

## DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 30M5-122

DIST. 4 REGION                     

W.P. No. 83-74-25

CONT. No. 83-11

W. O. No. \_\_\_\_\_

STR. SITE No. 10-319

HWY. No. QEW

LOCATION QEW Overpass

No. of PAGES -                     

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. \_\_\_\_\_

REMARKS: \_\_\_\_\_

FOUNDATION INVESTIGATION REPORT  
FAIRVIEW STREET - Q.E.W. OVERPASS  
W.P. 83-74-25 SITE 10-319  
DISTRICT 4 BURLINGTON

Distribution:

13 copies	Ministry of Transportation and Communications
2 copies	Morton & Partners Limited

Prepared by

Morton & Partners Limited  
50 Galaxy Blvd., Unit 11  
Rexdale, Ontario, M9W 4Y5

Date: January 5, 1981

GROCES 30 M 5-122

01.80.070

## 1. INTRODUCTION

Morton & Partners Limited has been retained by the Ministry of Transportation and Communications to carry out a foundation investigation at the site of the proposed Fairview Street - Q.E.W. Overpass, site 10-319, W.P. 83-74-25, in Burlington, Ontario.

This report summarizes the results of this investigation. Sections 2 to 5 inclusive provide factual information. Section 6 is interpretative and contains recommendations for foundation treatment, based on current knowledge on the type of structure planned.

## 2. SITE

The site is located near the north east corner of the present intersection of the Q.E.W. and Plains Road in Burlington, Ontario as shown on the Key Plan on the attached drawing.

The site is relatively flat at about elevation 96 and is crossed by existing Maple Avenue. An existing building known as the Tien Kui Inn and its parking lot occupy part of the site.

## 3. SITE GEOLOGY AND GEOMORPHOLOGY

The proposed highway structure is located within a low terrace of land formed as a wide depositional beach in glacial Lake Iroquois. The shore cliff (or strand line) of this glacial feature lies some 1.2 km northwest from the site location, immediately on the north and northwest side of Provincial Highway 403. The offshore edge of the wide, glacial lake and beach (in the strand flat) is located along the edge of present-day Lake Ontario (and Hamilton Harbour) some 2.0 km southeastward.

Surficial sediments accumulated on the wide strand flat comprise rather uniformly graded fine to coarse, slightly silty sands. Scattered gravel and small rock fragments occur throughout these sands probably transported offshore by ice floating away from the former shoreline beach and confining small cliff in Queenston Shale or Halton Till. The Halton Till unit of late Pliestocene age is found to underlie the strand flat sediments at about 4.15 m depth.

Evidence of interstadial deposition prior to formation of the Halton Till is provided by several of the boreholes, by existence of a substratum of finely stratified (varved?) clayey silt to silty clay. This "clay" in turn possesses a basal layer about 0.75 m thick of water bearing clayey beach deposit of silty sand and gravel, in which the gravel tends to comprise now-weathered fragments of red shale from the underlying bedrock. The presence of this coarse basal sediment below an upwards fining lacustrine sedimentary stratum confirms that the lake water in which it was sedimented was transgressive and not regressive.

Bedrock at about 12 to 13 m depth (about elevation 85) comprises essentially horizontally bedded red shale or mudstone of the Queenston Formation, of Upper Ordovician age.

The depth/level of intersection recorded in the boreholes corresponds very closely with the general bedrock subcrop position indicated in Ontario Geological Map 2034, though it must be noted that it is our experience that very rapid lateral changes in bedrock level of 3 to 5 m do occur in the Burlington area due to the existence of narrow former creek beds eroded into the shale and filled with interstadial and glacial sediment. No such rapid change in bedrock level appears to exist between the 8 boreholes of this specific study, but we understand on the basis of field comments with adjacent project investigators that changes may occur within the total confines of the intended interchanges.

Seismic risk in the Lake Ontario - Lake Erie fringe is noted as Level I. The possibility of seismically induced consolidation or liquifaction of the uppermost stratum of loose to dense uniform sand is therefore considered remote.

#### 4. FIELD WORK

The field work for this investigation was carried out during the period of November 18 to 26, 1980 inclusive and consisted of eight detailed boreholes at the locations shown on the attached drawing. The boreholes were advanced with a power auger using solid stem or hollow stem augers.

Samples were taken using a split spoon driven by the Standard Penetration Test method. Bedrock was core drilled using a BXL core barrel. All samples were shipped to our laboratory for further examination and testing. Samples remaining after testing will normally be stored for a period of three months following the date of this report and then discarded, unless other instructions are received.

Unsealed piezometers were installed in two boreholes to determine the current groundwater level as well as to facilitate future observations.

Elevations referred to in this report are metric and relative to a temporary benchmark, supplied by MTC, and consisting of a nail in the root of the seventh of a row of Maple trees along Maple Avenue, east of the existing restaurant. The benchmark is geodetic and reported to be at elevation 96.139 m.

## 5. SOIL CONDITIONS

The soil strata and the range of elevations between which they occur at the borehole locations are listed below.

Soil Type	Approximate Range of Elevation
Fill	between 97 and 94
Sand	between 96 and 92
Clay, Silt with Sand and trace of Gravel (Glacial Till)	between 93 and 87
Clay and Clayey Silt	between 89 and 85
Sand and Gravel	between 86 and 85
Bedrock	between 86 and 85

(Ground level at the site varies between about elevations 96 and 97)

The detailed soil conditions and their extent, groundwater levels and the results of laboratory testing are shown on the attached "Record of Borehole" sheets. Estimated stratigraphical profiles, based on these data, are shown on the attached drawing.

