FOUNDATION INVESTIGATION REPORT

CONTRACT NO. 93-89

Ontario

Ministry of
Transportation

INDEX

..../2

Stability of Slopes
W.P. 199-77-06, Site -
Hwy 403, District 4 Burlington

High Mast Lighting & Overhead Signs
W.P. 199-77-06A, Site -
Hwy QEW/403, District 4 Burlington

Hwy 403 WBL Over Ramp QEW/E-403/W &
Ramp 403/E-QEW/S
W.P. 199-77-07, Site 10-480
Hwy QEW/403, District 4 Burlington

Hwy 403 EBL Over Ramp QEW/E-403/W &
Ramp 403/E-QEW/S
W.P. 199-77-08, Site 10-481
Hwy QEW/403, District 4 Burlington

Note: For purposes of the contract, this report supersedes all other Foundation Reports prepared by, or for the Ministry in connection with the above mentioned projects.

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:

R Q D (%)	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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL

e	1,%	VOID RATIO
n	1,%	POROSITY
w	1,%	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_P	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_P	%	PLASTICITY INDEX = $w_L - w_P$
I_L	1	LIQUIDITY INDEX = $\frac{w - w_P}{I_P}$
I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_P}$
e_{max}	1,%	VOID RATIO IN LOOSEST STATE

e_{min}	1,%	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

FOUNDATION INVESTIGATION REPORT
For
High Mast Lighting
Freeman Interchange Phase 2
QEW/Hwy. 403
W.P. 199-77-01
District 4, Burlington

INTRODUCTION

This report contains the results of a soil investigation carried out at the above-mentioned site to provide information for the design and construction of the proposed high mast light poles.

The field work for this project was carried out between 91 01 28 and 91 02 04, and comprised of seven sampled boreholes and Dynamic Cone Penetration Test adjacent to these holes.

All the boreholes, with the exception of BH 1, were advanced at the proposed pole locations. However, the drilling machine could not be positioned at the proposed pole #1 location and the boring for this pole was carried out 3 m east of the original location. Boreholes were advanced to a maximum depth of 8.8 m (elevation 97.5 m) below the existing ground level using a continuous flight hollow stem auger.

SITE DESCRIPTION

The site is located within the ultimate QEW/Hwy. 403 interchange between Brant Street and King Road in the City of Burlington, Regional Municipality of Halton.

As a part of the ultimate QEW/Hwy. 403 interchange, it is proposed to illuminate the interchange area with high mast light poles. The height of the poles is anticipated to be about 35 m.

This site is located within the physiographic region known as the "South Slope". The area is characterized by a ground moraine of limited relief. The bedrock underlying the site is a red shale with siltstone of the Queenston Formation.

SUBSURFACE CONDITIONS

General

The underlying subsoil at this site consists of very stiff to hard cohesive glacial till which is underlain by shale bedrock of the Queenston Formation. In addition, firm to stiff silty clay to clay deposit was encountered immediately below ground level at pole locations #1 and #6. The extent of the area investigated covers more than a kilometre in length and it is not practical to give detail description for the individual strata. Reference should be made to the Record of Borehole sheets where details of the stratification at a particular boring location are given. However, for classification purposes, the soils encountered at this site can be divided into three different zones.

a) Silty Clay to Clay
b) Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)
c) Queenston Shale Bedrock.

The subsurface conditions encountered during the course of the investigation, together with the field and laboratory test results are shown on the Record of Borehole sheets contained in the Appendix of this report. The results of the Atterberg Limit Test carried out on representative soil samples are shown on Figures 1 and 2. In addition, the Gradation Test results for cohesive glacial till deposit are shown on Figure 3 in an envelope form. The location of the boreholes are shown on the Drawing No. 1997701-A.*

Groundwater Conditions

The groundwater level was encountered only in BH 4 and 6 and other boreholes were observed to be dry during our investigation which was carried out between 91 01 28 and 91 02 04.

BH. No.	Elevation
4	101.9
6	101.8

* SHEET NO 311-1 OF THE CONTRACT DWG'S

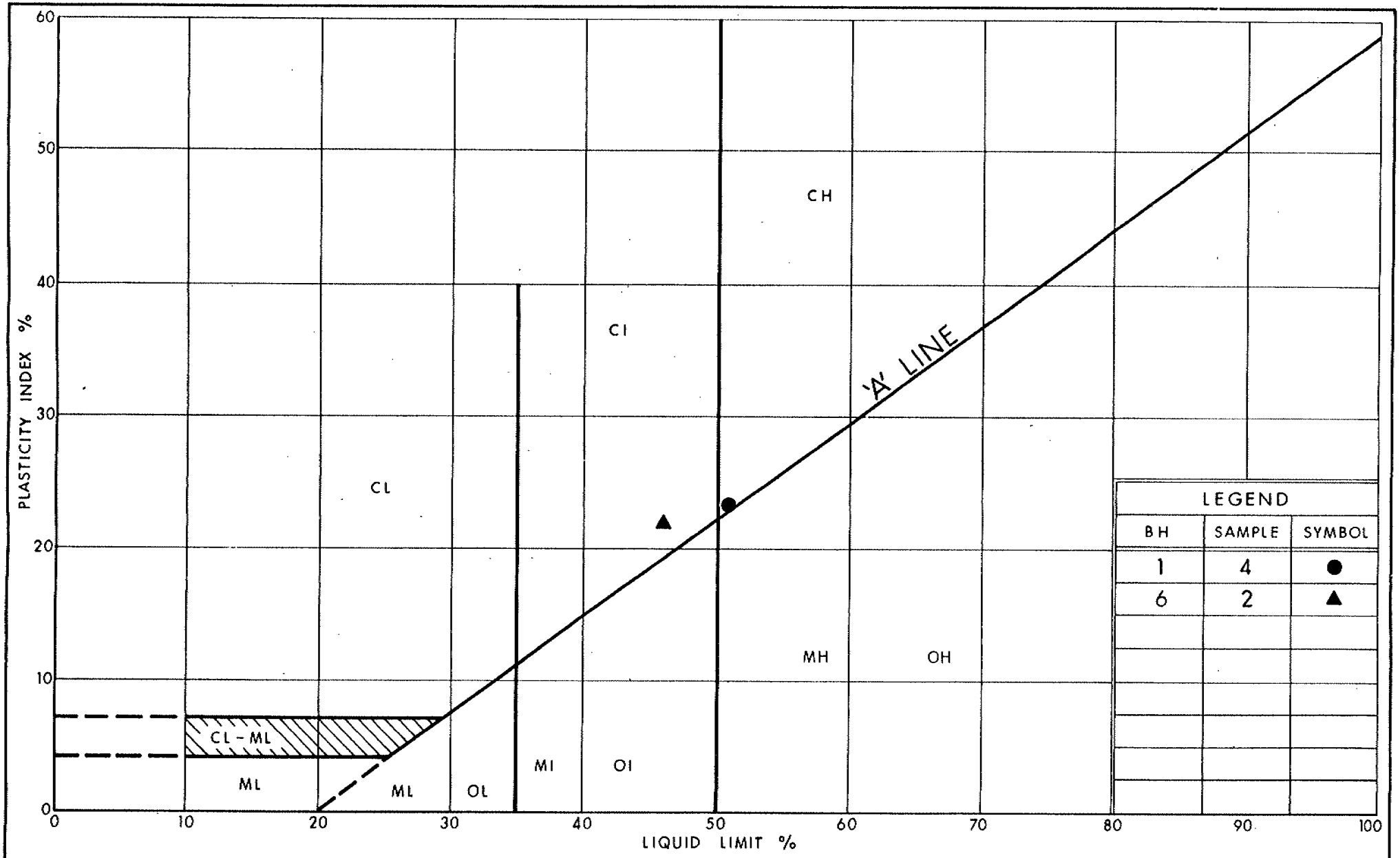
MISCELLANEOUS

The field work for this investigation was carried out under the supervision of M. Vasavithasan and Micheal Plant. The equipment used was owned and operated by London Soil test. This report was prepared by M. Vasavithasan, Foundation Engineer, reviewed by Mr. P. Payer, Senior Foundation Engineer and approved by M. Devata, Chief Foundation Engineer.

P. Payer, P. Eng.
Senior Foundatation Engineer

M.S. Devata, P. Eng.
Chief Foundation Engineer

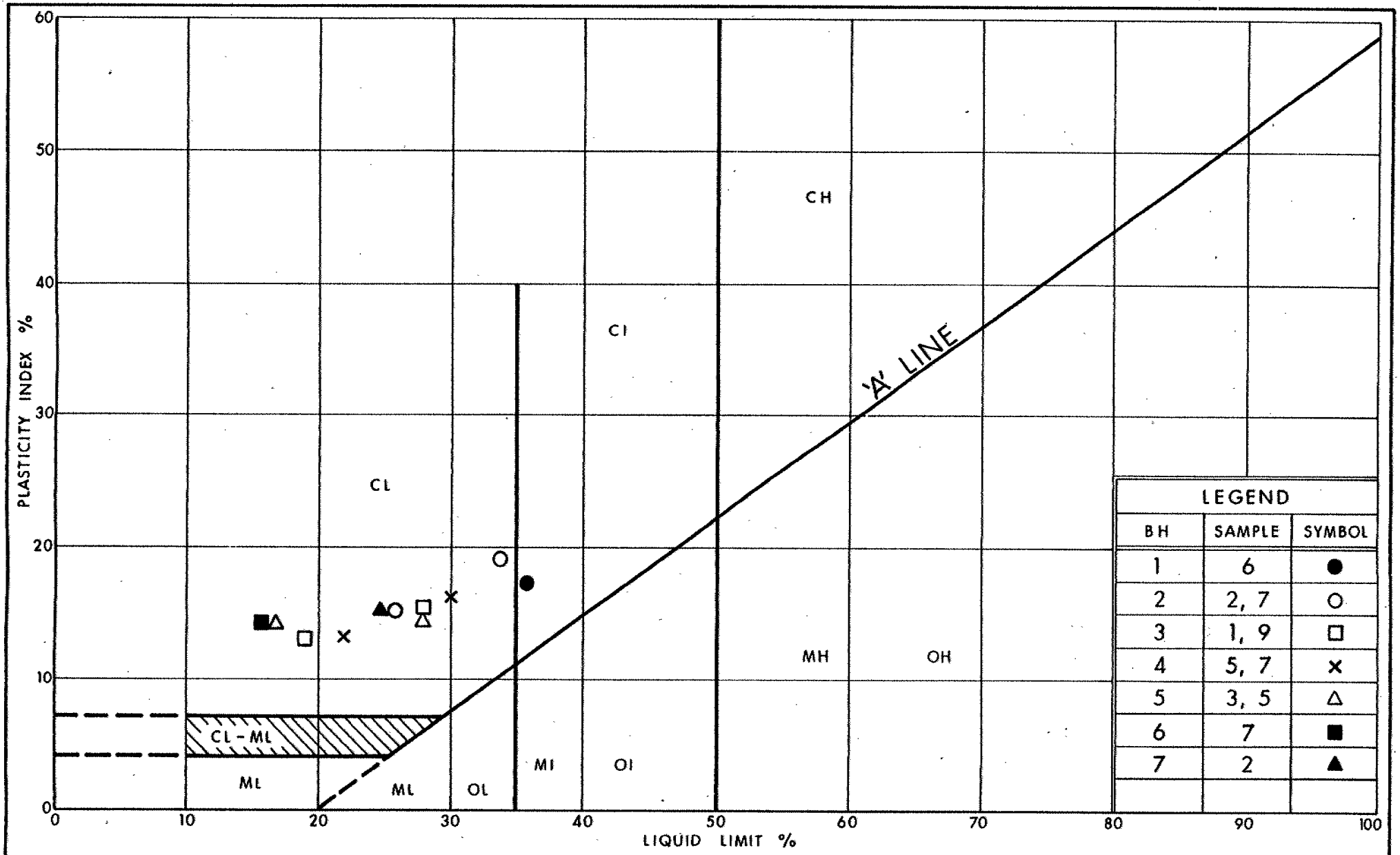
APPENDIX



Ministry of Transportation
Ontario

PLASTICITY CHART
SILTY CLAY TO CLAY

FIG No 1
W P 199-77-01



Ministry of Transportation
Ontario

PLASTICITY CHART

HET MIXTURE OF

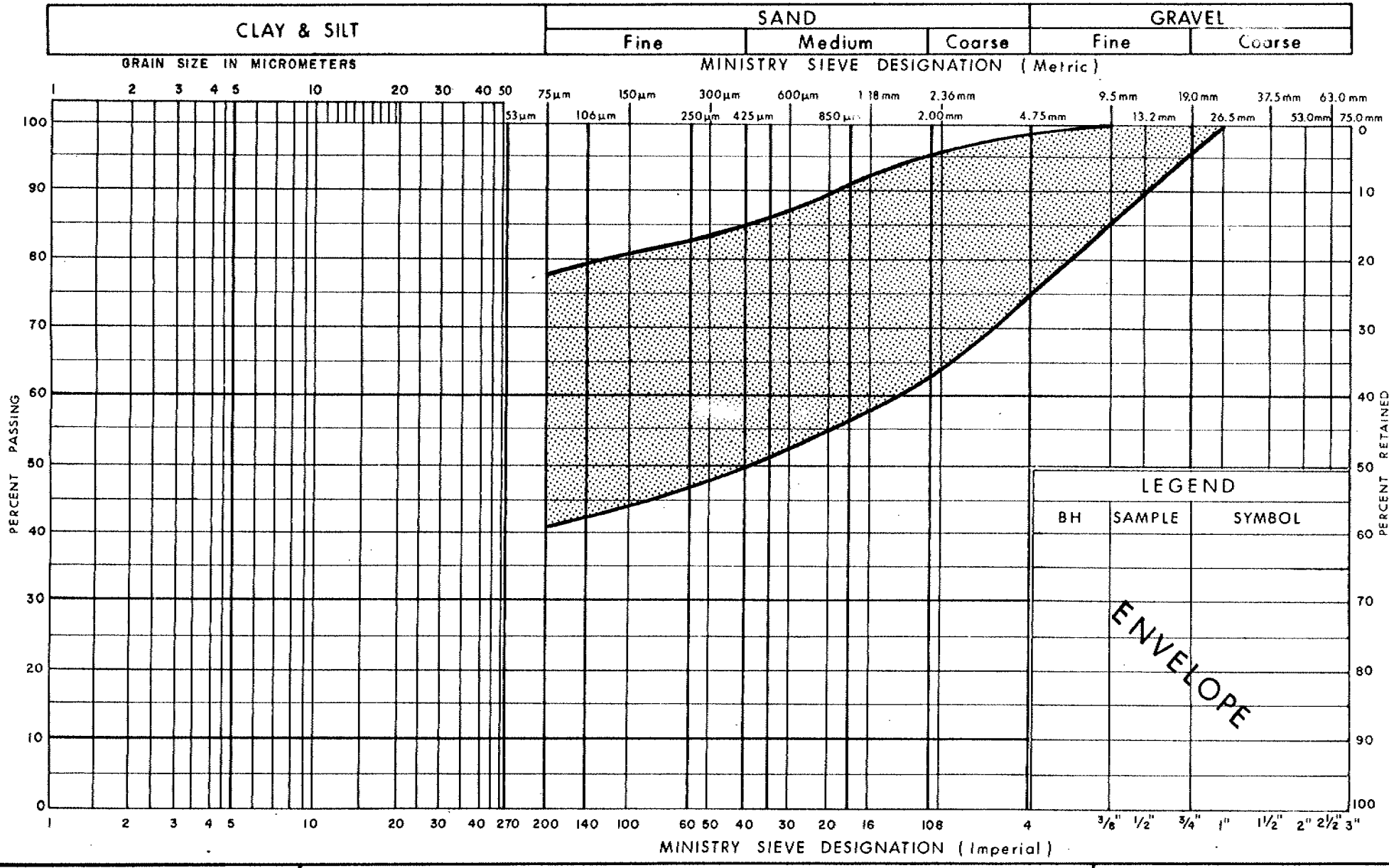
CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 2

W P 199 - 77 - 01

6

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION
HET MIXTURE OF
CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 3
W P 199 - 77 - 01
01

ROCK CORE DESCRIPTION
WP 199-77-01

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
7	5	3.05-4.57	87	7	3.05-6.10	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (18%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures extremely close to moderately close spaced, flat to near vertical, planar, smooth.
	6	4.57-6.10	92	27		

***CR** = CORE RECOVERY
***RQD** = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

RECORD OF BOREHOLE No 1 — 1 OF 1 — METRIC

W.P. 199 - 77 - 01 LOCATION CO - ORDS. N 4 799 454.0; E 277 749.5 ORIGINATED BY M V&M P
DIST 4 HWY QEW/403 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V
DATUM GEODETIC DATE 91 01 28 CHECKED BY P P

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS
108.9	Ground Surface					
0.0	SILTY CLAY, Trace of Sand, Stiff (Fill)		1	SS	11	DRY
107.1	Organics		2	SS	15	
1.8	SILTY CLAY to CLAY, Trace of Sand, Stiff		3	SS	14	
105.2			4	SS	14	
3.7	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Very Stiff to Hard (Glacial Till)		5	SS	23	
			6	SS	58	
			7	SS	78	/15cm
102.7			8	SS	109	/15cm
6.2	QUEENSTON SHALE BEDROCK Highly Weathered					
101.0			9	SS	100	/11cm
7.9	End of Borehole					

ELEVATION SCALE: 108, 107, 106, 105, 104, 103, 102

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa
o UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

120/25cm

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30

51

UNIT WEIGHT 7 kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)	GR	SA	SI	CL
	0	7	(93)	
	7	15	(78)	

$+^3$, $\times^5$: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 2 1 OF 1 METRIC

W.P. 199 - 77 - 01 LOCATION CO - ORDS. N 4 799 279.4; E 277 605.7 ORIGINATED BY M P

DIST 4 HWY QEW/403 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V

DATUM GEODETIC DATE 91 01 29 CHECKED BY P P

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
109.1	403 E/QEW Ramp Shoulder							20 40 60 80 100	10 20 30	7	
0.0						DRY *					
			1	SS	21		108				
	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Very Stiff to Stiff (Glacial Till)		2	SS	29		107		o		1 3 (96)
			3	SS	23						
			4	SS	15		106				
			5	SS	8		105	120/27cm			
	Very Stiff to Hard		6	SS	26		104				
			7	SS	51				o		14 25 (61)
			8	SS	122	/27cm	103				
101.9			9	SS	120	/8cm	102				
7.2	End of Borehole										

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15}\diamond\frac{5}{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 3 1 OF 1 METRIC

W.P. 199 - 77 - 01 LOCATION CO - ORDS. N 4 799 192.5; E 277 497.2 ORIGINATED BY M V&M P

DIST 4 HWY QEW/403 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V

DATUM GEODETIC DATE 91 01 29 CHECKED BY P P

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, x LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
109.1	Hwy. 403 Shoulder										
0.0						DRY		AUGER			
	Very Stiff to Stiff		1	SS	21		108		o ⊢		3 35 (62)
			2	SS	14						
			3	SS	10		107				
			4	SS	15		106				
			5	SS	23		105				
	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Very Stiff to Hard (Glacial Till)		6	SS	77		104	120/22cm			
			7	SS	86		103				
			8	SS	57		102				
			9	SS	120	/15cm	101		o ⊢		20 34 (46)
100.3											
8.8	End of Borehole										

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4 1 OF 1 METRIC

W.P. 199 - 77 - 01 LOCATION CO - ORDS. N 4 799 095.4; E 277 396.4 ORIGINATED BY M P

DIST 4 HWY QEW/403 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V

DATUM GEODETIC DATE 91 01 30 CHECKED BY P P

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
108.3	Ground Surface										
0.0							108				
			1	SS	21						
							107				
			2	SS	19						
							106				
			3	SS	16						
							105				
			4	SS	30						
			5	SS	87			120/25cm			13 19 (68)
	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Very Stiff to Hard (Glacial Till)						104				
			6	SS	90						
			7	SS	120	/11cm	103				
			8	SS	120/13cm	▼	102				
			9	SS	120	/1cm					
100.7							101				
7.6	End of Borehole										

+3, x5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 5 1 OF 1 METRIC

W.P. 199 - 77 - 01 LOCATION CO - ORDS. N 4 798 960.0; E 277 285.7 ORIGINATED BY M P
DIST 4 HWY QEW/403 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V
DATUM GEODETIC DATE 91 01 30 CHECKED BY P P

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
107.9	Ground Surface										
0.0	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Very Stiff to Hard (Glacial Till)					DRY	107				
			1	SS	21						
			2	SS	22		106				
			3	SS	76			120/17cm			8 26 (66)
			4	SS	70		105				
			5	SS	120	/5cm	104				25 34 (41)
			6	SS	120	/5cm					
			7	SS	130	/15cm	103				
102.0											
5.9	QUEENSTON SHALE BEDROCK, Highly Weathered		8	SS	101	/1cm	102				
101.0											
6.9	End of Borehole										

SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE

$+^3$, $\times^5$: Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 6 1 OF 1 METRIC

W.P. 199 - 77 - 01 LOCATION CO - ORDS. N 4 798 819.8; E 277 177.7 ORIGINATED BY M V&M P
DIST 4 HWY QEW/403 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V
DATUM GEODETIC DATE 91 01 28 & 91 01 29 CHECKED BY P P

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
108.4	Ground Surface										
0.0	SILTY CLAY, Trace of Sand, Trace of Gravel, Firm to Stiff		1	SS	7		108				
			2	SS	12		107				2 10 (88)
106.2											
2.2	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Very Stiff to Hard (Glacial Till)		3	SS	19		106				
			4	SS	45		105				
			5	SS	137			120/22cm			
			6	SS	100	/1cm	104				
			7	SS	105	/15cm	103		o H		18 34 (48)
			8	SS	120	/8cm ▼	102				
101.2			9	SS	120	/15cm					
7.2	QUEENSTON SHALE BEDROCK, Highly Weathered						101				
100.5			10	SS	120	/15cm					
7.9	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

20
15◇5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 7 1 OF 1 METRIC

W.P. 199 - 77 - 01 LOCATION CO - ORDS. N 4 799 627.8; E 278 280.1 ORIGINATED BY M P

DIST 4 HW QEW/403 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V

DATUM GEODETIC DATE 91 01 31 TO 91 02 04 CHECKED BY P P

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
103.6	Ground Surface										
0.0 / 102.9	ORGANIC SILT, Some Sand, Trace of Gravel					DRY	103				
0.7 / 100.9	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Very Stiff to Hard (Glacial Till)		1	SS	28						
			2	SS	120 /5cm		102	75/ 8cm			2 42 (56)
			3	SS	120 /11cm		101				
2.7	Highly Weathered		4	SS	120 /14cm						
	QUEENSTON SHALE BEDROCK Unweathered		5	RC NX	REC 87%		100				RQD 7%
97.5			6	RC NX	REC 92%		99				RQD 27%
							98				
6.1	End of Borehole										

+3, ×3 : Numbers refer to Sensitivity

15 ◇ 5 (%) STRAIN AT FAILURE (20 / 10)

FOUNDATION INVESTIGATION REPORT
For
Sign Support Structures
Q.E.W. and Hwy. 403 Interchange
W.P. 199-77-01 (A)
District 4, Burlington

INTRODUCTION

The subsoil information contained in this report was obtained from various foundation investigations carried out for existing and proposed structures in this area under W.P. 194-58, W.P. 199-77-01, W.P. 83-74-07, W.P. 199-77-02 and W.P. 516-90-02. No additional borings were carried out in the area where the sign support structures are proposed to be constructed.

SITE DESCRIPTION

The six sites for the proposed sign support structures are located within the ultimate QEW/Hwy. 403 interchange between Brant Street and King Road in the City of Burlington, Regional Municipality of Halton.

As a part of the reconstruction of the QEW/Hwy. 403 interchange, it is proposed to construct the sign support structures at various locations for directing the traffic.

This site is located within the physiographic region known as the "South Slope". The area is characterized by a ground moraine of limited relief. The bedrock underlying the site is a red shale with siltstone of the Queenston Formation.

SUBSURFACE CONDITIONS

General

The underlying subsoil in the area proposed for sign support structures consists of very stiff to hard cohesive glacial till underlain by shale bedrock of the Queenston Formation, and in addition, isolated pockets of silty clay to clay and compacted fills in the area where there are approach embankments. The extent of the area involved covers more than a kilometre in length and it is not practical to give detail description for the individual strata. Reference should be made to the Record of Borehole sheets where details of the stratification at a particular boring location are given. However, for classification purposes, the soils encountered in the project area can be divided in to four different zones.

a) Silty Clay (BH #7, Fill Material)
b) Silty Clay to Clay
c) Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)
d) Queenston Shale Bedrock

The subsurface conditions that may be expected at the proposed locations of the sign support structures, together with the field and laboratory test results are shown on the Record of Borehole sheets contained in the Appendix of this report. The results of the Atterberg Limit Test are shown on Figures 1 and 2. In addition, the Gradation Test results for cohesive glacial till deposit are shown on Figure 3 in an envelope form. The location of the boreholes are shown on the Dwg. No. 1997701(A)-1.*

Groundwater Conditions

It appears that five of the boreholes were dry during the investigations. However, in the remaining boreholes, the groundwater level is as follows:

* SHEET NO 299-1 OF THE CONTRACT DWG'S

Borehole No.	Elevation
2	101.8
3	101.9
6	103.3
8	100.7
9	101.3

Since these boreholes were not advanced at the locations where the sign support structures are proposed, the groundwater conditions may vary from those given in the Record of Borehole sheets. However, for the purposes of design, the groundwater level may be assumed at elevation 101.5 m.

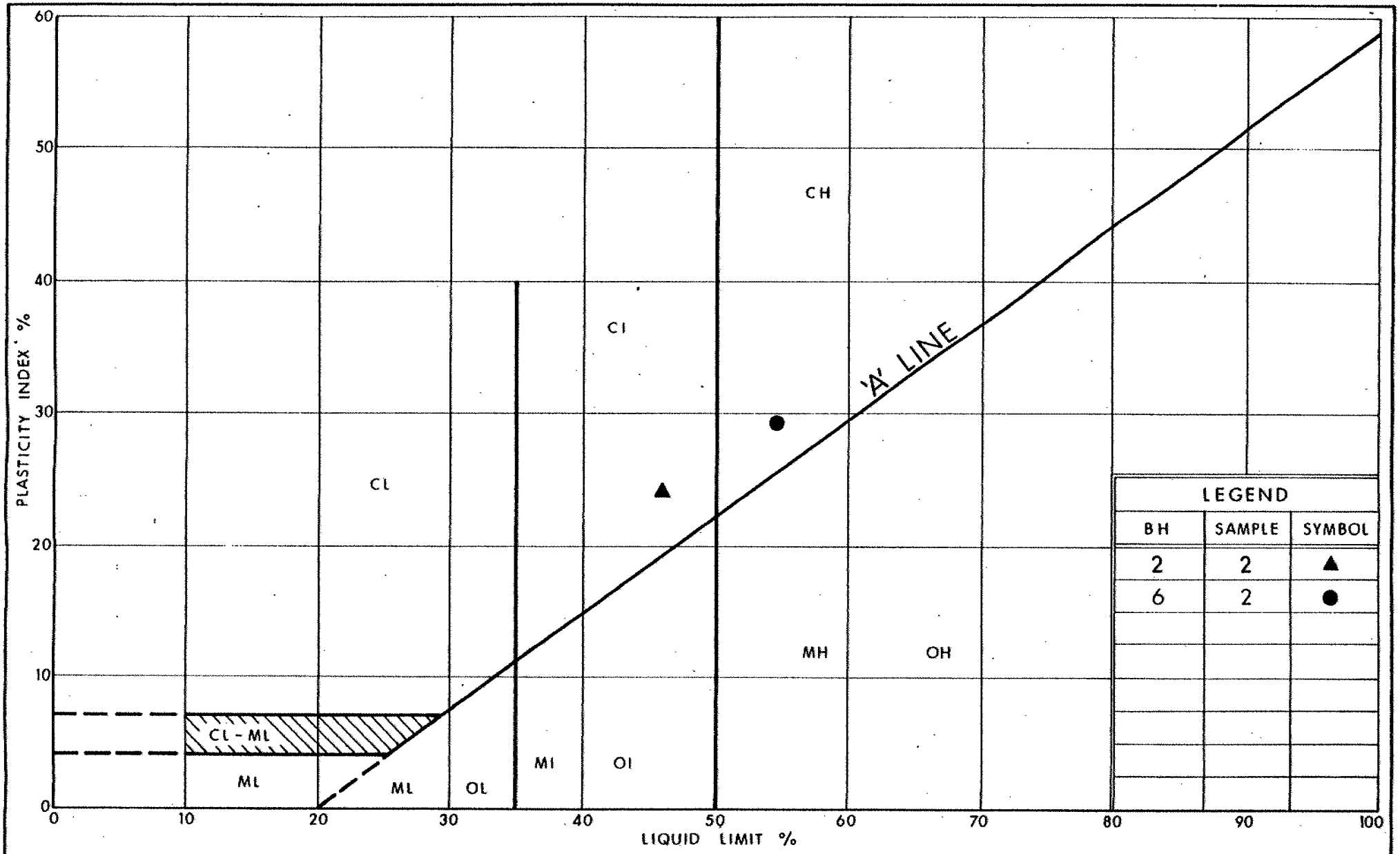
MISCELLANEOUS

This report was prepared by Mr. M. Vasavithasan, Foundation Engineer, reviewed by Mr. P. Payer, Senior Foundation Engineer, and approved by Mr. M. S. Devata, Chief Foundation Engineer.

P. Payer, P. Eng.
Senior Foundatation Engineer

M.S. Devata, P. Eng.
Chief Foundation Engineer

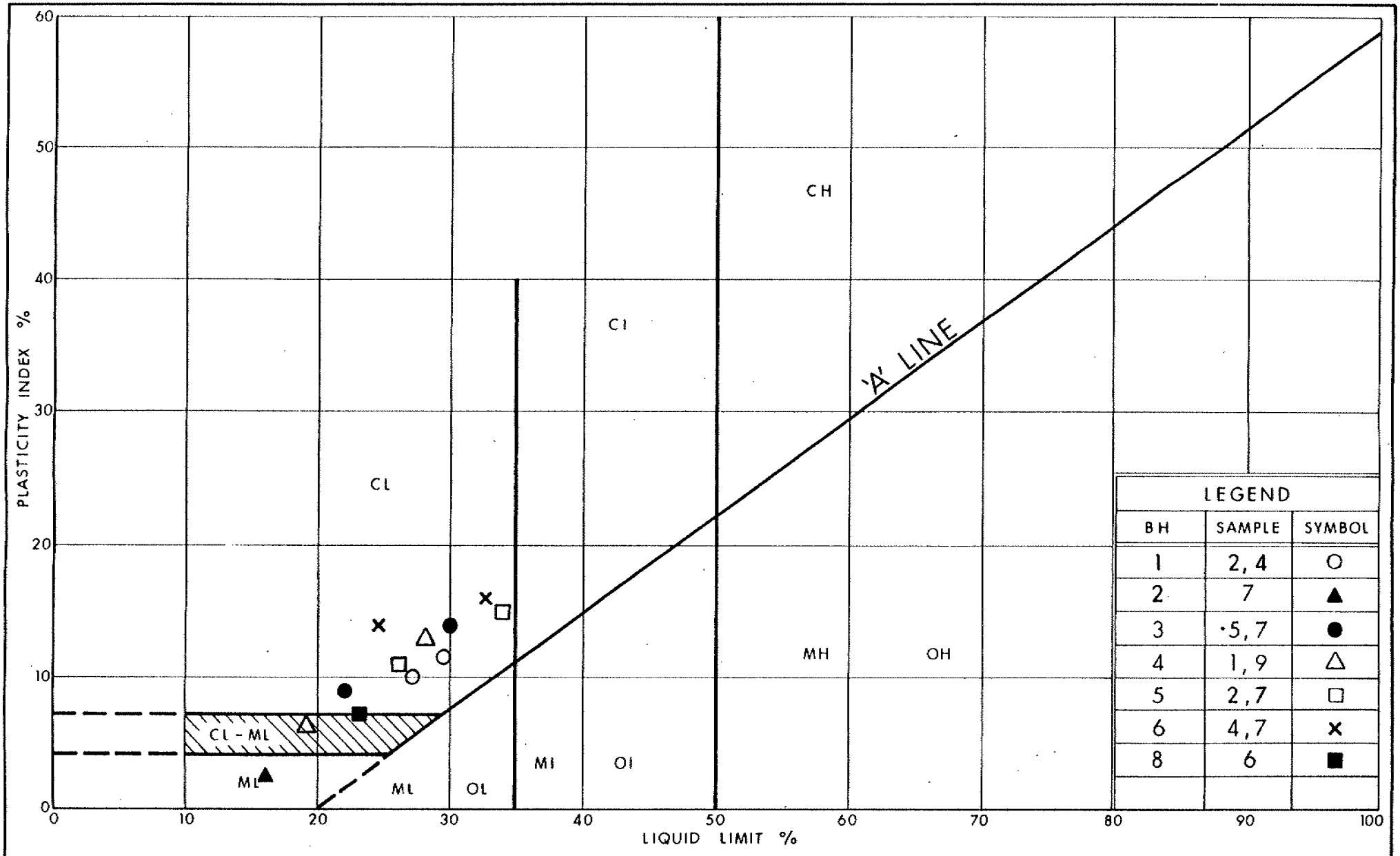
APPENDIX



Ministry of Transportation
Ontario

PLASTICITY CHART
SILTY CLAY TO CLAY

FIG No 1
W P 199-77-01 (A)

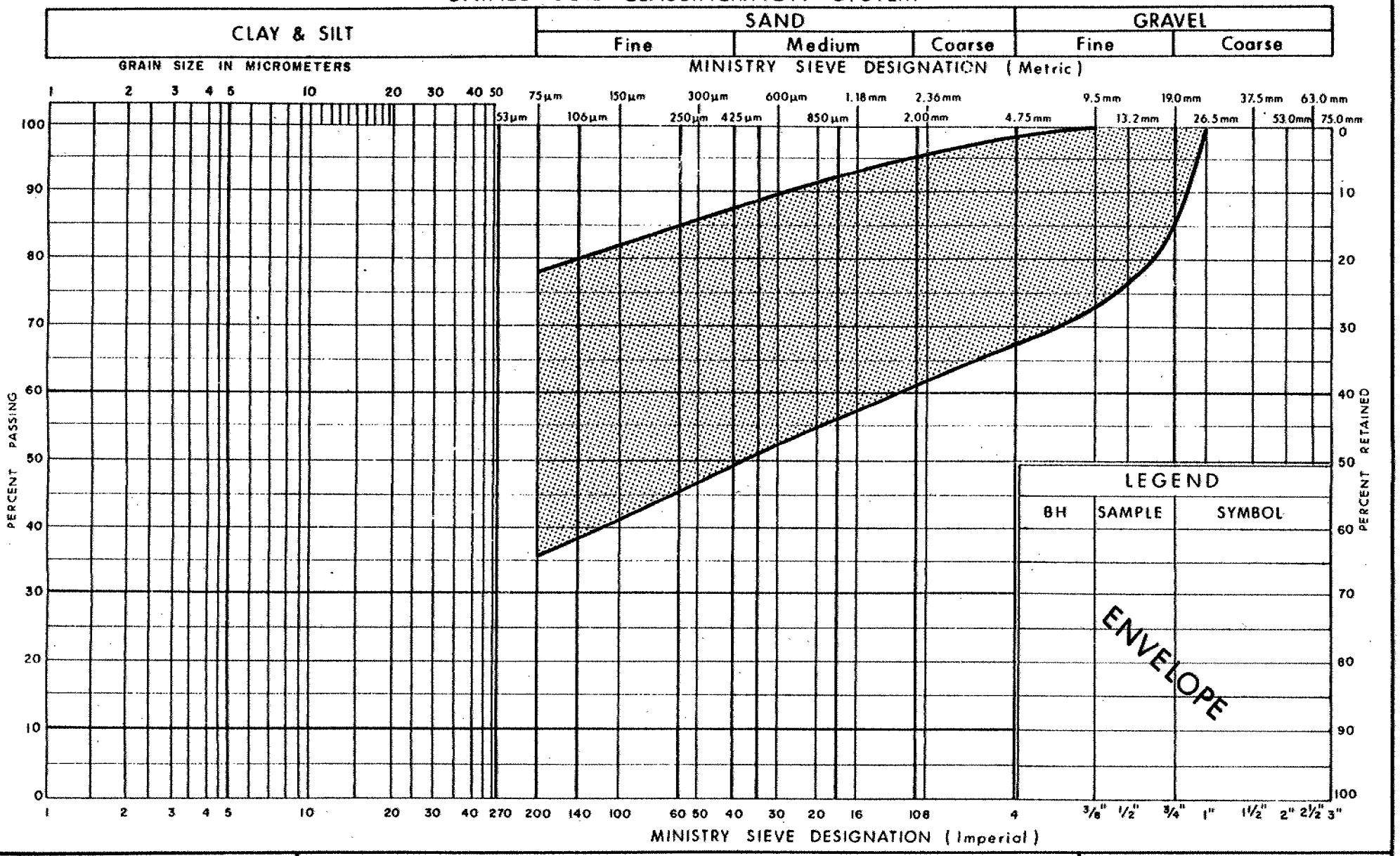


Ministry of Transportation
Ontario

PLASTICITY CHART
HET MIXTURE OF
CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 2
W P 199-77-01 (A)

