		SAMPLE			GROUND WATER	REMARKS
	DESCRIPTION	SYMBOL	NUMBER	TYPE	N' BLS / 0.3		
99.2	Ground Surface						
0.0	350 mm Topsoil Sandy Silt, Some Topsoil Brown-Dark Mottled Possibly FILL Compact	[Symbol]					
98.0			1	SS	18		
1.2	Fine SAND, Some Silt Brown, Dense	[Symbol]					
97.1			2	SS	88		
2.1	Silty Clay TILL to Extremely Weathered Shale Red-Grey Mottled Hard	[Symbol]					
96.2			3	SS	112 0.2		
3.0	REFUSAL, PROBABLY BEDROCK						

Wet Cave at
Elevation 97.2 m.

PROJECT No. G-85.0208 LOG OF BOREHOLE (10 C)
 (G-86.1102) STA 4 + 850; 22 m Rt.
 CLIENT: E.S. Mitchell, Architect DRILLING DATA
 PROJECT: Re/Max Office Building Method: Augering
 LOCATION: Millcreek Drive, Mississauga, Ont. Diameter: 125 mm
 DATUM ELEVATION: Local Date: Feb. 22, 1985

m		SOIL PROFILE		SAMPLE			GROUND WATER	REMARKS
ELEV.	DEPTH.	DESCRIPTION	SYMBOL	NUMBER	TYPE	N' BLS / 0.3		
98.9		Ground Surface						
0.0		125 mm Topsoil						W.L. 97.6 m
		Clayey Silt with Dark Pockets of Topsoil						
		Pockets of Topsoil						
		Possibly FILL						
		Brown						
97.9		Compact		1	SS	22		
1.0		Fine SAND						
		Brown						
		Dense						
				2	SS	32		
96.5								
2.4		Clayey Silt TILL		3	SS	84		
		with Pockets of Sand						
		Red-Grey Mottled		4	SS	162		
		Hard						
95.2								
3.7		REFUSAL, PROBABLY BEDROCK						

LOG OF BOREHOLEI).....

CLIENT: M.O.E. c/o Marshall Macklin Monaghan
PROJECT: Meadowvale North Feedermain
LOCATION: Mississauga, Ontario
DATUM ELEVATION: Geodetic

DRILLING DATA
Method: Augering
Diameter: 100 mm
Date: December 19, 1986

REF. NO: G-86.1102
ENCL. NO: 15

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT			UNIT WEIGHT γ	REMARKS B GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
m ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' BLOWS 0.3 m			SHEAR STRENGTH					W _p	W	W _L		
								UNCONFINED QUICK TRIAXIAL		FIELD VANE LAB VANE							
190.2	Ground Surface																
0.0	150 mm Topsoil SILTY CLAY TILL some sand embedded gravel brown-grey mottled hard		1	SS	34		190										
188.6																	
1.6	SAND fine to medium some silt reddish brown dense		2	SS	29												
187.6							188										
2.6	CLAYEY SILT TILL some sand reddish brown, hard (possibly completely weathered shale)		3	SS	58												
			4	SS	90 0.25												
			5	SS	50 0.1		186										
185.7																	
4.5	SHALE		6	SS	50 0.05	DRY											
185.6																	
4.6	END OF BOREHOLE															HOLE DRY	

LOG OF BOREHOLE12....

CLIENT: M.O.E. c/o Marshall Macklin Monaghan
 PROJECT: Meadowvale North Feedermain
 LOCATION: Mississauga, Ontario
 DATUM ELEVATION: Geodetic

DRILLING DATA
 Method: Augering
 Diameter: 100 mm
 Date: December 19, 1986

REF. NO: G-86.1102
 ENCL. NO: 16

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 SI CL
m ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' BLOWS 0.3 m		20	40	60	80	100					
192.4	Ground Surface															
0.0	150 mm Topsoil					192										
	SILTY SAND															
	some gravel, clayey		1	SS	16											
	compact to very dense		2	SS	33											1 68 24 7
			3	SS	50	190										
189.6																
2.8	FINE SAND															
	trace silt and clay		4	SS	65											1 90 5 4
	brown															
	wet		5	SS	51											0 88 9 3
	very dense		6	SS	60											
186.8																
5.6	SHALE															
	weathered		7	SS	50											
186.2																
6.2	END OF BOREHOLE															

LOG OF BOREHOLE13....

CLIENT: M.O.E. c/o Marshall Macklin Monaghan
 PROJECT: Meadowvale North Feedermain
 LOCATION: Mississauga, Ontario
 DATUM ELEVATION: Geodetic

DRILLING DATA
 Method: Augering
 Diameter: 100 mm
 Date: December 19, 1986

REF. No: G-86.1102
 ENCL. No: 17

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 8 GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' BLOWS 0.3 m		20	40	60	80	100					
190.5	Ground Surface															
0.0	SILTY CLAY TILL some sand, trace of gravel shale fragments occasional silt and sand seams red-grey mottled stiff to hard	T														
		T														
		T	1	SS	37											
		T	2	SS	20											
		T														
		T	3	SS	14											
		T														
		T	4	SS	23											
186.9																
3.6	SAND fine to coarse trace of gravel, some silt wet brown very dense															
			5	SS	70											
			6	SS	50 0.12											
184.7																
5.8	SHALE weathered															
184.3			7	SS	50 0.08											
6.2	END OF BOREHOLE															

LOG OF BOREHOLE14....

CLIENT: M.O.E. c/o Marshall Macklin Monaghan
 PROJECT: Meadowvale North Feedermain
 LOCATION: Mississauga, Ontario
 DATUM ELEVATION: Geodetic

DRILLING DATA
 Method: Augering
 Diameter: 100 mm
 Date: December 19, 1986

REF. No: G-86.1102
 ENCL. No: 18

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 8 GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
m ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' BLOWS 0.3 m		20	40	60	80	100					
193.6	Ground Surface															
0.0	250 mm Topsoil															
192.6	SILTY CLAY multy coloured (possibly fill)															
1.0	SILTY SAND some gravel, and pockets of silt till, trace of clay occasional cobbles, boulders, compact to very dense		1	SS	26											
			2	SS	40											16 69 11 4
			3	SS	55											
	moist															
	wet															8 55 32 5
	boulders		4	SS	50 0.1											
189.8																
3.8	FINE SAND some silt brown, wet very dense		5	SS	0.12											2 88 8 2
			6	SS	80											
188.6																
5.0	END OF BOREHOLE															DATE W.L. December 19 190.7 m February 10 190.8 m

LOG OF BOREHOLE15....

CLIENT: M.O.E. Marshall Macklin Monaghan
 PROJECT: Meadowvale North Feedermain
 LOCATION: Mississauga, Ontario
 DATUM ELEVATION: Geodetic

DRILLING DATA
 Method: Augering
 Diameter: 100 mm
 Date: December 18, 1986

REF. No: G-861102
 ENCL. No: 19

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 8 GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
m ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' BLOWS 0.3 m		20	40	60	80	100					
189.7	Ground Surface															
0.0	FINE SAND some silt wet brown compact					W.L. 188.8										
			1	SS	16											
			2	SS	16	188										1 89 10 -
187.1			3	SS	50 0.12											
2.6	CLAYEY SILT TILL or completely weathered SHALES red hard	T														
		T	4	SS	50 0.08											
		T	5	SS	50 0.1	186										
185.4		T														
4.3	SHALE BEDROCK weathered		6	SS	50 0.1											
183.5			7	SS	50 0.05	184										
6.2	END OF BOREHOLE															

LOG OF BOREHOLE ...16....