The various soil types are briefly described in the following paragraphs.

### 5.1 Fill

Fill was encountered in most boreholes and consists generally of loose fine to sometimes medium and coarse sand, locally mixed with gravel. It is generally somewhat organic and, although otherwise relatively clean, occasionally clayey and mixed with foreign material such as brick, cinder and wood pieces.

It should be noted that, as the fill is relatively clean, the boundary

between the fill and the underlying sand is not always clearly defined and, consequently, the boundaries shown on the "Record of Borehole" sheets may be approximate.

The relative density of the fill is variable, as indicated by the "N" values which ranged from 8 to 43 blows per 0.3 m. The higher values may be due to obstructions and in general the relative density of the fill is considered to range from loose to compact.

## 5.2 Sand

The fill is underlain by a stratum of brown sand. As a waterlain deposit, it exhibits considerable variations in gradation both in the horizontal and vertical direction. In general the sand is fairly uniformly fine with a tendency to become less uniform and coarser with depth. The gravel content in some boreholes became noticeably greater near the bottom of the stratum.

Grainsize analyses were carried out on all samples of the sand from Borehole 1 and the results are shown on the "Record of Borehole" sheets. The envelope of the grain size distribution curves is shown in Figure 1. It should be noted that the envelope probably covers the finer sizes, but not the coarser sizes across the site.

"N" values obtained in the stratum ranged from 5 to greater than 100 with a median value of 34 blows per 0.3 m, indicating its variable, but generally compact to dense nature. It should be noted that the lower values were invariably obtained in the upper part of the stratum.

## 5.3 Clay, Silt with Sand and trace of Gravel (Glacial clayey till)

Beneath the sand, in all boreholes, is a glacial deposit, generally with

a clayey silt to clay matrix, but occasionally very silty with little or no clay. Cobble or boulder sizes were not encountered but they are likely to exist within the stratum.

"N" values obtained within the stratum ranged from 38 to over 100 blows per 0.3 m, with a median value of 61 indicating a hard consistency.

#### 5.4 Clay and Clayey Silt

Beneath the above glacial deposit, in all boreholes, is a stratum of stratified silty clay and clayey silt. The "N" value obtained in this deposit ranged from 39 to 75 blows per 0.3 m, with a median value of 52 indicating a hard consistency.

#### 5.5 Sand and Gravel

Underlying the clay in most and possibly all boreholes is a stratum of sand and gravel. As the stratum is relatively shallow and, because of its frequent clay and weathered shale content, difficult to distinguish from the underlying weathered rock, its boundaries were difficult to define.

The "N" values obtained in this stratum are relatively low, but probably influenced by temporary excess hydrostatic pressure during sampling.

#### 5.6 Bedrock

Bedrock was core drilled in Boreholes 1 and 2 and assumed to have been reached in all boreholes following practical refusal to further penetration. The bedrock consists of reddish brown generally horizontally bedded, Queenston Shale of upper Ordovician age. The upper part of the shale is moderately to heavily weathered, but the core recovery in Boreholes 1 and 2 combined with the depth at which refusal to augering was met elsewhere, suggest that the weathered part of the rock is not extensive and of the order of 1 m.



## 6. GROUND WATER

During drilling, free water was encountered in the upper sand in all boreholes. This water level did not appreciably change during or after the drilling operations. Consequently, unsealed piezometers were used to observe the groundwater conditions likely to be encountered during construction.

The groundwater level, stabilized very quickly following completion of the boreholes, but appeared to be subject to precipitation. During the period of investigation, the groundwater level fluctuated between elevations 94.0 and 94.5 across the site.

The piezometers referred to above were installed in Boreholes 1 and 2 only, i.e., on opposite ends of the proposed structure. They were capped and should be usable for future observation if required.

## 7. DISCUSSION AND RECOMMENDATIONS

### 7.1 General

The project is part of the reconstruction of the Q.E.W. from Lockhardt Road northerly to Brant Street. At the site covered by this report both the Q.E.W. and Plains Road will be realigned, the former easterly and the latter southerly so as to meet the extension of Fairview Street east of the Q.E.W.

The proposed overpass will consist of twin bridges to each accommodate three Q.E.W. through lanes. When warranted by traffic volume both structure decks will be widened towards the highway centreline, to provide 2 additional through lanes.

The proposed grade elevation at the centreline of Fairview Street is about 96 at the point where it crosses the Q.E.W. The grade elevation of the latter at this point will be about 104, resulting in a grade separation of about 8 m.

The type of structure proposed for the overpass is not known at this time. The design would probably depend partly on the final alignments of the ramps to and from the Q.E.W. and Fairview Street. Presumably, the abutment could either be a full abutment acting as retaining wall or it may take the form of a pier and perched abutment combination.

## 7.2 Spread Footings

Footings should be provided with not less than 1.3 m of earth cover for frost protection. As the profile control point of Fairview Street at the point of intersection is at elevation 96 and as the pavement at this point has a 3.3% rate of super elevation, the footings at the north and south abutments (or piers) should therefore be founded at or below elevations 95.3 and 94.1 respectively.