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

HET MIXTURE OF

CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 3

W P 199-77-01(A)

25

RECORD OF BOREHOLE No 1 — 1 OF 1 — METRIC

W.P. 199 - 77 - 01(A) LOCATION CO - ORDS. N 4 798 594.5; E 277 027.0 ORIGINATED BY B K

DIST 4 HWY 403 BOREHOLE TYPE WASH BORING & AXL ROCK CORING COMPILED BY

DATUM GEODETIC DATE 59 07 08 CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	WATER CONTENT (%) (w_P PLASTIC LIMIT, w NATURAL MOISTURE CONTENT, w_L LIQUID LIMIT)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
110.8	Ground Surface										
0.0						*					
			1	SS	54		110			20.4	
			2	SS	75		109				
			3	SS	76		108				
			4	SS	70		107			23.4	
	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)						106				
			5	SS	111		105				
							104				
							103				
101.7			6	SS	112		102				
9.1	QUEENSTON SHALE BEDROCK, Weathered		7	RC AX	REC		101				
100.1											
10.7	End of Borehole										

* Note: Groundwater Level Not Established

Note: Formerly BH# 1 of W.P - 194 - 58

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15}\diamond\frac{5}{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 2 1 OF 1 METRIC

W.P. 199 - 77 - 01(A) LOCATION CO - ORDS. N 4 798 819.8; E 277 177.7 ORIGINATED BY M V&M P

DIST 4 HWY QEW/403 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V

DATUM GEODETIC DATE 91 01 28 & 91 01 29 CHECKED BY P P

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) / WATER CONTENT (%) (PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
108.4	Ground Surface									
0.0	SILTY CLAY, Trace of Sand, Trace of Gravel, Firm to Stiff		1	SS	7		108			
			2	SS	12		107			2 10 (88)
106.2										
2.2	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Very Stiff to Hard (Glacial Till)		3	SS	19		106			
			4	SS	45		105			
			5	SS	137			120/22cm		
			6	SS	100	/1cm	104			
			7	SS	105	/15cm	103			18 34 (48)
			8	SS	120	/8cm ▼	102			
101.2			9	SS	120	/15cm				
7.2	QUEENSTON SHALE BEDROCK, Highly Weathered		10	SS	120	/15cm	101			
100.5										
7.9	End of Borehole									
	Note: Formerly BH# 6 of W.P - 199 - 77 - 01									

$+^3$, $\times^5$; Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 3 1 OF 1 METRIC

W.P. 199 – 77 – 01(A) LOCATION CO – ORDS. N 4 799 095.4; E 277 396.4 ORIGINATED BY M P

DIST 4 HWY QEW/403 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V

DATUM GEODETIC DATE 91 01 30 CHECKED BY P P

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
108.3	Ground Surface										
0.0	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Very Stiff to Hard (Glacial Till)		1	SS	21		108				
			2	SS	19		107				
			3	SS	16		106				
			4	SS	30		105				
			5	SS	87			120/25cm			13 19 (68)
			6	SS	90		104				
			7	SS	120/11cm		103				
			8	SS	120/13cm	▼	102				
			9	SS	120/1cm		101				
100.7											
7.6	End of Borehole Note: Formerly BH# 4 of W.P – 199 –77 – 01										

+³, ×⁵ : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4 1 OF 1 METRIC

W.P. 199 - 77 - 01(A) LOCATION CO - ORDS. N 4 799 192.5; E 277 497.2 ORIGINATED BY M V&M P

DIST 4 HWY QEW/403 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V

DATUM GEODETIC DATE 91 01 29 CHECKED BY P P

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	WATER CONTENT (%) (PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
109.1	Hwy. 403 Shoulder										
0.0						DRY		AUGER			
			1	SS	21		108		o		3 35 (62)
	Very Stiff to Stiff		2	SS	14		107				
			3	SS	10						
			4	SS	15		106				
			5	SS	23		105				
			6	SS	77			120/22cm			
	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Very Stiff to Hard (Glacial Till)						104				
			7	SS	86						
			8	SS	57		103				
							102				
			9	SS	120	/15cm			o		20 34 (46)
100.3							101				
8.8	End of Borehole										

Note:
Formerly BH# 3 of W.P - 199 - 77 - 01

$+^3$, $\times^5$: Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 5 1 OF 1 METRIC

W.P. 199 - 77 - 01(A) LOCATION CO - ORDS. N 4 799 279.4; E 277 605.7 ORIGINATED BY M P

DIST 4 HWY QEW/403 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER & CONE TEST COMPILED BY M V

DATUM GEODETIC DATE 91 01 29 CHECKED BY P P

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
109.1	403 E/QEW Ramp Shoulder										
0.0						DRY *					
			1	SS	21		108				
	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Very Stiff to Stiff (Glacial Till)		2	SS	29		107		o——		1 3 (96)
			3	SS	23						
			4	SS	15		106				
			5	SS	8		105	120/27cm			
			6	SS	26						
	Very Stiff to Hard		7	SS	51		104		o——		14 25 (61)
			8	SS	122	/27cm	103				
101.9			9	SS	120	/8cm	102				
7.2	End of Borehole										
	Note: Formerly BH# 2 of W.P - 199 - 77 - 01										

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ S (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 6 1 OF 1 METRIC

W.P. 199 - 77 - 01(A) LOCATION CO - ORDS. N 4 799 228.0; E 277 831.0 ORIGINATED BY R T

DIST 4 HWY QEW/403 BOREHOLE TYPE SOLID STEM AUGER & BXL ROCK CORING COMPILED BY

DATUM GEODETIC DATE 85 02 06 CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
104.6	Ground Surface										
0.0	SILTY CLAY to CLAY, Some Sand, Some Gravel, Very Stiff		1	SS	17		104				
102.6			2	SS	16	▼	103		34.5		
2.0	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Occasional Boulders, Hard (Glacial Till)		3	SS	44		102				
			4	SS	64						
			5	SS	81	/15cm	101				3 19 48 30
			6	SS	74		100				
			7	SS	67		99				
			8	SS	100	/10cm					
97.5			9	SS	100	/23cm	98				
7.1	Weathered										
	QUEENSTON SHALE BEDROCK, Unweathered		10	RC	REC		97				
				BX	95%		96				RQD 41%
95.2											
9.4	End of Borehole										

Note:
Formerly BH# 13 of
W.P.- 83 - 74 - 07

+3, ×5 ; Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 7 1 OF 1 METRIC

W.P. 199 - 77 - 01(A) LOCATION CO - ORDS. N 4 799 370.5; E 277 934.7 ORIGINATED BY GOLDER

DIST 4 HWY QEW/403 BOREHOLE TYPE SOLID STEM AUGER COMPILED BY

DATUM GEODETIC DATE 90 08 24 CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
103.4	Ground Surface										
0.0	SILTY CLAY, Trace of Sand, Occasional Gravel, Trace of Organics, Stiff					DRY	103				
102.3	(Fill)		1	SS	12	*			○		
1.1	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)		2	SS	73		102		○		
			3	SS	37		101		○		
			4	SS	50 /8cm				○		
			5	SS	50 /5cm		100		○		
99.0							99				
98.7	QUEENSTON SHALE BEDROCK		6	SS	50 /10cm				○		
4.7	End of Borehole										

Note:
Formerly BH# 22 of W.P - 199 - 77 - 02

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 8 1 OF 1 METRIC

W.P. 199 - 77 - 01(A) LOCATION CO - ORDS. N 4 799 341.0; E 278 002.0 ORIGINATED BY R T

DIST 4 HWY QEW/403 BOREHOLE TYPE SOLID STEM AUGER & BXL ROCK CORING COMPILED BY

DATUM GEODETIC DATE 85 02 08 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
102.2	Ground Surface										
0.0	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Very Stiff to Hard (Glacial Till)		1	SS	24	▼	102				
			2	SS	51		101				
			3	SS	69		100				14 22 46 18
			4	SS	100 /15cm		99				17 28 45 10
	Silty Sand		5	SS	100 /23cm		98	o			
			6	SS	100 /8cm			o			
96.6	Silty Sand		7	SS	100 /10cm		97				
5.6	Weathered										
	QUEENSTON SHALE BEDROCK, Unweathered		8	RC	REC		96				RQD 88%
94.9				BX	98%		95				
7.3	End of Borehole										

Note:
Formerly BH# 8 of
W.P - 83 - 74 - 07

+³, ×⁵ : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 9 1 OF 1 METRIC

W.P. 199 - 77 - 01(A) LOCATION CO - ORDS. N 4 799 687.0; E 278 325.5 ORIGINATED BY GOLDER

DIST 4 HWY QEW/403 BOREHOLE TYPE HOLLOW STEM AUGER & NQ ROCK CORING COMPILED BY

DATUM GEODETIC DATE 90 08 15 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
103.7	Ground Surface										
0.0	Topsoil										
0.3	Completely to Highly Weathered						103				
			1	SS	96						
	Moderately to Slightly Weathered						102				
			2	RC NQ	REC 92%						RQD 23%
	QUEENSTON SHALE BEDROCK						101				
			3	RC NQ	REC 97%		100				RQD 56%
99.0							99				
4.7	End of Borehole										

Note:
Formerly BH# 5 of
W.P - 516 - 90 - 02

90 09 14
* GROUND WATER CONDITIONS

PIEZO. NO.	GROUND WATER ELEVATION (Metres)
1	101.27

$+^3$, $\times^5$: Numbers refer to Sensitivity

$15 \diamond^{20}_{10} 5$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 10 1 OF 1 METRIC

W.P. 199 - 77 - 01(A) LOCATION CO - ORDS. N 4 799 668.5; E 278 331.5 ORIGINATED BY GOLDER

DIST 4 HWY QEW/403 BOREHOLE TYPE CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY

DATUM GEODETIC DATE 90 08 14 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
103.4	Ground Surface										
0.0 / 102.9	Topsoil					DRY	103				
0.5	Completely to Highly Weathered		1	SS	64				○		
			2	SS	70	/15cm	102		○		
	Moderately to Slightly Weathered		3	SS	60	/8cm					
	QUEENSTON SHALE BEDROCK						101				
100.3			4	SS	50	/3cm					
3.1	End of Borehole										

Note:

Formerly BH# 4 of

W.P - 516 - 90 - 02

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15}\diamond^{5}_{10}$ (%) STRAIN AT FAILURE

FOUNDATION INVESTIGATION REPORT
For
Culvert #5, W.P. 199-77-01B
Hwy. 403/Q.E.W. (Freeman) Interchange
District 4, Burlington

INTRODUCTION

This report summarizes the results of a Foundation Investigation conducted in conjunction with the reinforced concrete box culvert (culvert #5) proposed at the Hwy. 403/Q.E.W. (Freeman) Interchange. The culvert will carry the Q.E.W./E - 403/W ramp, Q.E.W. WBL and Q.E.W. EBL and will transmit its waters to the constructed culvert #6 located along the same channel and immediately south of culvert #5.

SITE DESCRIPTION AND GEOLOGY

The site of the proposed culvert is located along the Q.E.W. corridor approximately 0.5 km west of Brant St. in the City of Burlington, Regional Municipality of Halton. The culvert is a component of the Hwy. 403/Q.E.W. interchange and is one of many structures proposed at the interchange. At the time of the investigation, a number of construction activities associated with the construction of the Q.E.W./Hwy. 403 EB ramp structures were in progress immediately west of the proposed culvert #5. The Q.E.W. ramp to Niagara and the existing Hwy. 403 WB is also located immediately west of the site.

The roadways present at the site are separated by grass covered medians and drainage ditches. The roadways include the Q.E.W. Westbound and Eastbound lanes, the Hwy. 403 WB-Q.E.W. EB ramp and the Brant St. S. - Hwy. 403 WB ramp. An existing hydro electric corridor is located south of the site and the existing North Service Rd. is located north of the site.

The terrain surrounding the site is generally flat and consists of grassland and a few isolated deciduous trees in the areas beyond the construction site and existing roadways.

Physiographically, the site is located in the region known as the "Iroquois Plain". The Iroquois Plain is the product of the advance and retreat of the Wisconsinan ice sheet which covered the area during the Pleistocene epoch (over 12,000 years ago). At the site, the lowland bordering Lake Ontario, when the last glacier was receding, was inundated by the glacial lake called Lake Iroquois. Conditions in the old lake plain vary greatly from site to site. At the site location, a thin veneer of a heterogeneous mixture of clayey silt, sand and gravel overlies shale bedrock of the Queenston Formation.

INVESTIGATION PROCEDURE

The field work for the investigation was carried out between 92 03 23 and 92 03 25 inclusive and consisted of three (3) sampled boreholes advanced to depths ranging from 9.1 m to 9.4 m below the existing ground surface. A track mounted Diedrich D50 drilling unit, equivalent to a CME 55, was used to advance the boreholes. Solid stem augering techniques were used to penetrate the overburden and the surficial weathered bedrock. Rock coring techniques employing BW casing and a BQ core barrel were used to retrieve up to 6.1 metres of rock core.

In view of the shallow thicknesses of overburden at the site, most of the field program consisted of rock coring. Rock core were identified in the field and physical index properties were determined by visual examination and also by measurement of rock quality designations (RQD's) and core recovery. All rock core were placed in standard rock core boxes and carefully transported to the laboratory.

The few subsoil samples that were obtained were retrieved using a standard split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586). In general, subsoil samples were retrieved at 0.7 m intervals for the surficial 3 metres. Subsoil samples were identified in the field and then placed in sealed plastic jars to ensure the preservation of the in-situ natural moisture contents. Samples were subsequently transported to the laboratory for further examination and testing.

Groundwater levels were determined by monitoring the water levels in the open boreholes throughout the duration of the field investigation. All boreholes were backfilled upon completion of the field work.

The survey related to the location and elevation of the individual boreholes was provided by Central Region Surveys and Plans.

Laboratory Analyses

All subsoil samples were carefully visually examined in the laboratory in accordance with the procedures outlined in the Visual Method described in Chapter 2 of the MTO Soil Classification Manual. The behaviour, gradation and other pertinent properties of the soil were determined by conducting the appropriate laboratory tests on representative samples. These tests included:

1) Atterberg Limit Tests
2) Particle Size Analysis
3) Natural Moisture Contents
4) Bulk Unit Weights

Sample preparation and testing were conducted in accordance with the MTO Laboratory Testing Manual.

Detailed rock core logging was conducted in the laboratory by an in-house resident geologist.

Laboratory test results have been summarized below in the subsequent section of this report entitled "Subsurface Conditions" and are illustrated on the corresponding boreholes and figures included in the Appendix to this report.

Subsurface Conditions

The existing ground surface elevation at the site varies between 106 m to 107.5 m reflecting the presence of the roadways and adjoining drainage ditches. The

subsurface conditions, however, are generally uniform across the site and consists of a natural thin veneer of a cohesive heterogeneous mixture of clayey silt, sand and gravel with a thickness of approximately 1.2 to 1.8 metres overlying completely to highly weathered shale ranging up to 2 metres in thickness which in turn is underlain by more competent shale bedrock with interbedded siltstone. Shallow thicknesses of brown sand and gravel fill material up to approximately 0.8 metres are also present as encountered in the boreholes advanced adjacent to the roadway.

The boundaries between the various soil types, in-situ and laboratory test results as well as groundwater levels established at the time of investigation, are shown on the attached Record of Borehole sheets in the Appendix. A plan of the site illustrating the locations and elevations of the boreholes and a subsoil stratigraphical section are provided on Dwg. 1997701B-A*.

A detailed description of the subsurface conditions encountered is given below.

Sand and Gravel (Fill Material)

A brown, compact sand and gravel fill material exists as a roadway base at various locations across the site. The thickness of this fill material encountered was approximately 0.8 metres.

Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)

The surficial native deposit spread across the site consists of a heterogeneous mixture of clayey silt, sand and gravel of thickness up to approximately 1.8 metres. Boulders and cobbles, although not encountered during the investigation, are characteristic components of the deposit and hence may exist in this deposit. This deposit directly overlies the shale bedrock across the site and fragments of the parent rock are often found suspended within the lower depths of the cohesive matrix of this till deposit of glacial origin.

* SHEET NO 153-1 OF THE CONTRACT DWG'S

The deposit has been oxidized and therefore, is primarily brown in colour. In the lower metre or so of the deposit however, the deposit has a red colour characteristic of the underlying Queenston Shale.

The main component of this unsorted unstratified deposit is the clayey silt material. This material essentially binds the coarser sands and gravels within the deposit. Grain size distribution curves of representative samples of this material as determined by mechanical sieve and hydrometer analyses are given in Figure 1 in the Appendix. The curves illustrate that the fine grained portion of the deposit exceeds 50% of the deposit and hence the deposit is defined by its behaviour.

Atterberg Limit tests were carried out to define the behaviour and plasticity of the fine grained portion of the soil and the results are plotted in Figure 2. The test results reveal that the fine grained portion of the deposit is of low plasticity and hence is categorized as clayey silt. Liquid limits range from 26% to 31% and plasticity indices range from 11% to 13%. Natural moisture contents are slightly less than the plastic limit of the soil.

Standard Penetration tests conducted in this deposit produced "N" values ranging from 13 blows/0.3 m to 33 blows/0.3 m. Based on these "N" values, it can be concluded that the deposit has a consistency ranging from stiff to hard.

Bedrock

The overburden across the site is underlain by shale bedrock with interbedded siltstone of the Queenston Shale Formation. The depth to bedrock ranges from approximately 1.2 m to 2.6 m, equivalent to elevations ranging from 105.5 m to 104.3 m. Based on these elevations, it appears that the bedrock surface slopes slightly downward in a southerly direction. The surficial 1 to 2 metres of the bedrock were severely degraded and weathered. Solid stem augering techniques was used to penetrate this upper severely weathered zone and split spoon samples were retrieved albeit with considerable penetration resistance (typically 100 blows/0.15 m). More competent shale exists beneath the highly weathered zone and

below elevations ranging from 103.5 to 103,7 m, the bedrock is unweathered.

The shale bedrock is generally greyish red and has randomly interbedded greenish grey siltstone layers ranging from approximately 25 mm to 200 mm in thickness. The rock is horizontally bedded and is an extremely friable material with a very low slaking durability. The rock contains close to extremely close spaced fractures that are generally flat, planar to undulating and smooth.

Core recoveries and Rock Quality Designations (RQD's) were determined in-situ to evaluate the competence and integrity of the rock. Core recoveries ranged from 78% to 100% but, were generally close to 100%. Rock Quality Designations (RQD's) ranged from 0% to 98% indicating a rock quality ranging from very poor to excellent. However, in general rock qualities were in the 50% to 90% indicating a rock of fair to good quality. Rock quality generally improved with depth.

Rock strength as determined by index property examination in the laboratory is generally weak to very weak.

A detailed description of the characteristics and properties of the rock as determined by the logging of the rock core in the laboratory is attached in the Appendix under the heading "Rock Core Descriptions".

GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water level in the open boreholes throughout the duration of the field investigation. Groundwater levels determined at the time of investigation were uniform across the site and were approximately 2.5 m to 2.7 m below the ground surface (Elevation 104.4 m to 104.0 m).

Groundwater levels, in general, are subject to seasonal fluctuations and hence can vary from the values given in this report.

MISCELLANEOUS

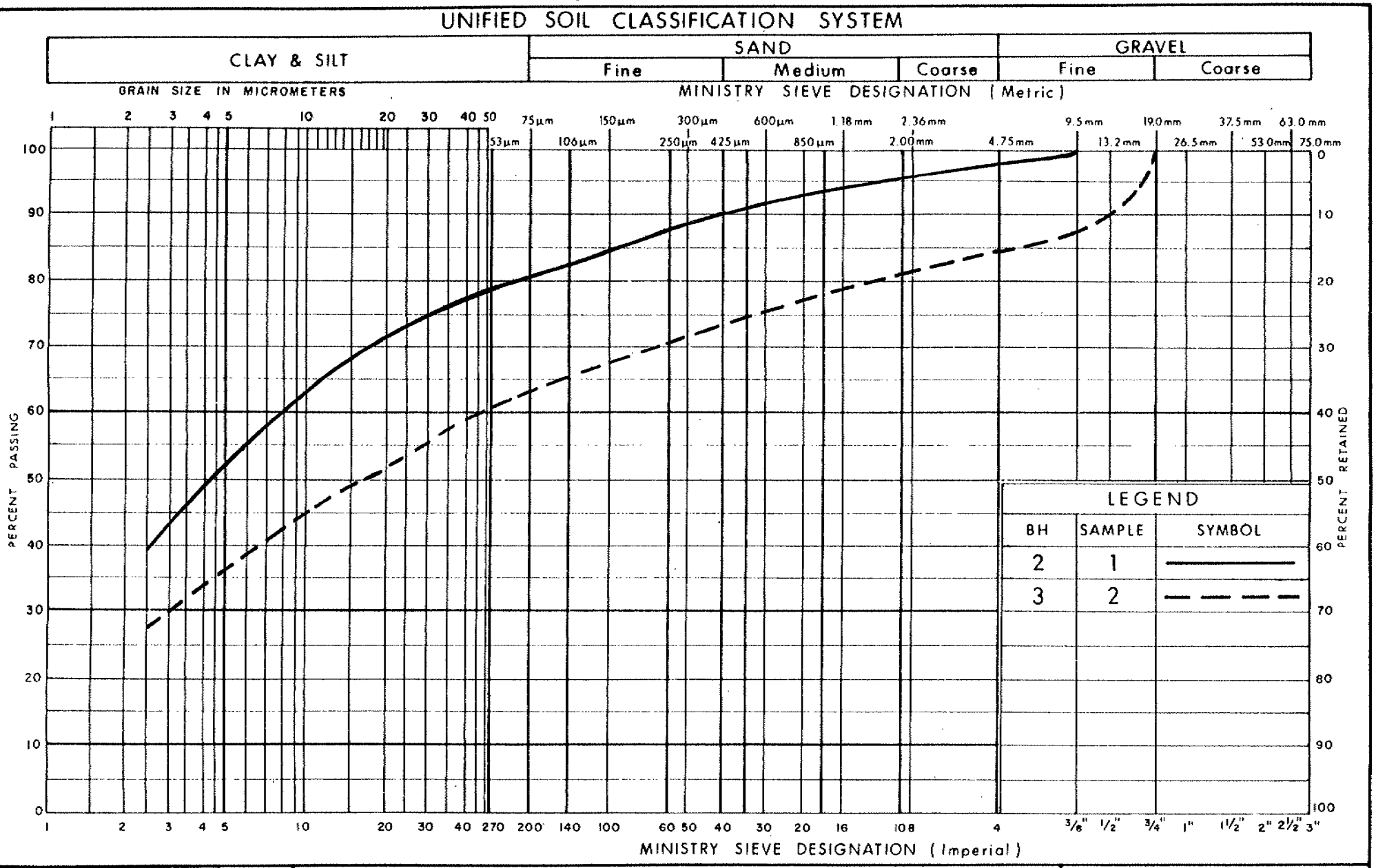
The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano, Foundation Engineer, utilizing equipment owned and operated by Master Soils Investigation.

The project was carried out by T. Sangiuliano under the general supervision of P. Payer, Senior Foundation Engineer. The report was written by T. Sangiuliano, reviewed by P. Payer and approved by Mr. M.S. Devata, Chief Foundation Engineer.

P. Payer, P. Eng.
Senior Foundatation Engineer

M.S. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

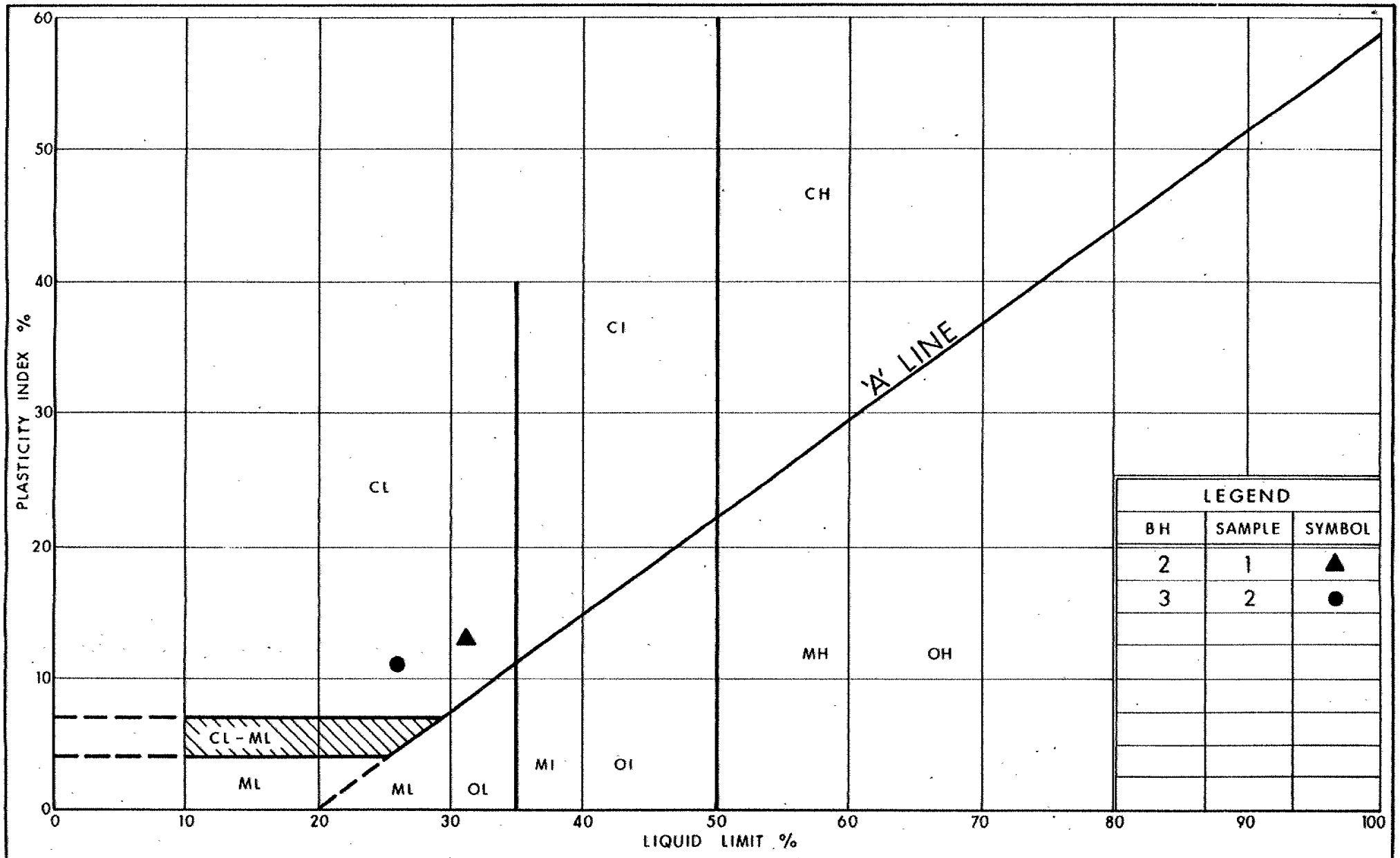
HETEROGENEOUS MIXTURE OF

CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 1

W P 199 - 77 - 01 B

444



Ministry of Transportation
Ontario

PLASTICITY CHART
HETEROGENEOUS MIXTURE OF
CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 2
W P 199-77-01B

ROCK CORE DESCRIPTION
WP 199-77-01B

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	4	3.20-4.72	95	43	3.20-9.30	**SHALE**, greyish red, with interbedded greenish grey **SILTSTONE** (17%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures moderately close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	5	4.72-6.25	100	78		
	6	6.25-7.77	98	64		
	7	7.77-9.30	100	88		
2	5	3.20-4.72	78	0	3.20-9.09	**SHALE**, greyish red, with interbedded greenish grey **SILTSTONE** (17%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures moderately close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	6	4.72-6.25	98	70		
	7	6.25-7.77	97	88		
	8	7.77-9.09	100	81		
3	5	3.28-4.80	98	0	3.28-9.37	**SHALE**, greyish red, with interbedded greenish grey **SILTSTONE** (17%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures moderately close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	6	4.80-6.32	100	58		
	7	6.32-7.85	100	88		
	8	7.85-9.37	100	98		

***CR** = CORE RECOVERY
***RQD** = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

RECORD OF BOREHOLE No 1 1 OF 1 METRIC

W.P. 199-77-01B LOCATION Co-ords: N 4 799 837 E 278 240 ORIGINATED BY TS

DIST 4 HWY QEW BOREHOLE TYPE SS Auger, BW Casing, BQ Rock Core COMPILED BY TS

DATUM Geodetic DATE 92 03 23 CHECKED BY PP

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
106.7	Ground Surface										
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)										
105.5	Brown, Hard		1	SS	33		106				
1.2			2	SS	100	/15cm					
	Weathered					▼*	104				
	Unweathered		3	SS	100	/15cm					
	Shale Bedrock with interbedded Siltstone Red with interbedded Grey, Weak to Very Weak		4	RC	REC 95%						RQD = 43%
			5	RC	REC 100%		102				RQD = 78%
			6	RC	REC 98%		100				RQD = 64%
			7	RC	REC 100%		98				RQD = 88%
97.4											
9.3	End of Borehole										
	▪ 92 03 26										

+³, ×⁵: Numbers refer to Sensitivity

15 20 10 S (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 2 1 OF 1 METRIC

W.P. 199-77-01B LOCATION Co-ords: N 4 799 795 E 278 268 ORIGINATED BY TS

DIST 4 HWY QEW BOREHOLE TYPE SS Auger, BW Casing, BQ Rock Core COMPILED BY TS

DATUM Geodetic DATE 92 03 24 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
106.9	Ground Surface										
0.0	Sand and Gravel (Fill Material)										
106.1	Brown										
0.8	Heterogenous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Brown		1	SS	13		106			22.2	2 17 44 37
	Red		2	SS	20						
104.6	Stiff to Very Stiff		3	SS	100 /15cm	▼*					
2.3	Weathered / Unweathered		4	SS	100 /15cm		104				
	Shale Bedrock with interbedded Siltstone Red with interbedded Grey, Weak to Very Weak		5	RC	REC 78%						RQD = 0%
			6	RC	REC 98%		102				RQD = 70%
			7	RC	REC 97%		100				RQD = 88%
			8	RC	REC 100%						RQD = 81%
97.8							98				
9.1	End of Borehole										
	* 92 03 26										

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 3 1 OF 1 METRIC

W.P. 199-77-01B LOCATION Co-ords: N 4 799 742 E 278 288 ORIGINATED BY TS

DIST 4 HWY QEW BOREHOLE TYPE SS Auger, BW Casing, BQ Rock Core COMPILED BY TS

DATUM Geodetic DATE 92 03 25 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
106.9	Ground Surface										
0.0	Sand and Gravel (Fill Material)										
106.1	Brown										
0.8	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Stiff to Very Stiff		1	SS	14		106				
			2	SS	16				o——	21.6	15 22 38 25
	Brown										
104.3	Red		3	SS	80	▼*					
2.6							104				
	Weathered		4	SS	60	/8cm					
	Unweathered		5	RC	REC 98%						RQD = 0%
							102				
	Shale Bedrock with interbedded Siltstone		6	RC	REC 100%						RQD = 58%
	Red with interbedded Grey, Weak to Very Weak		7	RC	REC 100%		100				RQD = 88%
			8	RC	REC 100%		98				RQD = 98%
97.5											
9.4	End of Borehole										
	* 92 03 26										

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
$\frac{}{10}$

GEOTECHNICAL INVESTIGATION
PROPOSED BRIDGE NO. 37
SITE 10-332
FREEMAN INTERCHANGE
BURLINGTON, ONTARIO
W.P. 199-77-02 DISTRICT 4

1. INTRODUCTION

Golder Associates Ltd. has been retained by the Ministry of Transportation of Ontario (MTO) to carry out a series of site specific subsurface investigations for the design of structures for the proposed reconstruction of the Freeman Interchange in Burlington, Ontario. This report presents the results of a subsurface investigation carried out at the site of the proposed Bridge No. 37. As presently proposed, Bridge 37 will carry the 403 West/QEW East Ramp traffic over the 403 East/QEW South traffic as shown on the Key Plan, Drawing 1997702-A*.

The purpose of the investigation was to determine the subsurface conditions at the site.

2. SITE AND PROJECT DESCRIPTION

The site of the proposed Bridge 37 is situated north of the existing 403 west bound lanes and west of the existing QEW south bound lanes as shown on Drawing 1997702-A*. The proposed alignment of the bridge is generally in an east-west orientation, traversing an existing drainage course to the west and the existing QEW southbound lanes to the east.

The bridge will consist of a three span structure with a central span of 26 metres and end spans each 16 metres in

* SHEET NO 393 OF THE CONTRACT DWG'S

length. An existing drainage course is situated between the proposed west abutment and west pier The proposed east pier would be situated immediately adjacent to the existing QEW southbound lanes. The elevation of the existing QEW southbound lanes is about 2 to 3 metres below the elevation of the existing ground surface at the proposed abutments and west pier.

The site is situated within the physiographic region of Southwestern Ontario known as the Iroquois Plain. Available geologic information indicates that the overburden in the general area of the site consists of a thin veneer of sands, glacial till and/or residual soil derived from the weathering of the underlying shale bedrock. The Queenston shale formation which comprises the bedrock in the area generally consists of thinly bedded red shale with occasional bands of grey limestone.

3. INVESTIGATION PROCEDURE

The field work for this investigation was carried out between August 16 and August 22, 1990 during which time one test pit was excavated and four boreholes were drilled. The locations of the boreholes (numbered 19, 20, 21 and 22) and test pit (number 7) are shown on Drawing 1997702-A.*

The initial stage of the field work consisted of excavating a test pit north of the proposed west abutment. The test pit was excavated using a "John Deere 690" hydraulic backhoe supplied and operated by a local contractor. Chunk samples were obtained from the predominant soil strata exposed in the

* SHEET NO 393 OF THE CONTRACT DWG'S

test pit. The test pit was loosely backfilled following sampling and logging.

The boreholes were drilled using track mounted power auger drillrigs equipped for rotary drilling and supplied by a specialist drilling contractor. Boreholes 20 and 21 fully penetrated the overburden and were core drilled in NQ size some 3 metres into the bedrock. Boreholes numbered 19 and 22 were drilled to practical auger refusal. The boreholes were advanced within the overburden and the upper portion of the bedrock using both nominal 150 millimetre outside diameter hollow stem augers and nominal 100 millimetre diameter solid stem augers. Standard penetration testing and sampling was carried out within the overburden encountered in the boreholes using 35 millimetre inside diameter split spoon sampling equipment.

Samples of the overburden and the rock core recovered from the test pit and boreholes were taken to our Hamilton laboratory for examination and classification testing. Water contents were determined on samples of the overburden. Grain size analyses and Atterberg limits determinations were carried out on selected samples of the overburden.

The soil and rock stratigraphy encountered in the boreholes and test pit are shown in detail on the Records of Boreholes and Records of Test Pit following the text of this report and on Drawing 1997702-A*. The results of the field and laboratory testing are also shown on the Record of Borehole and Record of Test Pit sheets, and on Figures 1 and 2.

* SHEET NO 393 OF THE CONTRACT DWG'S

Groundwater levels were observed in the open boreholes during drilling and in the test pit during and after excavation. A piezometer was installed in borehole 20 as detailed on the Record of Borehole sheet. Notes pertaining to the groundwater conditions encountered in the boreholes and test pits are shown on the Records of Boreholes and Test Pit and on Drawing 1997702-A*.

The locations and ground surface elevations at the boreholes and test pit have been determined by Golder Associates staff with reference to site specific points and bench marks provided by McCormick Rankin & Associates Limited. The elevations provided are understood to be referred to geodetic datum. The final locations and ground surface elevations at the boreholes were subsequently verified by McCormick Rankin.

4. SUBSURFACE CONDITIONS

4.1 General

The subsurface conditions encountered in the boreholes and test pit put down at the site are shown in detail on the Records of Borehole and Record of Test Pit sheets and in summary form on Drawing 1997702-A*. The soil boundaries and rock stratigraphy indicated, particularly for the boreholes, are inferred from non-continuous sampling and resistance to auger advance. These boundaries typically represent a transition between one soil or rock type to another and are not intended to define an exact plane of geological change. Conditions will vary between and beyond the borehole and test pit locations.

* SHEET NO 393 OF THE CONTRACT DWG'S

The subsurface conditions encountered at the site generally consisted of fill and topsoil and surficial sand strata, overlying glacial till and completely to highly weathered shale underlain by more competent shale bedrock.

The following discussion has been simplified in terms of major soil and rock strata for the purposes of geotechnical design.

It should be noted that due to the relatively soft and weathered nature of the Queenston shale formation, particularly the upper zone, together with the effects of glacial overriding at the bedrock surface, it can be difficult to accurately define the bedrock surface both from a geological and a contractual standpoint.

During the course this investigation, a stratigraphic unit directly overlying the shale bedrock, which in strictly geological terms is described as deformation till, has been encountered. This stratigraphic unit consists of an imbricate embedment of fragments of bedrock in a till matrix which has been formed from glacial overriding of the parent bedrock. This till is characterized by the presence of rounded and sub-angular clasts of the parent rock with non horizontal bedding. Based on the consistency, the relatively high penetration resistance encountered in the boreholes and the difficulty of excavation experienced in the test pits, this stratum could be contractually interpreted as a zone of the bedrock and for this reason has been referred to in this report as an upper zone of the bedrock formation.