CLIENT: M.O.E. c/o Marshall Macklin Monaghan
PROJECT: Meadowvale North Feedermain
LOCATION: Mississauga, Ontario
DATUM ELEVATION: Geodetic

DRILLING DATA

Method: Augering
Diameter: 100 mm
Date: December 18, 1986

REF. NO: C-86.1102

ENCL. No: 20

[illegible]

LOG OF BOREHOLE ...17....

CLIENT: M.O.E. Marshall Macklin Monaghan
PROJECT: Meadowvale North Feedermain
LOCATION: Mississauga, Ontario
DATUM ELEVATION: Geodetic

DRILLING DATA
Method: Augering
Diameter: 100 mm
Date: December 23, 1986

REF. No: G-86.1102
ENCL. No: 21

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT Σ					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
m ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' BLOWS 0.3 m			SHEAR STRENGTH										WATER CONTENT(%)		
								UNCONFINED + FIELD VANE QUICK TRIAXIAL & LAB VANE										10 20 30		
195.9	Ground Surface																			
0.0	250 mm Topsoil																			
	CLAYEY SILT																			
	some gravel, sandy		1	SS	14															
	brown																			
	very stiff																			
193.9			2	SS	19															
2.0	SAND and GRAVEL																			
	some silt,		3	SS	50 0.12											34 56 7 3				
	trace of clay,																			
	occasional cobbles,		4	SS	50 0.1															
	boulders, and																			
	pockets of silt till		5	SS	50 0.05											40 43 12 5				
			6	SS	50 0.08											52 36 12 -				
			7	SS	68											24 61 12 3				
			8	SS	50 0.02											42 48 10 -				

LOG OF BOREHOLE ...17.(CONT.)

CLIENT: M.O.E. Marshall Macklin Monaghan
PROJECT: Meadowvale North Feedermain
LOCATION: Mississauga, Ontario
DATUM ELEVATION: Geodetic

DRILLING DATA
Method: Augering
Diameter: 100 mm
Date: December 23, 1986

REF. NO: G-86.1102
ENCL. NO: 21 A

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT Σ					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS B GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' BLOWS 0.3 m			20	40	60	80	100					
186.3	CONTINUATION																
9.6	SAND and GRAVEL						186										
	BOULDERS or highly weathered SHALE		10	SS	50 0.02												very hard drilling below 10.4 m (EL. 185.5 m) boulders or bedrock
			11	AS	—		184										
183.7			12	SS	50 0.02												
12.2	END OF BOREHOLE																could not put down casing due to caving conditions, relocate BH 17 A 1.5 m south.

LOG OF BOREHOLE ...17A...

CLIENT: M.O.E. Marshall Macklin Monaghan
PROJECT: Meadowvale North Feedermain
LOCATION: Mississauga, Ontario
DATUM ELEVATION: Geodetic

DRILLING DATA

Method: Augering-Diamond Drilling
Diameter: 100 to 65 mm
Date: January 13, 1987

REF. No: G-86.1102

ENCL. No: 22

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 (%)
m ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' BLOWS 0.3 m		20	40	60	80	100					
195.9	Ground Surface															
0.0	CLAYEY SILT sandy some topsoil brown loose (possibly fill)															
194.1			1	SS	28											
1.8	SAND and GRAVEL some silt trace of clay occasional cobbles, boulders, pockets of silt till brown very dense															
			2	SS	50 0.08											
			3	SS	100 0.28											40 52 8
			4	SS	160											33 50 12 5
			5	SS	100 0.2											39 53 8
			6	SS	107 0.23											45 47 8
186.3																
9.6	continued on ENCLOSURE 22 A															DATE W.L. January 13 191.3 m February 10 191.1 m

LOG OF BOREHOLE ..17A.(CONT.)

CLIENT: M.O.E. Marshall Macklin Monaghan
PROJECT: Meadowvale North Feedermain
LOCATION: Mississauga, Ontario
DATUM ELEVATION: Geodetic

DRILLING DATA
Method: Augering-Diamond Drilling
Diameter: 100 to 65 mm
Date: January 13, 1987
REF. No: G-86.1102
ENCL. No: 22 A

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 SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' BLOWS 0.3 m		20	40	60	80	100				
186.3	CONTINUATION														
9.3	SAND and GRAVEL					186									
185.7															
10.2	weathered unweathered SHALE BEDROCK very fine grained with bands of hard siltstone		7	SS	100 0.02										
			8	RC (BXL) Rec. 92% RQD. 50%		180									
			9	RC (BXL) Rec. 97% RQD. 56%											
			10	RC (BXL) Rec. 100% RQD. 100%		182									
181.7															
14.2	END OF BOREHOLE														

LOG OF BOREHOLE18....

CLIENT: M.O.E. Marshall Macklin Monaghan
PROJECT: Meadowvale North Feedermain
LOCATION: Mississauga, Ontario
DATUM ELEVATION: Geodetic

DRILLING DATA

Method: Augering-Diamond Drilling ENCL. No: 23
Diameter: 100 to 65 mm
Date: December 22, 1986 to January 14 and 15, 1987

REF. NO: G-86.1102

ENCL. NO: 23

Diameter: 100 to 65 mm

Date: December 22, 1986 to January 14 and 15, 1987

[illegible]

LOG OF BOREHOLE ...18.(CONT.)

CLIENT: M.O.E. Marshall Macklin Monaghan
PROJECT: Meadowvale North Feedermain
LOCATION: Mississauga, Ontario
DATUM ELEVATION: Geodetic

DRILLING DATA

Method: Augering-Diamond Drilling
Diameter: 75 to 65 mm
Date: January 14 and 15, 1987

REF. NO: G-86,1102

ENCL. NO: 23 A

[illegible]

LOG OF BOREHOLE19....

CLIENT: M.O.E. Marshall Macklin Monaghan
PROJECT: Meadowvale North Feedermain
LOCATION: Mississauga, Ontario
DATUM ELEVATION: Geodetic

DRILLING DATA
Method: Augering
Diameter: 100 mm
Date: December 18, 1986

REF. No: G-86.1102
ENCL. No: 24

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
in ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' BLOWS 0.3 m		20	40	60	80	100	W _p	W	W _L		
197.4	Ground Surface															
0.0	FILL															
196.5	sand and gravel															
0.9	SILTY CLAY TILL	T	1	SS	14											
	some sand, embedded gravel, occasional boulder, brown, hard.	T	2	SS	57											
		T	3	SS	50 0.08											
		T	4	SS	50 0.1											
193.4			5	SS	50 0.05											
4.0	END OF BOREHOLE					DRY										
	Refusal possibly boulder															

LOG OF BOREHOLE ...20.....

CLIENT: M.O.E. Marshall Macklin Monaghan
 PROJECT: Meadowvale North Feedermain
 LOCATION: Mississauga, Ontario
 DATUM ELEVATION: Geodetic

DRILLING DATA
 Method: Augering
 Diameter: 100 mm
 Date: December 18, 1986

REF. No: G-86.1102
 ENCL. No: 25

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 a GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
IN ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' BLOWS 0.3 m		20	40	60	80	100				
203.3	Ground Surface														
0.0	FILL														
202.4	sand and gravel														
0.9	SILTY CLAY TILL	T	1	SS	45										
	sandy, some gravel, cobbles, brown, hard	T	2	SS	63										
		T	3	SS	50 0.12										
		T	4	SS	50 0.08										
		T	5	SS	50 0.05										
	BOULDER														
198.6		T	6	SS	50 0.08										
4.7	END OF BOREHOLE					DRY									

LOG OF BOREHOLE ...2!.....