At both abutments the above elevations are either in fill or (in most cases), in the relatively loose, upper part of the sand. It is therefore recommended that, for design purposes, the footings be founded in undisturbed natural sand at approximately elevation 93.5. It is further recommended that following its exposure, the bearing surface be inspected for any obvious loose pockets and that such pockets be either compacted or, if necessary, replaced and compacted. Following general acceptance, the bearing surface should then be uniformly compacted by several passes of a vibrating roller. Provided these measures are taken, an allowable bearing pressure of 335 kPa may be used for footing design.

If a greater design bearing pressure is advantageous, or if a deeper

penetration is necessary for stability reasons, the footing may, alternatively, be placed in or on the clayey glacial deposit, at about elevation 92.5, using an allowable bearing pressure of 430 kPa.

Settlements of footings founded either on sand or on the glacial material, using the recommended bearing pressures, are estimated to be small and within 25 mm total and 12 mm differential.

#### 7.2.1 Excavation for Spread Footings

The groundwater level at the time of the investigation ranged from elevations 94 to 94.5. This level will fluctuate with the seasons, but it would appear that excavation for footings could be in excess of 1 m below groundwater level. As the sand is quite pervious, with a coefficient of permeability of the order of  $10^{-3}$  cm/sec, and as the excavation will be of considerable size, a positive method of dewatering, such as well points, will probably be required.

#### 7.3 Piled Foundations

Potential groundwater problems in footing excavations, and possibly, stability considerations, may lead to the consideration of an alternative foundation on piles.

Piles should be driven to practical refusal and preferably on or into bedrock. In view of the hard consistency of the glacial deposit and in view of the potential presence of boulders in both the glacial and lower granular deposits, a steel H pile provided with a point and/or reinforced tip is the most suitable type of pile.

01.80.070

1150

360  
(180)  
0.89  
0.3  
267  
10 89  
1.157

The pile size and its design load are dependent on structural considerations, such as total loads to be transferred and pile spacing versus pile cap thickness and reinforcement, as well as on geotechnical considerations. For piles driven to sound bedrock, it is now common to use a design load equal to the allowable structural capacity of the pile, where the latter is defined as the product of the total steel area and 30 to 35% of the yield strength of the steel. Translated to e.g. a 310 HP 110 steel H pile, and using 303 MPa steel, the allowable load would be of the order of 1,280 to 1,490 kN.

It should be noted, however, that piles may refuse within the glacial deposit. It should further be noted that piles driven into the relatively soft bedrock may be subject to relaxation. For these reasons, it is recommended that the piles be designed to carry a design load not exceeding 75% of the allowable structural load. For the 310 HP 110 pile considered above, the recommended design load is therefore of the order of 960 to 1,120 kN.

During driving, the approximate pile capacity may be checked by applying the Hiley formula in accordance with standard MTC principles.

For estimating purposes, it may be assumed that piles driven into rock will refuse at an average elevation of approximately 84. As noted earlier, it may not be possible to drive all piles to bedrock. It should be appreciated, however, that apparent refusal above rock does not necessarily indicate a boulder obstruction. Where refusal occurs suddenly, this assumption is probably true. In the case of progressively harder driving, however, the increase in pore pressures may cause apparent refusal. It is therefore recommended that such piles be re-tapped following an appropriate interval of time.

An earth cover of not less than 1.3 m, measured from the underside of the

pile cap, should be provided for frost protection.

#### 7.4 Stability of Foundations

As noted earlier, details regarding the type of structure are not available. The following paragraphs, therefore, contain only general parameters for design.

For resistance to sliding of a horizontal footing resting on sand the coefficient of friction is  $\tan \phi$ , where  $\phi$  may be taken as 30 degrees. The resistance to sliding of the same footing on the clayey glacial material may be determined by using a friction value of 95 kPa. In either case, passive resistance will be afforded by sand and a value of  $K_p$  of 3.5 is suggested for an assumed  $\delta = 0$ .

When the abutment is acting as retaining wall it is recommended that backfill behind the wall consist of well graded, free draining, compacted granular material and provisions for drainage should be incorporated. For design purposes a coefficient of active earth pressure  $K_a$ , of 0.3 may be used for an assumed  $\delta = 0$ .

#### 7.5 Embankments.

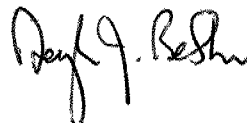
The height of the approach embankments will be of the order of 8 m. On the assumption that the soil conditions encountered during this investigation prevail laterally north and south of the structure, the approach embankments should be stable under a standard side slope of 2:1.

## 8. MISCELLANEOUS

The field work for this investigation was carried out under the supervision of Mr. P.M. Thompson, P.Eng., using equipment owned and operated by Master Soil Investigations Limited. This report was written by Mr. A. Prior, P.Eng. and reviewed by Mr. D.J. Belshaw, P.Eng.