4.2 Topsoil

A relatively thin layer of topsoil was encountered at the ground surface in boreholes 19 and 20, and in test pit 7.

4.3 Silty Clay, trace sand, trace to some topsoil, occ. gravel (Fill)

Fill was encountered to depths of about 0.8 to 1.2 metres below the existing ground surface in boreholes 19, 21, 22 and test pit 7. The fill, generally consisted of silty clay with traces of topsoil and occasional gravel. Two standard penetration tests carried out in the silty clay fill resulted in "N" values of 8 and 12 blows per 0.3 metres indicating a firm to stiff consistency. Samples of the silty clay fill recovered from the standard penetration testing had in-situ water contents of about 32 per cent.

4.4 Silty Sand

A layer of silty sand was encountered beneath the fill in boreholes 19 and 22 and in test pit 7 and underlying the topsoil in borehole 20. N values of 6 and 12 blows per 0.3 metres were measured in two standard penetration tests carried out in the silty sand indicating a loose to compact consistency. The silty sand had natural water contents ranging from about 9 to 28 per cent.

4.5 Clayey Silt, trace to some sand, occ. gravel (Till)

Glacial till was encountered in all of the boreholes and in

the test pit and is generally characterized by an upper zone of hard brown to grey clayey silt and a lower zone of reddish brown clayey silt which is somewhat harder and slightly coarser than the overlying till. The upper till was not encountered in borehole 21 drilled near the proposed east pier location (where the ground surface elevation is some 3 metres lower than at the other borehole locations).

The N values determined in the upper till zone ranged from 18 to 91 blows per 0.3 metres. The natural water content of samples of the upper till recovered from the boreholes and test pit ranged from about 8 to 11 per cent.

Standard penetration testing was also carried out in the lower till zone, but due to its hard consistency it was not practical to advance the sampler the entire 450 millimetres required to establish an N value. However, N values of the order of greater than 100 blows per 0.3 metres can generally be inferred from the penetration testing. The natural water content of the lower till typically ranged from about 8 to 12 per cent.

The corresponding liquid and plastic limits of the lower till as shown on the plasticity chart, Figure 2, were about 29 and 17 per cent respectively based on a single Atterberg Limit determination. A grain size distribution curve for a sample (obtained by a 35 millimetre I.D. sampler) of the lower till is shown on Figure 1.

The till material as indicated by the gradation curve is fine grained in nature and no major concentrations of coarse

particles such as boulders were encountered during this investigation. This does not necessarily mean that the coarser particle sizes are not present at random or in concentrations within the deposit since till is an inherently variable material.

4.6 Shale, completely to slightly weathered (Bedrock)

The overburden encountered in the boreholes and test pit is underlain by shale bedrock of the Queenston Formation. Bedrock was encountered between about elevations 98.5 and 99.0 metres or from about 2 to 6 metres below the existing ground surface.

The upper zone of the bedrock is generally highly weathered and has been described as deformation till in boreholes 19 and 21.

The rock core recovered from the boreholes generally consists of moderately to slightly weathered, thin to medium bedded reddish brown shale interbedded with fine grained argillaceous limestone.

The rock core recovered from the boreholes is in general, highly fractured. The total core recovery (TCR) ranged from about 87 to 100 per cent, while the solid core recovery (SCR) ranged from about 32 to 90 per cent. The rock quality designation (RQD) ranged from about 10 to 72 per cent.

4.7 Groundwater Conditions

Groundwater was encountered at about elevations 102.8 and 103 metres in borehole 20 and test pit 7, respectively. Borehole 22 was dry to the depth of auger refusal. The groundwater level was measured at about elevation 101.7 metres or at about a depth of about 2.9 metres below the existing ground surface, in the piezometer in borehole 20 about 8 days after installation.

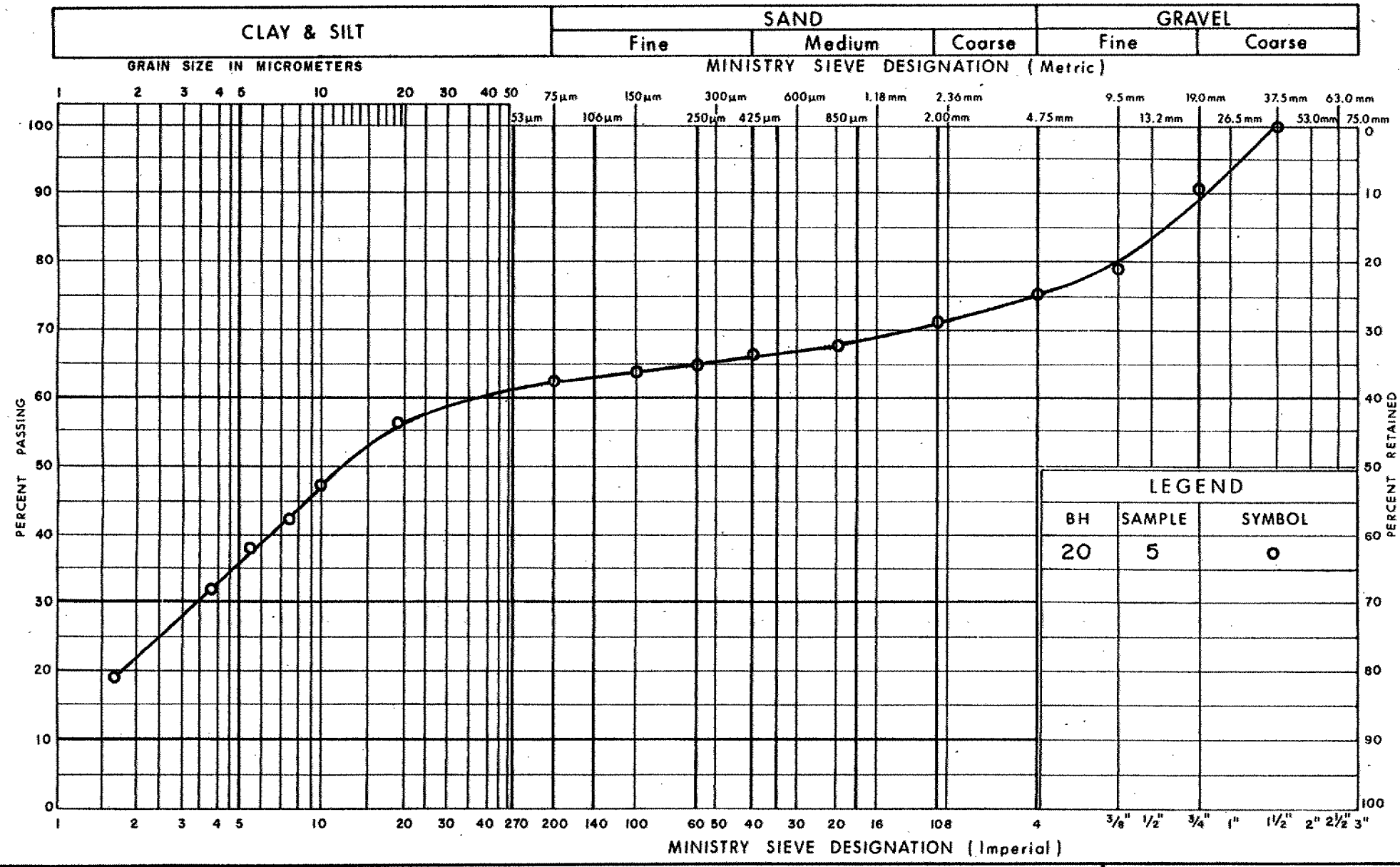
It should be noted that the piezometric groundwater level within the subsoil and underlying bedrock is subject to fluctuation not only due to precipitation conditions, but also due to seasonal variations. The water levels given above may not necessarily reflect stabilized conditions.

Note: The preceding report is a copy of the factual information from the Foundation Report prepared by GOLDER ASSOCIATES LTD (consulting geotechnical engineers for this project), under the technical supervision of the M.T.O. Foundation Design Section.

P. Payer, P. Eng.
Senior Foundatation Engineer

M.S. Devata, P. Eng.
Chief Foundation Engineer

UNIFIED SOIL CLASSIFICATION SYSTEM



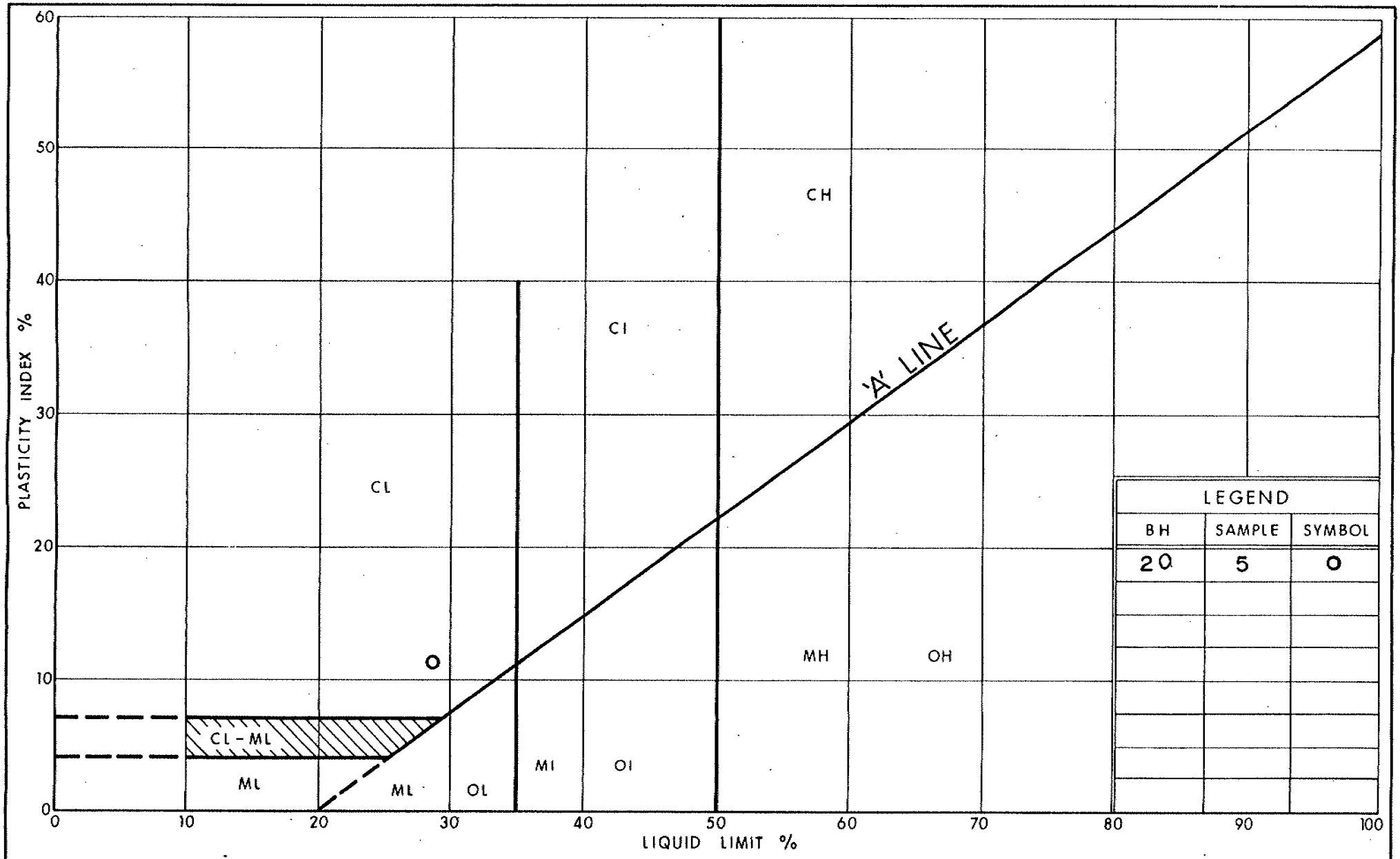
Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION
CLAYEY SILT TILL

FIG No 1
W P 199 - 77 - 02

59

Oct 75, FF-S-21



Ministry of Transportation
Ontario

PLASTICITY CHART

CLAYEY SILT TILL

FIG No 2

W P 199 - 77 - 02

60

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 19 METRIC

W P 199-77-02 LOCATION Co-ordinates N4,799,351.2 E277,879.3 ORIGINATED BY CB

DIST 4 HWY 403/QEW BOREHOLE TYPE Hollow Stem Augers COMPILED BY MHW

DATUM Geodetic DATE August 21, 1990 CHECKED BY VCH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
104.6	Ground Surface						
104.4	Topsoil						
0.2	Silty Clay (Fill) trace sand, occasional gravel						104
103.4	Firm Reddish Brown		1	SS	8		
1.2	Silty Sand with layers of silty clay & gravel						
102.7	Loose Brown		2	SS	6	▼	
1.9	Clayey Silt (Till) tr. sand, occasional gravel		3	SS	88		102
101.3	Hard Brown						
3.3	Clayey Silt tr. Sand		4	SS	91		
3.5	Clayey Silt (Till) tr. sand, occasional		5	SS	81		
			6	SS	50/75mm		100
	Grey brown becoming reddish brown at about elev. 100 m		7	SS	73/50mm		
98.5	Hard		8	SS	73/50mm		
6.1	Shale (Deformation Till) completely weathered						98
97.9							
6.7	Shale Bedrock		9	SS	50/75mm		
6.9	End of Borehole						
							96

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE

PLASTIC LIMIT Wp | NATURAL MOISTURE CONTENT W | LIQUID LIMIT Wl

WATER CONTENT (%) 10 20 30

Groundwater encountered at 102.8 metres August 21, 1990

UNIT WEIGHT γ

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 20

METRIC

W P 199-77-02 LOCATION Co-ordinates N4,799,354.0 E277,895.7 ORIGINATED BY VCH

DIST 4 HWY 403/QEW BOREHOLE TYPE Hollow Stem Auger/NQ Rock Core COMPILED BY MHW

DATUM Geodetic DATE August 21, 22, 1990 CHECKED BY VCH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
104.3	Ground Surface						
104.1	Topsoil						104
0.2	Silty sand, occasional silty clay layers						
103.2	Compact Brown		1	SS	12		
1.1	Clayey Silt (Till) trace to some sand, occasional gravel		2	SS	18		
			3	SS	82	▼	102
			4	SS	72		
			5	SS	85/200mm		
			6	SS	50/75mm		100
98.8	Hard Reddish Brown						
5.5	Shale Bedrock		7	SS	100/50mm		
5.8	Shale bedrock moderately to slightly weathered thin to medium bedded Reddish Brown interbedded with fine grained argillaceous Limestone		8	NQ RC	*TCR= 87% SCR= 45% RQD= 10%		98
			9	NQ RC	TCR= 93% SCR= 70% RQD= 10%		96
95.5							
8.8	End of Borehole.						94

Water level measured in piezometer at elevation 101.7 m August 30, 1990

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE

PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L

WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ

REMARKS & GRAIN SIZE DISTRIBUTION (%)

GR SA SI CL

21 17 40 22

*TCR: Total Core Recovery
SCR: Solid Core Recovery
RQD: Rock Quality Designation

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 21

METRIC

W P 199-77-02 LOCATION Co-ordinates N4,799,353.9 E277,906.9 ORIGINATED BY VCH

DIST 4 HWY 403/QEW BOREHOLE TYPE Solid Stem Augers, NQ Rock Core COMPILED BY MHW

DATUM Geodetic DATE August 21, 1990 CHECKED BY VCH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
101.0	Ground Surface										
0.0	Silty Clay (Fill) with roots and debris							Water level at ground surface during augering			
100.2	Black										
0.8	Clayey silt trace to some sand (Till), occasional gravel		1	SS	80/150mm		100		○		
			2	SS	77/150mm				○		
98.7	Hard Reddish Brown								○		
2.3	Shale (Deformation Till)		3	SS	70/75mm						
2.6	Shale Bedrock Highly weathered		4	SS	75/150mm						
97.9							98				
3.1	Shale Bedrock moderately to slightly weathered thin to medium bedded Reddish Brown interbedded with fine grained argillaceous Limestone		5	NQ RC	*TCR= 98% SCR= 77% RQD= 65%						
			6		TCR= 94% SCR= 32% RQD= 24%		96				
			7	NQ RC	TCR= 100% SCR= 90% RQD= 72%						
94.8											
6.2	End of Borehole						94				

* TCR = Total Core Recovery

SCR = Solid Core Recovery

RQD = Rock Quality Designation

+3, ×5 : Numbers refer to Sensitivity

15 20 10 ◇ 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 22

METRIC

W P 199-77-02 LOCATION Co-ordinates N4,799,370.5 E277,934.7 ORIGINATED BY VCH

DIST 4 HWY 403/QEW BOREHOLE TYPE Solid Stem Augers COMPILED BY MHW

DATUM Geodetic DATE August 24, 1990 CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
103.4	Ground Surface										
0.0	Silty Clay (Fill) tr. sand, tr. topsoil occasional gravel										
102.3	Stiff Brown		1	SS	12				○		
1.1	Clayey Silt (Till) trace to some sand.						102				
			2	SS	73			Borehole dry during drilling	○		
	Grey brown becoming reddish brown at about elev. 100 m		3	SS	37				○		
			4	SS	50/75mm				○		
							100				
			5	SS	50/50mm				○		
99.0	Hard										
4.4	Shale Bedrock		6	SS	50/100mm				○		
4.7	End of Borehole						98				

OFFICE REPORT ON SOIL EXPLORATION

$+^3$, $\times^5$: Numbers refer to Sensitivity

15 20/10 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF TEST PIT No. 7

METRIC

W P 199-77-02 LOCATION Co-ordinates N4,799,360 E277,879 ORIGINATED BY VCH

DIST 4 HWY 403/QEW BOREHOLE TYPE Backhoe Dug: John Deere 690 COMPILED BY MHW

DATUM Geodetic DATE August 16, 1990 CHECKED BY VCH

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
104.7	Ground Surface										
104.5	Topsoil										
0.2 / 103.8	Silty Clay (Fill) tr. sand, occasional gravel Brown						104				
0.9 / 102.9	Silty Sand, occasional clayey silt layers Brown		1	CS					○		
			2	CS		▽		Water seeping in at elevation 103.0 metres during excavation		○	
1.8 / 100.9	Clayey Silt (Till) tr. sand, occasional cobbles and gravel Grey Brown		3	CS			102		○		
3.8	End of Test Pit						100				

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20/10 5 (%) STRAIN AT FAILURE

GEOTECHNICAL INVESTIGATION
PROPOSED BRIDGE 41
SITE 10-333
FREEMAN INTERCHANGE
BURLINGTON, ONTARIO
W.P. 199-77-03 DISTRICT 4

1. INTRODUCTION

Golder Associates Ltd. has been retained by the Ministry of Transportation Ontario (MTO) to carry out a series of site specific subsurface investigations for the design of structures for the proposed reconstruction of the Freeman Interchange in Burlington, Ontario. This report presents the results of a subsurface investigation carried out at the site of the proposed Bridge No. 41 to be constructed as part of the 403/QEW East ramp as shown on the Key Plan, Drawing No. 1997703-A.*

The purpose of the investigation was to determine the subsurface conditions at the site.

2. SITE AND PROJECT DESCRIPTION

The site of the proposed Bridge 41 is located in a relatively flat, grassed area, south of the east bound 403/QEW ramp, west of the QEW north/QEW east ramp and east of the QEW north/403 west ramp in Burlington, Ontario. The location of the site is shown on the Key Plan, Drawing 1997703-A.*

The site is situated within the physiographic region of Southwestern Ontario known as the Iroquois Plain. Available geologic information indicates that the overburden in the general area of the site consists of a thin veneer of sands, glacial till and/or residual soil derived from the weathering

* SHEET NO 418 OF THE CONTRACT DWG'S

of the underlying shale bedrock. The Queenston shale formation which comprises the bedrock in the area generally consists of thinly bedded red shale with occasional bands of grey limestone.

Bridge No. 41 will carry 403 west/QEW east ramp traffic over the QEW East bound lanes and the QEW/403 north ramp.

The proposed bridge will consist of a three span structure (spans of approximately 45, 56 and 47 metres west to east respectively), with two abutments and two piers. Approach fills of some 11 to 13 metres in height will be required.

3. INVESTIGATION PROCEDURE

The field work for this investigation was carried out on August 18 and August 28, 1990 at which time one test pit was excavated and five boreholes were drilled. The locations of the boreholes and test pits are shown on Drawing 1997703-A*, enclosed.

The initial stage of the field work consisted of excavating a test pit (numbered 8) near the east limit of the proposed bridge. The test pit was excavated to a depth of about 3.6 metres using a "John Deere 690" hydraulic backhoe supplied and operated by a local contractor. Chunk samples were obtained from the predominant soil strata exposed in the test pit and the test pit was loosely backfilled following sampling and logging.

The boreholes were drilled using track mounted power auger drillrigs supplied and operated by a specialist drilling

* SHEET NO 418 OF THE CONTRACT DWG'S

contractor. Boreholes numbered 24, 25 and 26 were advanced to bedrock, through about 2.5 to 3.5 metres of overburden, and the shale bedrock encountered beneath the overburden was core drilled in NQ size for about 3 metres in these boreholes. Boreholes numbered 23 and 27 were drilled to practical auger refusal. The boreholes were advanced within the overburden and the highly weathered shale using both nominal 150 millimetre diameter hollow stem augers and nominal 100 millimetre diameter solid stem augers. Standard penetration testing and sampling was carried out within the overburden encountered in the boreholes using 35 millimetre inside diameter split spoon sampling equipment.

Samples of the overburden and the rock core recovered from the test pit and boreholes were taken to our Hamilton laboratory for examination and water content determinations. Grain size analyses and Atterberg limit determinations were carried out on selected samples of the overburden.

The soil and rock stratigraphy encountered in the boreholes and test pit are shown in detail on the Records of Boreholes and Record of Test Pit following the text of this report and on Drawing 1997703-A.* The results of the field and laboratory testing are also shown on the Record of Borehole and Record of Test Pit sheets and on Figures 1 and 2.

Groundwater levels were observed in the open boreholes during drilling and in the test pits during and after excavation. A piezometer was installed in borehole 25 as detailed on the Record of Borehole sheet. Notes pertaining to the groundwater conditions encountered in the boreholes and test pit are also shown on the Record of Borehole and Test Pit

* SHEET NO 418 OF THE CONTRACT DWG'S

sheets and on Drawing 1997703-A.*

The locations and ground surface elevations at the borehole and test pit locations have been determined by Golder Associates staff with reference to site specific points and temporary bench marks provided by McCormick Rankin & Associates Limited. The final locations and ground surface elevations of the boreholes were subsequently verified by McCormick Rankin. The elevations provided are understood to be referred to geodetic datum.

4. SUBSURFACE CONDITIONS

4.1 General

The subsurface conditions encountered in the boreholes and test pit put down at the site are shown in detail on the Records of Borehole and Record of Test Pit sheets, and in summary form on Drawing 1997703-A*. The soil boundaries and rock stratigraphy indicated, particularly for the boreholes, are inferred from non-continuous sampling and resistance to drilling advance. These boundaries typically represent a transition between one soil or rock type to another and are not intended to define an exact plane of geological change. Conditions will vary between and beyond the borehole and test pit locations.

The subsurface conditions encountered at the site generally consisted of topsoil, fill, glacial till, strata of sandy silt to silty sand, and completely to highly weathered shale underlain by more competent shale bedrock.

* SHEET NO 418 OF THE CONTRACT DWG'S

The following discussion has been simplified in terms of major soil and rock strata for the purposes of geotechnical design.

It should be noted that due to the relatively soft and weathered nature of the Queenston shale formation, particularly the upper zone, together with the effects of glacial overriding at the bedrock surface, it is difficult to accurately define the bedrock surface both from a geological and a contractual standpoint.

During the course of this investigation, a stratigraphic unit directly overlying the shale bedrock, which in strictly geological terms is described as deformation till, has been encountered. This stratigraphic unit consists of an imbricate embedment of fragments of bedrock in a till matrix which has been formed from glacial overriding of the parent bedrock. This till is characterized by the presence of rounded and sub-angular clasts of the parent rock with non-horizontal bedding. Based on the consistency, the relatively high penetration resistance encountered in the boreholes and the difficulty of excavation experienced in the test pits, this stratum could be contractually interpreted as a zone of the bedrock and for this reason has been referred to in this report as an upper zone of the bedrock formation.

4.2 Topsoil

A relatively thin layer of topsoil was encountered at the ground surface in all of the boreholes and in the test pit put down at the site.

4.3 Clayey Silt, trace sand, trace organics occasional gravel (Fill)

Fill generally consisting of clayey silt was encountered beneath the granular road base in test pit 8 and below the surface topsoil in boreholes 26 and 27. The thickness of the fill material ranged from about 1.6 metres in test pit 8 to about 1.9 metres in borehole 27. The fill generally consists of reddish brown to brown clayey silt to silty clay with traces of organics, sand and occasional gravel. In borehole 27 a 0.5 metre layer of black silty sand fill was encountered below the clayey silt fill.

The clayey fill had an in-situ water content of about 14 per cent. N-values of 12 and 18 blows per 0.3 metres were determined in standard penetration testing carried out in the fill.

4.4 Clayey Silt, trace to some sand, occasional gravel (Till)

Clayey Silt till was encountered in all of the boreholes and in the test pit and was generally characterized by a brown upper zone and a lower zone of reddish brown clayey silt till which was somewhat harder and slightly coarser than the overlying till.

The N values determined in the upper till zone ranged from 28 to 112 blows per 0.3 metres. The natural water content of samples of the upper till recovered from the boreholes and test pit ranged from about 10 to 20 per cent.

Standard penetration testing was also carried out in the

lower till zone, but due to its hard consistency it was not practical to advance the sampler the entire 450 millimetres required to establish an N value. However, N values of the order of greater than 100 blows per 0.3 metres can generally be inferred from the penetration testing. The natural water content of the lower till typically ranged from about 6 to 13 per cent.

The corresponding liquid and plastic limits of the lower till were about 20 and 15 per cent, respectively, based on the average of three Atterberg Limit determinations shown on the plasticity chart, Figure 2. Grain size distribution curves for samples (obtained by a 35 millimetre I.D. sampler) of the lower till are shown on Figure 1.

The till material as indicated by the gradation curve is fine grained in nature and no major concentrations of coarse particles, such as boulders, were encountered during this investigation. This does not necessarily mean that the coarser particle sizes are not present in concentrations or at random within the deposit, since till is an inherently variable material.

4.5 Sandy Silt, Silty Fine Sand

Layers of sandy silt and silty fine sand were encountered beneath the upper till in borehole 23 and below the lower till in borehole 27. These strata were about 1 and 0.4 metres thick and were very dense with inferred N values in the order of greater than 100 blows per 0.3 metres. The natural water content of these strata was about 16 per cent.

4.6 Shale, Completely to slightly weathered (Bedrock)

At the borehole locations, the overburden materials were underlain by shale bedrock of the Queenston Formation. Bedrock was encountered between about elevations 98.4 and 100 metres, or at depths of from about 2.4 to 4.7 metres below the existing ground surface.

The upper zone of the bedrock is generally highly weathered and has been described as deformation till in boreholes 24, 26 and 27. More competent shale was encountered in boreholes 24, 25 and 26 between about elevations 97.5 and 99 metres, or at depths of about 3 to 4.5 metres below existing ground surface. The bedrock core recovered from boreholes 24, 25 and 26 generally consists of moderately to slightly weathered thinly bedded reddish-brown shale, interbedded with thinly bedded light grey, fine grained argillaceous limestone up to about 0.5 metres in thickness.

The rock core recovered from the boreholes generally exhibited a relatively high degree of fracturing. However the quality of the rock core recovered generally improved with depth. The total core recovery (TCR) ranged from about 84 to 97 per cent for the upper 1.5 metres of rock cored and was typically 100 per cent for the lower 1.5 metres of rock. The solid core recovery (SCR) ranged from about 37 to 76 percent for the upper 1.5 metres of rock core and from about 85 to 97 percent for the lower 1.5 metres of rock core. Similarly the rock quality designation (RQD) ranged from about 28 to 45 percent in the upper 1.5 metres of rock core compared to 67 to 75 percent for the lower 1.5 metres of rock core.

4.7 Groundwater Conditions

Groundwater was not encountered during the field drilling/ digging operations in boreholes 23 and 27 which were terminated at practical auger refusal, or in test pit 8 which was terminated in the red (lower) clayey silt till. Boreholes 24 and 25 were dry to the depth of practical auger refusal, corresponding to about elevations 97.7 and 98.3 metres, respectively. Groundwater was encountered at about elevation 100.8 metres, or at about 2.1 metres below the existing ground surface in borehole 26. The groundwater level was measured at about elevation 101.5, or at a depth of about 0.3 metres below the existing ground surface, in the piezometer in borehole 25, about 1 week after the completion of drilling.

It should be noted that the piezometric groundwater levels within the subsoil and underlying bedrock is subject to fluctuation not only due to precipitation conditions, but also due to seasonal variations. The water levels given above may not necessarily reflect stabilized conditions and may very from the conditions which are encountered during construction.

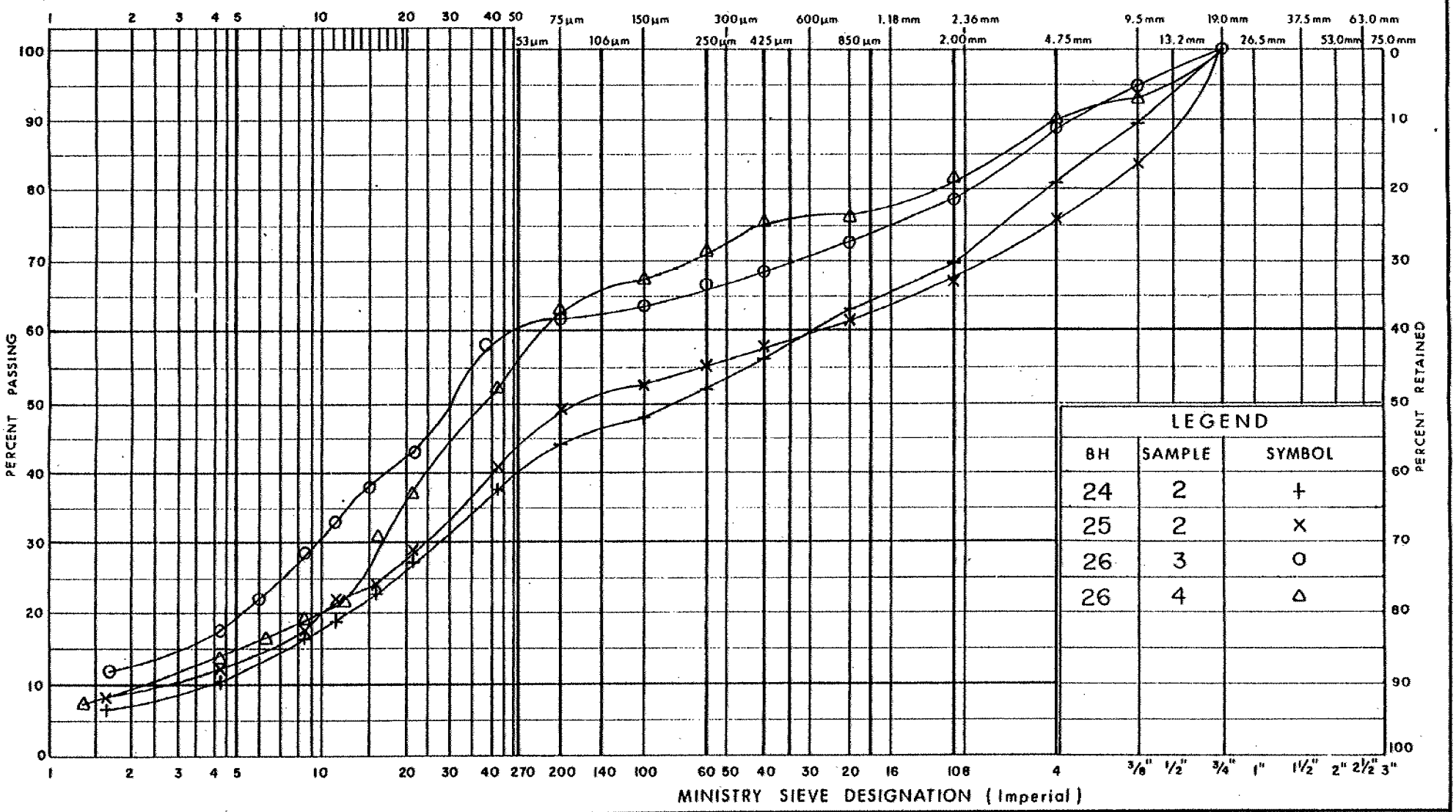
Note: The preceding report is a copy of the factual information from the Foundation Report prepared by GOLDER ASSOCIATES LTD (consulting geotechnical engineers for this project), under the technical supervision of the M.T.O. Foundation Design Section.

P. Payer, P. Eng.
Senior Foundatation Engineer

M.S. Devata, P. Eng.
Chief Foundation Engineer

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



Ministry of Transportation
Ontario

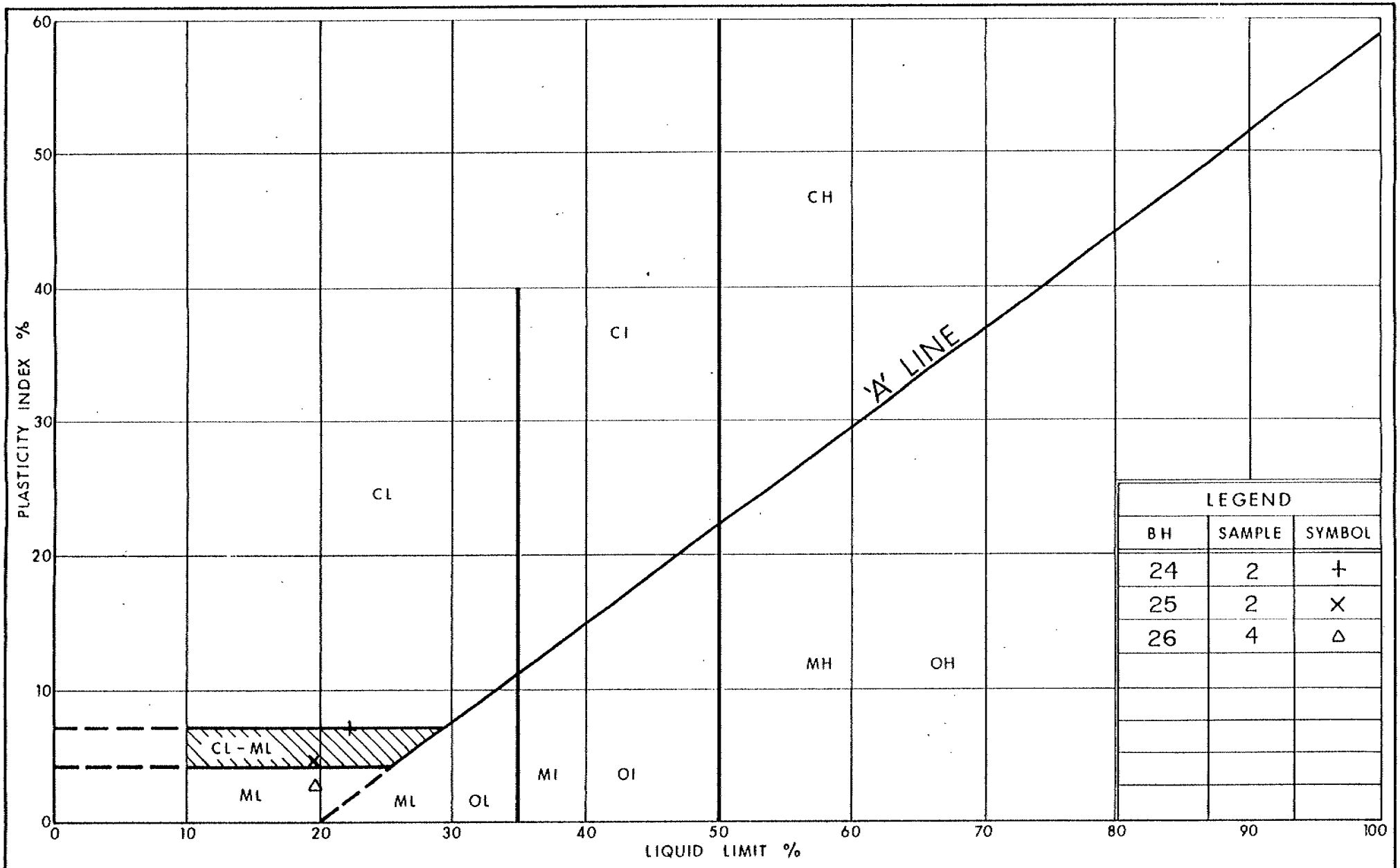
GRAIN SIZE DISTRIBUTION

CLAYEY SILT TILL

FIG No 1

W P 199-77-03

75



Ministry of Transportation
Ontario

PLASTICITY CHART
CLAYEY SILT TILL

FIG No 2
W P 199-77-03

76

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 23 METRIC

W P 199-77-03 LOCATION N4,799,406.8 E278,067.0 ORIGINATED BY CB

DIST 4 HWY 403/QEW BOREHOLE TYPE Solid Stem Augers COMPILED BY MHW

DATUM Geodetic DATE August 24, 1990 CHECKED BY JGM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
102.3	Ground Surface						
102.1	Topsoil						
0.2	Clayey Silt trace sand, occasional gravel (Till)		1	SS	33		102
			2	SS	61		
100.2	Hard Brown						
2.1	Silty sand, occ. gravel Very Dense red Brown		3	SS	70/10cm		100
99.6							
2.7	Sandy silt, tr. clay Very Dense Red Brown						
99.2							
3.1	Shale Bedrock Highly to moderately weathered		4	SS	50/25mm		
			5	SS	50/15mm		
97.7	Reddish Brown						98
4.6	End of Borehole						

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE

PLASTIC LIMIT Wp | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W_L

WATER CONTENT (%) 10 20 30

Borehole dry during drilling.