CLIENT: M.O.E. Marshall Macklin Monaghan
PROJECT: Meadowvale North Feedermain
LOCATION: Mississauga, Ontario
DATUM ELEVATION: Geodetic

DRILLING DATA
Method: Augering
Diameter: 100 mm
Date: December 18, 1986

REF. No: G-86.1102
ENCL. No: 26

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 8 GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' BLOWS 0.3 m			20	40	60	80	100					
206.8	Ground Surface																
0.0	25 mm Asphalt 250 mm Sand																
	CLAYEY SILT TILL some sand, embedded gravel occasional cobbles, reddish brown hard		1	SS	27		206										
			2	SS	53												
			3	SS	95												
			4	SS	50 0.12		204										
			5	SS	60	DRY											
202.2			6	SS	50 0.05												
4.6	END OF BOREHOLE																

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

Fine

Medium

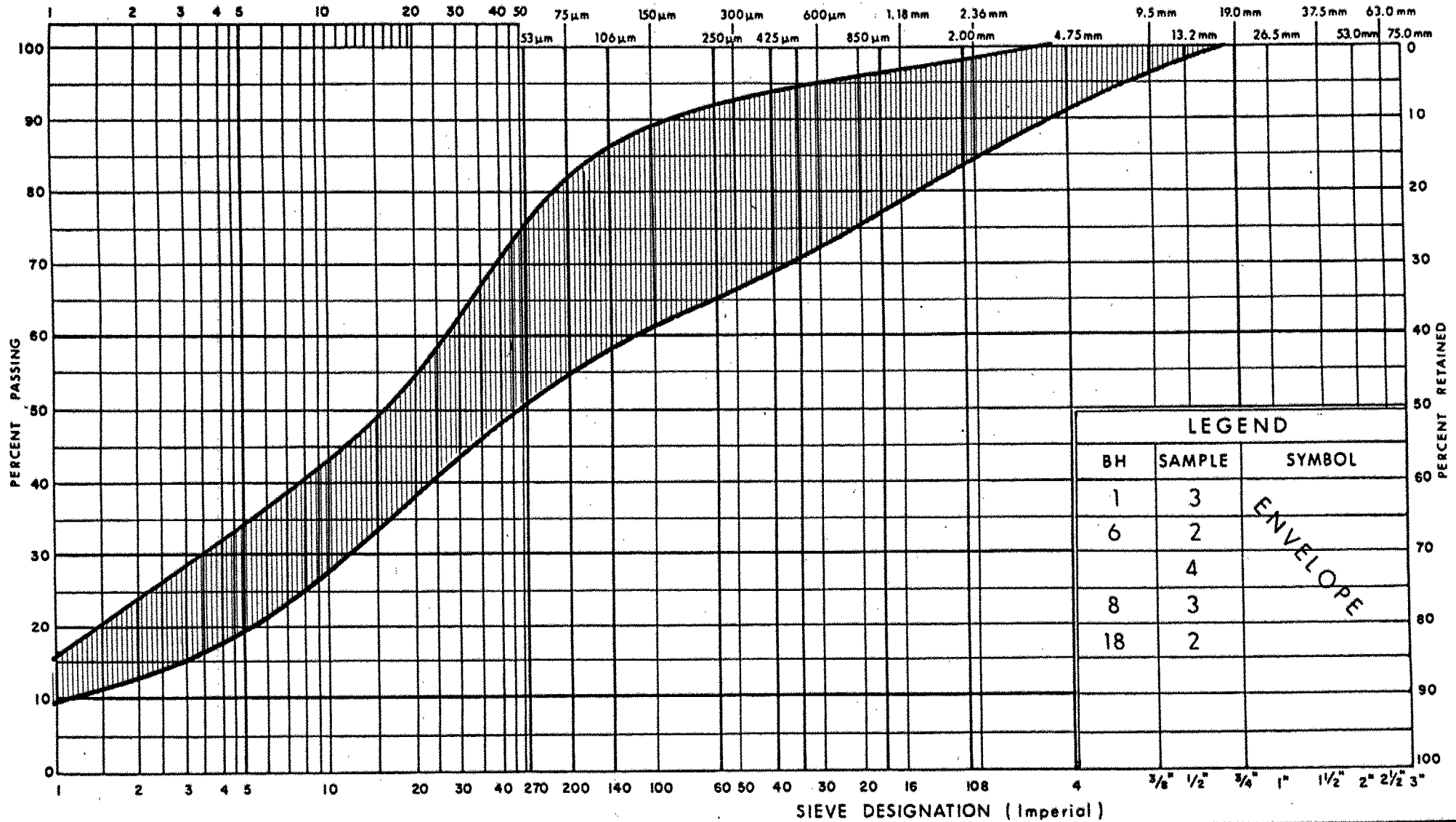
Coarse

Fine

Coarse

GRAIN SIZE IN MICROMETERS

SIEVE DESIGNATION (Metric)