A. Prior, P. Eng.,  
Senior Associate



D.J. Belshaw, P. Eng.,  
Vice President

January 5, 1981

# RECORD OF BOREHOLE No 1

METRIC

W P 83-74-25 (Site 10-319) LOCATION CHAINAGE 10+218.56 - 33.1 Rt  
DST 4 HWY Q.E.W. BOREHOLE TYPE Solid and hollow stem auger, BXL core  
DATUM Geodetic DATE 80-11-18 & 19  
ORIGINATED BY  
COMPILED BY  
CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100		
96.8								SHEAR STRENGTH						
								○ UNCONFINED + FIELD VANE						
								● QUICK TRIAXIAL x LAB VANE						
								WATER CONTENT (%)						
								Wp W WL						
								10 20 30						
0.0	Fill, silty sand, trace of gravel & clay, Brick & cinder pieces, Brown		1	SS	42		96							0 94 6
95.7			2	SS	16									2 89 9
1.1	Sand, irregularly bedded. Uniform fine to fine to coarse with gravel, trace of silt. Loose to dense. Brown		3	SS	5									2 89 9
			4	SS	5									20 76 4
			5	SS	27									1 93 6
			6	SS	95									0 94 6
			7	SS	20									11 83 6
			8	SS	34									
92.6			9	SS	33									
4.2	Mixture of silty clay to clayey silt and sand, trace of gravel (Glacial till) Hard Light-grey-brown to grey		10	SS	87									
			11	SS	42									
			12	SS	>100									
			13	SS	88									
88.0														
8.8	Clayey silt interbedded with clay, some sand seams, Hard, Grey		14	SS	44									
86.3			15	SS	39									
10.5	Sand, gravel with clay (Glacial till) Dense Reddish Brown		16	SS	39									
85.5														
11.3	Shale Bedrock		17	SS	>100									
			18	RC BXL	100%									
			19	RC BXL	100%									
82.9														
13.9	End of Borehole													

+3, x5: Numbers refer to Sensitivity  
20  
15 5 (%) STRAIN AT FAILURE  
10



Ministry of  
Transportation and  
Communications  
Ontario

# RECORD OF BOREHOLE No 2

METRIC

W P 83-74-25 (site 10-319) LOCATION CHAINAGE 10+292.36 - 23.5 Lt ORIGINATED BY \_\_\_\_\_  
DIST 4 HWY Q.E.W. BOREHOLE TYPE Solid and hollow stem augers; BXL Core COMPILED BY \_\_\_\_\_  
DATUM Geodetic DATE 80-11-20 & 21 CHECKED BY \_\_\_\_\_

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH					
95.8														
0.0	Fill, sand with gravel, clayey parts. Brown to dark brown		1	SS	29									
93.8			2	SS	16									
2.0	Sand, bedded fine to coarse with gravel, trace of silt, compact to dense. Brown		3	SS	47									
			4	SS	26									
92.5			5	SS	35									
3.3	Mixture of silty clay to clayey silt and sand, trace of gravel (Glacial till) Hard light grey brown to grey		6	SS	74									
			7	SS	63									
			8	SS	41									
			9	SS	>100									
			10	SS	100									
			11	SS	93									
87.6			12	SS	100									
8.2	Clayey silt interbedded with clay Hard Grey		13	SS	75									
86.2			14	SS	46									
9.6	Sand, gravel with clay (Glacial till) Dense Reddish Brown		15	SS	40									
85.0			16	SS	>100									
10.8	Shale Weathered Bedrock Sound		17	RC BXL	65%									
83.5														
12.3	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

\*3, \*5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10





Ministry of  
Transportation and  
Communications  
Ontario

# RECORD OF BOREHOLE No3

METRIC

W P 83-74-25 (Site 10-319) LOCATION CHAINAGE 10+217.06 - 24.2 Lt ORIGINATED BY \_\_\_\_\_  
DIST 4 HWY Q.E.W. BOREHOLE TYPE Hollow stem auger COMPILED BY \_\_\_\_\_  
DATUM Geodetic DATE 80-11-21 CHECKED BY \_\_\_\_\_

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80					
96.2																
0.0	Fill, sand, trace of gravel and clay Reddish brown		1	SS	43											
94.1			2	SS	22											
2.1	Sand, bedded, fine to medium, trace of gravel and silt Loose to dense Brown		3	SS	11											
92.3			4	SS	60											
3.9	Mixture of silty clay to clayey silt and sand, trace of gravel (Glacial till) Hard Light grey brown to grey		5	SS	53											
			6	SS	>100											
			7	SS	82											
			8	SS	56											
88.4			9	SS	54											
7.8	Clayey silt interbedded with clay Hard Grey		10	SS	50											
86.1			11	SS	49											
10.1	Shale Bedrock Weathered															
84.7																
11.5	End of Borehole Refusal to auger on assumed sound bedrock															

OFFICE REPORT ON SOIL EXPLORATION

+3, x<sup>2</sup>: Numbers refer to  
Sensitivity

20  
15-5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 4

METRIC

W P 83-74-25 (Site 10-319) LOCATION CHAINAGE 10+292.76 - 34.5 Rt ORIGINATED BY \_\_\_\_\_  
 DIST 4 HWY Q.E.W. BOREHOLE TYPE Hollow stem auger COMPILED BY \_\_\_\_\_  
 DATUM Geodetic DATE 80-11-24 CHECKED BY \_\_\_\_\_