UNIT WEIGHT γ

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

OFFICE REPORT ON SOIL EXPLORATION

$+^3, \times^5$: Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 24 METRIC

W P 199-77-03 LOCATION N4,799,420.8 E278,095.4 ORIGINATED BY VCH

DIST 4 HWY 403/QEW BOREHOLE TYPE Hollow Stem Augers; NQ Rock Core COMPILED BY MHW

DATUM Geodetic DATE August 27 & 28, 1990 CHECKED BY JGM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
102.0	Ground Surface										
0.1	Topsoil										
	Clayey silt trace to some sand, occ. gravel (Till)		1	SS	62/250mm				○		
			2	SS	70/150mm		100	Pressuremetre Test 24-1	○		18 7 37 8
			3	SS	70/100mm			Borehole dry to elevation 97.5 metres during drilling	○		
98.3	Hard Brown to Reddish Brown										
3.7	Shale (Deformation Till) completely to highly weathered		4	SS	70/125mm		98		○		
97.8											
4.3	Shale highly weathered										
97.5											
4.6	Shale Bedrock moderately to slightly weathered thinly to medium bedded Reddish Brown interbedded with fine-grained grey argillaceous limestone		5	NQ RC	*TCR= 97% SCR= 76% RQD= 45%			Pressuremetre Test 24-2			
							96				
			6	NQ RC	TCR= 100% SCR= 97% RQD= 75%			Pressuremetre Test 24-3			
94.3											
7.7	End of Borehole						94				

* TCR: Total core recovery
SCR: Solid core recovery
RQD: Rock Quality Designation

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 25 METRIC

W P 199-77-03 LOCATION N4,799,436.9 E278,120.8 ORIGINATED BY CB

DIST 4 HWY 403/QEW BOREHOLE TYPE Solid Stem Augers; NQ Rock Core COMPILED BY MHW

DATUM Geodetic DATE August 24, 1990 CHECKED BY JGM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
101.8	Ground Surface										
0.1	Topsoil										
	Clayey Silt trace to some sand, occ. gravel (Till)					Water level at Elev. 101.5 metres August 30, 1990			○		
			1	SS	28						
	Very stiff to hard		2	SS	78/150mm		100	Pressuremetre Test 25-1	○ ⊢		25 26 40 9
99.4	Brown to reddish brown										
2.4	Shale Bedrock highly weathered										
98.8			3	SS	30/<10mm						
3.0	Shale Bedrock moderately to slightly weathered thinly to medium bedded Reddish Brown interbedded with grey fine-grained argillaceous limestone		4	NQ RC	*TCR= 84% SCR= 37% RQD= 28%		98	Pressuremetre Test 25-2			
			5	NQ RC	TCR= 100% SCR= 89% RQD= 71%		96	Pressuremetre Test 25-3			
95.4											
6.4	End of Borehole						94				

* TCR: Total Core Recovery
SCR: Solid Core Recovery
RQD: Rock Quality Designation

$+^3$, $\times^5$: Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 26

METRIC

W P 199-77-03 LOCATION N4,799,456.4 E278,158.3 ORIGINATED BY VCH

DIST 4 HWY 403/QEW BOREHOLE TYPE Solid Stem Augers; NQ Rock Core COMPILED BY MHW

DATUM Geodetic DATE August 23, 1990 CHECKED BY JGM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPo	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L / WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
102.9	Ground Surface										
0.1	Topsoil										
	Clayey silt (Fill) trace sand & organics occasional gravel & asphalt		1	SS	26		102				
101.0	Very Stiff Brown		2	SS	19						
1.9	Clayey silt trace sand, occ. gravel (Till)		3	SS	112	▼		Water seepage encountered at Elev. 100.8 metres during drilling			11 29 48 12
99.9	Hard Red Brown						100				
3.0	Shale (Deformation Till) completely weathered		4	SS	50/75mm			Pressuremetre Test 26-1			10 27 55 8
99.2											
3.7	Shale highly weathered		5	SS	100/50mm						
98.8											
4.1	Shale Bedrock moderately to slightly weathered thinly to medium bedded Reddish Brown interbedded with grey fine-grained argillaceous limestone		6	NQ RC	*TCR= 97% SCR= 57% RQD= 42%		98	Pressuremetre Test 26-2			
			7	NQ RC	TCR= 100% SCR= 85% RQD= 67%			Pressuremetre Test 26-3			
96.0							96				
6.9	End of Borehole										

* TCR: Total Core Recovery
SCR: Solid Core Recovery
RQD: Rock Quality Designation

OFFICE REPORT ON SOIL EXPLORATION

$+^3$, $\times^5$: Numbers refer to Sensitivity

20 / 15 / 10 / 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 27

METRIC

W P 199-77-03 LOCATION N4,799,469.1 E278,169.8 ORIGINATED BY VCH

DIST 4 HWY 403/QEW BOREHOLE TYPE Solid Stem Augers COMPILED BY MHW

DATUM Geodetic DATE August 23, 1990 CHECKED BY JGM

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
103.7	Ground Surface										
103.5 / 0.2	Topsoil										
	Clayey silt (Fill) tr. sand, occ. gravel, tr. topsoil		1	SS	18						
102.3 / 1.4	Very Stiff Brown Silty Sand (Fill)										
101.8 / 1.9	Compact Black Clayey silt tr. to some sand, occ. gravel (Till)		2	SS	12		102				
			3	SS	25			Borehole dry during drilling			
			4	SS	35						
	Very stiff to hard at about Elev. 100.0 m Brown to Red Brown						100				
			5	SS	50/75mm						
99.4 / 4.3	Silty fine sand										
99.0 / 4.7	Reddish Brown Shale Bedrock (Deformation Till) completely weathered		6	SS	70/150mm						
98.3 / 5.4	End of Borehole		7	SS	70/100mm		98				

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF TEST PIT No. 8

METRIC

W P 199-77-03 LOCATION N4,799,458 E278,176 ORIGINATED BY VCH

DIST 4 HWY 403/QEW BOREHOLE TYPE Backhoe Dug "John Deere 690" COMPILED BY MHW

DATUM Geodetic DATE August 18, 1990 CHECKED BY JCM

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL / WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
103.8	Ground Surface										
103.5	Granular Road Base										
0.3	Clayey Silt, trace sand, occasional gravel (Fill)		1	CS							
102.2	Brown										
1.6	Clayey Silt, trace to some sand, occasional gravel, rootlets at top of layer (Till)		2	CS			102	Test pit dry following excavation			
100.5	Brown		3	CS							
3.3	Clayey silt trace sand (Till) Red Brown										
3.6	End of Test Pit						100				

OFFICE REPORT ON SOIL EXPLORATION

+3, x5 : Numbers refer to Sensitivity

15 20/10 5 (%) STRAIN AT FAILURE

GEOTECHNICAL INVESTIGATION
PROPOSED BRIDGE 42
SITE 10-334
FREEMAN INTERCHANGE
BURLINGTON, ONTARIO
W.P. 199-77-04 DISTRICT 4

1. INTRODUCTION

Golder Associates Ltd. has been retained by the Ministry of Transportation Ontario (MTO) to carry out a series of site specific subsurface investigations for the design of structures for the proposed reconstruction of the Freeman Interchange in Burlington, Ontario. This report presents the results of a subsurface investigation carried out at the site of the proposed Bridge No. 42. As presently proposed, Bridge 42 will carry the 403 west/QEW south traffic over the 403 east/Fairview Street ramp as shown on the Key Plan, Drawing 1997704-A.*

The purpose of the investigation was to determine the subsurface conditions at the site.

2. SITE AND PROJECT DESCRIPTION

The site of the proposed Bridge 42 is located in a relatively flat, grassed area, situated between the existing 403-QEW south and, the 403 east-QEW south ramps of the Freeman Interchange in Burlington, Ontario. The location of the site is shown on the Key Plan, Drawing 1997704-A.*

The site is situated within the physiographic region of Southwestern Ontario known as the Iroquois Plain. Available geologic information indicates that the overburden in the

* SHEET NO 446 OF THE CONTRACT DWG'S

general area of the site consists of a thin veneer of sands, glacial till and/or residual soil derived from the weathering of the underlying shale bedrock. The Queenston shale formation which comprises the bedrock in the area generally consists of thinly bedded red shale with layers of grey limestone.

The bridge will carry 403 east/QEW south traffic over the 403 south/Fairview Street ramp.

The proposed bridge will consist of a 9.5 metre span rigid frame, 50 metre in length. Two sections of retaining wall, 25 metres and 40 metres in length are required at the northwest and southeast corners, of the proposed structure. Approach fills of some 7 metres in height will also be required.

3. INVESTIGATION PROCEDURE

The field work for this investigation was carried out on August 17 and 22, 1990 at which time two test pits were excavated and four boreholes were drilled. The locations of the boreholes and test pits are shown on Drawing 1997704-A*.

The initial stage of the field work consisted of excavating two test pits (numbered 9 and 10) at the west and east limits of the proposed bridge. The test pits were excavated to a depth of about 3.8 metres below the existing ground surface using a "John Deere 690" hydraulic backhoe supplied and operated by a local contractor. Chunk samples were obtained from the predominant soil strata exposed in the test pits and

* SHEET NO 446 OF THE CONTRACT DWG'S

the test pits were loosely backfilled following sampling and logging.

The boreholes were drilled using a track mounted power auger equipped for rotary drilling, which was supplied and operated by a specialist drilling contractor. Boreholes numbered 29 and 30 were advanced to bedrock, through about 5.2 to 5.8 metres of overburden, and the shale bedrock encountered beneath the overburden was core drilled in NQ size for 3 metres in these boreholes. Boreholes numbered 28 and 31 were drilled to practical auger refusal. The boreholes were advanced in the overburden using nominal 150 millimetre diameter hollow stem augers. Standard penetration testing and sampling was carried out within the overburden encountered in the boreholes using 35 millimetre inside diameter split-spoon sampling equipment.

Samples of the overburden and the rock core, recovered from the test pits and boreholes, were taken to our Hamilton laboratory for examination and water content determinations. The grain size distribution and Atterberg limits were determined on selected samples of the overburden.

The soil and rock stratigraphy encountered in the boreholes and test pits are shown in detail on the Records of Boreholes and Records of Test Pits following the text of this report and on Drawing 1997704-A.* The results of the field and laboratory testing are also shown on the Record of Borehole and Record of Test Pit sheets and on Figures 1 and 2.

Groundwater levels were observed in the open boreholes during

* SHEET NO 446 OF THE CONTRACT DWG'S

drilling and in the test pits during and after excavation. A piezometer was installed in Borehole 29 as detailed on the Record of Borehole sheet. Notes pertaining to the groundwater conditions observed in the boreholes and test pits are also shown on the Records of Boreholes and Test Pits and on Drawing 1997704-A.*

The locations and ground surface elevations at the borehole and test pit locations have been determined by Golder Associates staff with reference to site specific points and temporary bench marks provided by McCormick Rankin & Associates Limited. The final locations and ground surface elevations at the boreholes were subsequently verified by McCormick Rankin. The elevations provided are understood to be referred to geodetic datum.

4. SUBSURFACE CONDITIONS

4.1 General

The subsurface conditions encountered in the boreholes and test pits put down at the site are shown in detail on the Record of Borehole and Record of Test Pit sheets, and in summary form on Drawing 1997704-A.* The soil boundaries and rock stratigraphy indicated, particularly for the boreholes, are inferred from non-continuous sampling and resistance to drilling advance. These boundaries typically represent a transition between one soil or rock type to another and are not intended to define an exact plane of geological change. Conditions will vary between and beyond the borehole and test pit locations.

* SHEET NO 446 OF THE CONTRACT DWG'S

The subsurface conditions encountered at the site generally consisted of topsoil, fill, glacial till, and completely to highly weathered shale underlain by more competent shale bedrock, at depth.

The following discussion has been simplified in terms of major soil and rock strata for the purposes of geotechnical design.

It should be noted that due to the relatively soft and weathered nature of the Queenston shale formation, particularly the upper zone, together with the effects of glacial overriding at the bedrock surface, it is difficult to accurately define the bedrock surface both from a geological and a contractual standpoint.

During the course of this investigation, a stratigraphic unit directly overlying the shale bedrock, which in strictly geological terms is described as deformation till, has been encountered. This stratigraphic unit consists of an imbricate embedment of fragments of bedrock in a till matrix which has been formed from glacial overriding of the parent bedrock. This till is characterized by the presence of rounded and sub-angular clasts of the parent rock with non horizontal bedding. Based on the consistency, the relatively high penetration resistance encountered in the boreholes and the difficulty of excavation experienced in the test pits, this stratum could be contractually interpreted as a zone of the bedrock and for this reason has been referred to in this report as an upper zone of the bedrock formation.

4.2 Topsoil

Topsoil was encountered at the ground surface in the boreholes and the test pits put down at the site. The thickness of the topsoil layer ranged from about 0.1 to 0.2 metres at the locations investigated.

4.3 Clayey Silt, Silty Clay, Sand and Gravel (Fill)

A layer of fill was encountered overlying the glacial till in all of the boreholes and test pits. The thickness of the fill material ranged from about 0.6 metres to about 1.8 metres. The fill generally consisted of brown clayey silt with trace sand and organics and occasional gavel. A layer of sand and gravel fill was encountered below the topsoil in borehole 29.

The clayey silt fill has in-situ water contents ranging from about 8 to 37 per cent. The N-values determined in standard penetration testing carried out in the clayey silt fill ranged from 15 to 22 blows per 0.3 metres indicating a very stiff consistency.

4.4 Clayey Silt trace sand, occasional gravel and cobbles (Till)

Glacial till was encountered in all of the boreholes, and in the test pits, and was generally characterized by an upper zone of very stiff to hard brown to grey clayey silt and a lower zone of reddish brown clayey silt which is somewhat harder than the overlying till.

The N values determined in the upper till zone ranged from 46 to 120 blows per 0.3 metres. The natural water content of samples of the upper till recovered from the boreholes and test pits ranged from about 8 to 14 per cent. The corresponding plastic and liquid limits of the upper till are about 14 and 27 respectively based on a single Atterberg limit determination. A grain size distribution curve for a sample of the clayey silt till (recovered from a 35 millimetre I.D split spoon sampler) is shown on Figure 1 and a corresponding plasticity chart is shown on Figure 2.

Test pits 9 and 10 were terminated in the upper till deposit at a depth of about 3.8 metres below the existing ground surface. The upper till deposit was fully penetrated in the boreholes at depths of about 4 to 5 metres below the existing ground surface, or between about elevations 96 and 98 metres.

Beneath the grey-brown clayey silt till in boreholes 28, 29 and 30, a reddish brown clayey silt till deposit was encountered.

Standard penetration testing was carried out in the lower till zone, but due to its hard consistency it was not practical to advance the sampler the entire 450 millimetres required to establish an N value. However, N values of the order of greater than 100 blows per 0.3 metres can generally be inferred from the penetration testing. The natural water content of the lower till typically ranged from about 6 to 10 per cent. The lower till deposit tended to be slightly coarser than the overlying till.

The till deposits encountered were generally fine grained in nature and no major concentrations coarse particles such as boulders were encountered during this investigation. This does not necessarily mean that the coarser particle sizes are not present at random or in concentrations within the deposit, since till is an inherently variable material.

4.5 Shale, Completely to Slightly weathered (Bedrock)

At the borehole locations, the overburden materials were underlain by shale bedrock of the Queenston Formation. Bedrock was encountered between about elevations 95.6 and 96.6 metres, or at depths of from about 5.0 to 5.8 metres below the existing ground surface.

The upper zone of the bedrock is generally highly weathered and has been described as deformation till in the boreholes. More competent shale was encountered in boreholes 29, and 30 between about elevations 94.6 and 95.3 metres, or at depths of about 6 metres below existing ground surface. The bedrock core recovered from boreholes 29 and 30 generally consists of moderately to faintly weathered thinly bedded reddish-brown shale, interbedded with thinly bedded light grey, fine grained argillaceous limestone up to about 0.5 metres in thickness.

The rock core recovered from the boreholes generally exhibited a relatively high degree of fr[illegible]uring. The total core recovery (TCR) ranged from about 9[illegible] 100 per cent and the solid core recovery (SCR) ranged fro[illegible] about 52 to 97 per cent. The rock quality designation (RQD) ranged from about

32 to 55 per cent.

4.6 Groundwater Conditions

Groundwater was not encountered during the field drilling/ digging operations in boreholes 28 and 31 which were terminated at auger refusal, or in test pits 9 and 10 which were terminated in the grey brown (upper) clayey silt till. Boreholes 29 and 30 were dry to the depth of practical auger refusal, corresponding to about elevations 95.3 and 94.6 metres respectively. The groundwater level was measured at about elevation 101.1 metres or at a depth of about 0.3 metres below the existing ground surface, in the piezometer in Borehole 29, about 2 weeks after the completion of drilling and at about elevation 100.5 metres some 3 months after drilling.

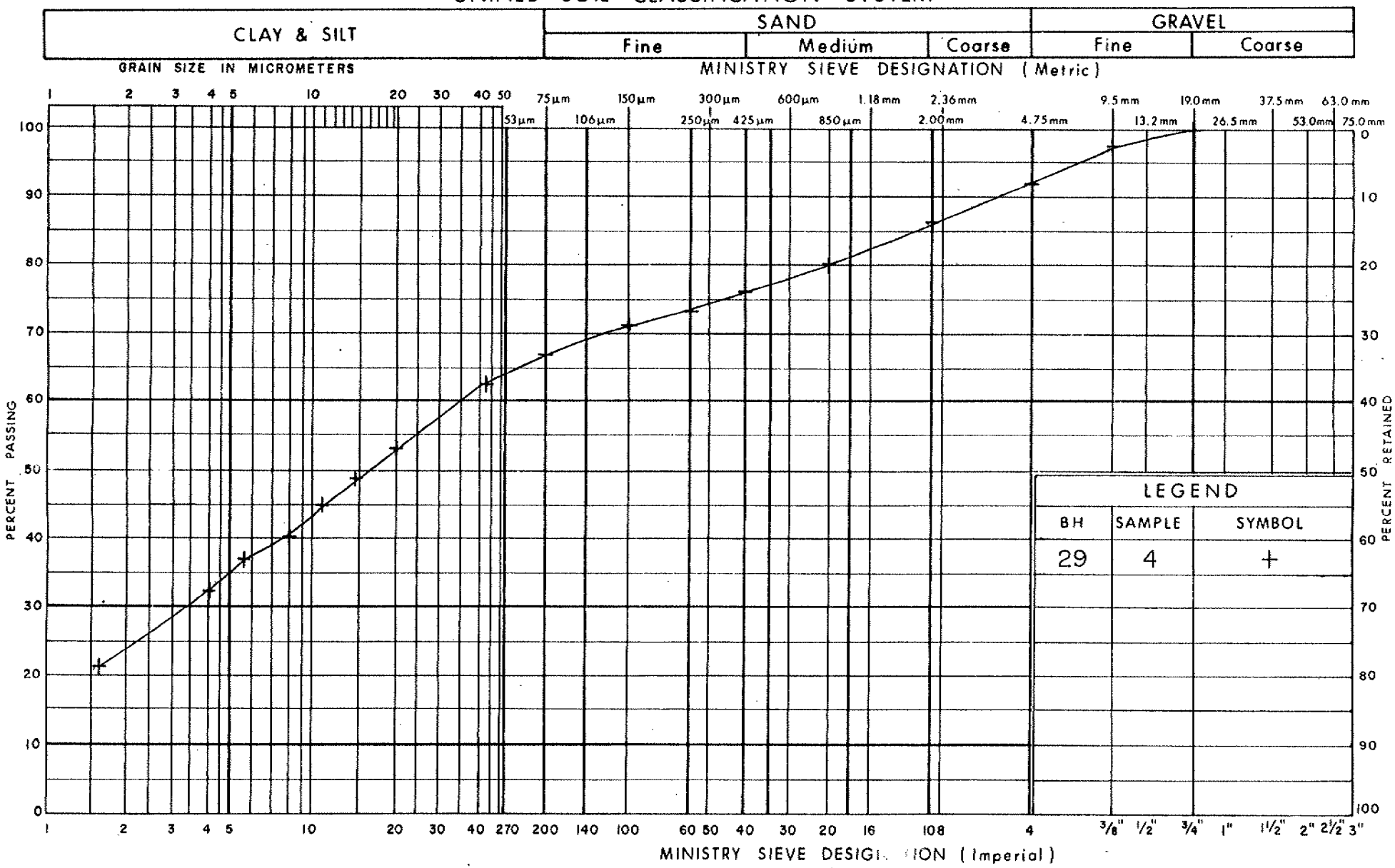
It should be noted that the piezometric groundwater level within the subsoil and underlying bedrock is subject to fluctuation not only due to precipitation conditions, but also due to seasonal variations.

Note: The preceding report is a copy of the factual information from the Foundation Report prepared by GOLDER ASSOCIATES LTD (consulting geotechnical engineers for this project), under the technical supervision of the M.T.O. Foundation Design Section.

P. Payer, P. Eng.
Senior Foundatation Engineer

M.S. Devata, P. Eng.
Chief Foundation Engineer

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

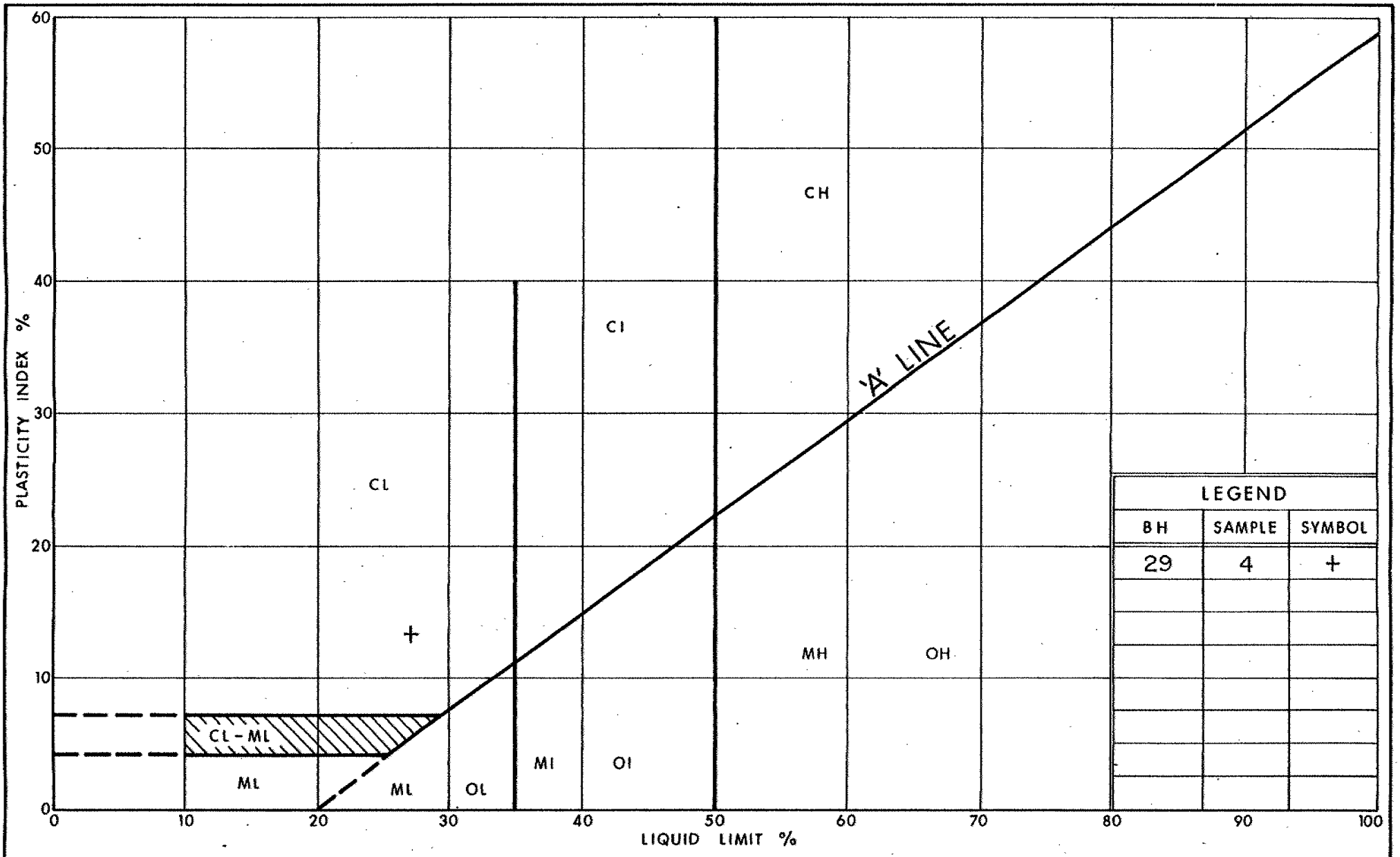
GRAIN SIZE DISTRIBUTION

GREY BROWN CLAYEY SILT TILL

FIG No 1

W P 199-77-04

92



Ministry of Transportation
Ontario

PLASTICITY CHART

GREY BROWN CLAYEY SILT TILL

FIG No 2

W P 199-77-04

93

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 28

METRIC

W P 199-77-04 LOCATION Co-ordinates N4,799,237.5 E277,943 ORIGINATED BY VCH

DIST 4 HWY 403/QEW BOREHOLE TYPE Solid Stem Augers COMPILED BY MHW

DATUM Geodetic DATE August 22, 1990 CHECKED BY VCH.

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
101.6	Ground Surface										
0.1	Topsoil										
101.0	Clayey Silt (Fill) occ. gravel Brown										
0.6	Clayey Silt (Till) trace sand, occasional gravel		1	SS	57				○		
			2	SS	66		100		○		
	Grey brown to red brown at about elevation 97.8		3	SS	64				○		
			4	SS	57		98		○		
			5	SS	60/75mm			Borehole dry during drilling	○		
96.6	Hard		6	SS	70/100mm				○		
5.0	Shale (Deformation Till) comp. weathered										
96.2			7	SS	65/150mm		96		○		
5.4	Shale Bedrock Highly weathered										
95.5			8	SS	60/25mm						
6.1	End of Borehole						94				

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20/10 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 29 METRIC

W P 199-77-04 LOCATION Co-ordinates N4,799,218 E277,961 ORIGINATED BY VCH

DIST 4 HWY 403/QEW BOREHOLE TYPE Solid Stem Augers; NQ Rock Core COMPILED BY MHW

DATUM Geodetic DATE August 22, 1990 CHECKED BY VCH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
101.4	Ground Surface										
0.1	Topsoil										
	Sand and Gravel (Fill)										
100.6	Brown										
0.8	Clayey Silt (Fill) trace sand and topsoil occ. gravel		1	SS	22						
99.9	Very Stiff Brown						100				
1.5	Clayey Silt, trace sand, occ. gravel and rock fragments (Till)		2	SS	53						
			3	SS	65						
			4	SS	59		98				7 26 43 24
			5	SS	58						
	Hard brown becoming reddish brown at about elevation 97.0		6	SS	60/ 150mm						
			7	SS	60/ 100mm		96				
95.6											
5.8	Shale (Deformation Till)										
95.3	Completely weathered										
6.1	Shale Bedrock moderately to slightly weathered thinly to medium bedded Reddish Brown interbedded with grey fine grained argillaceous limestone		8	NQ RC	*TCR= 98% SCR= 63% RQD= 32%		94				
			9	NQ RC	TCR= 100% SCR= 97% RQD= 55%						
92.3											
9.1	End of Borehole						92				

Water level above Elevation 101.1 metres August 30, 1990 and at 100.5 metres November 19, 1990

* TCR: Total Core Recovery
SCR: Solid Core Recovery
RQD: Rock Quality Designation

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 30 METRIC

W P 199-77-04 LOCATION Co-ordinates N4,799,182 E277,970 ORIGINATED BY VCH

DIST 4 HWY 403/QEW BOREHOLE TYPE Hollow Stem Augers, NQ Rock Core COMPILED BY MHW

DATUM Geodetic DATE August 22, 1990 CHECKED BY VCH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPo (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
100.8	Ground Surface										
	Topsoil										
0.1	Gravel and Silty Clay (Fill)										
99.9	Firm Brown						100				
0.9	Clayey Silt (Till) tr. sand, occ. gravel		1	SS	46						
			2	SS	60						
			3	SS	75						
			4	SS	86		98				
	Hard Grey brown becoming red brown at about elevation 96.2 m		5	SS	120						
			6	SS	60/75mm						
95.6							96	Borehole dry to Elevation 94.6 during drilling			
5.2	Shale (Deformation Till) completely weathered		7	SS	70/100mm						
95.0											
5.8	Shale Bedrock highly weathered		8	SS	70/100mm						
94.6											
6.2	Shale Bedrock moderately to slightly weathered thin to medium bedded, Reddish Brown interbedded with fine grained argillaceous limestone		9	NQ RC	* TCR= 90% SCR= 52% RQD= 40%		94				
					* TCR= 100% SCR= 60% RQD= 43%						
91.5							92				
9.3	End of Borehole										
							90				

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 31

METRIC

W P 199-77-04 LOCATION Co-ordinates N4,799,158 E277,988 ORIGINATED BY CB

DIST 4 HWY 403/QEW BOREHOLE TYPE Solid Stem Augers COMPILED BY MHW

DATUM Geodetic DATE August 22, 1990 CHECKED BY VCM.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
101.7	Ground Surface										
0.0	Clayey silt (Fill) with sand, trace organics, occ. gravel		1	SS	15						
99.9	Stiff Brown		2	SS	15		100				
1.8	Clayey Silt (Till) trace sand, occasional gravel		3	SS	74						
			4	SS	106/100mm						
			5	SS	113		98	Borehole dry during drilling			
			6	SS	85						
96.3	Hard Grey Brown										
5.4	Shale (Deformation		7	SS	>50/25mm						
95.9	Till) comp. weathered						96				
5.8	Shale Bedrock										
95.5	Highly weathered		8	SS	>50/75mm						
6.2	End of Borehole						94				

OFFICE REPORT ON SOIL EXPLORATION

+3, x5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF TEST PIT No. 9

METRIC

W P 199-77-04 LOCATION Co-ordinates N4,799,213.5 E277,950 ORIGINATED BY VCH

DIST 4 HWY 403/QEW BOREHOLE TYPE Bachoe Dug "John Deere 690" COMPILED BY MHW

DATUM Geodetic DATE August 17, 1990 CHECKED BY VCM

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL / WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
101.0	Ground Surface										
100.8	Topsoil										
0.2	Clayey Silt (Fill) with zones of gravel and sand		1	CS			100		○		
99.8	Brown							Test pit dry following excavation			
1.2	Clayey Silt (Till) tr. sand, occasional gravel and cobbles		2	CS			98		○		
97.3	Grey Brown										
3.7	Bottom of Pit						96				

OFFICE REPORT ON SOIL EXPLORATION

$+^3$, $\times^5$: Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF TEST PIT No. 10

METRIC

W P 199-77-04 LOCATION Co-ordinates N4,799,172.5 E277,982 ORIGINATED BY VCH

DIST 4 HWY 403/QEW BOREHOLE TYPE Backhoe Dug "John Deere 690" COMPILED BY MHW

DATUM Geodetic DATE August 17, 1990 CHECKED BY VCH

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
101.5	Ground Surface										
101.3	Topsoil										
0.2	Clayey Silt (Fill) tr. sand and organics occasional gravel		1	CS					○		
99.9	Brown		2	CS			100		○		
1.6	Clayey Silt (Till) tr. sand, occasional gravel		3	CS				Test pit dry following excavation	○		
97.7	Grey Brown						98				
3.8	Bottom of Test Pit						96				

OFFICE REPORT ON SOIL EXPLORATION

$+^3$, $\times^5$: Numbers refer to Sensitivity

15 20/10 5 (%) STRAIN AT FAILURE

GEOTECHNICAL INVESTIGATION
PROPOSED BRIDGE 33
SITE 10-335
FREEMAN INTERCHANGE
BURLINGTON, ONTARIO
W.P. 199-77-05 DISTRICT 4

1. INTRODUCTION

Golder Associates Ltd. has been retained by the Ministry of Transportation of Ontario (MTO) to carry out a series of site specific subsurface investigations for the design of structures for the proposed reconstruction of the Freeman Interchange in Burlington, Ontario. This report presents the results of a subsurface investigation carried out at the site of the proposed Bridge No. 33. As presently proposed, Bridge 33 will carry the QEW east/403 west ramp traffic over the 403 east/QEW south ramp traffic. The proposed high level Bridges 34 and 35 will carry the 403 westbound and eastbound traffic over bridge 33. The location of the site is shown on the Key Plan, Drawing 1997705-A*.

The purpose of the investigation was to determine the subsurface conditions at the site.

2. SITE AND PROJECT DESCRIPTION

The site of the proposed Bridge 33 is located in a relatively flat, grassed area, situated south of the existing QEW/403 west ramp and north of the existing QEW southbound lanes and the QEW east/403 west ramp. The location of the site is shown on the Key Plan, Drawing 1997705-A*.

The site is situated within the physiographic region of Southwestern Ontario known as the Iroquois Plain. Available geologic information indicates that the overburden in the

* SHEET NO 465 OF THE CONTRACT DWG'S

general area of the site consists of a thin veneer of sands, glacial till and/or residual soil derived from the weathering of the underlying shale bedrock. The Queenston shale formation which comprises the bedrock in the area generally consists of thinly bedded red shale with occasional bands of grey limestone.

The bridge will carry QEW east/403 west ramp traffic over the 403 east/QEW south ramp. The proposed high level bridges (34 and 35) will carry the 403 west and east bound traffic over Bridge 33.

The proposed bridge will consist of a 19 metre span rigid frame, some 17 metres in length. Approach fills of some 7 metres in height will be required.

3. INVESTIGATION PROCEDURE

The field work for this investigation was carried out on August 16 and 20, 1990 at which time one test pit (numbered 3) was excavated and two boreholes (numbered 6 and 7) were drilled. The locations of the boreholes and test pit are shown on Drawing 1997705-A.*

In addition, the results of borehole 16 drilled as part of the investigation programme for Bridge No. 35 (Site 10-480 WP 199-77-07)have been included in this report.

The initial stage of the field work consisted of excavating one test pit (numbered 3) some 20 metres west of the west abutment of the proposed Bridge 33. The test pit was excavated to a depth of about 3.7 metres using a "John Deere 690" hydraulic backhoe supplied and operated by a local

* SHEET NO 465 OF THE CONTRACT DWG'S

contractor. Chunk samples were obtained from the predominant soil strata exposed in the test pit and the test pit was loosely backfilled following sampling and logging.

The boreholes were drilled using track mounted power auger drillrigs equipped for rotary drilling which was supplied and operated by a specialist drilling contractor. The boreholes were drilled to practical auger refusal using both nominal 150 millimetre outside diameter hollow stem augers and nominal 100 millimetre diameter solid stem augers. Standard penetration testing and sampling was carried out within the overburden encountered in the boreholes using 35 millimetre inside diameter split spoon sampling equipment.

Samples of the overburden recovered from the test pit and boreholes, were taken to our Hamilton laboratory for examination and water content determinations.

The soil and rock stratigraphy encountered in the boreholes and test pit are shown in detail on the Records of Boreholes and Record of Test Pit following the text of this report and on Drawing 1997705-A.* The results of the field and laboratory testing are also shown on the Record of Borehole and Record of Test Pit sheets.

Groundwater levels were observed in the open boreholes during drilling and in the test pit during and after excavation. Notes pertaining to the groundwater conditions encountered in the boreholes and test pit are shown on the Records of Boreholes and Test Pit and on Drawing 1997705-A.*

The locations and ground surface elevations at the borehole and test pit locations have been determined by Golder

* SHEET NO 465 OF THE CONTRACT DWG'S

Associates staff with reference to site specific points and temporary bench marks provided by McCormick Rankin & Associates Limited. The final locations and ground surface elevations at the boreholes were subsequently verified by McCormick Rankin. The elevations provided are understood to be referred to geodetic datum.

4. SUBSURFACE CONDITIONS

4.1 General

The subsurface conditions encountered in the boreholes and test pits put down at the site are shown in detail on the Record of Borehole and Record of Test Pit sheets, and in summary form on Drawing 1997705-A*. The soil boundaries and rock stratigraphy indicated, particularly for the boreholes, are inferred from non-continuous sampling and resistance to drilling advance. These boundaries typically represent a transition between one soil or rock type to another and are not intended to define an exact plane of geological change. Conditions will vary between and beyond the borehole and test pit locations.

The subsurface conditions encountered at the site generally consisted of fill and topsoil overlying glacial till, and completely to highly weathered shale.

The following discussion has been simplified in terms of major soil and rock strata for the purposes of geotechnical design.