GEO-CANADA

GRAIN SIZE DISTRIBUTION
SILTY CLAY to CLAYEY SILT TILL

FIG No 1

REF. No G-86.1102

DATE JAN. 1987

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

Fine

Medium

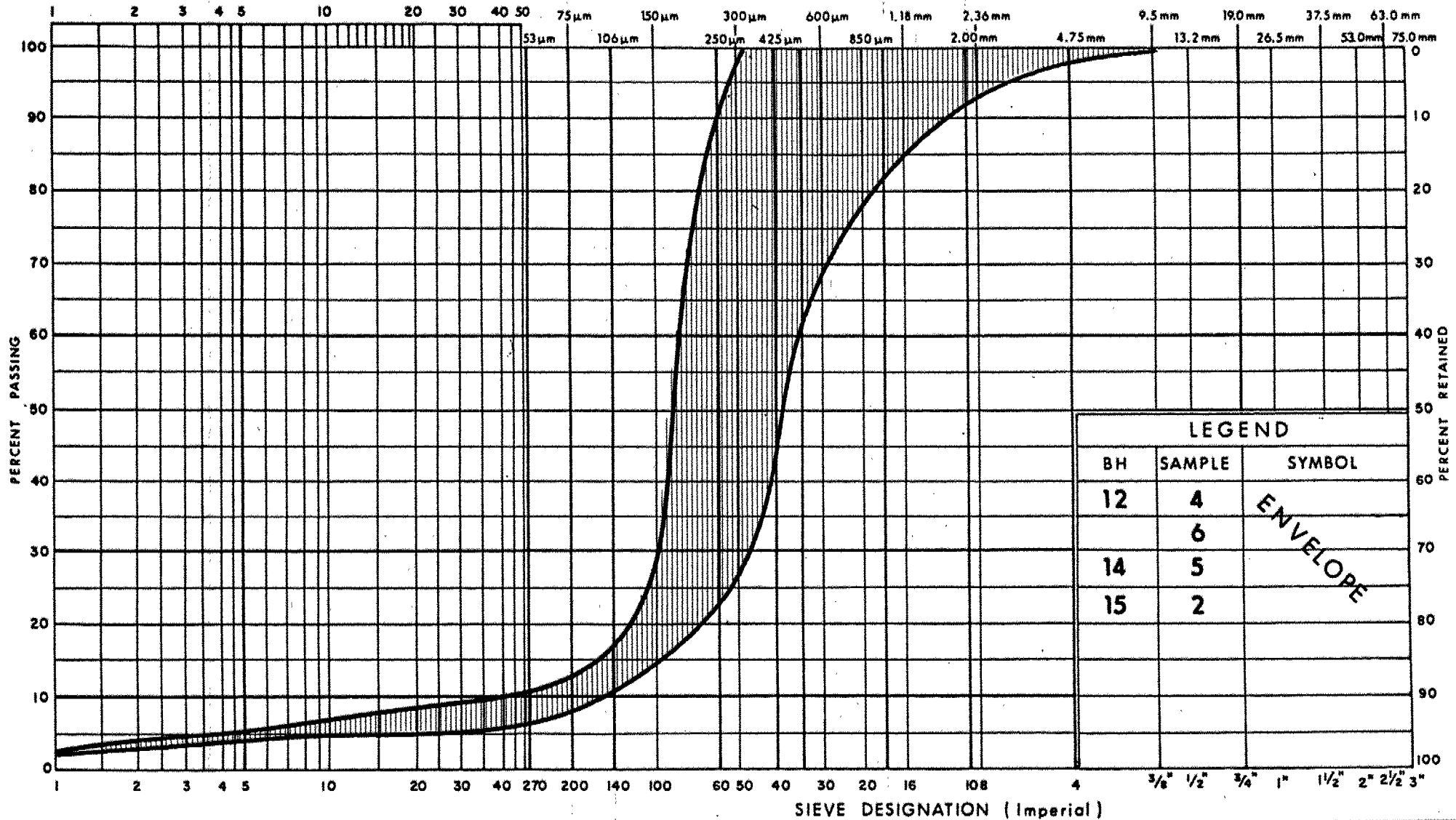
Coarse

Fine

Coarse

GRAIN SIZE IN MICROMETERS

SIEVE DESIGNATION (Metric)



GRAIN SIZE DISTRIBUTION

FINE TO MEDIUM SAND

FIG No 2

REF. No G-86.1102

DATE JAN. 1987

GEO-CANADA

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

Fine

Medium

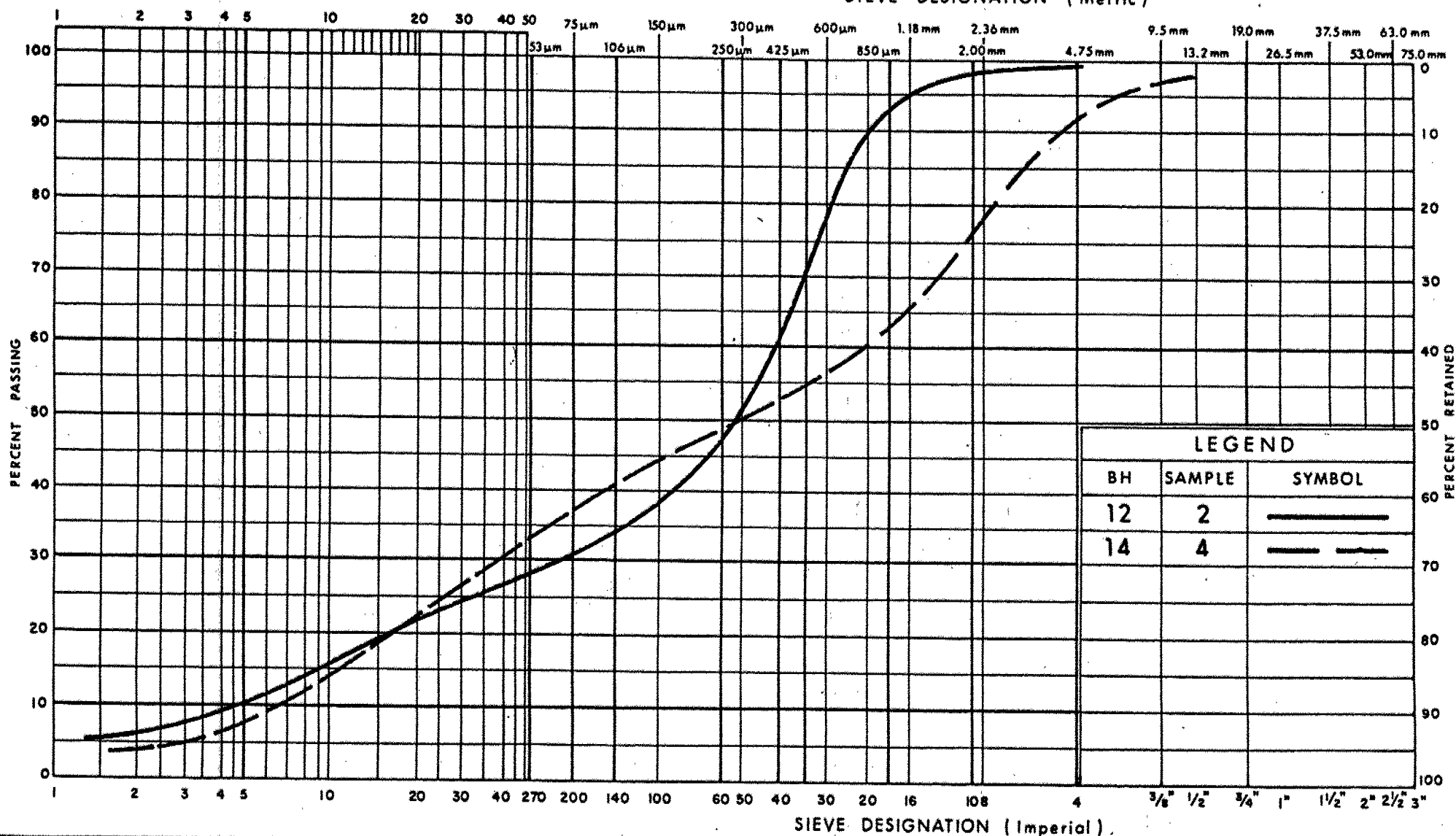
Coarse

Fine

Coarse

GRAIN SIZE IN MICROMETERS

SIEVE DESIGNATION (Metric)