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100					
96.1																
0.0	Fill, silty sand Reddish brown		1	SS	10											
94.0			2	SS	9											
2.1	Sand, fine to medium, sandy gravel at bottom Compact to dense. Brown		3	SS	24											
92.8			4	SS	96											
3.3	Mixture of silty clay to clayey silt and sand with some gravel (Glacial till) Hard Light grey brown to grey		5	SS	54											
			6	SS	52											
			7	SS	61											
			8	SS	46											
88.4			9	SS	50											
7.7	Clayey silt interbedded with clay  Hard Grey		10	SS	52											
86.0																
10.1	Probably weathered Shale		11	SS	100/50 mm											
85.4																
10.7	End of Borehole Refusal to sampler on assumed sound bedrock															

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 5

METRIC

W P 83-74-25 (Site 10-319) LOCATION CHAINAGE 10+291.36 - 23.5 Rt ORIGINATED BY  
DIST 4 HWY Q.E.W. BOREHOLE TYPE Hollow stem auger COMPILED BY  
DATUM Geodetic DATE 80-11-24 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>	WATER CONTENT (%)	10 20 30				
95.9	0.0 Fill, silty sand Reddish brown		1	SS	8												
94.1	1.8 Sand, bedded fine to coarse to sandy gravel Dense to very dense Brown		2	SS	9												
			3	SS	45												
			4	SS	74												
92.2	3.7 Mixture of silty clay to clayey silt and sand, trace of gravel (Glacial till) Hard Light grey brown to grey		5	SS	38												
			6	SS	55												
			7	SS	61												
			8	SS	74												
			9	SS	68												
87.4	8.5 Clayey silt interbedded with clay Hard Grey		10	SS	54												
85.3	10.6 Sand & Gravel (Till)		11	SS	54												
84.5	Weathered Shale																
11.4	End of Borehole Refusal to auger on assumed sound bedrock																

OFFICE REPORT ON SOIL EXPLORATION

# RECORD OF BOREHOLE No6

METRIC

W P 83-74-25 (Site 10-319) LOCATION CHAINAGE 10+217.06 - 6.5 Rt ORIGINATED BY \_\_\_\_\_  
 DIST 4 HWY Q.E.W. BOREHOLE TYPE Hollow stem auger COMPILED BY \_\_\_\_\_  
 DATUM Geodetic DATE 80-11-25 CHECKED BY \_\_\_\_\_

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
97.1														
0.0	Fill (?)													
96.4														
0.7	Sand, bedded, fine to medium with trace of gravel, with layers of sandy gravel. Loose to very dense. Reddish brown to brown		1	SS	7									
			2	SS	5									
			3	SS	100									
			4	SS	60									
			5	SS	64									
92.5														
4.6	Mixture of silty clay to clayey silt and sand, trace of gravel (Glacial till) Hard Light grey brown to grey		6	SS	59									
			7	SS	66									
			8	SS	90									
			9	SS	90									
88.5														
8.6	Clayey silt interbedded with clay Hard Grey		10	SS	53									
86.2														
10.9	Sand & Gravel (Till)		11	SS	100									
84.8	Weathered Shale													
12.3	End of Borehole Refusal to auger on assumed sound bedrock													

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity  
 20  
 15  
 10  
 5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 7

METRIC

W P 83-74-25 (Site 10-319) LOCATION CHAINAGE 10+297.06 - 2.6 Rt ORIGINATED BY \_\_\_\_\_  
 DIST 4 HWY Q.E.W. BOREHOLE TYPE Hollow stem auger COMPILED BY \_\_\_\_\_  
 DATUM Geodetic DATE 80-11-25 CHECKED BY \_\_\_\_\_

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60						80	100
								SHEAR STRENGTH								WATER CONTENT (%)	
95.8															GR SA SI CL		
0.0	Fill, silty sand and clayey silt																
94.7	Dark Brown		1	SS	14												
1.1	Sand, bedded, fine to medium, layers of sandy gravel. Compact to very dense. Reddish brown to brown		2	SS	12												
			3	SS	55												
			4	SS	57												
92.5			5	SS	60												
3.3	Mixture of silty clay to clayey silt and sand, trace of gravel (Glacial till) Hard Light grey brown to grey		6	SS	49												
			7	SS	53												
			8	SS	54												
			9	SS	69												
86.8			10	SS	55												
9.0	Clayey silt interbedded with clay																
85.4	Hard Grey																
10.4	Sand & Gravel (Till)		11	SS	51												
84.4	Weathered Shale																
11.4	End of Borehole Refusal to auger on assumed sound bedrock																

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

20  
15  
10  
5  
[%] STRAIN AT FAILURE

# RECORD OF BOREHOLE No 8

METRIC

W P 83-74-25 (Site 10-319) LOCATION CHAINAGE 10+219.06 - 9.5 Lt  
 DIST 4 HWY Q.E.W. BOREHOLE TYPE Hollow stem auger  
 DATUM Geodetic DATE 80-11-26