It should be noted that due to the relatively soft and weathered nature of the Queenston shale formation,

* SHEET NO 465 OF THE CONTRACT DWG'S

particularly the upper zone, together with the effects of glacial overriding at the bedrock surface, it is difficult to accurately define the bedrock surface both from a geological and a contractual standpoint.

During the course of this investigation, a stratigraphic unit directly overlying the shale bedrock, which in strictly geological terms is described as deformation till, has been encountered. This stratigraphic unit consists of an imbricate embedment of fragments of bedrock in a till matrix which has been formed from glacial overriding of the parent bedrock. This till is characterized by the presence of rounded and sub-angular clasts of the parent rock with non horizontal bedding. Based on the consistency, the relatively high penetration resistance encountered in the boreholes and the difficulty of excavation experienced in the test pits, this stratum could be contractually interpreted as a zone of the bedrock and for this reason has been referred to in this report as an upper zone of the bedrock formation.

4.2 Topsoil

Layers of topsoil were encountered at the ground surface depths in borehole 16 and test pit 3 and beneath the fill in borehole 7 and test pit 3.

4.3 Silty Clay, trace sand, trace to some topsoil, occasional gravel (Fill)

Layers of silty clay fill were encountered to depths of about 1 metre in boreholes 6 and 7 and in test pit 3 and to a depth of about 1.7 metres in borehole 16. The silt clay fill in borehole 16 had an in-situ water content of about 20 per cent

and an N value as determined in the standard penetration test of 16 blows per 0.3 metres.

4.4 Clayey Silt, trace to some sand, occasional gravel (Till)

Glacial till was encountered beneath the fill and topsoil and generally consisted of an upper zone of stiff to hard brown clayey silt and a lower zone of reddish brown clayey silt which is somewhat harder than the overlying till.

The N values determined in the upper till zone ranged from 13 to 43 blows per 0.3 metres. The natural water content of samples of the upper till recovered from the boreholes and test pit ranges from about 11 to 20 per cent. The upper till deposit was fully penetrated in the boreholes and test pit at depths of about 2 to 2.5 metres below the existing ground surface, or at about elevation 103.6 metres.

Standard penetration testing was carried out in the lower till zone, but due to its hard consistency it was not practical to advance the sampler the entire 450 millimetres required to establish an N value. However, N values of the order of greater than 100 blows per 0.3 metres can generally be inferred from the penetration testing. The natural water content of the lower till typically ranges from about 5 to 14 per cent.

Both of the till layers encountered were generally fine grained in nature and no major concentrations of coarse particles such as boulders were encountered during this investigation. This does not necessarily mean that the coarser particle sizes are not present at random or in

concentrations within the deposit, since till is an inherently variable material.

4.5 Shale, completely to slightly weathered (Bedrock)

At the borehole locations, the overburden materials are underlain by shale bedrock of the Queenston Formation. Bedrock was encountered between about elevations 102.1 and 102.8 metres, or at depths of from about 3.1 to 3.7 metres below the existing ground surface.

The upper zone of the bedrock is generally highly weathered and has been described as deformation till in borehole 7 and test pit 3. More competent shale was encountered in borehole 16, at about elevation 101 metres.

4.6 Groundwater Conditions

Groundwater was not encountered during the field drilling operations in boreholes 6 and 7 which were terminated at auger refusal. Minor groundwater seepage into test pit 3 was observed at about elevation 104.9 metres or at a depth of about 1.2 metres below the existing ground surface.

It should be noted that the piezometric groundwater level within the subsoil and underlying bedrock is subject to fluctuation not only due to precipitation conditions, but also due to seasonal variations. The groundwater conditions reported above may therefore not necessarily represent stabilized conditions or conditions which may be encountered during construction.

Note: The preceding report is a copy of the factual information from the Foundation Report prepared by GOLDER ASSOCIATES LTD (consulting geotechnical engineers for this project), under the technical supervision of the M.T.O. Foundation Design Section.

P. Payer, P. Eng.
Senior Foundatation Engineer

M.S. Devata, P. Eng.
Chief Foundation Engineer

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 6

METRIC

W P 199-77-05 LOCATION Co-ordinates N4,799,544.5 E277,853.4 ORIGINATED BY CB

DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Auger COMPILED BY MHW

DATUM Geodetic DATE August 20, 1990 CHECKED BY [illegible]

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
105.9	Ground Surface										
0.0	Fill. Silty Clay Some Topsoil										
105.0	Brown to Black										
0.9	Clayey Silt (Till) tr sand occasional gravel		1	SS	14						
			2	SS	13		104				
	Stiff to Hard		3	SS	101/150mm			Borehole dry following drilling			
	Brown becoming reddish brown at about elev. 103.8		4	SS	82/150mm						
102.2							102				
3.7	Shale Bedrock moderately to slightly weathered thinly to medium bedded		5	SS	87/125mm						
			6	SS	50/75mm						
	Reddish Brown										
99.8							100				
6.1	End of Borehole						98				

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 7

METRIC

W P 199-77-05 LOCATION Co-ordinates N4,799,553.2 E277,868.4 ORIGINATED BY VCH

DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Auger COMPILED BY MHW

DATUM Geodetic DATE August 20, 1990 CHECKED BY VCH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
105.9	Ground Surface										
0.0 / 105.2	Fill - Silty clay Reddish Brown										
0.7	Topsoil										
0.9	Clayey Silt (Till) Trace to some sand		1	SS	14				○		
			2	SS	43		104		○		
	Stiff to Hard Brown becoming reddish brown at about elev. 103.8 m		3	SS	65/75mm			Borehole dry following drilling	○		
102.8											
3.1	Shale (Deformation Till) completely to highly weathered		4	SS	50/50mm				○		
101.9	Reddish Brown		5	SS	70/75mm		102				
4.0	Shale Bedrock Highly to moderately weathered										
101.3			6	SS	70/100mm						
4.6	End of Borehole						100				

OFFICE REPORT ON SOIL EXPLORATION

$+^3$, $\times^5$: Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF TEST PIT No. 3

METRIC

W P 199-77-05 LOCATION Co-ordinates N4,799,534 E277,833 ORIGINATED BY VCH

DIST 4 HWY 403/QEW BOREHOLE TYPE Backhoe Dug; John Deere 690 COMPILED BY MW

DATUM Geodetic DATE August 16, 1990 CHECKED BY VCH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
106.1	Ground Surface						106				
0.0	Topsoil										
0.3	Silty Clay (Fill) trace sand occ. gravel Brown										
105.2											
0.9	Topsoil										
1.1	Clayey Silt (Till) trace sand, occ. gravel		1	CS		▼					
	Brown to Red Brown							Water Seepage at elevation 104.9 metres during excavation	○		
102.7							104				
3.4	Shale (Deformation Till)										
3.7	Bottom of Pit						102				

OFFICE REPORT ON SOIL EXPLORATION

+3, x5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 16

METRIC

W P 199-77-08 LOCATION Co-ordinates N4799544.2 E277872.3 ORIGINATED BY VCH

DIST 4 HWY 403/QEW BOREHOLE TYPE Hollow Stem Auger; NQ Rock Core COMPILED BY MHW

DATUM Geodetic DATE August 29, 1990 CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPo ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
105.5	Ground Surface										
0.0	Topsoil										
0.2	Silty Clay trace sand, tr topsoil occ. gravel (Fill)		1	SS	16						
103.8	Stiff to Very Stiff Brown						104				
1.7	Clayey Silt trace to some sand occasional gravel (Till)		2	SS	14						
			3	SS	65/100mm			Pressuremeter Test 16-1			7 30 43 20
			4	SS	90/150mm						
101.8	Hard Reddish Brown						102				
3.7	Shale Bedrock highly weathered		5	SS	50/50mm			Borehole dry to elev. 101.1 during drilling			
101.1	Reddish Brown										
4.4	Shale Bedrock moderately to slightly weathered thinly to medium bedded Reddish Brown interbedded with fine grained argillaceous Limestone		6	NQ RC	*TCR =93% SCR =57% RQD = 8%		100	Pressuremeter Test 16-2			
			7	NQ RC	TCR =100% SCR =78% RQD =42%			Pressuremeter Test 16-3			
98.0							98				
7.5	End of Borehole						96				

* TCR: Total Core Recovery
SCR: Solid Core Recovery
RQD: Rock Quality Designation

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE

STABILITY OF SLOPES
CUT AND FILL OF HIGHWAY 403
between Freeman Interchange
and Highway 5
W.P. 199-77-06
District 4, Burlington

INTRODUCTION

Further to the meeting of 92 01 30, this office received a request from the Regional Geotechnical Section on February 6, 1992, with regard to the stability of cut anf fill slopes along the proposed Hwy. 403 between Freeman Interchange and Highway 5.

Based on the request, this Section has reviewed the subsurface conditions obtained from the previous field investigations within the area (W.P. 199-77-09/10/11/13/17/19/21). No additional fieldwork was carried out for these analyses. However, the results obtained from the previous investigations are utilized in this report.

This report contains factual information from the previous investigations.

SITE DESCRIPTION

The site is located on the proposed alignment of Hwy. 403 between Freeman Interchange and Hwy. 5 in the City of Burlington, Regional Municipality of Halton as shown on Figure A. The topography in the area is generally flat to gently undulating with ground surface sloping to the south toward Lake Ontario. Land use in the vicinity of the site is primarily residential and commercial subdivision development and agricultural north of Hwy. 5.

SUBSURFACE CONDITIONS

The subsoil conditions are generally uniform across the site. In general, under a thin veneer of topsoil and occasional fill deposits, the overburden consists of a deposit of glacial till underlain by shaly bedrock.

Based on the available borehole information obtained from the previous field investigations within the area as shown on representative borehole logs in the Appendix (W.P. 199-77-09/10/11/13/17/19/21), it is determined that the fill is mainly clayey silt which is underlain by a cohesive glacial till consisting of a heterogeneous mixture of clayey silt, sand and gravel. The bedrock is known to be Queenston Shale which is underlain with cohesive glacial till. The thickness of these deposits varies across the site. The groundwater level is found to be about 3 m below the original ground surface.

MISCELLANEOUS

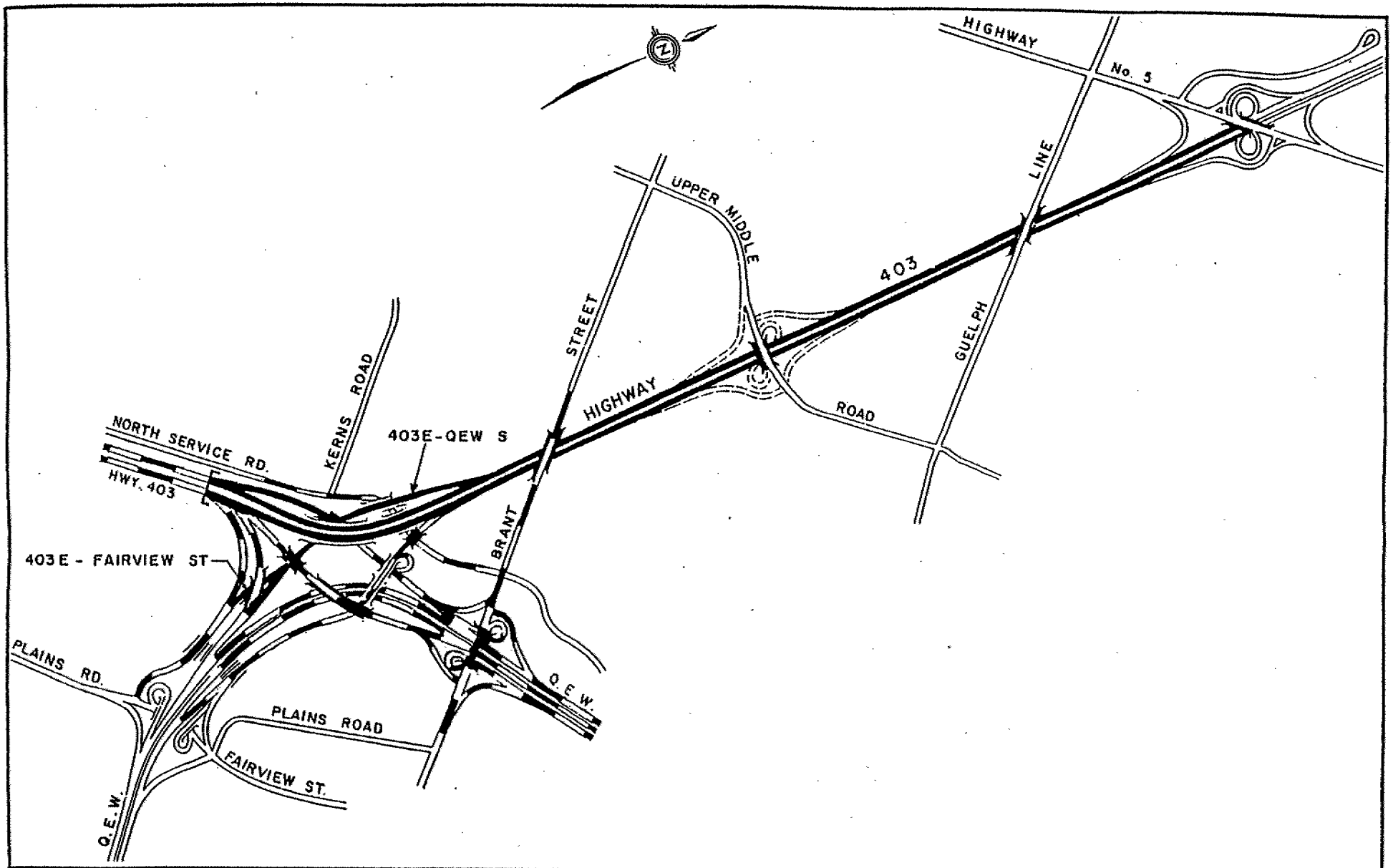
No fieldwork was carried out for these analyses. The results obtained from the previous field investigations within the area were utilized in this report (W.P. 199-77-09/10/11/13/17/19/21).

This report was written by Tae C. Kim, Sr. Foundation Engineer, reviewed by M. Devata, Chief Foundation Engineer

P. Payer, P. Eng.
Senior Foundatation Engineer

M.S. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX



Ministry of Transportation
Ontario

PROJECT LOCATION MAP

FIG No A

WP 199-77-06

RECORD OF BOREHOLE No 31-E 1 OF 1 METRIC

W.P. 199-77-06(Formerly 199-77-09) LOCATION Co-ords: N 4 799 930; E 277 941 ORIGINATED BY AH

DIST 4 HWY 403 BOREHOLE TYPE S.S. Auger / NQ Coring COMPILED BY JB

DATUM Geodetic DATE September 24, 1991 CHECKED BY BI

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
117.2	Ground Surface										
0.0	Heterogeneous Mixture of Clayey Silt Some Sand and Gravel (Glacial Till)		1	SS	20	*	116				
			2	SS	16						
			3	SS	17		114				
			4	SS	18						
			5	SS	7						
	Stiff to Very Stiff		6	SS	32		112				
	Hard		7	SS	29						
			8	SS	94						
108.6	Greyish Brown		9	SS	103		110				
8.6	Heterogeneous Mixture of Sandy Silt, Some Gravel and Clay (Glacial Till)		10	SS	50/5cm		108				
107.0	Very Dense Brown										
10.2	Greyish Red		11	RC	REC 10%		106				RQD 0%
	Weathered / Sound		12	RC	REC 80%						RQD 27%
	Bedrock Shale		13	RC	REC 83%		104				RQD 37%
	Containing Siltstone Interbeds		14	RC	REC 70%		102				RQD 24%
101.0											
16.2	End of Borehole										

* Groundwater Elevation not Established.

$+^3$, $\times^5$: Numbers refer to Sensitivity

$15 \overset{20}{\underset{10}{\diamond}} 5$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 32-B 1 OF 1 METRIC

W.P. 199-77-06(Formerly 199-77-10) LOCATION Co-ords: N 4 799 867; E 277 948 ORIGINATED BY AH

DIST 4 HWY 403 BOREHOLE TYPE S.S. Auger / BXL coring COMPILED BY JB

DATUM Geodetic DATE September 18, 1991 CHECKED BY BI

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
115.8	Ground Surface							20 40 60 80 100	10 20 30		
0.0	Topsoil/Clayey Silt Fill Trace of Root Fibres — Brown		1	SS	41						
114.4	Clayey Silt, Some Sand (Possible Fill) — Brownish Grey		2	SS	28						
1.4	Heterogeneous Mixture of Clayey Silt Some Sand and Gravel (Glacial Till)		3	SS	22		114				
			4	SS	25						
			5	SS	23		112				
			6	SS	28						
	Very Stiff — Hard		7	SS	23				o		
			8	SS	39		110				
108.7	Brownish Grey		9	SS	82				o ⊢⊣		12 18 42 28
7.1	Greyish Red — Heterogeneous Mixture of Sandy Silt Some Gravel and Clay (Glacial Till) Very Dense		10	SS	60/13cm	*	108		o		
106.2			11	SS	60/10cm	P1					
9.6	Weathered — Sound		12	RC	REC 83%		106				RQD 67%
	Bedrock Shale Containing Siltstone Interbeds		13	RC	REC 95%		104				RQD 81%
102.8											
13.0	End of Borehole										

1991 09 24
* GROUND WATER CONDITIONS

PIEZO. NO.	GROUND WATER ELEVATION (Metres)
1	107.2

+³, ×⁵ : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 36-A 1 OF 1 METRIC

W.P. 199-77-06(Formerly 199-77-11) LOCATION Co-ords: N 4 799 828; E 277 885 ORIGINATED BY JB

DIST 4 HWY 403 BOREHOLE TYPE S.S. Auger / NQ Coring COMPILED BY JB

DATUM Geodetic DATE September 17, 1991 CHECKED BY BI

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
117.6	Ground Surface										
0.0	150mm Clayey Silt Fill										
116.2	Clayey Silt, Some Sand (Possible Fill) Brown		1	SS	34						
1.4	Brownish Grey to Grey		2	SS	17		116				
			3	SS	18						
	Heterogeneous Mixture of Clayey Silt Some Sand and Gravel (Glacial Till)		4	SS	26		114				
			5	SS	23						
			6	SS	19						
			7	SS	24		112				
	Very Stiff		8	SS	21						
	Hard		9	SS	68						
			10	SS	71/23cm		110	o			
	Brownish Grey to Grey					*					
	Greyish Red		11	SS	77/19cm						
107.5			12	SS	50/1cm		108				
10.1	Weathered										
	Sound		13	RC	REC 57%	P1					RQD 7%
	Bedrock Shale		14	RC	REC 66%		106				RQD 21%
	Containing Siltstone Interbeds		15	RC	REC 82%		104				RQD 10%
102.6											
15.0	End of Borehole										

1991 09 24
* GROUND WATER CONDITIONS

PIEZO. NO.	GROUND WATER ELEVATION (Metres)
1	108.8

$+^3$, $\times^5$: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 1 METRIC

W P 199-77-06 (Formerly 199-77-13) LOCATION Co-ords. N 4 800 814.5; E 277 884.0 ORIGINATED BY BR

DIST 4 HWY 403 BOREHOLE TYPE Hollow Stem Auger COMPILED BY BR

DATUM Geodetic DATE 85 01 17 CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
130.2	Ground Surface										
0.0	Silty Clay Some Gravel and Sand Fill Stiff		1	SS	11						
			2	SS	15						
127.5			3	SS	15						21 41 26 11
2.7	Heterogeneous Mixture of Silty Clay, Sand and Gravel Hard Glacial Till occasional cobbles and boulders		4	SS	34						
			5	SS	40	▼					
			6	SS	70						
			7	SS	33						
			8	SS	49						
			9	SS	99						
			10	SS	100						
118.3											25 26 38 11
11.9	Bedrock Weathered Queenston Shale		11	SS	100/6 cm						
116.7			12	SS	100/5 cm						
13.5	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 3 1 OF 1 METRIC

W.P. 199-77-06(Formerly 199-77-17) LOCATION Co-ord: N 4801 977.5 E 277 888.5 ORIGINATED BY T.K.

DIST 4 HWY 403 BOREHOLE TYPE Cone Test, H.S. Auger, NQ Core COMPILED BY J.L.

DATUM Geodetic DATE April 19, 1990 CHECKED BY T.K.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
142.8	GROUND SURFACE						
0.0	CLAYEY SILT (FILL) Stiff Brown		1	SS	12		142
141.7							
1.1	Dark Brown CLAYEY SILT,Stiff (Topsoil) Dark Brown						
141.1			2	SS	12		141
1.7	Red						
			3	SS	63		140
			4	SS	39		
			5	SS	51		139
			6	SS	102 /10cm		138
	BEDROCK QUEENSTON SHALE						
	Weathered		7	SS	109 /8cm		137
	Sound		8	RC	REC 92%		136
			9	RC	REC 87%	P1	135
133.8							134
9.0	End of Borehole						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE; 5 10 15 20 25

120/25cm

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%): 10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)	GR	SA	SI	CL
	1	1	63	35
	0	0	80	20
RQD 30%				
RQD 33%				

* G.W.L. 5.8 m was not stabilized

$+^{3}$, $\times^{5}$: Numbers refer to Sensitivity

$\frac{20}{15}\diamond\frac{}{10}5$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 6 1 OF 1 METRIC

W.P. 199-77-06(Formerly 199-77-19) LOCATION Co-ord: N 4803 407.2 E 277 883.5 ORIGINATED BY F.L.R.

DIST 4 HWY 403 BOREHOLE TYPE S.S. Auger COMPILED BY J.L.

DATUM Geodetic DATE April 23, 1990 CHECKED BY T.K.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) / WATER CONTENT (%) (PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L)	UNIT WEIGHT kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
164.9	Ground Surface									
0.0	Clayey Silt (Topsoil)									
	Clayey Silt (Fill)						164			
163.4	Brown									
1.5	Reddish Brown		1	SS	41		163			
			2	SS	50		162			
			3	SS	83					
			4	SS	82		161			
			5	SS	115		160			
			6	SS	150	/25cm	159	o ⊢		19 26 42 13
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel Hard (Glacial Till)						158			
			7	SS	131		157			
			8	SS	150	/25cm	156			
			9	SS	152		155	o ⊢ ⊢		15 28 46 11
			10	SS	94	▼	154			
151.1	Reddish Brown		11	SS	120	/8cm	153			
13.8	End of Borehole Red Weathered Shale						152			

+³, ×⁵ : Numbers refer to Sensitivity

15 ◇ 5 (%) STRAIN AT FAILURE (20 / 10)

RECORD OF BOREHOLE No 5 1 OF 1 METRIC

W.P. 199-77-06(Formerly 199-77-21) LOCATION Co-ord: N 4804 724.3 E 277 787.8 ORIGINATED BY T.K.

DIST 4 HWY 403 BOREHOLE TYPE H.S. Auger COMPILED BY J.L.

DATUM Geodetic DATE April 25, 1990 CHECKED BY T.K.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
160.4	Ground Surface								
0.0 / 159.7	Clayey Silt (Fill)					DRY	160		
0.8	Heterogeneous Mixture of Clayey Silt, Sand and Gravel; Firm to Hard; (Glacial Till); Brown		1	SS	5		159		
			2	SS	7				
			3	SS	29		158		
	Reddish Brown		4	SS	21		157		4 18 59 19
156.0			5	SS	51				
4.4	Heterogeneous Mixture of Sandy Silt, Gravel and Clay; Very Dense; (Glacial Till)		6	SS	122/23cm		156		
			7	SS	120/15cm		155		12 27 56 5
152.5	Reddish Brown		8	SS	166/20cm	P1	154		
7.9	Red Bedrock; Queenston Shale						153		
151.2	Weathered		9	SS	120/8cm		152		
9.2	End of Borehole Sound								

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L

WATER CONTENT (%): 10 20 30

* GROUND WATER CONDITIONS

PIEZO. NO.	GROUND WATER ELEVATION (Metres)
1	Dry

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

FOUNDATION INVESTIGATION REPORT
FOR
HML POLES AND OVERHEAD SIGNS
HWY 403/Q.E.W., WP 199-77-06A
DISTRICT 4, BURLINGTON

INTRODUCTION

This report summarizes the results of a Foundation Investigation conducted in conjunction with High Mast Lighting Poles and Overhead Signs for the proposed Highway 403 between Highway 5 and the new Q.E.W./Hwy. 403 (Freeman) Interchange, the existing Q.E.W. northbound between Highway 2 and Fairview Street and the existing Highway 403 at King Road. The High Mast Lighting Pole and the Overhead Sign structures have been strategically positioned within the above mentioned areas, hereafter designated as sub-sections 1, 2 and 3, respectively.

SITE DESCRIPTION AND GEOLOGY

The three major sub-sectional areas, within which the investigation was conducted, are located within the City of Burlington, Regional Municipality of Halton. During the time of the investigation, construction activities were evident at various locations within the new Highway 403. Within the Freeman Interchange, new bridge structures and associated approach embankment fills were under construction and beyond this interchange, (North of North Service Road) excavation cuts were observed in a northerly direction up to approximately Upper Middle Road. Within sub-section 1 and north of North Service Road, the area is

located adjacent to existing residential developments. The other two sub-sections are located within the existing respective highway right-of-way.

The terrain within the site areas in generally flat or gently sloping and a number of meandering creeks traverse the area. Sections of the site which were not excavated consists of grassland.

Physiographically, the site is located in the region known as the "Iroquois Plain". The Iroquois Plain is the product of the advance and retreat of the Wisconsinan ice sheet which covered the area during the Pleistocene epoch (over 12,000 years ago). At the site, the lowland bordering Lake Ontario, was inundated by the glacial lake called Lake Iroquois. Conditions in the old lake plain vary greatly from site to site.

At the site location two native deposits of glacial till origin were encountered. A cohesive, unsorted, unstratified heterogeneous mixture of clayey silt, sand and gravel exists surficially, underlain by a non-cohesive heterogeneous mixture of silt, sand and gravel. The overburden is underlain by shale bedrock of the Queenston Formation of the Upper Ordovician Period.

INVESTIGATION PROCEDURE

Physical and mechanical soil properties were obtained by in situ and laboratory testing. The field and laboratory investigation and testing programs are summarized below.

Field Investigation

The fieldwork for the investigation was carried out between 92-11-09 to 92-12-01 and consisted of (26) sampled boreholes advanced to depths ranging from 6.5 m to 18.9 m below the existing ground surface. A diesel powered track mounted Central Mining Equipment (CME) 55 drilling unit was used to advance the boreholes. Conventional solid stem augering techniques were used to penetrate the overburden and the surficial weathered bedrock. Rock coring techniques employing NW casing and a NX core barrel were used to retrieve up to 3.0 metres of rock core.

Four additional boreholes advanced as part of previous investigations conducted in the area (WP 199-77-09 and WP 199-77-10) between 91 09 18-25 have also been included in this report. The boreholes, formerly BH 31-A, BH 32-A, BH 31-E, and BH 32-E have been used to provide data for the foundation design of High Mast Lighting poles 7 and 8. These boreholes were also advanced using a diesel track mounted CME 55 drilling unit employing conventional solid stem augering and rock coring techniques.

Disturbed subsoil samples were retrieved at 1.5 metre intervals employing a standard split spoon sampler in accordance with the Standard Penetration Test (ASTM D1585). All subsoil samples were identified in the field and then placed in sealed plastic jars to ensure the preservation of the in situ natural moisture contents. Samples were subsequently transported to the laboratory and then classified employing both visual and laboratory methods as described below.

Rock core were identified in the field and physical index properties were determined by visual examination and also by measurement of rock quality designations (RQD's) and core recovery. All rock core were placed in standard rock core boxes and carefully transported to the laboratory.

Groundwater levels were determined by monitoring the water levels in the open boreholes throughout the duration of the field investigation. All boreholes were backfilled upon completion of the fieldwork.

The survey related to the location and elevation of the individual boreholes was provided by Central Region Surveys and Plans.

Laboratory Analyses

All subsoil samples were carefully visually examined in the laboratory in accordance with the procedures outlined in the Visual Method described in Chapter 2 of the MTO Soil Classification Manual. The behaviour, gradation and other pertinent properties of the soil were determined by conducting the appropriate laboratory test on representative samples. These tests included:

1) Atterberg Limit Tests
2) Particle Size Analysis
3) Natural Moisture Contents
4) Bulk Unit Weights

Sample preparation and testing were conducted in accordance with the MTO Laboratory Testing Manual and as described in Chapter 3 of the MTO Soil Classification Manual.

Detailed rock core logging was conducted in the laboratory by an in-house resident geologist.

Laboratory test results have been summarized below in the subsequent section of this report entitled "Subsurface Conditions" and are illustrated on the corresponding boreholes and figures included in the Appendix to this report.

SUBSURFACE CONDITIONS

General

The subsurface conditions across the three sub-sections are generally uniform and in many areas consists of an extensive surficial natural deposit, comprised of a cohesive heterogeneous mixture of clayey silt, sand and gravel. This deposit is a glacial till which extends to depths ranging from 3.5 m to 12.2 m, and as is characteristic of these deposits, boulders and cobbles inferred during augering, are present within this deposit.

The cohesive heterogeneous mixture of clayey silt, sand and gravel is generally, although not always, underlain by a second glacial till deposit consisting of a cohesionless heterogeneous mixture of silt, sand and gravel. This lower deposit has a thickness ranging up to 6.1 m. Both glacial till deposits are extremely competent and strongly over-consolidated materials. Refusal of the SPT was frequently encountered in both deposits indicating a hard cohesive heterogeneous

mixture of clayey silt, sand and gravel and a very dense heterogeneous mixture of silt, sand and gravel.

The lower cohesionless heterogeneous mixture of silt, sand and gravel when present is underlain by weathered shale ranging up to approximately 1.5 m in thickness at some locations. The weathered shale is underlain by more competent unweathered shale bedrock with interbedded siltstone.

At some locations across the site, the native material is overlain by fill material. The most prominent placement of fill material explored during the investigation exists at the north approach to the N/B and S/B Q.E.W. Underpass at ramp Q.E.W.-S to Highway 403 (WP 83-74-28 and 83-74-29), which is the location of the proposed Overhead Sign #8. At this location, an irregular mixture of a cohesive clayey silt, sand and gravel material has been placed up to a thickness of 10.8 metres. Some of this cohesive fill material was also encountered at the proposed high mast lighting pole #6, located at the west toe of the above-mentioned approach embankment. At this location, approximately 2.1 metres of this fill material was encountered.

At various other locations, cohesionless fill comprised of materials ranging from an irregular mixture of silt, sand and gravel to silt also exists. These materials were primarily used as roadbase fill materials or backfill to pipe culverts. Thicknesses of these materials were within 2 metres.

The boundaries between the various soil types, in situ and laboratory test results as well as groundwater levels established at the time of investigation are shown on the attached Record of Borehole sheets in the Appendix. A plan of the site illustrating the locations and elevations of the boreholes are provided on Dwg. No. 1997706A-A*. A detailed description of the subsurface conditions encountered at the site is given below.

Cohesionless Fill Material

Cohesionless fill materials were encountered at various locations across the entire site area and the fill composition varies from location to location. Generally the material varies from an irregular mixture of silt, sand and gravel to a silt with some clay and traces of sand and extends surficially for depths up to approximately 2 metres. The material is brown, moist and in a loose to compact state of denseness.

Cohesive Irregular Mixture of Clayey Silt to Silty Clay, Sand and Gravel (Fill Material)

The north approach embankment to the N/B and S/B Q.E.W. Underpass at ramp Q.E.W-S to Highway 403 (WP 83-74-28 and 83-74-29), the location of the proposed Overhead Sign #8, is composed of an irregular mixture of clayey silt, sand and gravel fill material. The material, which is brown in colour appears to be borrow material excavated from a native heterogeneous mixture of clayey silt, sand and gravel (Glacial Till) perhaps within the general area. The material exhibits a cohesive behaviour attributable to the clayey silt compositions which essentially binds the coarser sands and gravels. The thickness of this fill

* SHEET NO 311-2 OF THE CONTRACT DWG'S

material extends up to 10.8 metres at the top of the embankment. At the proposed High Mast Lighting Pole #6 (see BH H6), approximately 2.1 metres of this fill material was encountered at the toe of the above mentioned embankment, and the binder consisted of silty clay.

Grain size distribution curves determined by mechanical sieve and hydrometer analyses on samples of this fill material are illustrated in Figure 1 in the Appendix. The curves exhibit a broad range of material sizes with the fine grained portion (<75 micrometres) exceeding 50 percent of the material composition. The material is therefore categorized according to its behaviour and hence Atterberg Limit Tests were conducted on samples to determine the plasticity of the finer material (<425 micrometres). The test results shown in Figure 2 illustrate that the fine grained portion of the deposit has a low to intermediate plasticity and hence can be classified as a clayey silt to silty clay. Natural moisture contents are in the order of 14 to 17 percent, presumably close to the optimum compaction moisture contents.

The results of the Standard Penetration Test (SPT) conducted within this material revealed "N" values ranging from 13 blows/0.3 m to 27 blows/0.3 m indicating a stiff to very stiff consistency.

Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)

The predominant native material within the 3 sub-sections consists of a deposit comprised of a cohesive heterogeneous mixture of clayey silt, sand and gravel. This deposit of glacial till origin also contains boulders and cobbles as inferred by auger grinding during the borehole advancement and sampler bouncing during sample retrieval.

In the areas where this material has not been excavated, the upper 3 metres or so of the deposit has been oxidized and hence is brown in colour. Beneath the oxidized depth, the material is grey in colour. The colour at the interface with the underlying material varies from reddish brown to greyish red.

The main component of this unsorted, unstratified deposit is the clayey silt material. This material matrix essentially binds the coarser sands and gravels within the deposit. A grain size distribution envelope for the deposit as determined by mechanical sieve and hydrometer analyses is given in Figure 3 in the Appendix. The envelope includes particle sizes up to 75 mm (coarse gravel) and hence excludes the boulder and cobble sizes. The envelope reveals that the fine grained portions (less than 75 micrometre) contribute from approximately 48 percent to as much as 93 percent of this deposit.

Atterberg Limit Tests were carried out to define the behaviour and plasticity of the fine grained position of the soil and the results are plotted in Figure 4. A summary of the indices is provided in Table 1. Bulk unit weights and natural moisture contents are also included in the table.

TABLE 1

HETEROGENEOUS MIXTURE OF

CLAYEY SILT, SAND AND GRAVEL

(GLACIAL TILL)

	RANGE	NO. OF TESTS
Natural Moisture Content (w%)	4 - 20	21
Liquid Limit (W_L%)	20 - 35	21
Plastic Limit (w_p%)	13 - 19	21
Plasticity Index (I_p%)	7 - 16	21
Unit Weight (KN/m^3), γ	20.1 - 24.8	21

The test results reveal that the fine grained portion of the deposit is of low plasticity and hence is classified as clayey silt. Natural moisture contents are generally close to and less than the plastic limit of the soil indicating that the soil is in a plastic to semi-solid state.

Standard Penetration Tests (SPT) carried out in this deposit revealed N values ranging from 5 blows/0.3 m to 100 blows/0.08 m. The lower "N" values were encountered at shallower depths and penetration resistance increased with depth. SPT refusal was encountered frequently within this deposit particularly at lower depths. These "N" values are representative of an overconsolidated material of hard consistency. The consistency of the material in the upper portions of the deposit ranges generally from stiff to very stiff.

Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till)

The cohesive heterogeneous mixture of clayey silt, sand and gravel is underlain at many locations by a greyish red cohesionless heterogenous mixture of silt, sand and gravel. Boulders and cobbles, as inferred by auger grinding and sampler bouncing are also present within this deposit. The thickness of this deposit ranges up to 6.1 metres.

A grain size distribution envelope determined by mechanical sieve and hydrometer analyses is given in Figure 5 in the Appendix. Boulder and cobble sizes are not illustrated on the figure.

Standard Penetration Tests carried out in this deposit generally encountered refusal which is indicative of the very dense state of denseness inherent of this deposit.

Bedrock

The overburden across the site is underlain by shale bedrock with interbedded siltstone of the Queenston Shale Formation. The depth to bedrock varied from approximately 3.1 metres to 15.2 metres but generally varied between 7.5m to 10.5 m. Ground surface elevations and hence bedrock surface elevations vary considerably across the site as identified on the individual borehole logs.

The surficial 0.5 to 1.5 metres of the bedrock is severely weathered and deteriorated at various locations across the site. Solid stem augering methods easily penetrated this zone and sample retrieval was possible, although with

considerable penetration resistance (typically 100 blows/0.08 m).

Rock core ranging from 1.5m to 4.1m was retrieved using an NX core barrel. In general, three (3) metres of rock core was retrieved. The rock core confirms a surficial weathered zone underlain by more competent unweathered bedrock. Occasional clay seams approximately 50 mm to 100 mm in thickness exist within the weathered zone.

The shale bedrock is generally greyish red and has randomly interbedded greenish grey siltstone layers ranging from approximately 25 mm 200 mm in thickness. The rock is horizontally bedded and is an extremely friable material with a very low slaking durability. The rock contains close to extremely close spaced fractures that are generally flat, planar to undulating and smooth.

Core recoveries and Rock Quality Designations (RQD's) were determined in-situ to evaluate the competence and integrity of the rock. Core recoveries ranged from 78% to 100% but were generally close to 100%. Rock Quality Designations (RQD's) ranged from 0% to 82% indicating a rock quality ranging from very poor to good. However, in general rock qualities were in the 30% to 70% indicating a rock of poor to fair quality. Rock quality generally improved with depth.