LEGEND

BH	SAMPLE	SYMBOL
12	2	————
14	4	- - - - -

GEO-CANADA

GRAIN SIZE DISTRIBUTION

SILTY SAND

FIG No 3

REF. No G-86.1102

DATE JAN. 1987

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

Fine

Medium

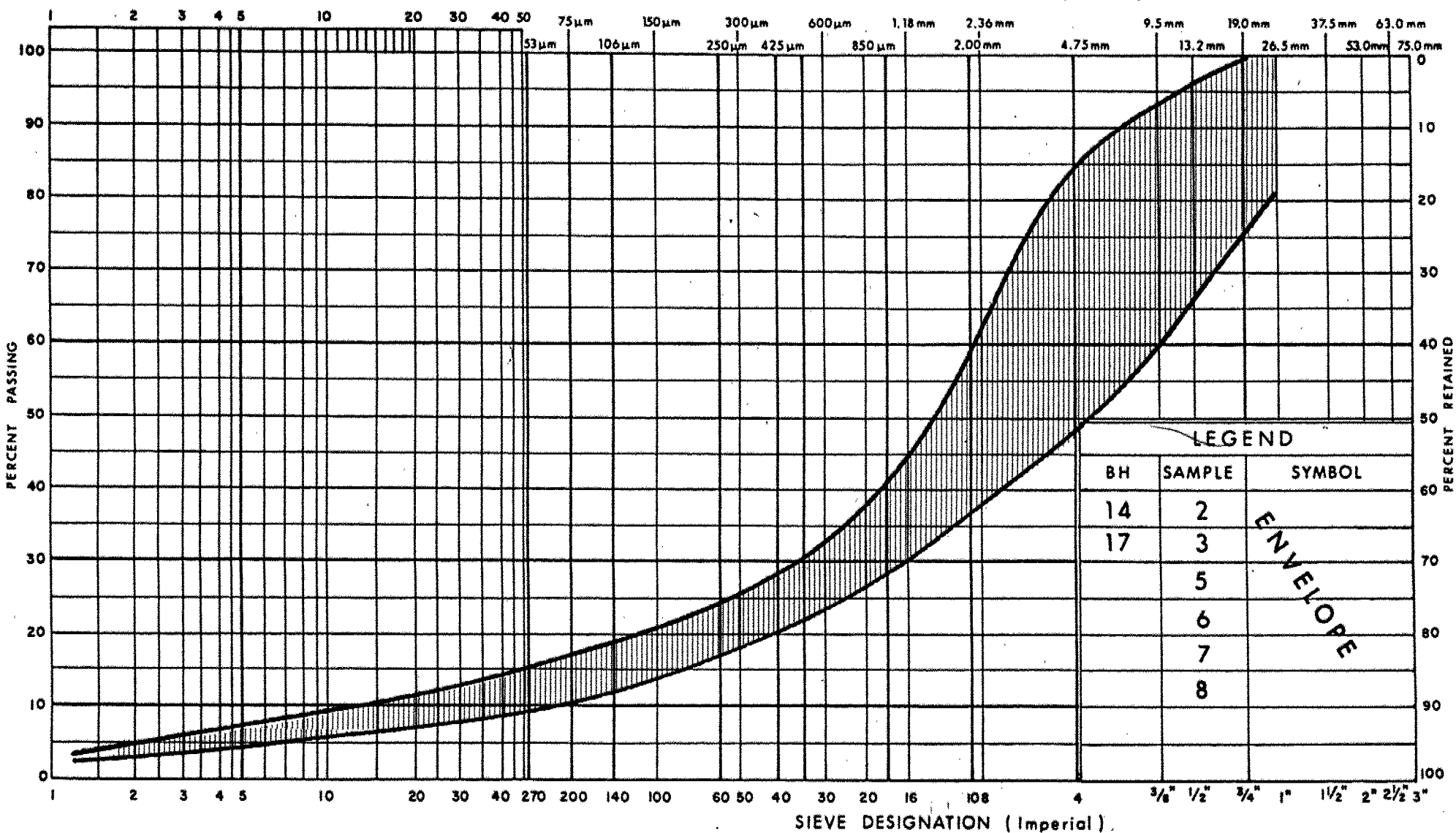
Coarse

Fine

Coarse

GRAIN SIZE IN MICROMETERS

SIEVE DESIGNATION (Metric)