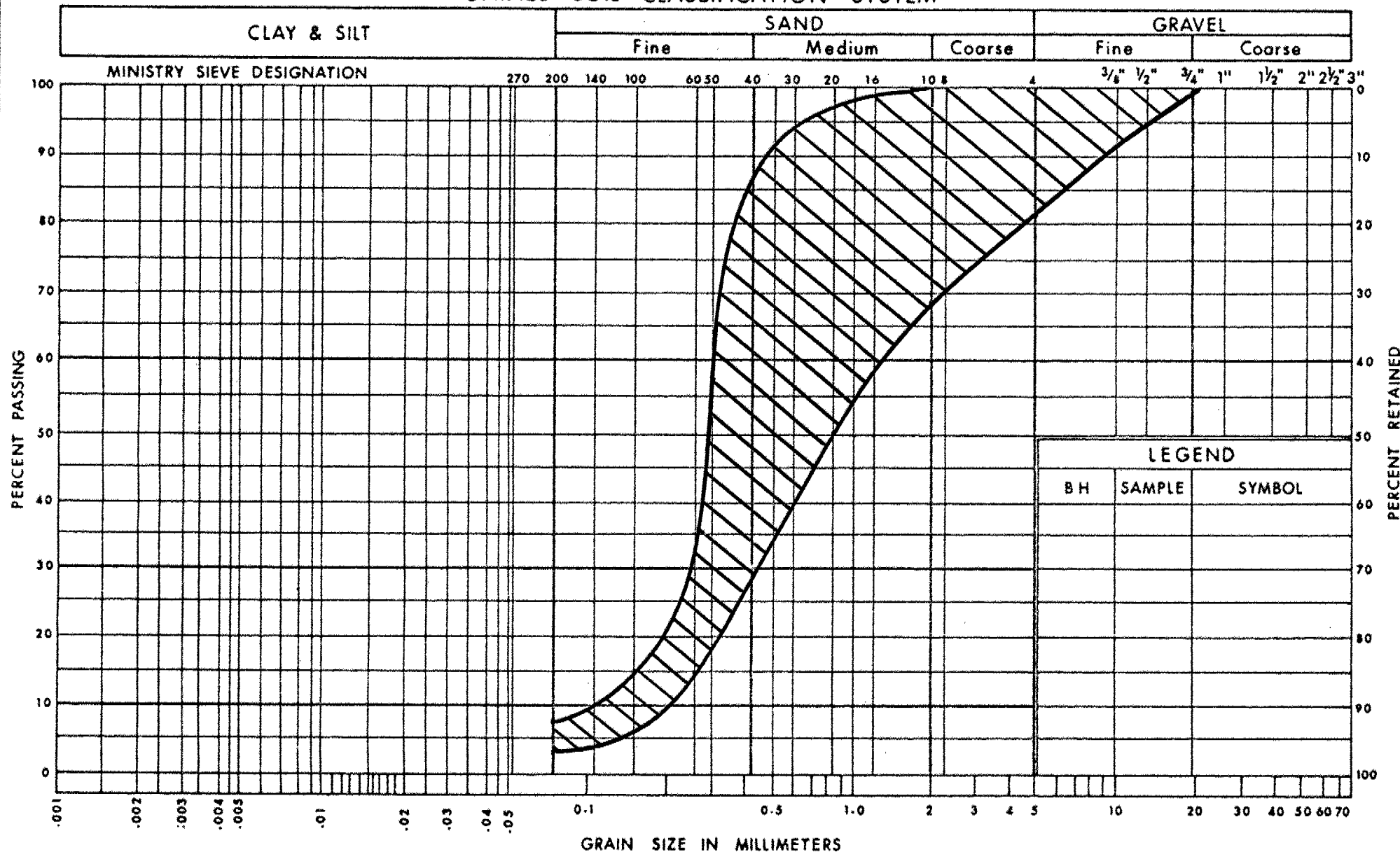
ORIGINATED BY  
 COMPILED BY  
 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
95.9																	
0.0	Sand, bedded fine to medium, trace of gravel and silt. Layer of sandy gravel at bottom. Compact to dense. Reddish brown to brown.		1	SS	12												
			2	SS	>100												
			3	SS	15												
92.5			4	SS	34												
3.4	Mixture of silty clay to clayey silt and sand trace of gravel (Glacial till). Hard. Light grey brown to grey.		5	SS	52												
			6	SS	67												
			7	SS	79												
			8	SS	60												
87.9			9	SS	61												
8.0	Clayey silt interbedded with clay. Hard Grey.		10	SS	40												
85.8																	
10.1	Sand & Gravel (Till)																
84.8	Weathered Shale		11	SS	>100												
11.1	End of Borehole. Refusal to auger on assumed sound bedrock.																

OFFICE REPORT ON SOIL EXPLORATION

\*3, \*5: Numbers refer to Sensitivity  
 20  
 15  
 10  
 (% ) STRAIN AT FAILURE

## UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

 Ministry of  
Transportation and  
Communications

## GRAIN SIZE DISTRIBUTION

(ENVELOPE)

FIG No 1

W P 83-74-25

SITE 10-319

## EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

### MECHANICAL PROPERTIES OF SOIL

$m_v$	$\text{kPa}^{-1}$	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	$\text{m}^2/\text{s}$	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_t$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### STRESS AND STRAIN