Rock strength as determined by index property examination in the laboratory is generally weak to very weak.

A detailed description of the characteristics and properties of the rock as determined by the logging of the rock core in the laboratory is attached in the Appendix under the heading "Rock Core Descriptions".

GROUNDWATER CONDITIONS

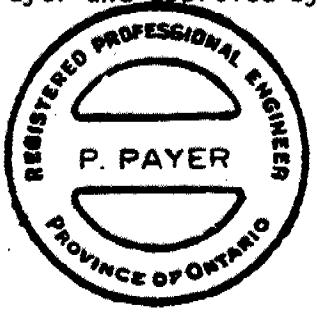
Observation of the groundwater level was carried out by measuring the water level in the open boreholes throughout the duration of the field investigation. The groundwater regime varies from location to location and groundwater levels are illustrated on the individual borehole logs.

Groundwater levels, in general, are subject to seasonal fluctuations and hence can vary from the values given in this report.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano, Foundation Engineer and D. Walters, Engineering attachment utilizing equipment owned and operated by Malone's Soil Samples.

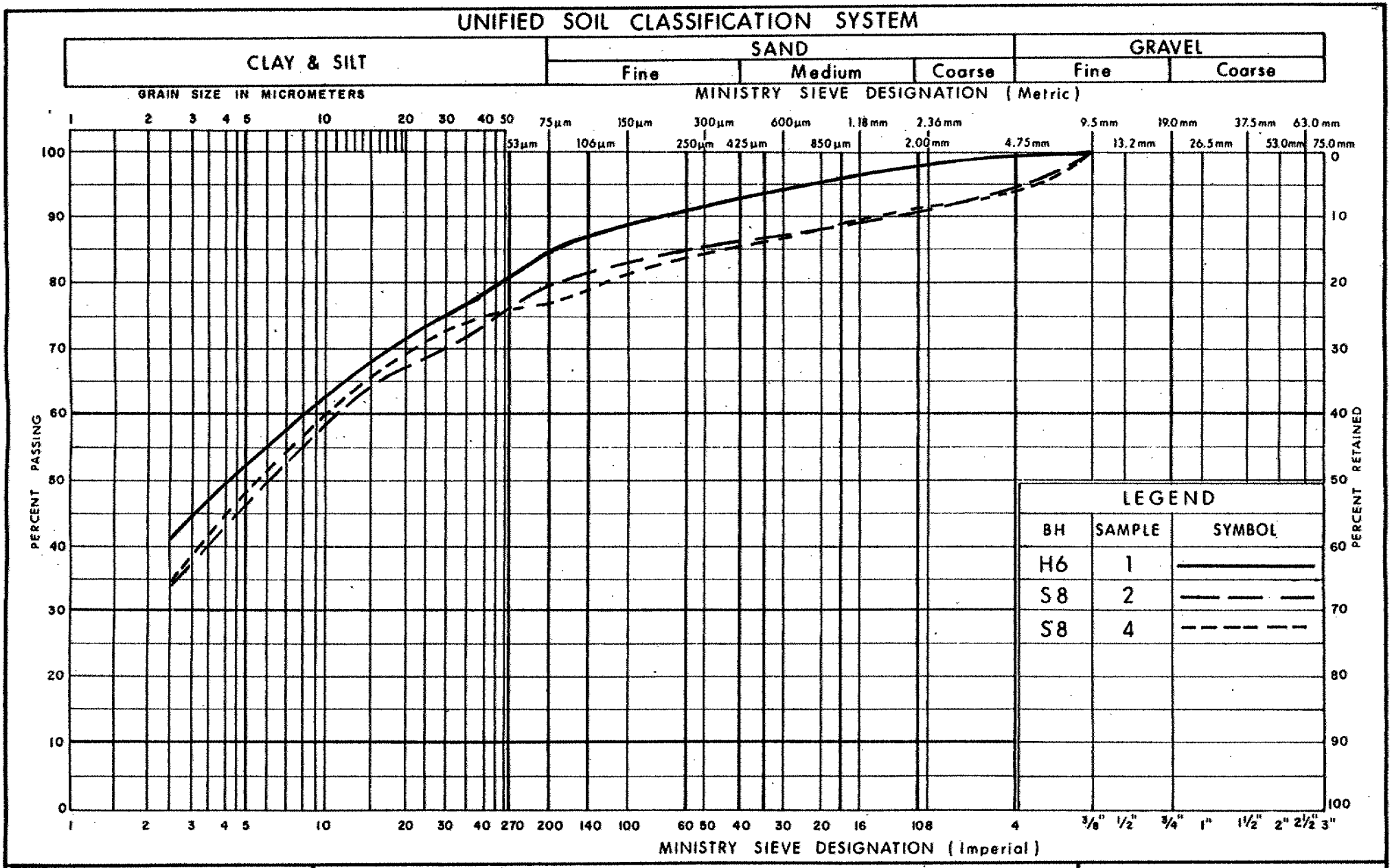
The project was carried out by T. Sangiuliano under the general supervision of P. Payer, Senior Foundation Engineer. The report was written by T. Sangiuliano, reviewed by P. Payer and approved by Mr. M.S. Devata, Chief Foundation Engineer.



P. Payer, P. Eng.
Senior Foundatation Engineer

M.S. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX



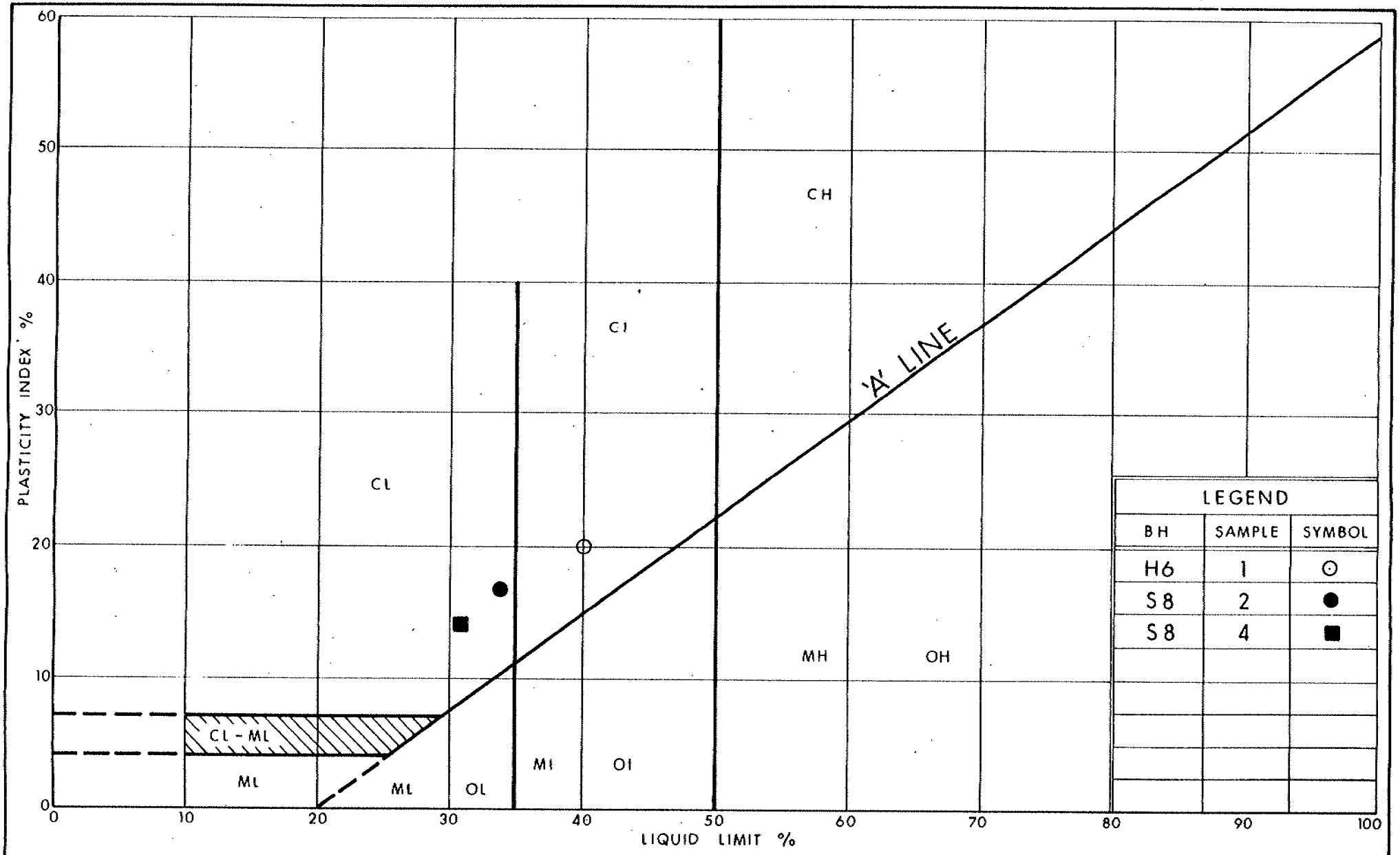
Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

IRREGULAR MIXTURE OF CLAYEY SILT TO SILTY CLAY SAND & GRAVEL (FILL MATERIAL)

FIG No 1

W P 199-77-06A

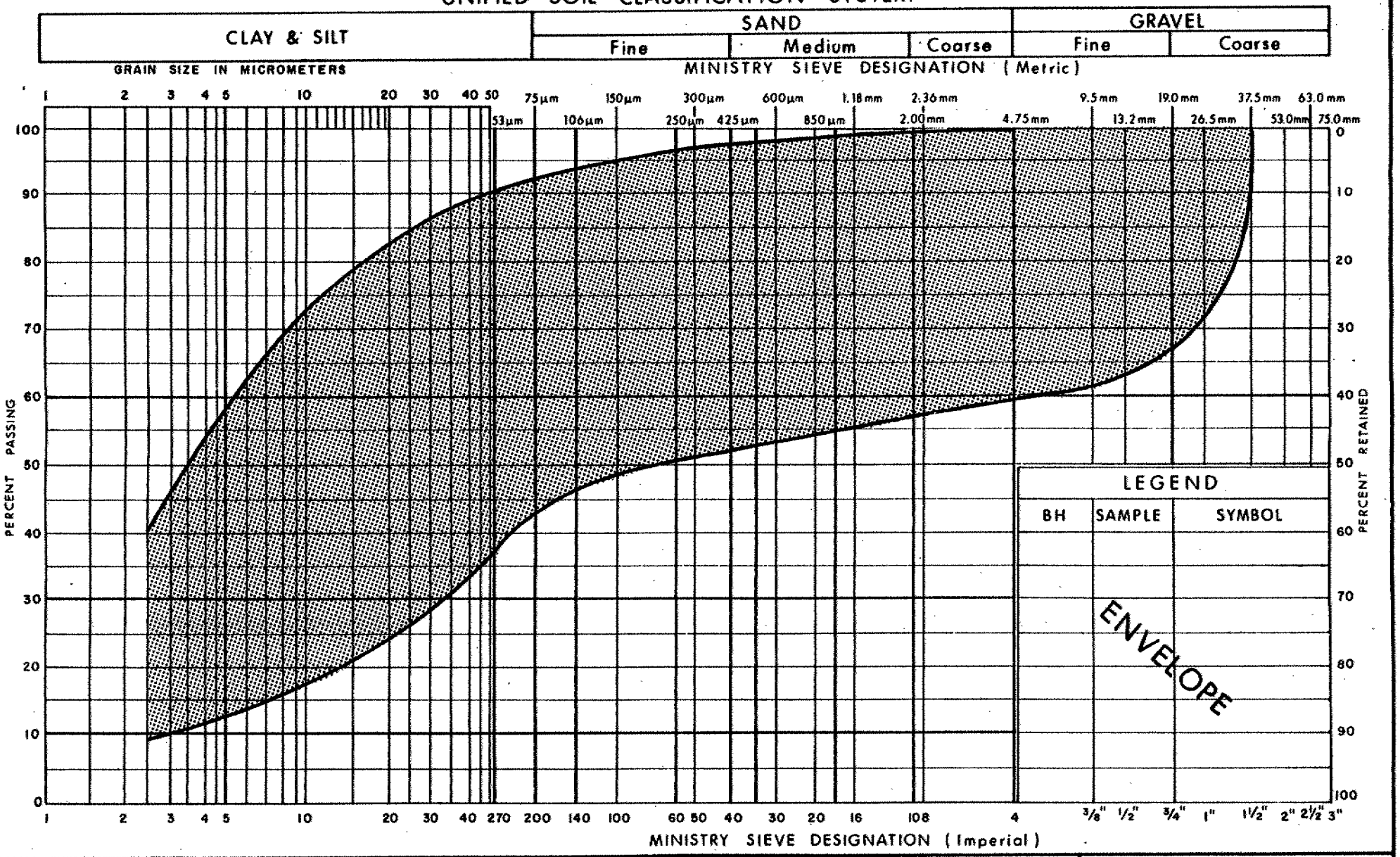


Ministry of Transportation
Ontario

PLASTICITY CHART
IRREGULAR MIXTURE OF CLAYEY SILT TO SILTY CLAY, SAND & GRAVEL (FILL MATERIAL)

FIG No 2
W P 199-77-06 A

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

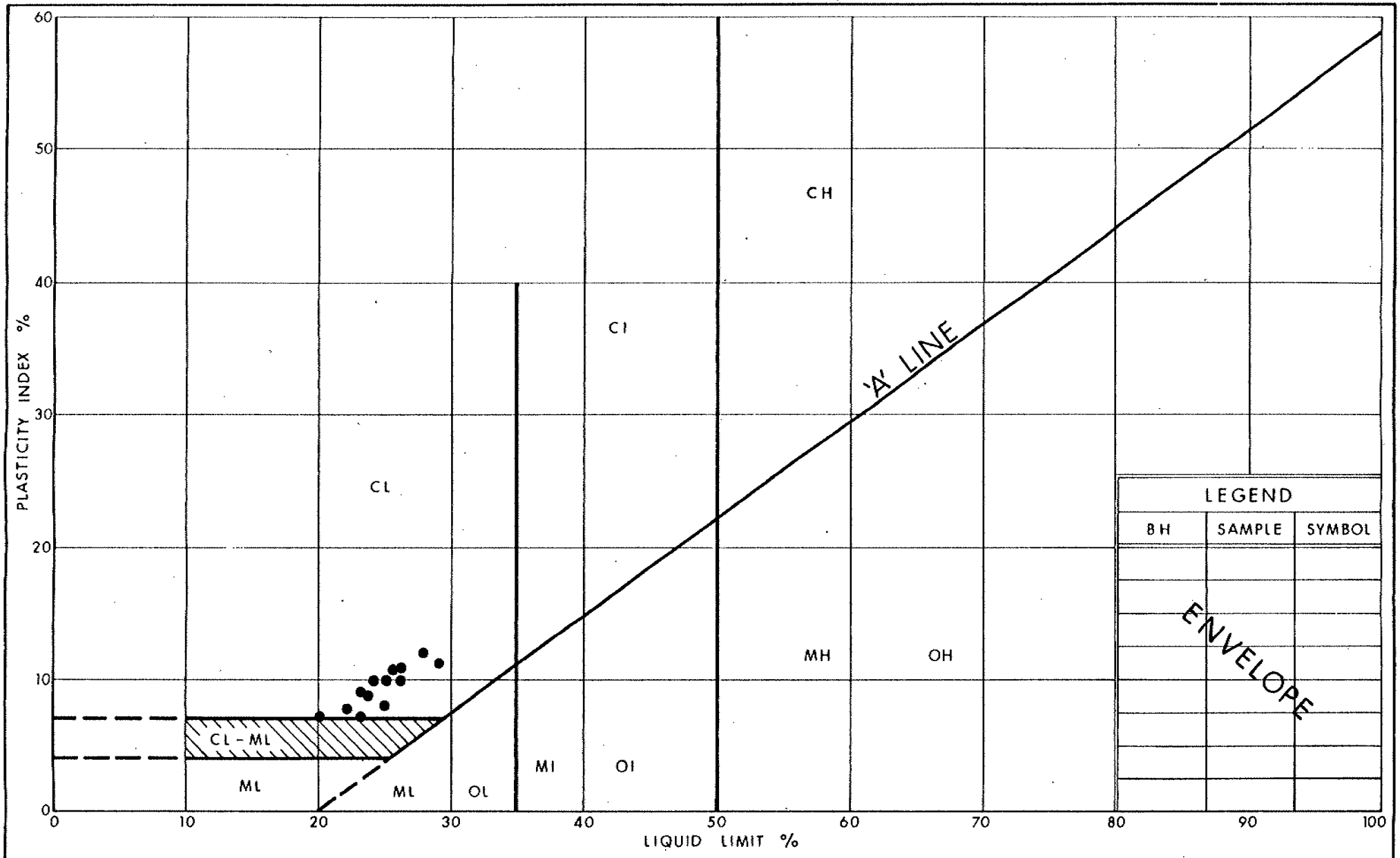
HET MIXTURE OF

CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 3

W P 119 - 77 - 06A

139



Ministry of Transportation
Ontario

PLASTICITY CHART

HET MIXTURE OF

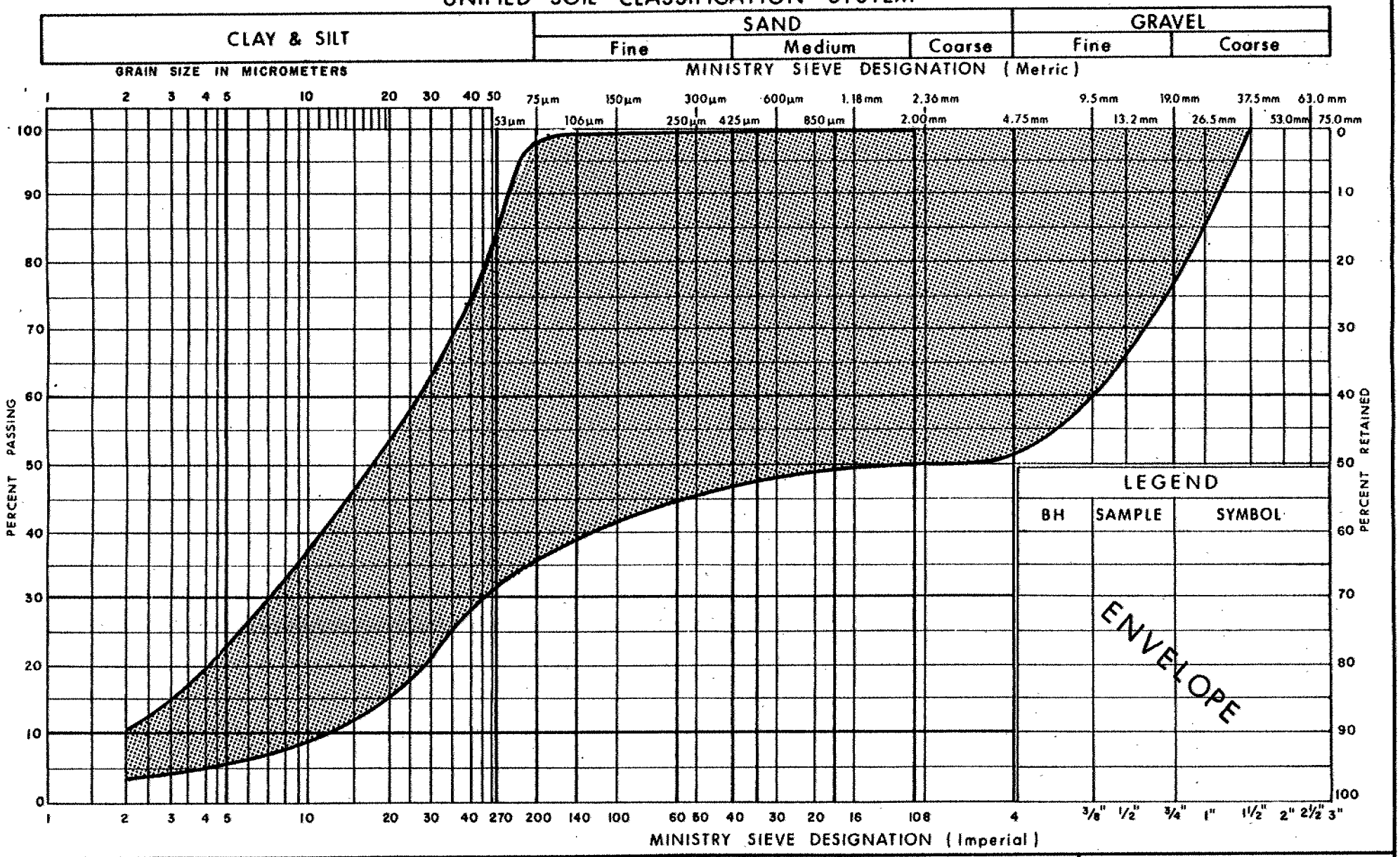
CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 4

W P 199 - 77 - 06 A

140

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

GRAIN SIZE DISTRIBUTION

HET MIXTURE OF

SILT, SAND & GRAVEL (Glacial Till)

FIG No 5

W P 199 - 77 - 06 A

141

RECORD OF BOREHOLE No H1 1 OF 1 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 798 397.8; E 276 852.1 ORIGINATED BY TS
DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NX Core COMPILED BY TS
DATUM Geodetic DATE 92 11 26 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
110.9	Ground Surface										
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)										
	Very Stiff		1	SS	17						
	Brown / Grey		2	SS	24						
			3	SS	20					21.4	0 8 57 35
			4	SS	20						
103.3											
7.6	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till)		5	SS	100	/15cm					
			6	SS	100	/15cm					
	Greyish Red, Very Dense										
100.2			7	SS	50	/3cm					
10.7	Weathered / Unweathered Shale Bedrock With interbedded Siltstone Weak to Very Weak, Greyish Red with Greenish Grey		8	RC	REC 100%						RQD = 57%
98.7											
12.2	End of Borehole										
	• 92 11 30										

$+^{3}$, $\times^{5}$: Numbers refer to Sensitivity

$\frac{20}{15}\diamond\frac{5}{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H2 1 OF 1 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 798 535.5; E 276 958.4 ORIGINATED BY TS

DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 92 11 26 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
109.8	Ground Surface										
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)						109				
	Stiff		1	SS	12						
	Brown						107				
	Grey		2	SS	16						
			3	SS	10		105				
103.7											
6.1	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till)		4	SS	60	/8cm	103				
	Greyish Red, Very Dense		5	SS	60	/5cm					
100.7			6	SS	60	/5cm	101				
9.1	Shale Bedrock with interbedded Siltstone		7	RC	REC 100%						RQD = 37%
99.1	Weak to Very Weak, Unweathered Greyish Red with Greenish Grey										
10.7	End of Borehole										
	▼ 92 11 30										

+³, ×⁵ : Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H3 1 OF 1 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 798 677.7; E 277 068.0 ORIGINATED BY TS

DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 92 11 30 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
109.0	Ground Surface										
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)										
	Hard		1	SS	32		108				
			2	SS	46		106				
	Brown / Grey		3	SS	39		104		o	22.3	2 16 51 31
102.9											
6.1	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till)		4	SS	70 /15cm	▼	102		o		9 28 57 6
	Greyish Red, Very Dense		5	SS	70 /15cm						
99.9							100				
9.1	Shale Bedrock with interbedded Siltstone		6	SS	100 /15cm						
	Weathered / Unweathered		7	RC	REC 100%						RQD = 50%
98.2	Weak to Very Weak, Greyish Red with interbedded Greenish Grey										
10.8	End of Borehole										
	• 92 12 01										

$+^{3}$, $\times^{5}$: Numbers refer to Sensitivity

$\frac{20}{15}\diamond\frac{5}{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H4 1 OF 1 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 799 591.0; E 277 833.8 ORIGINATED BY TS

DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 92 11 11 CHECKED BY PP

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
107.2	Ground Surface							20 40 60 80 100	10 20 30		
0.0	Irregular Mixture of Silt, Sand and Gravel (Fill Material) Brown, Compact										
105.7							106				
1.5	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till)		1	SS	5						
104.1	Greyish Red, Loose		2	SS	100	▼ /15cm	104				
3.1	Weathered / Unweathered Shale Bedrock with interbedded Siltstone Weak to Very Weak, Greyish Red with interbedded Greenish Grey		3	RC	REC 88%						RQD = 0%
			4	RC	REC 100%		102				RQD = 13%
			5	RC	REC 100%		100				RQD = 42%
99.3											
7.9	End of Borehole • 92 11 11										

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H5 1 OF 1 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 799 699.9 ; E 277 882.0 ORIGINATED BY TS

DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 92 11 09 / 10 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, x LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
110.9	Ground Surface										
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)						110				
	Brown, Stiff		1	SS	10	▼					
107.4			2	SS	12		108			20.3	23 29 27 21
3.5	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till)		3	SS	67 /15cm						
			4	SS	100 /15cm		106				
	Shale and Siltstone fragments		5	SS	100 /8cm				o H	22.3	50 5 38 7
	Greyish Red, Very Dense		6	SS	100 /15cm						
103.9			7	SS	100 /8cm		104				
7.0	Shale Bedrock with interbedded Siltstone		8	RC	REC 100% = 100%						RQD = 34%
	Weak to Very Weak, Unweathered Greyish Red with interbedded Greenish Grey		9	RC	REC 100% = 100%		102				RQD = 55%
100.8											
10.1	End of Borehole										
	• 92 11 10										

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15}\diamond^{5}_{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H6 1 OF 1 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 799 814.8; E 278 011.2 ORIGINATED BY TS

DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 92 11 09 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
110.7	Ground Surface										
0.0	Irregular Mixture of Silty Clay, Sand and Gravel (Fill Material) Brown, Stiff						110				
108.6			1	SS	13	▼			o	18.5	0 15 48 37
2.1	Trace Organics						108				
	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till) Greyish Red, Stiff		2	SS	12				o		13 27 50 10
106.1			3	SS	100	/15cm	106				
4.6	Shale Bedrock with interbedded Siltstone		4	RC	REC 100%						RQD = 37%
	Weak to Very Weak, Unweathered Greyish Red with interbedded Greenish Grey		5	RC	REC 100%		104				RQD = 78%
102.9											
7.8	End of Borehole • 92 11 16										

+³, ×⁵ : Numbers refer to Sensitivity

20
15◇5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No H7 1 OF 1 METRIC

(Formerly BH 31-A, WP 199-77-09)

W.P. 199-77-06A LOCATION Co-ords: N 4 799 815.0 ; E 277 928.0 ORIGINATED BY MM

DIST 4 HWY 403 BOREHOLE TYPE SS Auger COMPILED BY JB

DATUM Geodetic DATE 91 09 18 CHECKED BY BI

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
114.0	Ground Surface										
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Grey. Very Stiff to Hard		1	SS	49	*					
			2	SS	20		112				
			3	SS	16						
			4	SS	17						
			5	SS	78		110				
			6	SS	120						
108.2			7	SS	78						
5.8	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till) Greyish Red. Very Dense		8	SS	120 /15cm		108				26 34 30 10
			9	SS	90 /8cm		106				
105.6											
8.4	Shale Bedrock with interbedded Siltstone		10	SS	120 /5cm						
104.8											
9.2	End of Borehole										

* G.W.L. not established

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15\text{-}5}$ (%) STRAIN AT FAILURE
$\frac{}{10}$

RECORD OF BOREHOLE No H7A 1 OF 1 METRIC

(Formerly BH 32-A, WP 199-77-10)

W.P. 199-77-06A LOCATION Co-ords: N 4 799 820.0; E 277 952.0 ORIGINATED BY MM

DIST 4 HWY 403 BOREHOLE TYPE SS Auger COMPILED BY JB

DATUM Geodetic DATE 91 09 18 CHECKED BY BI

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
113.1	Ground Surface										
0.0						*					
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		1	SS	22		112				
			2	SS	16						
	Very Stiff		3	SS	14				o		
	Hard		4	SS	31		110				
			5	SS	78				o		
			6	SS	81						
	Grey		7	SS	130	/28cm	108				
	Greyish Red					**					
106.6			8	SS	175	/23cm			o		
6.5	End of Borehole										

* G.W.L not established.

** Sampler Bouncing (Probable Bedrock)

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15}\diamond^{5}_{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H8 1 OF 1 METRIC

(Formerly BH 32-E, WP 199-77-10)

W.P. 199-77-06A LOCATION Co-ords: N 4 799 937.0; E 277 961.0 ORIGINATED BY AH

DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NQ Core COMPILED BY JB

DATUM Geodetic DATE 91 09 25 CHECKED BY BI

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
117.4 / 0.0	Ground Surface						117	
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		1	SS	17			
			2	SS	14			
	Grey		3	SS	14		115	
			4	SS	17			
			5	SS	15			
			6	SS	22		113	
			7	SS	24			
	Stiff to Very Stiff							
	Hard		8	SS	60/8cm			
			9	SS	60/13cm	▼*	111	10 32 35 23
			10	SS	60/13cm			
106.8			11	SS	60/3cm		109	
10.6	Shale Bedrock With interbedded Siltstone		12	RC	REC 100%			RQD = 45%
	Weak to Very Weak, Unweathered Greyish Red with interbedded Greenish Grey		13	RC	REC 92%		107	RQD = 33%
103.5							105	
13.9	End of Borehole = 91 09 26							

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
o UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No H8A 1 OF 2 METRIC

(Formerly BH 31-E, WP 199-77-09)

W.P. 199-77-06A LOCATION Co-ords: N 4 799 930.0; E 277 941.0 ORIGINATED BY AH

DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NQ Core COMPILED BY JB

DATUM Geodetic DATE 91 09 24 CHECKED BY BI

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
117.2	Ground Surface										
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		1	SS	20	*	116				
	Grey		2	SS	16				○		
			3	SS	17		114		○		
			4	SS	18				○		
			5	SS	7				○		
	Stiff to Very Stiff		6	SS	32		112		○		
	Hard		7	SS	29						
			8	SS	94		110				
108.6			9	SS	103						
8.6	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till)		10	SS	50/5cm		108				
107.0	Brown, Very Dense										
10.2			11	RC	REC 10%		106				RQD = 0%
	Weathered / Unweathered										
	Shale Bedrock with interbedded Siltstone		12	RC	REC 80%		104				RQD = 27%
	Weak to Very Weak. Greyish Red with interbedded Greenish Grey		13	RC	REC 83%						RQD = 37%
102.0			14	RC	REC 70%		102				RQD = 24%
15.2	Continued										Continued

+³, ×⁵ : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H8A 2 OF 2 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 799 930.0; E 277 941.0 ORIGINATED BY AH
DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NQ Core COMPILED BY JB
DATUM Geodetic DATE 91 09 24 CHECKED BY BI

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
102.0	Continued										
15.2			14	RC	REC 70%						RQD = 24%
101.0											
16.2	End of Borehole										
	• G.W.L. not established										

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No H9 1 OF 1 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 800 094.8; E 277 937.6 ORIGINATED BY TS

DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 92 11 18 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L / WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
118.9	Ground Surface										
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)						118				
	Grey		1	SS	13						
							116				
			2	SS	11						
			3	SS	17		114		o	20.1	7 15 50 28
	Stiff to Very Stiff					▼*					
	Hard		4	SS	60	/13cm					
							112				
111.3			5	SS	60	/13cm			o		13 28 53 6
7.6	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till)										
			6	SS	60	/10cm	110				
	Greyish Red, Very Dense										
108.2			7	SS	50	/0cm					
10.7	Shale Bedrock with interbedded Siltstone		8	RC	REC 100%		108				RQD = 70%
	Weak to Very Weak, Unweathered, Greyish Red with interbedded Greenish Grey		9	RC	REC 100%		106				RQD = 62%
105.2											
13.7	End of Borehole										
	* 92 11 19										

+³, ×⁵ : Numbers refer to Sensitivity

15 (20 / 10) 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H10 1 OF 1 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 800 239.8; E 277 934.2 ORIGINATED BY TS

DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 92 11 16 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, x LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
120.1	Ground Surface										
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		1	SS	18		118				
			2	SS	17				o——	22.0	8 15 50 27
			3	SS	21		116				
	Very Stiff / Hard		4	SS	104	▼	114				
	Grey / Greyish Red		5	SS	82		112				
			6	SS	70 /15cm		110				
109.1			7	SS	65 /15cm				o——	22.6	34 13 42 11
11.0	Shale Bedrock with interbedded Siltstone Weak to Very Weak, Unweathered Greyish Red with interbedded Greenish Grey		8	RC	REC 100%		108				RQD = 65%
106.1			9	RC	REC 97%						RQD = 62%
14.0	End of Borehole • 92 11 18										

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15}\diamond\frac{5}{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H11 1 OF 2 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 800 389.2; E 277 930.8 ORIGINATED BY TS
DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NX Core COMPILED BY TS
DATUM Geodetic DATE 92 11 18 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
124.5	Ground Surface							
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		1	SS	27			
			2	SS	12			
			3	SS	14			
			4	SS	20		21.2	11 15 47 27
			5	SS	24			
	Grey Stiff to Very Stiff / Greyish Red Hard		6	SS	50	▼*	21.2	12 24 48 16
			7	SS	60 /13cm			
112.3								
12.2	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till)		8	SS	60 /8cm			11 35 49 5
			9	SS	60 /3cm			
	Greyish Red Very Dense		10	SS	100 /3cm			
109.3								
15.2	Continued							Continued

ELEVATION SCALE: 124, 122, 120, 118, 116, 114, 112, 110

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa
o UNCONFINED + FIELD VANE
• QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 10 20 30

+³, ×⁵ : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No H11 2 OF 2 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 800 389.2; E 277 930.8 ORIGINATED BY TS

DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 92 11 18 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
109.3	Continued										
15.2	Weathered										
	Unweathered										
	Shale Bedrock with interbedded Siltstone		11	RC	REC 100%		108				RQD = 23%
	Weak to very Weak										
	Greyish Red with interbedded Greenish Grey		12	RC	REC 100%		106				RQD = 35%
105.6											
18.9	End of Borehole										
	▪ 92 11 20										

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No H12 1 OF 2 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 800 546.7; E 277 927.1 ORIGINATED BY TS
DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NX Core COMPILED BY TS
DATUM Geodetic DATE 92 11 20 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
125.3	Ground Surface										
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)						125				
	Brown, Hard		1	SS	32						
	Grey, Very Stiff						123				
			2	SS	20						
			3	SS	18		121				
			4	SS	21		119				
	Hard		5	SS	60	/13cm			o	22.5	40 14 33 13
			6	SS	60	/13cm	117				
114.5			7	SS	65	/15cm	115		o		18 16 55 11
10.8	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till)										
113.1	Greyish Red, Very Dense		8	SS	100	/8cm	113				
12.2	Weathered / Unweathered Shale Bedrock with interbedded Siltstone		9	RC	REC 100%						RQD = 14%
	Weak to Very Weak, Greyish Red with interbedded Greenish Grey		10	RC	REC 100%		111				RQD = 60%
110.1											

15.2 Continued

Continued

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No H12 2 OF 2 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 800 546.7; E 277 927.1 ORIGINATED BY TS

DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 92 11 20 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
110.1 / 110.0	Continued										
15.3	End of Borehole										
	▪ G.W.L not established										

+³, x⁵ : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H13 1 OF 1 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 800 689.6; E 277 923.8 ORIGINATED BY TS

DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 92 11 23 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
126.2	Ground Surface						
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Grey	1	SS	28			
		2	SS	22			
		3	SS	17			
	Very Stiff / Hard	4	SS	42		22.1	5 15 55 25
		5	SS	67	/15cm		
117.1					▼*		
9.1	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till) Greyish Red, Very Dense	6	SS	100	/15cm		6 26 59 9
115.5		7	SS	* *			
10.7	Weathered / Unweathered Shale Bedrock with interbedded Siltstone Weak to Very Weak	8	RC	REC 100%			RQD = 82%
114.0							
12.2	End of Borehole * 92 11 23 * * Sampler bouncing						

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
o UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 10 20 30

ELEVATION SCALE 126 124 122 120 118 116

+^{3}, ×^{5} : Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No H14 1 OF 1 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 800 828.1; E 277 920.7 ORIGINATED BY TS
DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NX Core COMPILED BY TS
DATUM Geodetic DATE 92 11 24/25 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
128.3	Ground Surface										
0.0	Silt, some Sand Brown, Compact						128				
126.3			1	SS	12						0 15 74 11
2.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Grey		2	SS	26	▼*	126				
			3	SS	28		124			22.0	2 16 58 24
	Very Stiff Hard		4	SS	48		122				
119.2			5	SS	60	/13cm	120				
9.1	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till) Greyish Red, Very Dense		6	SS	65	/15cm					0 2 89 9
117.6							118				
10.7	Weathered Unweathered		7	SS	100	/15cm					
	Shale Bedrock with interbedded Siltstone Weak to Very Weak, Greyish Red with interbedded Greenish Grey		8	RC	REC 100%						RQD = 37%
114.6			9	RC	REC 100%		116				RQD = 65%
13.7	End of Borehole • 92 11 25										

+³, ×⁵: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No S7 1 OF 1 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 799 800; E 277 870 ORIGINATED BY TS