GEO-CANADA

GRAIN SIZE DISTRIBUTION

SAND AND GRAVEL

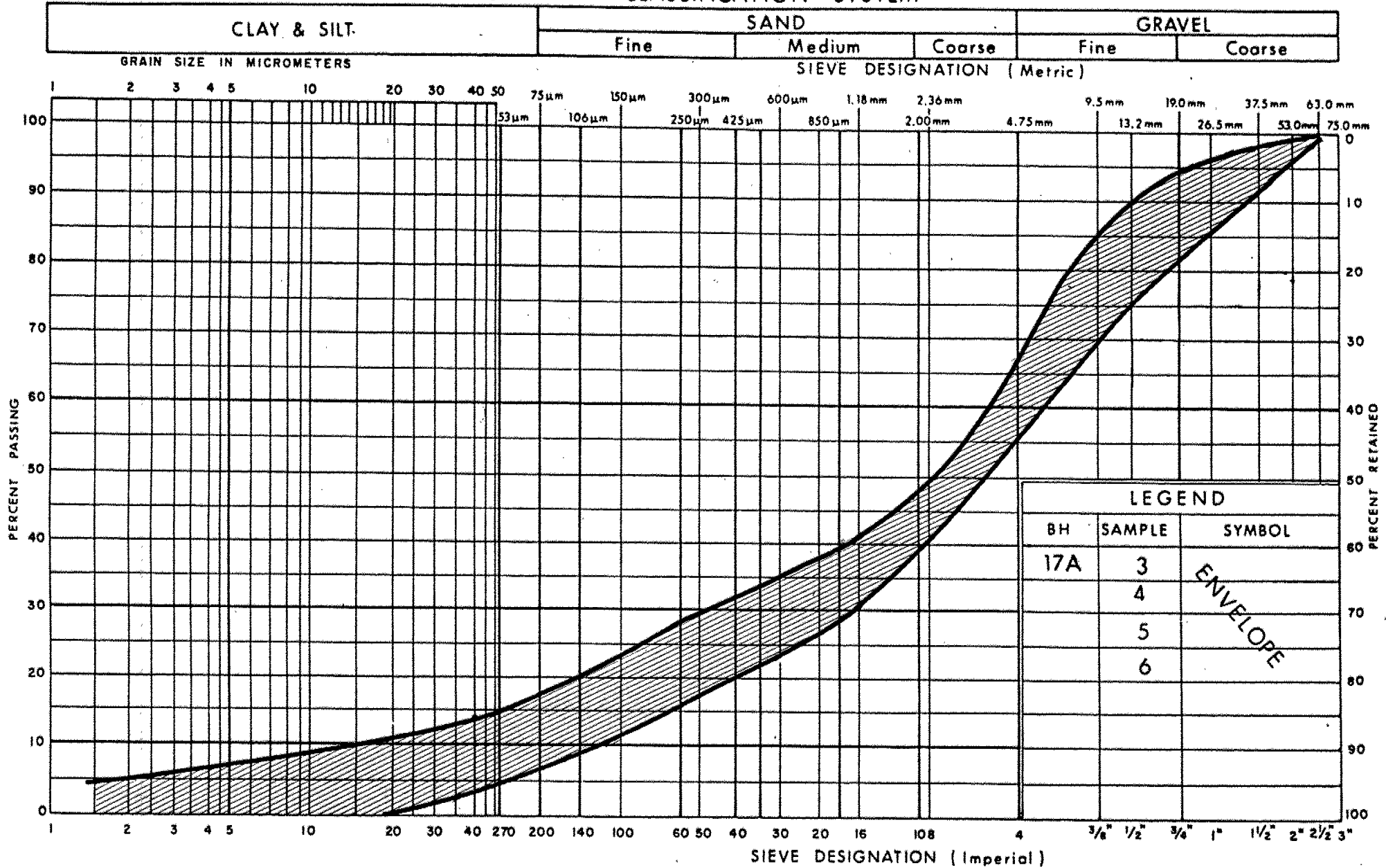
Some silt, trace clay

FIG No 4

REF. No G-86.1102

DATE JAN. 1987

UNIFIED SOIL CLASSIFICATION SYSTEM

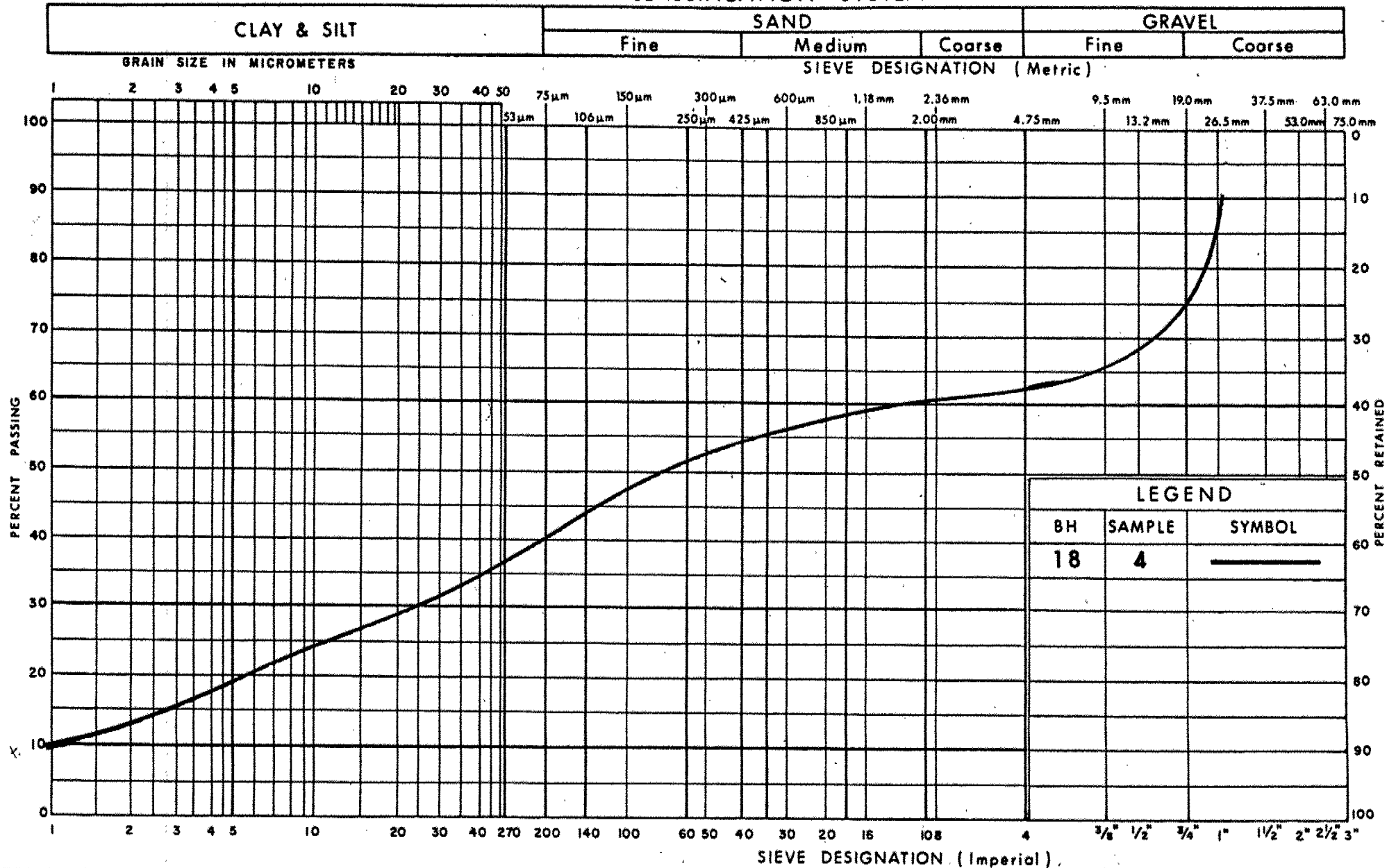


GEO-CANADA

GRAIN SIZE DISTRIBUTION
SAND AND GRAVEL
Some Silt, trace clay

FIG No 5
REF. No G-86.1102
DATE JAN. 1987

UNIFIED SOIL CLASSIFICATION SYSTEM



GEO-CANADA

GRAIN SIZE DISTRIBUTION

SILTY SAND AND GRAVEL (TILL)

FIG No 6

REF. No G-86.1102

DATE JAN. 1987

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

Fine

Medium

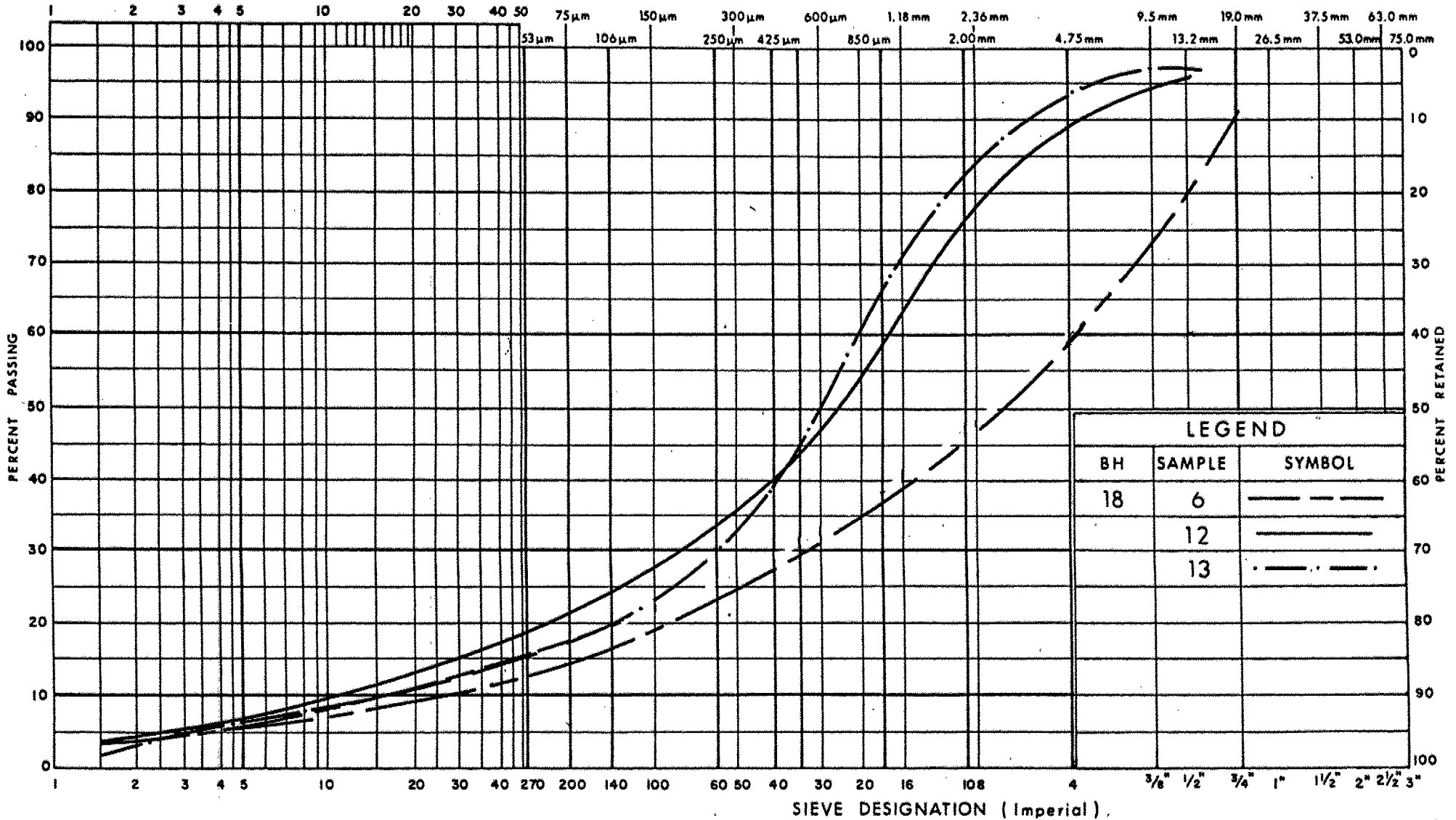
Coarse

Fine

Coarse

GRAIN SIZE IN MICROMETERS

SIEVE DESIGNATION (Metric)