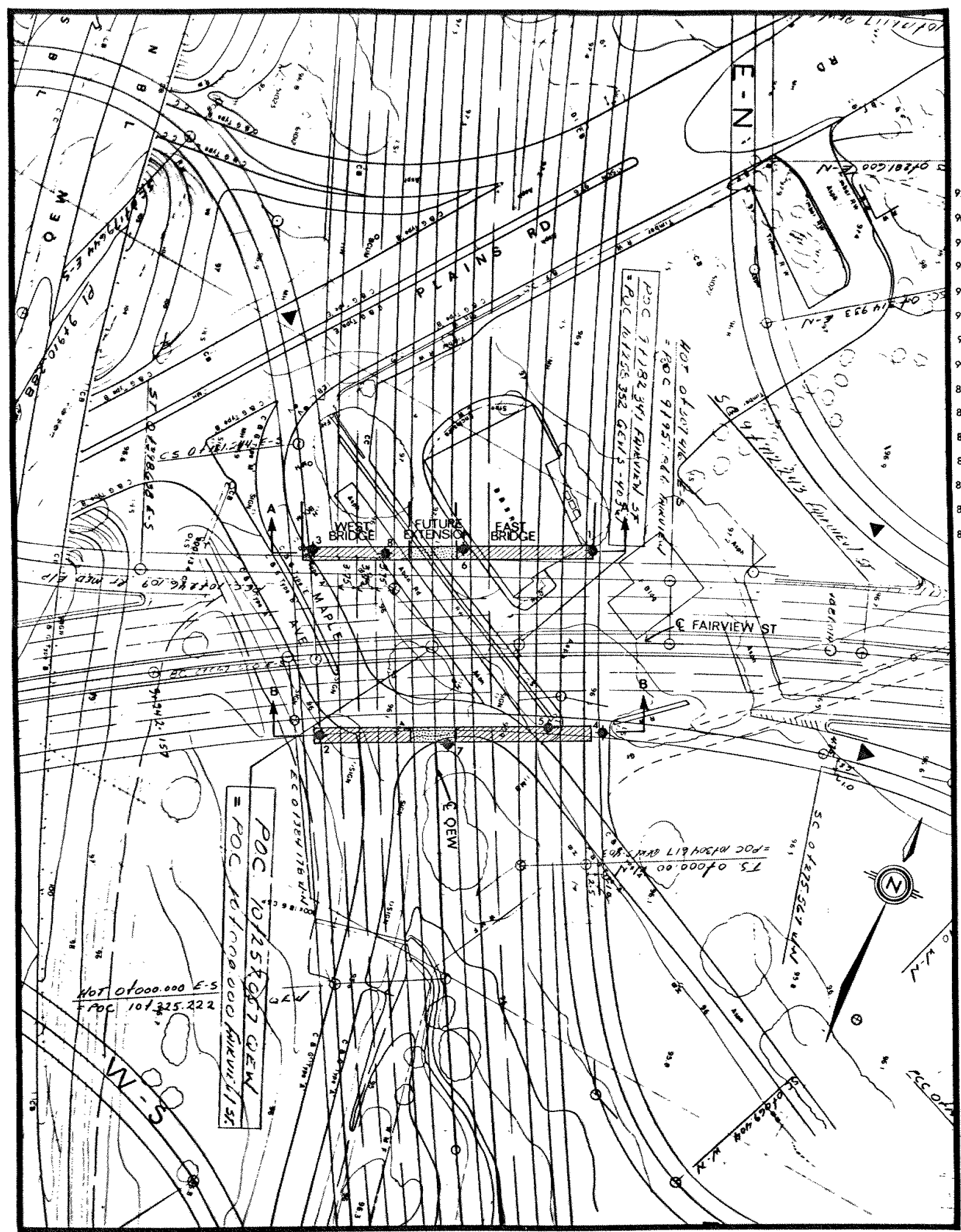
$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS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

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	$\text{kg}/\text{m}^3$	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\rho_w$	$\text{kg}/\text{m}^3$	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	$\text{kg}/\text{m}^3$	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	$\text{kg}/\text{m}^3$	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	$\text{m}^3/\text{s}$	RATE OF DISCHARGE
$\gamma_d$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	v	$\text{m}/\text{s}$	DISCHARGE VELOCITY
$\rho_{sat}$	$\text{kg}/\text{m}^3$	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
$\gamma_{sat}$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	$\text{m}/\text{s}$	HYDRAULIC CONDUCTIVITY
$\rho'$	$\text{kg}/\text{m}^3$	DENSITY OF SUBMERGED SOIL	$e_{max}$	1, %	VOID RATIO IN LOOSEST STATE	j	$\text{kN}/\text{m}^2$	SEEPAGE FORCE
$\gamma'$	$\text{kN}/\text{m}^3$	UNIT WEIGHT OF SUBMERGED SOIL						



MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO. 08-MT-3088 6-74



PLAN 0 10 20m

**METRIC**  
DIMENSIONS ARE IN  
METRES AND/OR  
MILLIMETERS UNLESS  
OTHERWISE SHOWN

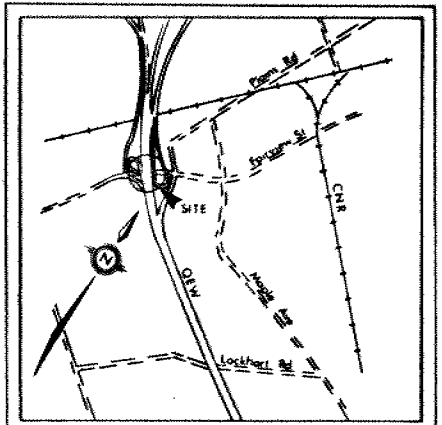
CONT No  
WP No 83-74-25

QEW OVERPASS  
(At Fairview Street)  
BORE HOLE LOCATIONS & SOIL STRATA



SHEET

MORTON & PARTNERS LTD

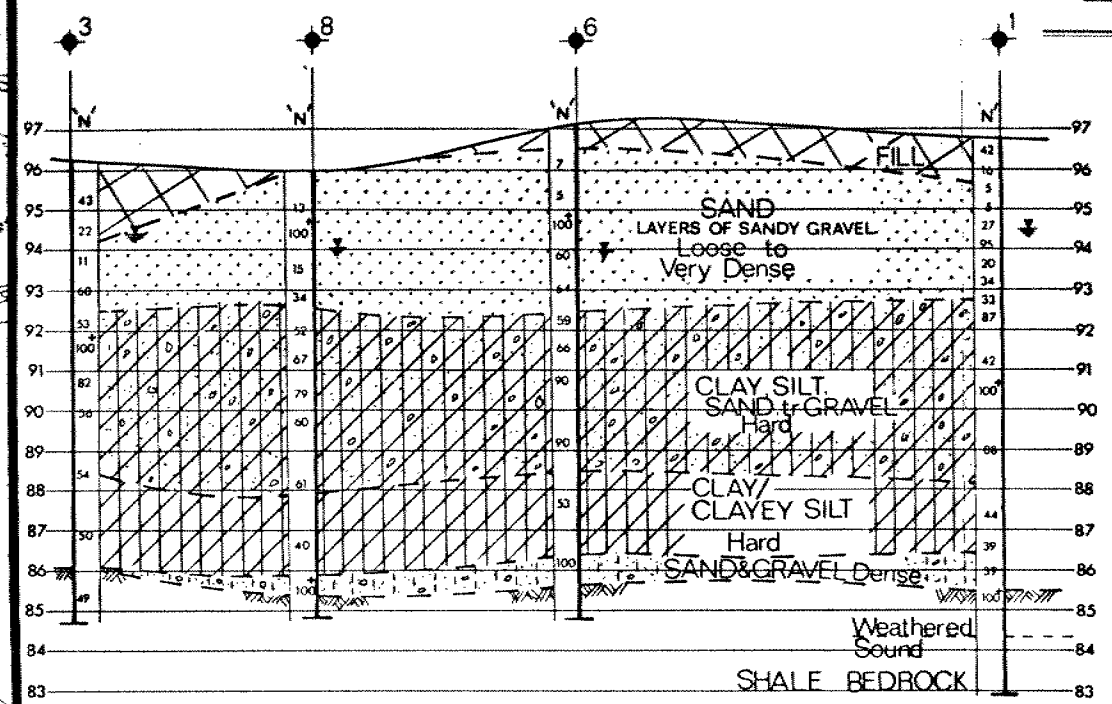


KEY PLAN

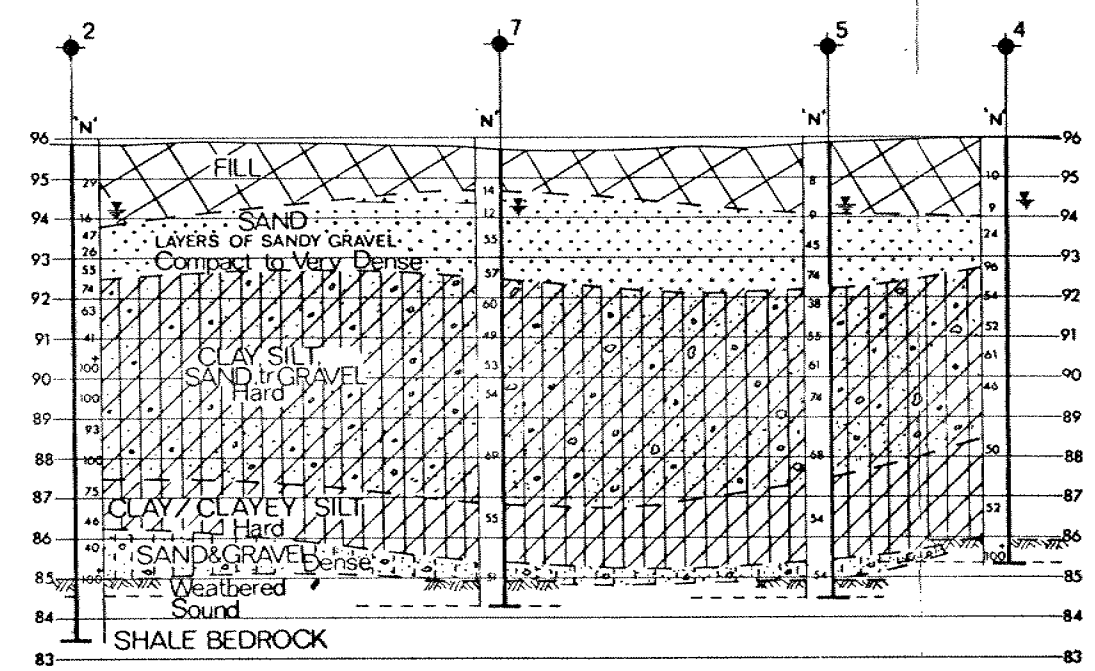
SCALE 0 0.5 1 Km

LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊙ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W/L at time of investigation 11/80



A-A



B-B

SECTIONS



NOTE

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

REVISIONS			
DATE	BY	DESCRIPTION	

Geocres No			
HWY No QEW AT FAIRVIEW ST	DIST	4	
SUBAPP	CHECKED	DATE	SITE 10-319
DRAWN	CHECKED	APPROVED	DWG 837425-A