DIST 4 HWY 403 BOREHOLE TYPE SS Auger COMPILED BY TS

DATUM Geodetic DATE 92 11 09 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS
117.7	Ground Surface					
0.0	Heterogenous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Grey		1	SS	26	
			2	SS	17	
			3	SS	20	
			4	SS	25	
	Very Stiff					
	Hard		5	SS	90	
			6	SS	70	
107.0						
10.7	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till) Greyish Red, Very Dense		7	SS	70	/38cm
105.4			8	SS	100	/19cm
12.3	End of Borehole ▪ 92 11 10 ▪ ▪ Shale Bedrock (Severely Weathered)					

ELEVATION SCALE: 117, 115, 113, 111, 109, 107

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa
o UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3$, $\times^5$; Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No S7A 1 OF 1 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 799 796; E 277 886 ORIGINATED BY TS

DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 92 11 10 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
116.4	Ground Surface										
0.0	Heterogenous Mixture of Cloyey Silt, Sand and Gravel (Glacial Till) Grey		1	SS	18		116				
			2	SS	19		114		○	23.4	13 22 39 26
			3	SS	19		112				
	Very Stiff / Hard		4	SS	74		110				
			5	SS	60	▼			○	24.8	6 22 42 30
107.3							108				
9.1	Heterogenous Mixture of Silt, Sand and Gravel (Glacial Till) Greyish Red, Very Dense		6	SS	82	/38cm			○		30 26 37 7
105.7			7	SS	100	/13cm	106				
10.7	Shale Bedrock with interbedded Siltstone Unweathered, Weak to Very Weak Greyish Red with interbedded Greenish Grey		8	RC	REC 100%						RQD = 28%
			9	RC	REC 100%		104				RQD = 27%
102.6											
13.8	End of Borehole • 92 11 10										

$+^3$, $\times^5$; Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
$\frac{}{10}$

RECORD OF BOREHOLE No S8 1 OF 2 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 799 760; E 278 055 ORIGINATED BY TS

DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 92 11 13 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
116.2	Ground Surface							
0.0	Irregular Mixture of Clayey Silt, Sand and Gravel (Fill Material) Brown, Very Stiff		1	SS	15			
			2	SS	17		20.7	5 15 47 33
			3	SS	16			
			4	SS	17		21.5	6 17 43 34
			5	SS	27			
			6	SS	27			
105.4								
10.8	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Greyish Red, Hard		7	SS	96	▼	24.5	
104.0								
12.2	Weathered / Unweathered Shale Bedrock with interbedded Siltstone		8	SS	100	/15cm		
			9	RC	REC 100%			RQD = 42%
	Greyish Red with interbedded Greenish Grey, Weak to Very Weak		10	RC	REC 100%			RQD = 27%
101.0								
15.2	Continued							Continued

ELEVATION SCALE: 116, 114, 112, 110, 108, 106, 104, 102

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%): 10 20 30

+^{3}, ×^{5}: Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No S8 2 OF 2 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 799 760; E 278 055 ORIGINATED BY TS

DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 92 11 13 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa o UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
101.0 100.8	Continued										
15.4	End of Borehole • 92 11 16										

$+^3$, $\times^5$: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No S9 1 OF 1 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 800 172; E 277 915 ORIGINATED BY TS

DIST 4 HWY 403 BOREHOLE TYPE SS Auger COMPILED BY TS

DATUM Geodetic DATE 92 11 17 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
120.2	Ground Surface										
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)		1	SS	18		120				
			2	SS	19		118				
			3	SS	16	▼*	116				
	Grey, Very Stiff										
	Greyish Red, Hard		4	SS	97	/10cm	114				
			5	SS	65	/15cm	112				
111.1											
9.1	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till) Greyish Red, Very Dense		6	SS	60	/10cm	110				
			7	SS	65	/15cm					
108.9	(Auger Grinding – Probable Bedrock)										
11.3	End of Borehole • 92 11 17										

$+^{3}$, $\times^{5}$: Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No S9A 1 OF 1 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 800 173; E 277 935 ORIGINATED BY TS

DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 92 11 17 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
119.5	Ground Surface										
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)					*	119				
			1	SS	13						
							117				
			2	SS	12						
							115				
			3	SS	11				+ H	22.5	2 15 56 27
	Grey, Stiff										
	Greyish Red, Hard		4	SS	103		113				
			5	SS	106						
110.4							111				
9.1	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till)		6	SS	60 /8cm				○ H	19.0	39 22 36 3
109.1	Greyish Red, Very Dense						109				
10.4	Weathered		7	RC	REC 73%						RQD = 0%
	Unweathered										
	Shale Bedrock with interbedded Siltstone										
	Weak to Very Weak, Greyish Red with interbedded Greenish Grey		8	RC	REC 100%						RQD = 80%
106.5							107				
13.0	End of Borehole										

* G.W.L not established

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15}\diamond^{5}_{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No S10 1 OF 1 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 800 846; E 277 900 ORIGINATED BY TS

DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 92 11 25 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
128.9	Ground Surface										
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)						128				
	Brown / Grey		1	SS	22	▼*	126				
			2	SS	26						
			3	SS	24		124				
	Very Stiff / Hard		4	SS	110	/25cm					
			5	SS	60	/15cm	122				
119.8			6	SS	60	/10cm	120				
9.1	Weathered / Unweathered		7	RC	REC 100%						RQD = 47%
	Shale Bedrock with interbedded Siltstone; Weak to Very Weak, Greyish Red with interbedded Greenish Grey		8	RC	REC 100%		118				RQD = 58%
116.3											
12.6	End of Borehole • 92 11 26										

+³, ×⁵ : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No S10A 1 OF 1 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 800 846; E 277 912 ORIGINATED BY TS

DIST 4 HWY 403 BOREHOLE TYPE SS Auger COMPILED BY TS

DATUM Geodetic DATE 92 11 25 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
128.3	Ground Surface										
0.0	Silt, trace Clay (Fill Material) Brown, Compact		1	SS	11		128		P		0 4 82 14
126.3											
2.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Grey		2	SS	16	▼*	126				
			3	SS	16		124		o		3 15 54 28
	Stiff										
	Hard		4	SS	41		122				
			5	SS	60	/15cm	120				
119.2											
9.1	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till) Greyish Red, Very Dense		6	SS	60	/8cm	118				
117.6					**						
10.7	End of Borehole * 92 11 26 ** Sampler Bouncing (Probable Shale Bedrock)										

$+^3$, $\times^5$: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No S11A 1 OF 1 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 801 378; E 277 886 ORIGINATED BY TS

DIST 4 HWY 403 BOREHOLE TYPE SS Auger COMPILED BY TS

DATUM Geodetic DATE 92 11 24 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
134.1	Ground Surface										
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Grey, Very Stiff		1	SS	17		132				
			2	SS	26		130				
129.5											
4.6	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till) Greyish Red, Very Dense		3	SS	60 /15cm	▼*	128				
			4	SS	60 /8cm						
126.5											
7.6	End of Borehole * 92 11 25 • • Sampler bouncing Powdered Shale in spoon (Probable Bedrock)										

+³, ×⁵: Numbers refer to Sensitivity

20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No S11A-A 1 OF 1 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 801 378; E 277 910 ORIGINATED BY TS

DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 92 11 23/24 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
134.0	Ground Surface										
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel Grey, Hard		1	SS	30		132		c	23.0	5 16 51 28
			2	SS	46						
129.4							130				
4.6	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till) Greyish Red, Very Dense		3	SS	60	/15cm ▼*			o	•	10 23 58 9
	Siltstone fragments		4	SS	60	/5cm	128				
126.4											
7.6	Shale Bedrock with interbedded Siltstone		6	RC	REC 100%		126				RQD = 71%
	Weak to Very Weak, Unweathered Greyish Red with interbedded Greenish Grey		7	RC	REC 100%		124				RQD = 67%
123.3											
10.7	End of Borehole * 92 11 25 * * Sampler bouncing										

$+^{3}$, $\times^{5}$: Numbers refer to Sensitivity

$\frac{20}{15}\diamond\frac{5}{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No S13 1 OF 1 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 803 856; E 277 820 ORIGINATED BY TS

DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NX Core COMPILED BY TS

DATUM Geodetic DATE 92 12 01 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
159.6	Ground Surface										
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Brown		1	SS	18	*	159		d	22.5	0 8 66 26
	Very Stiff						157				
	Hard		2	SS	70	/15cm					
			3	SS	80	/15cm	155				
			4	SS	60	/10cm			c		12 20 48 20
152.0			5	SS	**		153				
7.6	Weathered										
	Unweathered		6	RC	REC 100%		151				RQD = 62%
	Shale Bedrock with interbedded Siltstone		7	RC	REC 100%						RQD = 68%
148.9	Weak to Very Weak, Greyish Red to Greenish Grey						149				
10.7	End of Borehole										

* G.W.L not established

** Sampler Bouncing

$+^{3}$, $\times^{5}$: Numbers refer to Sensitivity

$\frac{20}{15}\diamond\frac{5}{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No S13A 1 OF 1 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 803 857; E 277 840 ORIGINATED BY TS

DIST 4 HWY 403 BOREHOLE TYPE SS Auger COMPILED BY TS

DATUM Geodetic DATE 92 12 01 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
159.3	Ground Surface										
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)					DRY *	159				
	Hard		1	SS	48						
							157				
			2	SS	67						
	Brown						155				
	Grey		3	SS	60	/8cm					
	Greyish Red		4	SS	65	/15cm	153				
151.7											
151.6			5	SS	80	/5cm					
7.7	End of Borehole										

* * Shallow Bedrock (Severely Weathered)

$+^{3}$, $\times^{5}$: Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No S14 1 OF 1 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 804 285; E 277 795 ORIGINATED BY TS
DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NX Core COMPILED BY TS
DATUM Geodetic DATE 92 11 27 CHECKED BY PP

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
159.2	Ground Surface										
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)					*	158				
	Brown, Hard		1	SS	60				○	23.2	1 11 59 29
			2	SS	100	/15cm	156				
154.6											
4.6	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till)		3	SS	60	/8cm	154				
	Greyish Red, Very Dense		4	SS	60	/15cm			○		3 20 68 9
151.6							152				
7.6	Shale Bedrock With interbedded Siltstone		5	SS	60	/15cm					
			6	SS	60	/15cm	150				
	Weak to Very Weak, Greyish Red with interbedded Greenish Grey		7	RC	REC 100%						RQD = 37%
	Weathered / Unweathered						148				
			8	RC	REC 100%						RQD = 55%
146.9											
12.3	End of Borehole * G.W.L. not established										

+³, ×⁵: Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No S14A 1 OF 1 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 804 283 E 277 823 ORIGINATED BY TS

DIST 4 HWY 403 BOREHOLE TYPE SS Auger COMPILED BY TS

DATUM Geodetic DATE 92 11 27 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
158.4	Ground Surface										
0.0	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Brown, Hard		1	SS	41	▼*	158				
			2	SS	60 /15cm		156				
153.8											
4.6	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till) Very Dense Grey / Greyish Red		3	SS	60 /15cm		154				
			4	SS	60 /15cm		152				
150.8											
7.6	Shale Bedrock with interbedded Siltstone Greyish Red, Weathered Weak to Very Weak		5	SS	60		150				
149.0			6	SS	60						
9.4	End of Borehole										
	* 92 12 01										

$+^{3}$, $\times^{5}$: Numbers refer to Sensitivity

$\frac{20}{15}\diamond\frac{5}{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No S15 1 OF 1 METRIC

W.P. 199-77-06A LOCATION Co-ords: N 4 798 666 E 279 202 ORIGINATED BY TS
DIST 4 HWY 403 BOREHOLE TYPE SS Auger, NW Casing, NX Core COMPILED BY TS
DATUM Geodetic DATE 92 11 30 CHECKED BY PP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
99.6	Asphaltic Surface										
0.0	Sand and Gravel (Fill Material) Brown, Compact					DRY *	99				
97.8			1	SS	11						
1.8	Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till) Brown						97				
96.6											
3.0	Heterogeneous Mixture of Silt, Sand and Gravel (Glacial Till) Very Dense Greyish Red		2	SS	80	/15cm					
	Grey		3	SS	100		95		o	24.0	6 20 53 21
	Silt, Very Dense, Grey		4	SS	70						
	Greyish Red						93				
			5	SS	100				o		7 8 76 9
90.5							91				
9.1	Shale Bedrock with interbedded Siltstone Unweathered, Weak to Very Weak		6	SS	100	/5cm					
88.9			7	RC	REC 100%		89				RQD = 8%
10.7	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

ROCK CORE DESCRIPTION
WP 199-77-06A

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
H1	8	10.69-12.22	100	57	10.69-12.22	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (3%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
H2	7	9.20-10.72	100	37	9.20-10.72	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (7%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
H3	7	9.30-10.82	100	50	9.30-10.82	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (15%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 9.30-9.91 m); fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
H4	3 4 5	3.66-5.18 5.18-6.40 6.40-7.92	88 100 100	0 13 42	3.66-7.92	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (11%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 3.66-3.96 m); fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
H5	8 9	7.01-8.53 8.53-10.06	100 100	34 55	7.01-10.06	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (19%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.

***CR** = CORE RECOVERY
***RQD** = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

ROCK CORE DESCRIPTION
WP 199-77-06A

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
H6	4	4.72-6.25	100	37	4.72-7.77	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (18%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 5.49-5.61 m); fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	5	6.25-7.77	100	78		
H8	12	10.90-12.34	100	45	10.90-13.87	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (13%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	13	12.34-13.87	92	33		
H8A	11	10.16-11.68	10	0	10.16-16.21	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (20%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 10.16-11.76 m); fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	12	11.68-13.21	80	27		
	13	13.21-14.68	83	37		
	14	14.68-16.21	70	24		
H9	8	10.69-12.22	100	70	10.69-13.74	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (14%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	9	12.22-13.74	100	62		
H10	8	10.97-12.50	100	65	10.97-14.02	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (18%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	9	12.50-14.02	97	62		

***CR** = CORE RECOVERY
***RQD** = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

ROCK CORE DESCRIPTION
WP 199-77-06A

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
H11	11 12	15.85-17.37 17.37-18.90	100 100	23 35	15.85-18.90	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (11%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
H12	9 10	12.27-13.79 13.79-15.32	100 100	14 60	12.27-15.32	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (21%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 12.27-12.60 m); fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
H13	8	10.72-12.24	100	82	10.72-12.24	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (20%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures moderate to very close spaced, flat to near vertical, planar to undulating, smooth.
H14	8 9	10.82-12.34 12.34-13.87	100 100	37 65	10.82-13.87	**SHALE** (with gypsum veinlets sub-parallel to bedding up to 0.2 cm thick, and gypsum-filled vugs, 13.26-13.80 m), greyish red, with interbedded greenish grey **SILTSTONE** (17%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.

***CR** = CORE RECOVERY
***RQD** = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

ROCK CORE DESCRIPTION
WP 199-77-06A

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
S7A	8	10.72-12.24	100	28	10.72-13.77	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (8%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	9	12.24-13.77	100	27		
S8	9	12.34-13.87	100	42	12.34-15.39	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (13%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 13.41-13.74 m); fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	10	13.87-15.39	100	27		
S9A	7	9.91-11.43	73	0	9.91-10.42	**OVERBURDEN** (till).
	8	11.43-12.95	100	80	10.42-12.95	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (18%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 10.42-10.80 m); fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
S10	7	9.60-11.13	100	47	9.60-12.65	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (18%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
	8	11.13-12.65	100	58		

***CR** = CORE RECOVERY
***RQD** = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

ROCK CORE DESCRIPTION
WP 139-7 6A

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
S11A-A	6 7	7.62-9.14 9.14-10.67	100 100	71 67	7.62-10.67	**SHALE** (with gypsum veinlets sub-parallel to bedding up to 0.5 cm thick, and gypsum-filled vugs, 9.85-10.36 m), greyish red, with interbedded greenish grey **SILTSTONE** (7%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
S13	6 7	7.64-9.17 9.17-10.69	100 100	62 68	7.64-10.69	**SHALE** (with gypsum veinlets sub-parallel to bedding up to 0.2 cm thick, and gypsum-filled vugs, 7.85-9.10 m), greyish red, with interbedded greenish grey **SILTSTONE** (3%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 7.64-7.85 m); fractures moderate to extremely close spaced, flat to dipping, planar to undulating, smooth.
S14	7 8	9.30-10.82 10.82-12.34	100 100	37 55	9.30-12.34	**SHALE** (with gypsum veinlets sub-parallel to bedding up to 0.2 cm thick, and gypsum-filled vugs, 11.21-11.28 m), greyish red, with interbedded greenish grey **SILTSTONE** (11%); very fine grained; weak to very weak; unweathered to slightly weathered (moderately weathered, 9.30-10.82 m); fractures moderate to extremely close spaced, flat to near vertical, planar to undulating, smooth.
S15	7	9.20-10.72	100	8	9.20-10.72	**SHALE,** greyish red, with interbedded greenish grey **SILTSTONE** (19%); very fine grained; weak to very weak; unweathered to slightly weathered; fractures close to extremely close spaced, flat to near vertical, planar to undulating, smooth.

***CR** = CORE RECOVERY
***RQD** = ROCK QUALITY DESIGNATION

(NOTE: Depths are approximated where core recovery is less than 100%)

Logged by: DAW, Soils and Aggregates Section

GEOTECHNICAL INVESTIGATION
PROPOSED BRIDGE 34
SITE 10-480
FREEMAN INTERCHANGE
BURLINGTON, ONTARIO
W.P. 199-77-07 DISTRICT 4

1. INTRODUCTION

Golder Associates Ltd. has been retained by the Ministry of Transportation Ontario (MTO) to carry out a series of site specific subsurface investigations for the design of structures for the proposed reconstruction of the Freeman Interchange in Burlington, Ontario. This report presents the results of a subsurface investigation carried out at the site of the proposed Bridge No. 34 to be constructed as part of the westbound Highway 403 lanes as shown on the Key Plan, Drawing 1997707-A*.

The purpose of the investigation was to determine the subsurface conditions at the site.

2. SITE AND PROJECT DESCRIPTION

The proposed Bridge No. 34 will be situated between the existing QEW north - 403 west ramp and the existing North Service Road. The proposed Bridge 35 (Site 10-481, W.P. 199-77-08) will be situated parallel to and immediately to the south of Bridge 34. The existing ground surface elevation along the centreline of the proposed structure varies from about 106.5 to 109.0 metres. The location of the site is shown on the Key Plan, Drawing 1997707-A*.

The site is situated within the physiographic region of

* SHEET NO 484 OF THE CONTRACT DWG'S

Southwestern Ontario known as the Iroquois Plain. Available geologic information indicates that the overburden in the general area of the site consists of a thin veneer of sands, glacial till and/or residual soil derived from the weathering of the underlying shale bedrock. The Queenston shale formation which comprises the bedrock in the area generally consists of thinly bedded red shale with occasional bands of grey limestone.

Bridge No. 34 will carry Highway 403 westbound traffic over Bridge No. 33, (Site 10-335, W.P. 199-77-05) the QEW east - 403 west ramp and the 403 east -QEW south ramp.

The proposed high level bridge will consist of a five span structure (spans of approximately 45, 60,60, 45 and 35 metres south to north respectively) with two abutments and 4 piers. Approach fills of some 8.5 to 9.5 metres in height will be required.

3. INVESTIGATION PROCEDURE

The field work for this investigation was carried out between August 16 and September 25, 1990 at which time one test pit was excavated and seven boreholes were drilled. The locations of the boreholes and test pit are shown on Drawing 1997707-A.*

In addition the results of test pit 3, excavated as part of the field investigation programme for Bridge No. 33 (Site 10-335, W.P. 199-77-05) have been included in this report.

* SHEET NO 484 OF THE CONTRACT DWG'S

The initial stage of the field work consisted of excavating a test pit (numbered 4) near the proposed east abutment. The test pit was excavated to a depth of about 3.4 metres below the existing ground surface using a "John Deere 690" hydraulic backhoe supplied and operated by a local contractor. Chunk samples were obtained from the predominant soil strata exposed in the test pit and the test pit was loosely backfilled following sampling and logging.

The boreholes were drilled using track mounted power auger drillrigs equipped for rotary drilling supplied and operated by a specialist drilling contractor. Boreholes numbered 9, 10, 11, and 12 were advanced to bedrock, through about 2.5 to 5.2 metres of overburden, and the shale bedrock encountered beneath the overburden was core drilled in NQ size for about 3 metres in these boreholes. Borehole 9B was cored in NQ size from about 2 metres above the bedrock surface to about 3 metres below the rock surface to verify the rock/soil interface and to investigate the quality of the upper portion of the bedrock. Boreholes numbered 8 and 13 were drilled to practical auger refusal. The boreholes were advanced in the overburden and the upper portion of the bedrock using nominal 150 millimetre outside diameter hollow stem augers and nominal 100 millimetre diameter solid stem augers. Standard penetration testing and sampling was carried out within the overburden encountered in the boreholes using 35 millimetre inside diameter split spoon sampling equipment.

Samples of the overburden and the rock core recovered from the test pits and boreholes were taken to our Hamilton laboratory for examination and water content determinations.

Grain size analyses and Atterberg limit determinations were determined on selected samples of the overburden.

The soil and rock stratigraphy encountered in the boreholes and test pits are shown in detail on the Records of Boreholes and Records of Test Pits following the text of this report and on Drawing 1997707-A.* The results of the field and laboratory testing are also shown on the Record of Borehole and Record of Test Pit sheets and on Figures 1 and 2.

Groundwater levels were observed in the open boreholes during drilling and in the test pits during and after excavation. Piezometers were installed in boreholes 9 and 12 as detailed on the Record of Borehole sheets. Notes pertaining to the groundwater conditions observed in the boreholes and test pits are also shown on the Record of Borehole and Test Pit sheets and on Drawing 1997707-A.*

The locations and ground surface elevations at the borehole and test pit locations have been determined by Golder Associates staff with reference to site specific points and temporary bench marks provided by McCormick Rankin & Associates Limited. The final locations and ground surface elevations of the boreholes were subsequently verified by McCormick Rankin. The elevations provided are understood to be referred to geodetic datum.

* SHEET NO 484 OF THE CONTRACT DWG'S

4. SUBSURFACE CONDITIONS

4.1 General

The subsurface conditions encountered in the boreholes and test pits put down at the site are shown in detail on the Records of Borehole and Record of Test Pit sheets, and in summary form on Drawing 1997707-A*. The soil boundaries and rock stratigraphy indicated, particularly for the boreholes, are inferred from non-continuous sampling and resistance to drilling advance. These boundaries typically represent a transition between one soil or rock type to another and are not intended to define an exact plane of geological change. Conditions will vary between and beyond the borehole and test pit locations.

The subsurface conditions encountered at the site generally consisted of fill, topsoil and glacial till, overlying completely to highly weathered shale and by more competent shale bedrock at depth.

The following discussion has been simplified in terms of major soil and rock strata for the purposes of geotechnical design.

It should be noted that due to the relatively soft and weathered nature of the Queenston shale formation, particularly the upper zone, together with the effects of glacial overriding at the bedrock surface, it is difficult to accurately define the bedrock surface both from a geological and a contractual standpoint.

* SHEET NO 484 OF THE CONTRACT DWG'S

During the course of this investigation, a stratigraphic unit directly overlying the shale bedrock, which in strictly geological terms is described as deformation till, has been encountered. This stratigraphic unit consists of an imbricate embedment of fragments of bedrock in a till matrix which has been formed from glacial overriding of the parent bedrock. This till is characterized by the presence of rounded and sub-angular clasts of the parent rock with non horizontal bedding. Based on the consistency, the relatively high penetration resistance encountered in the boreholes and the difficulty of excavation experienced in the test pits, this stratum could be contractually interpreted as a zone of the bedrock and for this reason has been referred to in this report as an upper zone of the bedrock formation.

4.2 Topsoil

A layer of topsoil was encountered at the ground surface in borehole 8 and in test pits 3 and 4. A layer of topsoil was also encountered underlying the fill in borehole 10 and test pit 3.

4.3 Clayey Silt, Silty Clay, occ. gravel (Fill)

Fill generally consisting of clayey silt and silty clay, was encountered in all of the boreholes and in the test pits. The fill and topsoil layers were fully penetrated in the boreholes and test pits at elevations varying between about 104.5 and 105.8 metres or at depths of about 1 to 4.4 metres below the existing ground surface. The greatest depth of fill was encountered in borehole 8. The fill at this

location probably consists of embankment fill placed in conjunction with the construction of the existing adjacent QEW south - 403 west ramp. Layers of granular fill associated with existing pavements were encountered at the ground surface in boreholes 9, 10 and 11.

The clayey fill has in-situ water contents ranging from about 14 to 31 per cent with an average in-situ water content of about 19 per cent. N-values ranging from 10 to 27 blows per 0.3 metres, were determined in standard penetration testing carried out in the clayey fill indicating a generally stiff to very stiff consistency.

4.4 Clayey Silt, trace to some sand, occ. gravel, occ. shale fragments (Till)

Glacial till was generally encountered beneath the fill and topsoil in all of the boreholes. In general, the till is characterized by an upper zone of very stiff to hard brown clayey silt and a lower zone of reddish brown clayey silt which is somewhat harder than the overlying till.

The N values determined in the upper till zone ranged from 19 to 54 blows per 0.3 metres. The natural water content of samples of the upper till recovered from the boreholes and test pit ranged from about 12 to 18 per cent.

Standard penetration testing was also carried out in the lower till zone, but due to its hard consistency, in most instances it was not practical to advance the sampler the entire 450 millimetres required to establish an N value. However, N values of the order of greater than 100 blows per

0.3 metres can generally be inferred from the penetration testing. The natural water content of the lower till typically ranged from about 6 to 14 per cent.

The corresponding liquid and plastic limits determined on a sample of the lower till were about 21 and 15 per cent, respectively. A grain size distribution curve for a sample (obtained by a 35 millimetre I.D. sampler) of the lower till is shown on Figure 1.

The till material as indicated by the gradation curve is relatively fine grained in nature and no major concentrations of coarse particles, such as boulders, were encountered during this investigation. This does not necessarily mean that the coarser particle sizes are not present at random or in concentrations within the deposit, since till is an inherently variable material.

4.5 Shale, Completely to slightly weathered (Bedrock)

At the borehole and test pit locations, the overburden materials are underlain by shale bedrock of the Queenston Formation. Bedrock was encountered between about elevations 100.2 and 105.8 metres, or at depths of from about 2.5 to 8.7 metres below the existing ground surface.

The upper zone of the bedrock is generally highly weathered and has been described as deformation till in boreholes 8, 9, 9B, 10, 12 and 13 and in test pits 3 and 4. More competent shale was encountered in boreholes 9, 9B, 10, 11, and 12 between about elevations 100 and 104 metres, or at depths of

about 3.1 to 6.5 metres below existing ground surface. The bedrock core recovered from boreholes 9, 9B, 10, 11, and 12 generally consists of moderately to faintly weathered thinly bedded reddish-brown shale, interbedded with thinly bedded light grey, fine grained argillaceous limestone up to about 0.5 metres in thickness.

The rock core recovered from the boreholes generally exhibited a relatively high degree of fracturing. However the quality of the rock core recovered generally improved with depth. The total core recovery (TCR) ranged from about 92 to 95 per cent for the upper 1.5 metres of rock cored and 94 to 100 per cent for the lower 1.5 metres of rock. The solid core recovery (SCR) ranged from about 33 to 59 percent for the upper 1.5 metres of rock core and from about 61 to 79 percent for the lower 1.5 metres of rock core. Similarly the rock quality designation (RQD) ranged from about 12 to 43 percent in the upper 1.5 metres of rock core compared to about 34 to 75 percent for the lower 1.5 metres of rock core.

4.6 Groundwater Conditions

Groundwater was not encountered during the field drilling/ digging operations in borehole 13 which was terminated at auger refusal, or in test pit 4 which was terminated in the red (lower) clayey silt till. Borehole 10 was dry to the depth of practical auger refusal, corresponding to about elevation 102.3 metres. Groundwater was encountered between about elevations 103.8 and 105.3 metres, or from about 1.5 to 5.2 metres below the existing ground surface in boreholes 11 and 8 respectively. The groundwater levels were measured at

about elevations 103.1 and 105.0 metres in the piezometers installed in boreholes 9 and 12 respectively. These water levels, recorded about 1 week after the completion of drilling, correspond to depths of about 3.5 and 2.2 metres below the existing ground surface. Water levels at elevations 102.9 and 104.6 metres were measured in the piezometers in boreholes 9 and 12 respectively about 1 month after installation.

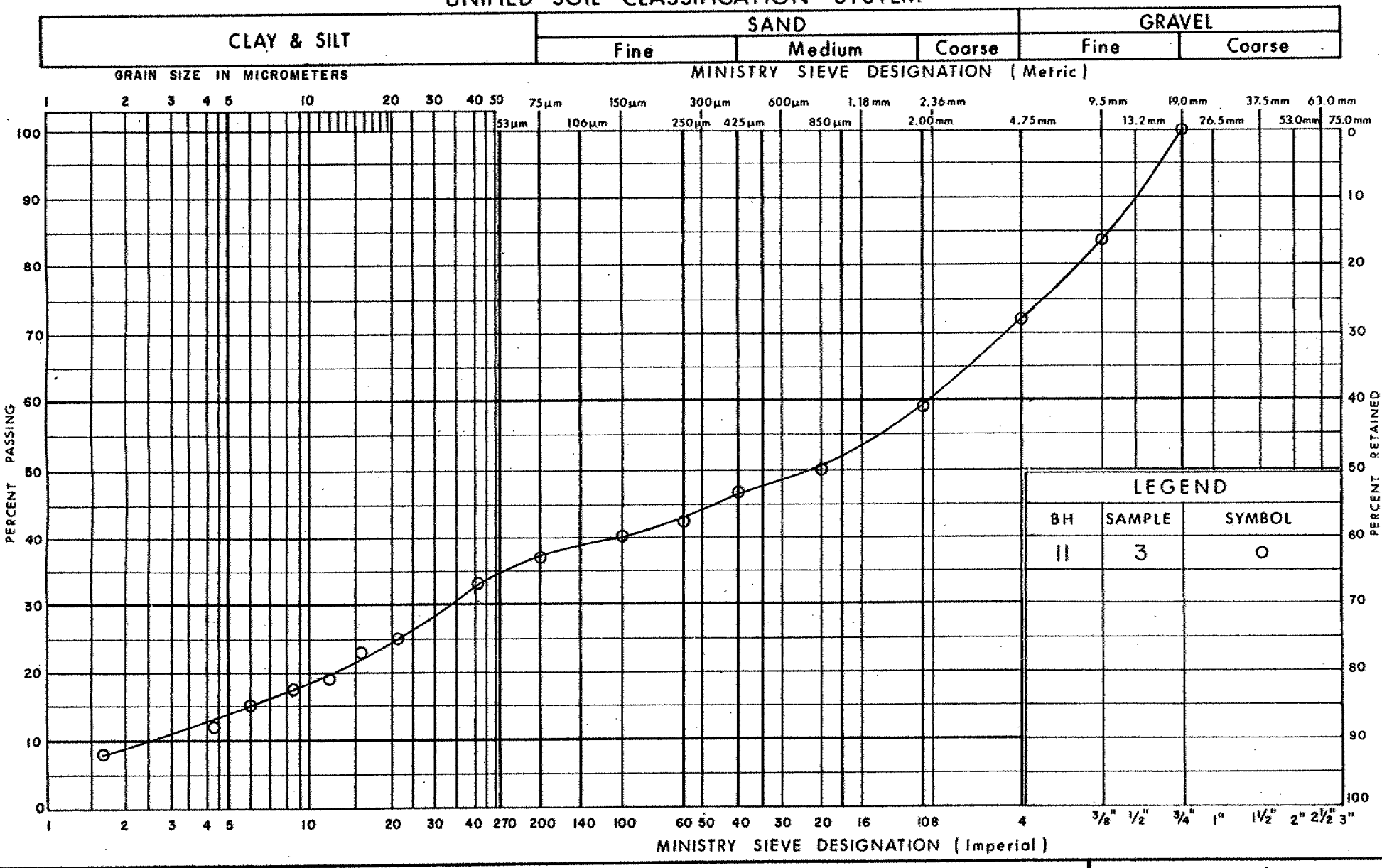
It should be noted that the piezometric groundwater level within the subsoil and underlying bedrock is subject to fluctuation not only due to precipitation conditions, but also due to seasonal variations. The water levels given above may not necessarily reflect stabilized conditions and may vary from the conditions which are encountered during construction.

Note: The preceding report is a copy of the factual information from the Foundation Report prepared by GOLDER ASSOCIATES LTD (consulting geotechnical engineers for this project), under the technical supervision of the M.T.O. Foundation Design Section.