GRAIN SIZE DISTRIBUTION

SAND AND GRAVEL

Some SILT, trace clay

FIG No 7

REF. No G. 86.1102

DATE JAN. 1987

GEO-CANADA

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

Fine

Medium

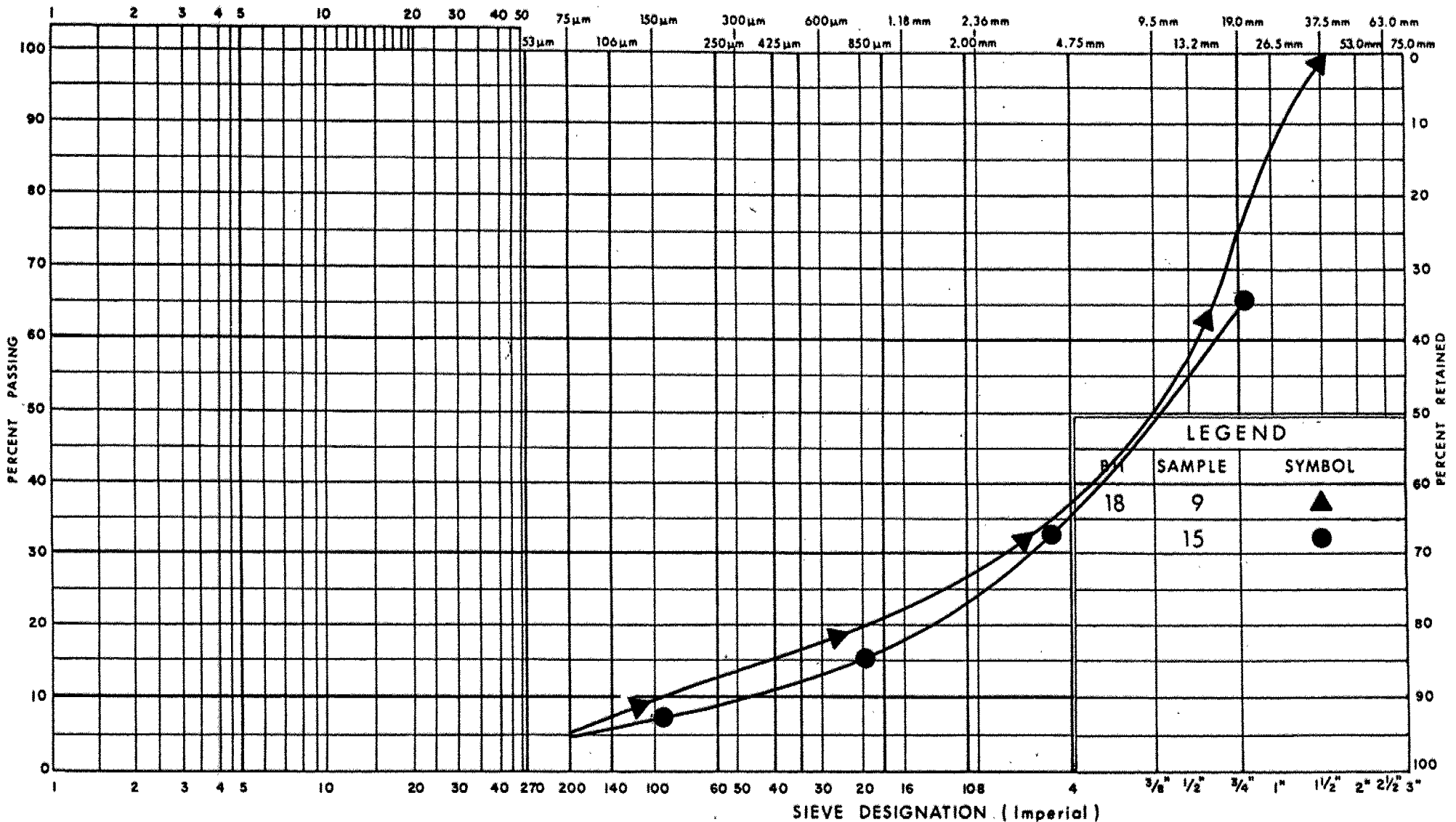
Coarse

Fine

Coarse

GRAIN SIZE IN MICROMETERS

SIEVE DESIGNATION (Metric)



LEGEND

SAMPLE	SYMBOL
9	▲
15	●

GRAIN SIZE DISTRIBUTION

SANDY GRAVEL
trace silt

FIG No 8.

REF. No G-86. 1102

DATE JAN. 1987

GEO-CANADA



GEO-CANADA LTD.
CONSULTING GEOTECHNICAL ENGINEERS

November 6, 1987

A.S. Copy
90 NOLAN CRT., UNIT 18
MARKHAM, ONT.
L3R 4L9
(416) 474-9255

Ref. No. M-87059

Marshall Macklin Monaghan Ltd.
275 Duncan Mill Road
Don Mills, Ontario
M3B 2Y1

Attention: Mr. A. Slywinskyj, P.Eng.

Re: Test Pit Inspection
Proposed Meadowvale North Feedermain
Mississauga, Ontario
Report No. 1

Dear Sirs:

On October 29, 1987, at your request, we have been present at the above site to witness the excavation of test pits put down in connection with the above project.

The purpose of the test pits was to provide additional information for the contractors presently bidding on the project. In total, eleven (11) test pits were dug at the approximate locations shown on the attached Enclosure 1. The test pit locations were selected by the engineering staff of Marshall Macklin Monaghan Ltd. The test pits were dug with a large size hydraulic backhoe (220 POCLAIN) equipped with a 2.0 cubic yard bucket and five flat cutting teeth. The equipment is owned and operated by Conro Excavation Ltd.

The records of the test pits are shown on the attached test pit logs, describing depth and thickness of the strata encountered, groundwater conditions, etc.

Generally, the test pits confirmed the stratification encountered in the boreholes and reported to you in February 1987 under our Ref. No. G-86.1102. The predominant rock/soil deposits were: the red shale bedrock, encountered at Test Pits 2, 7, 8 and 10 at depths between 2.1 and 2.5 m; the silty clay till which frequently overlies the shale bedrock, encountered in all test pits except 4 and 5; gravelly sand and cobbles with boulders encountered in Test Pits 3 and 4; silt, sand and silty sand in Test Pits 5 and 6; and 100 mm to 1300 mm of topsoil and fill overburden at the surface.



Groundwater seepage was observed in Test Pits 3 to 8, inclusive at rates from approximately 80 litres per minute in Test Pit 4 to very slow, approximately 1 litre per minute at Test Pit 8. In general, test pits were left open for only 1 to 10 minutes after completion (except Test Pit 3). As we have mentioned to your field Representative during the excavating, leaving the pits open for such a short time may not give an accurate indication of groundwater conditions as very dense and clayey soils often have very slow permeability and hence seepage may take some time to appear.

It took approximately 5 to 15 minutes to complete a test pit which measured approximately 1.5 to 2 m wide and 4 to 6 m long at the top and approximately 1.5 by 3 m at the base. Depths of the test pits ranged between 2.6 and 8.0 m. The removal of the rock in the test pits was relatively slow and hard, but, in our opinion, the size of the bucket and type of teeth on the bucket were not really suited for rock excavation.

The stability of sides of the excavations varied with the soils and water conditions encountered. The silty clay till remained stable at nearly vertical cuts; the upper, dry sand layers in Test Pits 5, 6 and 7 were stable as vertical cuts for the brief period over which the pits were left open; the lower, wet silty sand in Test Pits 5 and 6 caved quickly from the sides of the excavations; severe caving also occurred in the gravelly, sand and cobble deposits encountered in Test Pits 3 and 4.

We trust that the above report contains the information required, however if you have any questions or if we may be of further assistance to you, please do not hesitate to contact our office.

Sincerely,

GEO-CANADA LTD.

A handwritten signature in dark ink, appearing to read 'Dave Wismath'.

David C. Wismath, P.Eng.

DCW:bc

Enclosure

Distribution
3 copies

LOG OF TEST PIT 3

NORTH SIDE 401
CLOSE TO BH 18

CLIENT: Marshall Macklin Monaghan Ltd.

DATE: October 29, 1987

JOB No.: M-87059

LOCATION: See Plan

PROJECT: Meadowvale North Feedermain

ELEVATION: -

APPROX
ELEVATION

196.4 ±

193.2

191.2

(m) ELEV. DEPTH	DESCRIPTION	SYMBOL	GR. WATER	SAMPLES	TESTS
	Ground Surface				
0.0	100 mm Topsoil sand gravel boulders				
0.8	SILTY CLAY TILL red damp				
3.2	sand gravel cobbles occasional shale pieces damp to moist very dense				
5.2	medium sand gravel occasional cobbles, boulders red				
6.0	CONTINUED				

Start -8:41 am
Finish -9:20 am
Backfill-4:30 pm

Sides stable
in clay
Vertical cut

Sides cave
below 3.0 m.

B.H. 18
Water level
at 191.6

INVERT.
ELEVATION
191.2 ±

LOG OF TEST PIT 3 (CONT.)

CLIENT: Marshall Macklin Monaghan Ltd.


DATE: October 29, 1987

JOB No. : M-87059

LOCATION: See Plan

PROJECT: Meadowvale North Feedermain

ELEVATION: _

(m) ELEV. DEPTH	DESCRIPTION Continuation	SYMBOL	GR. WATER	SAMPLES	TESTS
6.0	medium sand gravel some cobbles boulders <div style="text-align: right;">moist ----- wet</div>	0 . . 0 . . 0 . . 0 . . 0 . . 0 . . 0 . . 0 . . 0 . . 0 . . 0 . .		W.L. 7.5 m + (182.9)	
8.0	END OF TEST PIT				

Seepage at 7.5 m
Rate 2-4 l/min.

9:20 - W.L. at
base

9:30 - W.L. 150
mm deep
(approx.)

10:45 - Sides
caved below
3.0 m
covering
base - no
water
visible
to 6.2 m
depth

4:15 - p.m.
further
cave
depth 6.0
m: cave
material
moist, no
free water

LOG OF TEST PIT 4

SOUTH SIDE 401
CLOSE TO BH 17

CLIENT: Marshall Macklin Monaghan Ltd.

DATE: October 29, 1987


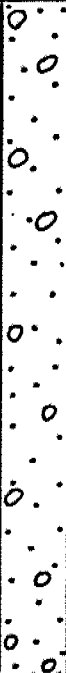


JOB No.: M-87059

LOCATION: See Plan

PROJECT: Meadowvale North Feedermain

ELEVATION: -

APPROX
ELEVATION
195.9 ±

(m) ELEV. DEPTH	DESCRIPTION	SYMBOL	GR. WATER	SAMPLES	TESTS
	Ground Surface				
0.0	100 mm Topsoil 25 mm Asphalt SAND AND GRAVEL FILL				
0.5	medium sand gravel cobbles occasional boulders weak or no cementation				
4.0	SAND AND GRAVEL fewer cobbles below 4.0 m moist				
6.0	CONTINUED 				

Start -9:54 am
Finish -10:21 am
Backfill-10:31 am

Sides temporarily
stable in near
vertical cut
to 6.0 m.

191.9

Benchore
17-191.1
w.c.

INVERT
ELEVATION
191.2 ±

189.9

Seepage at 6.0 m
Rate 80 l/min.
(approx.)

LOG OF TEST PIT 4 (CONT.)

CLIENT: Marshall Macklin Monaghan Ltd.



DATE: October 29, 1987

JOB No.: M-87059

LOCATION: See Plan

PROJECT: Meadowvale North Feedermain

ELEVATION:-

(m) ELEV. DEPTH	DESCRIPTION Continuation	SYMBOL	GR. WATER	SAMPLES	TESTS
6.0	SAND AND GRAVEL some cobbles red to grey wet				
7.6	END OF TEST PIT				

Side unstable
below 6.0 m.

10:18 am
W.L. 7.5 m (188.4)

10:31 am
W.L. 7.4 m

memorandum



To: E. Pong
Engineering Services
5000 Yonge Street

Tel: (416) 235-3731
Date: 1987 08 19

From: Foundation Design Section
Rm. 315, Central Building

RE: Proposed 900 m Watermain Crossing Hwy. 401
at 5th Line, West of Mississauga

In reviewing the tunnel specification for the watermain, we have the following comments:

- a) Using a tunnel boring machine (TBM) with compressed air is feasible, but may be prohibitively expensive for the size of tunnel that is required.
- b) A positive monitoring program is required to ensure that loss of ground does not occur during tunnelling. Details of this program should be submitted for review.
- c) Refer to our memorandum (1987 06 23) for further comments on the proposed watermain crossing.

Should you have any further questions, contact this office.

A handwritten signature in black ink, appearing to read "Mark Jolink".

M. Jolink

for:

D.H. Dundas, P. Eng.
Sr. Foundations Engineer

DHD/pb

memorandum



To: E. Pong
Engineering Services
5000 Yonge Street

From: Foundation Design Section
Room 315, Central Building

RE: Proposed 900 mm Watermain Crossing Hwy 401
at 5th line West of Mississauga

Tel: 235-3731
Date: 1987 06 23

In reviewing the foundation investigation report from Geo-Canada and drawing number 10-86017-17 from Marshall Macklin Monaghan, we have the following comments:

- a) In order to ensure the stability of Highway 401, from a geotechnical point of view, we recommend that the invert of the tunnel be maintained 1 metre above the prevailing groundwater level unless an approved dewatering scheme is incorporated.
- b) We understand that hand mining is the suggested method for removing boulders, should they be encountered during the tunnelling operation.
- c) Careful monitoring of the water table is required to determine its exact location. The method of monitoring should be submitted for review. In addition, monitoring of the roadway (Hwy. 401) is essential during construction.

Should you have any further questions, contact this office.

A handwritten signature in dark ink, appearing to read "Mark Jolink".

M. Jolink

for

A small handwritten signature in dark ink, appearing to read "M. Devata".

M. Devata

Chief Foundations Engineer
(East)

MD/pb