P. Payer, P. Eng.
Senior Foundatation Engineer

M.S. Devata, P. Eng.
Chief Foundation Engineer

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
Ontario

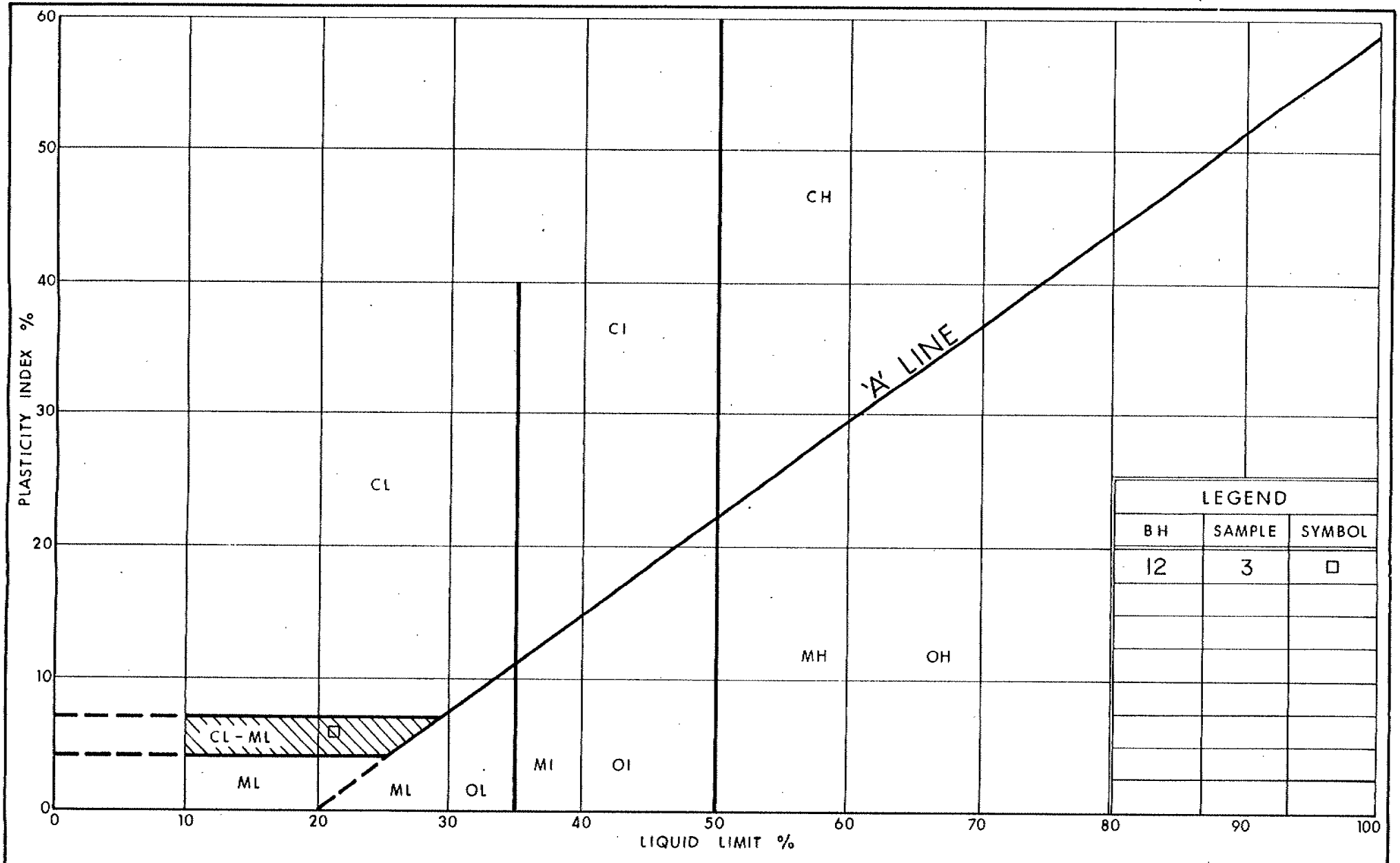
GRAIN SIZE DISTRIBUTION

CLAYEY SILT TILL

FIG No 1

W P 199-77-07

191



Ministry of Transportation
Ontario

PLASTICITY CHART

CLAYEY SILT TILL

FIG No 2

W P 199-77-07

192

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 8

METRIC

W P 199-77-07 LOCATION Co-ordinates N4,799,471.2 E277,794.3 ORIGINATED BY VCH

DIST 4 HWY 403/QEW BOREHOLE TYPE Solid Stem Augers COMPILED BY MHW

DATUM Geodetic DATE August 20, 1990 CHECKED BY VCH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
108.9	Ground Surface										
0.1	Topsoil										
108.1	Clayey Silt (Fill) tr sand, occasional gravel Red Brown										
0.8	Silty Clay (Fill), tr sand and organics, occasional gravel		1	SS	18		108		○		
			2	SS	18				○		
			3	SS	19				○		
	Stiff to very stiff		4	SS	12		106		○		
105.2	Reddish Brown										
3.7	Clayey Silt (Fill) trace sand, occ. gravel		5	SS	27				○		
104.5	Very Stiff Red Brown										
4.4	Clayey Silt (Till) trace sand, occ gravel and shale fragments		6	SS	54	▼	104		○		
	Water seeping in at Elevation 103.8 metres during drilling.		7	SS	130				○		
			8	SS	65/50mm				○		
			9	SS	55/25mm		102		○		
	Brown becoming reddish brown at about elev. 103.7		10	SS	70/50mm				○		
100.2	Hard										
8.7	Shale (Deformation Till)		11	SS	75/75mm		100		○		
99.7											
9.2	End of Borehole										
							98				

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20/10 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 9 METRIC

W P 199-77-07 LOCATION Co-ordinates N4,799,511.3 E277,814 ORIGINATED BY CB

DIST 4 HWY 403/QEW BOREHOLE TYPE Hollow Stem Augers, NQ Rock Core COMPILED BY MHW

DATUM Geodetic DATE August 20, 1990 CHECKED BY VCM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
106.6	Ground Surface										
0.0 / 106.0	Sand (Fill) Loose Brown										
0.6 / 105.4	Clayey Silt (Fill) tr sand, occ. pebbles Very Stiff Brown		1	SS	19		106				
1.2	Clayey Silt trace to some sand occ. gravel and shale fragments. (Till)		2	SS	19						
			3	SS	118/250mm		104				
			4	SS	50/75mm						
			5	SS	91/150mm						
	Very stiff to Hard		6	SS	70/50mm		102				
101.4	Reddish Brown										
5.2	Shale (Deformation Till) Completely to highly weathered		7	SS	97/125mm						
			8	SS	105/125mm						
100.1	Reddish Brown										
6.5	Probably highly to moderately weathered shale						100				
99.0	Reddish Brown										
7.6	Shale Bedrock moderately to slightly weathered thinly to medium bedded Reddish Brown interbedded with fine-grained argillaceous limestone		9	NQ RC	*TCR= 94% SCR= 44% RQD= 29%		98				
			10	NQ RC	TCR= 100% SCR= 68% RQD= 38%		96				
95.9											
10.7	End of Borehole						94				

Water level at elevation
103.1 metres
August 30, 1990
102.9 metres
Sept. 13, 1990
103.2 metres
Nov. 19, 1990

* TCR = Total Core Recovery
SCR = Solid Core Recovery
RQD = Rock Quality Designation

+3, ×5 : Numbers refer to Sensitivity

15 (20 / 10) 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 9B

METRIC

W P 199-77-07 LOCATION Co-ordinates N4,799,511.7 E277,817.2 ORIGINATED BY VCH

DIST 4 HWY QEW/403 BOREHOLE TYPE Hollow Stem Augers, NQ Rock Core COMPILED BY MHW

DATUM Geodetic DATE September 25, 1990 CHECKED BY VCM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
106.5 Ground Surface											
0.0 / 105.9	Sand (Fill) Brown						106				
0.6 / 105.3	Clayey silt (Fill) tr. sand, occ. pebbles. Very stiff Brown										
1.2	Clayey silt (Till) tr. sand occ. pebbles						104	Borehole dry to Elevation 103.1 metres during drilling.			
			1	* NQ RC	TCR= 8% SCR= 2% RQD= 0%						
101.3	Brown to Hard Reddish Brown						102				
5.2	Shale (Deformation Till) completely to highly weathered.		2	NQ RC	TCR= 23% SCR= 2% RQD= 0%						
99.8			3	NQ RC	TCR= 64% SCR= 31% RQD= 26%		100				
6.7	Shale bedrock, moderately weathered thinly bedded Reddish Brown interbedded with grey argillaceous limestone.		4	NQ RC	TCR= 93% SCR= 63% RQD= 0%						
98.0							98				
8.5	End of Borehole										

*TCR: Total Core Recovery

SCR: Solid Core Recovery

RQD: Rock Quality Designation

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 10

METRIC

W P 199-77-07 LOCATION Co-ordinates N4,799,574 E277,841 ORIGINATED BY CB

DIST 4 HWY 403/QEW BOREHOLE TYPE Hollow Stem Augers, NQ Rock Core COMPILED BY MHW

DATUM Geodetic DATE August 17, 1990 CHECKED BY VCA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
107.2	Ground Surface						
0.0 / 106.5	Granular road base (Fill) Grey						
0.7 / 105.5	Clayey Silt (Fill) trace sand, occ. gravel Very Stiff Brown		1	SS	15		106
1.7	Silty Topsoil		2	SS	30		
2.0	Clayey silt trace sand, occasional gravel and shale fragments. (Till)		3	SS	95/200mm		
			4	SS	60/150mm		104
102.9	Reddish Brown Hard		5	SS	60/75mm		
4.3 / 102.3	Shale (Deformation Till) completely to highly weathered Reddish Brown		6	SS	70/125mm		
4.9 / 101.1	Probably Shale Bedrock highly to moderately weathered Reddish Brown						102
6.1	Shale Bedrock moderately to slightly weathered thinly to medium bedded Reddish brown interbedded with fine grained argillaceous Limestone		7	NQ RC	*TCR= 95% SCR= 52% RQD= 42%		100
97.9			8	NQ RC	*TCR= 97% SCR= 61% RQD= 34%		98
9.3	End of Borehole						96

Borehole dry to Elev. 102.3 metres during drilling.

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE

PLASTIC LIMIT W_p | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W_l

WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

*TCR=Total Core Recovery
SCR=Solid Core Recovery
RQD=Rock Quality Designation

$+^3, \times^5$: Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 11 METRIC

W P 199-77-07 LOCATION Co-ordinates N4,799,623.5 E277,872.7 ORIGINATED BY CB

DIST 4 HWY 403/QEW BOREHOLE TYPE Hollow Stem Augers, NQ Rock Core COMPILED BY MHW

DATUM Geodetic DATE August 16, 1990 CHECKED BY VCM

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
106.8	Ground Surface										
0.0 / 106.2	Granular Road Base (Fill) Grey										
0.6	Sand (Fill), medium to coarse grained, trace silt, occ. gravel		1	SS	10		106		○		
104.9	Compact Brown		2	SS	19	▼		Water seepage encountered at Elev. 105.3 metres during drilling.	○		
1.9	Clayey silt (Till) trace to some sand occasional gravel		3	SS	50/75mm				○		28 35 28 9
103.1	Reddish Brown Hard		4	SS	50/150mm		104				
3.7	Shale Bedrock, moderately to highly weathered		5	SS	>50/25mm						
102.2											
4.6	Shale Bedrock moderately to slightly weathered thinly to medium bedded Reddish Brown inter-bedded with fine grained argillaceous Limestone		6	NQ RC	* TCR= 95% SCR= 59% RQD= 43%		102				
			7	NQ RC	TCR= 94% SCR= 79% RQD= 75%		100				
99.0											
7.8	End of Borehole						98				

*TCR=Total Core Recovery
SCR=Solid Core Recovery
RDQ=Rock Quality Designation

OFFICE REPORT ON SOIL EXPLORATION

$+^3$, $\times^5$: Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 12 METRIC

W P 199-77-07 LOCATION Co-ordinates N4,799,660.9 E277,690 ORIGINATED BY CB

DIST 4 HWY QEW/403 BOREHOLE TYPE Hollow Stem Augers; NQ Rock Core COMPILED BY MHW

DATUM Geodetic DATE August 23, 1990 CHECKED BY VCAS

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE 'N' VALUE	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
107.2	Ground Surface										
0.0 / 106.6	Sand (Fill) Brown										
0.6	Silty clay (Fill) trace sand and organics occasional gravel		1	SS	15		106				
			2	SS	10						
105.1	Stiff Dark Brown										
2.1 / 104.7	Clayey silt (Till) some Sand Hard Reddish Brwn		3	SS	85/125mm	▼		Water level at Elev. 105.0 metres, August 30, 1990			
2.5 / 104.1	Shale (Deformation Till) completely wethrd							104.6 metres Sept. 13, 1990 Destroyed Nov. 19, 1990			
3.1	Shale bedrock moderately to slightly weathered thinly to medium bedded Reddish Brown Interbedded with fine grained grey argillaceous limestone		4	SS	50/25mm		104				
			5	NQ RC	* TCR= 92% SCR= 33% RQD= 12%						
			6	NQ RC	TCR= 100% SCR= 68% RQD= 47%		102				
101.0											
6.2	End of Borehole						100				

* TCR: Total Core Recovery

SCR: Solid Core Recovery

RQD: Rock Quality Designation

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20/10 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 13 METRIC

W P 199-77-07 LOCATION Co-ordinates N4,799,687.6 E277,921.4 ORIGINATED BY CB

DIST 4 HWY 403/QEW BOREHOLE TYPE Solid Stem Augers COMPILED BY MW

DATUM Geodetic DATE August 15, 1990 CHECKED BY VCH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
107.2	Ground Surface										
0.0	Clayey Silt (Fill) trace sand and organics occasional gravel		1	SS	13		106		○		
105.2	Brown to Reddish Brown Stiff		2	SS	14				○		
2.0	Clayey silt trace to some sand, occasional gravel. (Till)		3	SS	60/150mm			Borehole dry during drilling.	○		
104.2	Hard Red Brown										
3.0	Shale (Deformation Till) Completely to moderately weathered Reddish Brown		4	SS	120		104		○		
103.6	Shale Bedrock moderately to highly weathered		5	SS	>50/25mm						
102.7	Reddish Brown		6	SS	>50/25mm						
4.5	End of Borehole						102				

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF TEST PIT No. 4

METRIC

W P 199-77-07 LOCATION Co-ordinates N4,799,691 E277,898.5 ORIGINATED BY VCH

DIST 4 HWY 403/QEW BOREHOLE TYPE Backhoe Dug; John Deere 690 COMPILED BY MHW

DATUM Geodetic DATE August 16, 1990 CHECKED BY VCH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
109.1	Ground Surface										
0.0 / 108.8	Topsoil										
0.3	Silty Clay (Fill) trace sand, occasional gravel and shale fragments with concrete and brick fragments above Elevation 106.1 metres		1	CS	--		108	Test Pit dry following excavation	○		
105.8	Brown to Reddish Brown		2	CS	--		106		○		
3.3	Shale (Deformation Till)										
3.4	Bottom of Pit						104				

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

20
15 ⊹ 5 (%) STRAIN AT FAILURE
10

GEOTECHNICAL INVESTIGATION
PROPOSED BRIDGE 35
SITE 10-481
FREEMAN INTERCHANGE
BURLINGTON, ONTARIO
W.P. 199-77-08 DISTRICT 4

1. INTRODUCTION

Golder Associates Ltd. has been retained by the Ministry of Transportation Ontario (MTO) to carry out a series of site specific subsurface investigations for the design of structures for the proposed reconstruction of the Freeman Interchange in Burlington, Ontario. This report presents the results of a subsurface investigation carried out at the site of the proposed Bridge No. 35 to be constructed as part of the eastbound Highway 403 lanes as shown on the Key Plan, Drawing 1997708-A*.

The purpose of the investigation was to determine the subsurface conditions at the site.

2. SITE AND PROJECT DESCRIPTION

The proposed Bridge No. 35 will be situated between the west edge of the existing QEW north 403 west ramp and the former North Service Road. The proposed Bridge 34 (Site 10-480, W.P. 199-77-07) will be situated parallel to and immediately north of Bridge 35. The existing ground surface to be traversed by the structure consists of the existing west bound QEW/403 ramp and grass covered medians. The existing ground surface elevation along the centreline of the proposed structure varies from about 105.5 to 108.7 metres. The location of the site is shown on the Key Plan, Drawing 1997708-A*.

* SHEET NO 519 OF THE CONTRACT DWG'S

The site is situated within the physiographic region of Southwestern Ontario known as the Iroquois Plain. Available geologic information indicates that the overburden in the general area of the site consists of a thin veneer of sands, glacial till and/or residual soil derived from the weathering of the underlying shale bedrock. The Queenston shale formation which comprises the bedrock in the area generally consists of thinly bedded red shale with occasional bands of grey limestone.

Bridge No. 35 will carry Highway 403 eastbound traffic over the QEW north - 403 west ramp, Bridge 33 (site 10-335, W.P. 199-77-05) and the 403 east - QEW south ramp.

The proposed high level bridge will consist of a five span structure (spans of approximately 35, 45, 60, 45, and 30 metres south to north respectively) with two abutments and four piers. Approach fills of some 10 to 16 metres in height will be required.

3. INVESTIGATION PROCEDURE

The field work for this investigation was carried out between August 15 and 29, 1990 at which time two test pits were excavated and six boreholes were drilled. The locations of the boreholes and test pits are shown on Drawing 1997708-A*.

The initial stage of the field work consisted of excavating two test pits (numbered 5 and 6) near the proposed south and north bridge abutments. Test pits 5 and 6 were excavated to depths of about 2.5 and 3.9 metres, respectively, using a "John Deere 690" hydraulic backhoe supplied and operated by

* SHEET NO 519 OF THE CONTRACT DWG'S

a local contractor. Chunk samples were obtained from the predominant soil strata exposed in the test pits and the test pits were loosely backfilled following sampling and logging.

The boreholes were drilled using track mounted power auger drillrigs equipped for rotary drilling, supplied and operated by a specialist drilling contractor. Boreholes numbered 15, 16 and 17 were advanced to bedrock, through about 3 to 6.7 metres of overburden. The bedrock encountered beneath the overburden in boreholes 15, 16 and 17 was core drilled in NQ size for about 3 metres. Boreholes numbered 13, 14 and 18 were drilled to practical auger refusal. The boreholes were advanced in the overburden and the upper portion of the bedrock using nominal 150 millimetre outside diameter hollow stem augers and nominal 100 millimetre diameter solid stem augers. Standard penetration testing and sampling was carried out within the overburden encountered in the boreholes using 35 millimetre inside diameter split spoon sampling equipment.

Samples of the overburden and the rock core recovered from the test pits and boreholes were taken to our Hamilton laboratory for examination and water content determinations. Grain size analyses and Atterberg limit determinations were carried out on selected samples of the overburden.

The soil and rock stratigraphy encountered in the boreholes and test pits are shown in detail on the Records of Boreholes and Records of Test Pits following the text of this report and on Drawing 1997708-A*. The results of the field and laboratory testing are also shown on the Record of Borehole

* SHEET NO 519 OF THE CONTRACT DWG'S

and Record of Test Pit sheets and on Figures 1 and 2.

Groundwater levels were observed in the open boreholes during drilling and in the test pits during and after excavation. Notes pertaining to the groundwater conditions observed in the boreholes and test pits are also shown on the Record of Borehole and Test Pit sheets and on Drawing 1997708-A*.

The locations and ground surface elevations at the borehole and test pit locations have been determined by Golder Associates staff with reference to site specific points and temporary bench marks provided by McCormick Rankin & Associates Limited. The final locations and ground surface elevations of the boreholes were subsequently verified by McCormick Rankin. The elevations provided are understood to be referred to geodetic datum.

4. SUBSURFACE CONDITIONS

4.1 General

The subsurface conditions encountered in the boreholes and test pits put down at the site are shown in detail on the Records of Borehole and Record of Test Pit sheets, and in summary form on Drawing 1997708-A*. The soil boundaries and rock stratigraphy indicated, particularly for the boreholes, are inferred from non-continuous sampling and resistance to drilling advance. These boundaries typically represent a transition between one soil or rock type to another and are not intended to define an exact plane of geological change. Conditions will vary between and beyond the borehole and test

* SHEET NO 519 OF THE CONTRACT DWG'S

pit locations.

The subsurface conditions encountered at the site generally consisted of topsoil, fill, glacial till and completely to highly weathered shale underlain by more competent shale bedrock at depth.

The following discussion has been simplified in terms of major soil and rock strata for the purposes of geotechnical design.

It should be noted that due to the relatively soft and weathered nature of the Queenston shale formation, particularly the upper zone, together with the effects of glacial overriding at the bedrock surface, it is difficult to accurately define the bedrock surface both from a geological and a contractual standpoint.

During the course of this investigation, a stratigraphic unit directly overlying the shale bedrock, which in strictly geological terms is described as deformation till, has been encountered. This stratigraphic unit consists of an imbricate embedment of fragments of bedrock in a till matrix which has been formed from glacial overriding of the parent bedrock. This till is characterized by the presence of rounded and sub-angular clasts of the parent rock with non horizontal bedding. Based on the consistency, the relatively high penetration resistance encountered in the boreholes and the difficulty of excavation experienced in the test pits, this stratum could be contractually interpreted as a zone of the bedrock and for this reason has been referred to in this

report as an upper zone of the bedrock formation.

4.2 Topsoil

A relatively thin layer of topsoil was encountered at the ground surface in boreholes 14, 15, 16, and 18 and in test pits 5 and 6.

4.3 Silty Clay, Clayey Silt, trace topsoil
trace sand, (Fill)

Fill was encountered beneath the surficial topsoil layer in all of the boreholes and test pits and at the ground surface in borehole 13. The fill and topsoil layers were fully penetrated in the boreholes and test pits at elevations varying between about 103.8 and 105.2 metres or at depths of about 1.2 to 4.3 metres below the existing ground surface. Some 4.3 metres of fill was encountered in borehole 14 drilled immediately adjacent to the existing west bound QEW/403 ramp where the ground surface elevation is some 2 to 3 metres higher then at the other borehole locations.

The fill generally consisted of clayey silt to silty clay with traces of topsoil. A surface layer of sand and gravel fill was encountered in borehole 17 drilled adjacent to the existing 403 westbound lanes.

The clayey fill has in-situ water contents ranging from about 15 to 25 per cent with an average water content of about 20 per cent. N-values ranging from 7 to 22 blows per 0.3 metres, were determined in the standard penetration testing

carried out in the fill, indicating a generally firm to very stiff consistency.

4.4 Clayey Silt, trace to some sand, occ. Gravel (Till)

Glacial till was encountered beneath the fill in all of the boreholes and test pits. In general, the till was characterized by an upper zone of very stiff to hard brown clayey silt and a lower zone of reddish brown clayey silt which was somewhat harder and slightly coarser than the overlying till.

The N values determined in the upper till zone ranged from 27 to greater than 100 blows per 0.3 metres. The natural water contents of samples of the upper till recovered from the boreholes and test pits ranged from about 12 to 17 per cent.

Standard penetration testing was also carried out in the lower till zone, but due to its hard consistency, in most instances it was not practical to advance the sampler the entire 450 millimetres required to establish an N value. However, N values of the order of greater than 100 blows per 0.3 metres can generally be inferred from the results of the penetration testing. The natural water content of the lower till typically ranged from about 7 to 14 per cent.

The corresponding liquid and plastic limits of the lower clayey silt till were about 22 and 14 based on the average of two Atterberg limit determinations. The results of the Atterberg limit determinations for two samples of the clayey silt till are presented on the plasticity chart, Figure 2.

Grain size distribution curves for samples of the lower till (obtained by a 35 millimetre I.D. sampler) are shown on Figure 1.

The till material as indicated by the gradation curves is relatively fine grained in nature and no major concentrations of coarse particles, such as boulders, were encountered during this investigation. This does not necessarily mean that the coarser particle sizes are not present at random or in concentrations within the deposit, since till is an inherently variable material.

4.5 Shale, completely to slightly weathered (Bedrock)

At the borehole locations, the overburden materials were underlain by shale bedrock of the Queenston Formation. Bedrock was encountered between about elevations 101.7 and 103 metres, or at depths of from about 3 to 6.7 metres below the existing ground surface.

The upper zone of the bedrock was generally highly to completely weathered. More competent shale was encountered in boreholes 15, 16 and 17 between about elevations 100 and 102 metres. The bedrock core recovered from boreholes 15, 16 and 17 generally consists of moderately to faintly weathered thinly bedded reddish-brown shale, interbedded with thinly bedded light grey, fine grained argillaceous limestone up to about 0.5 metres in thickness.

The rock core recovered from the boreholes generally exhibited a relatively high degree of fracturing. The total

core recovery (TCR) ranged from about 93 to 100 per cent. The solid core recovery (SCR) ranged from about 57 to 85 per cent and the rock quality designation (RQD) ranged from about 8 to 75 percent.

4.6 Groundwater Conditions

Groundwater was not encountered during the field drilling/ digging operations in boreholes 13, 14 and 18 which were terminated at practical auger refusal, or in test pits 5 and 6 which were terminated in the till. Boreholes 15, 16 and 17 were dry to the depth of practical auger refusal, corresponding to about elevations 99.5 to 102 metres.

The groundwater level was measured at about elevations 102.9 and 104.6 metres in the piezometers installed in boreholes drilled at the site of the adjacent structure Bridge 34 (Site 10-480, WP 199-77-07). These water levels, recorded about 1 month after the completion of drilling, correspond to depths of about 3.7 and 2.6 metres below the existing ground surface.

It should be noted that the piezometric groundwater level within the subsoil and underlying bedrock is subject to fluctuation not only due to precipitation conditions, but also due to seasonal variations. The water levels given above may not necessarily reflect stabilized conditions and may vary from the conditions which are encountered during construction.

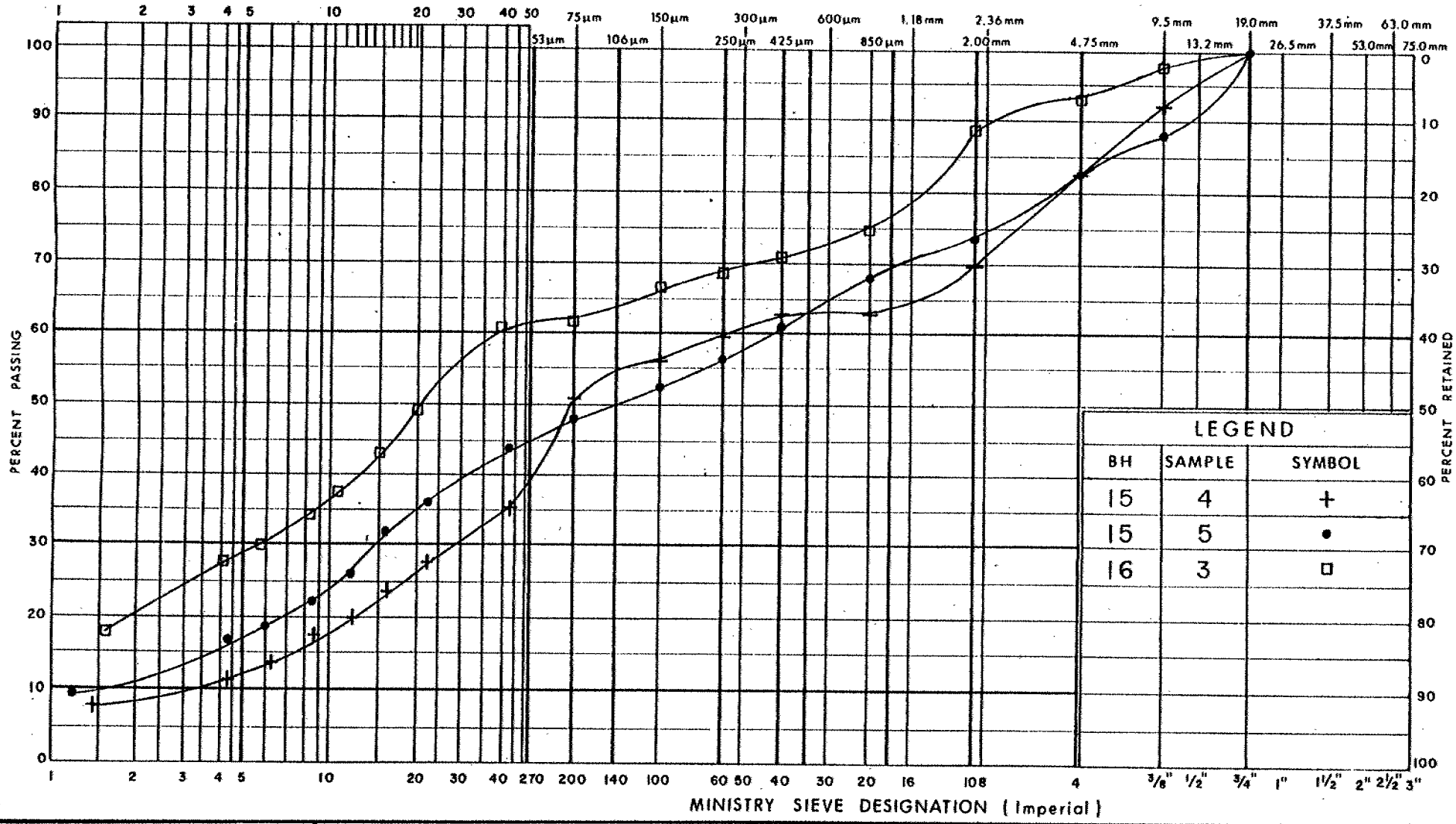
Note: The preceding report is a copy of the factual information from the Foundation Report prepared by GOLDER ASSOCIATES LTD (consulting geotechnical engineers for this project), under the technical supervision of the M.T.O. Foundation Design Section.

P. Payer, P. Eng.
Senior Foundatation Engineer

M.S. Devata, P. Eng.
Chief Foundation Engineer

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



Ministry of Transportation
Ontario

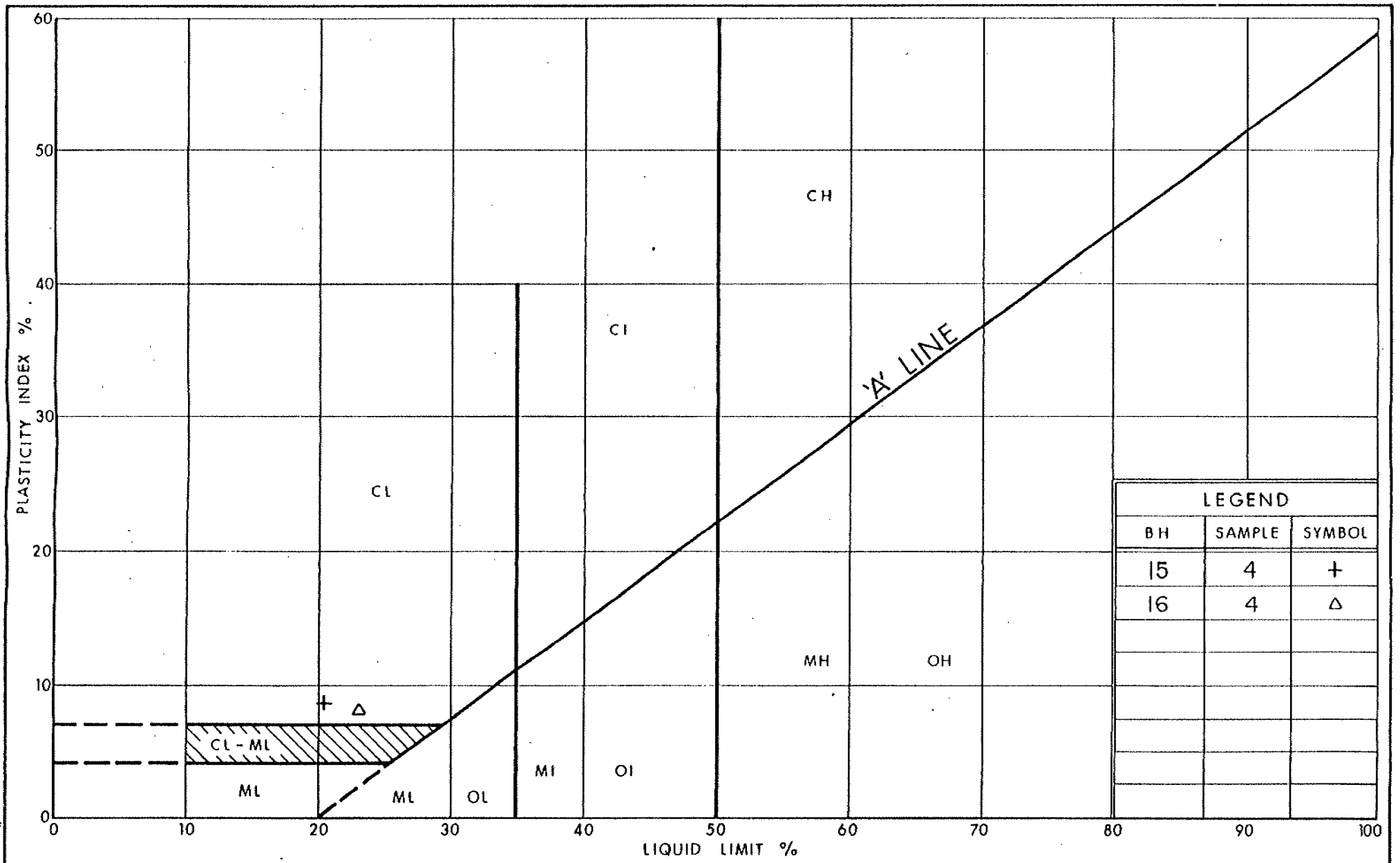
GRAIN SIZE DISTRIBUTION

CLAYEY SILT TILL

FIG No 1

W P 199-77-08

211



Ministry of Transportation
Ontario

PLASTICITY CHART
CLAYEY SILT TILL

FIG No 2
W P 199-77-08

212

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 13 METRIC

W P 199-77-07 LOCATION N4,799,687.6 E277,921.4 ORIGINATED BY CB

DIST 4 HWY 403/QEW BOREHOLE TYPE Solid Stem Augers COMPILED BY MW

DATUM Geodetic DATE August 15, 1990 CHECKED BY VCM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
107.2	Ground Surface										
0.0	Clayey Silt (Fill) trace sand and organics occasional gravel		1	SS	13		106		○		
105.2	Brown to Reddish Brown Stiff		2	SS	14				○		
2.0	Clayey silt trace to some sand, occasional gravel. (Till)		3	SS	60/150mm			Borehole dry during drilling.	○		
104.2	Hard Red Brown										
3.0	Shale (Deformation Till) Completely to moderately weathered Reddish Brown		4	SS	120		104		○		
103.6	Shale Bedrock moderately to highly weathered		5	SS	>50/25mm						
102.7	Reddish Brown		6	SS	>50/25mm						
4.5	End of Borehole						102				

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 14

METRIC

W P 199-77-08 LOCATION N4,799,481.2 E277,828.2 ORIGINATED BY VCH

DIST 4 HWY QEW/403 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MHW

DATUM Geodetic DATE August 20, 1990 CHECKED BY JGM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
108.7	Ground Surface										
	Topsoil										
0.1	Silty Clay, trace sand occasional gravel trace topsoil (Fill) Reddish Brown		1	SS	20		108				
107.3	Very Stiff										
1.4	Clayey Silt trace sand trace organics occ. gravel (Fill)		2	SS	7						
			3	SS	10		106				
			4	SS	22			Borehole dry following drilling.			
			5	SS	20						
104.4	Firm to very stiff Brown										
4.3	Clayey Silt trace to some sand occ. gravel occ. shale fragments		6	SS	53		104				
			7	SS	50/75mm						
	Brown to reddish brown at about Elevation 103.5m		8	SS	70/100mm						
102.0	Hard		9	SS	50/25mm		102				
6.7	Probably shale Bedrock Highly to moderately weathered Reddish Brown		10	SS	50/25mm						
99.6							100				
9.1	End of Borehole						98				

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity.

15 20/10 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 15 METRIC

W P 199-77-08 LOCATION N4,799,510.4 E277,849.71 ORIGINATED BY VCH

DIST 4 HWY 403/QEW BOREHOLE TYPE Hollow Stem Auger; NQ Rock Core COMPILED BY MHW

DATUM Geodetic DATE August 20-21, 1990 CHECKED BY JGM

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
106.1	Ground Surface						106
0.1	Topsoil						
	Clayey Silt trace sand, tr topsoil occ. gravel (Fill)		1	SS	20		
104.6	Very Stiff Brown						
1.5	Clayey Silt trace to some sand, occasional gravel, occ. shale fragments (Till)		2	SS	27		104
			3	SS	50/25mm		
	Very stiff to hard						
			4	SS	50/25mm		
	Grey becoming reddish brown at about Elev. 103.7m		5	SS	82/150mm		102
101.7							
4.4	Shale Bedrock Highly to moderately weathered		6	SS	78/150mm		
			7	SS	40/0mm		100
99.5	Reddish Brown						
6.6	Shale Bedrock moderately to slightly weathered thin to medium bedded Reddish Brown Interbedded with fine grained argillaceous limestone		8	NQ RC	* TCR= 100% SCR= 85% RQD= 75%		
			9	NQ RC	TCR= 100% SCR= 62% RQD= 16%		98
96.4							
9.7	End of Borehole						96

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE

PLASTIC LIMIT Wp NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L

WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Pressuremeter Test 15-1

18 31 42 9

18 34 37 11

Hole dry to elevation 99.5 metres during drilling

OFFICE REPORT ON SOIL EXPLORATION

* TCR: Total Core Recovery
SCR: Solid Core Recovery
RQD: Rock Quality Designation

$+^3$, $\times^5$: Numbers refer to Sensitivity

20 15 ◇ 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No 16 METRIC

W P 199-77-08 LOCATION N4799544.2 E277872.3 ORIGINATED BY VCH

DIST 4 HWY 403/QEW BOREHOLE TYPE Hollow Stem Auger; NQ Rock Core COMPILED BY MHW

DATUM Geodetic DATE August 29, 1990 CHECKED BY JGM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPo (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL / WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
105.5	Ground Surface										
0.0	Topsoil										
0.2	Silty Clay trace sand, tr topsoil occ. gravel (Fill)		1	SS	16						
103.8	Stiff to Very Stiff Brown						104				
1.7	Clayey Silt trace to some sand occasional gravel (Till)		2	SS	14						
			3	SS	65/100mm						7 30 43 20
			4	SS	90/150mm			Pressuremeter Test 16-1			
101.8	Hard Reddish Brown						102				
3.7	Shale Bedrock highly weathered		5	SS	50/50mm			Borehole dry to elev. 101.1 during drilling			
101.1	Reddish Brown										
4.4	Shale Bedrock moderately to slightly weathered thinly to medium bedded Reddish Brown interbedded with fine grained argillaceous Limestone		6	NQ RC	*TCR =93% SCR =57% RQD = 8%						
			7	NQ RC	TCR =100% SCR =78% RQD =42%		100	Pressuremeter Test 16-2			
98.0								Pressuremeter Test 16-3			
7.5	End of Borehole						98				
							96				

* TCR: Total Core Recovery
SCR: Solid Core Recovery
RQD: Rock Quality Designation

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 17

METRIC

W P 199-77-08 LOCATION N4,799,608.7 E277,901.4 ORIGINATED BY CB

DIST 4 HWY 403/QEW BOREHOLE TYPE Hollow Stem Auger, NQ Rock Core COMPILED BY MHW

DATUM Geodetic DATE August 16, 1990 CHECKED BY JGM

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
106.6	Ground Surface										
0.0 / 106.0	Sand and gravel; granular road base (Fill) Grey						106				
0.6 / 104.9	Clayey Silt, trace sand, occ. gravel (Fill) Stiff Brown		1	SS	15				○		
1.7	Clayey silt, trace to some sand, occ. gravel		2	SS	18				○		
	Very stiff to Hard		3	SS	93		104		○		
			4	SS	50/100mm						
102.9	Reddish Brown		5	SS	50/25mm						
3.7 / 102.0	Shale Bedrock probably highly to completely weathered Reddish Brown							Borehole dry to Elevation 102.0 metres during drilling.			
4.6	Shale Bedrock, moderately to slightly weathered thin to med. bedded, Reddish Brown, interbedded with fine-grained argillaceous Limestone.		6	NQ RC	* TCR= 100% SCR= 61% RQD= 38%		102				
			7	NQ RC	TCR= 100% SCR= 62% RQD 16%		100				
98.9											
7.7	End of Borehole						98				

* TCR= Total Core Recovery
SCR= Solid Core Recovery
RQD= Rock Quality Designation

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15}\diamond^{5}_{10}$ (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 18 METRIC

W P 199-77-08 LOCATION N4,799,642.5 E277,916.7 ORIGINATED BY CB
DIST 4 HWY 403/QEW BOREHOLE TYPE Solid Stem Augers COMPILED BY MHW
DATUM Geodetic DATE August 15, 1990 CHECKED BY JGM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
106.0	Ground Surface										
105.7	Black Silty Topsoil										
0.3	Clayey Silt, tr sand and organics, occ. gravel (Fill)		1	SS	8				○		
104.6	Firm Reddish Brown										
1.4	Clayey silt trace sand (Till) occasional gravel.		2	SS	100/250mm			Borehole dry following drilling.			
			3	SS	70/100mm		104		○		
103.0	Hard Reddish Brown										
3.0	Highly weathered Shale		4	SS	50/25mm						
3.4	End of Borehole						102				

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20/10 5 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF TEST PIT No. 5

METRIC

W P 199-77-08 LOCATION N4,799,491 E277,829 ORIGINATED BY VCH

DIST 4 HWY 403/QEW BOREHOLE TYPE John Deere 690 - Backhoe Dug COMPILED BY MHW

DATUM Geodetic DATE August 16, 1990 CHECKED BY JGM

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
107.0	Ground Surface										
	Topsoil										
0.1	Silty Clay, tr sand, occ. gravel and rootlets (Fill)		1	CS					○		
105.5	Red-Brown						106				
1.5	Topsoil		2	CS						○	
1.7	Silty Clay, tr sand, occasional gravel (Fill)		3	CS						○	
104.3	Reddish Brown										
2.7	Clayey Silt, tr sand, occ. gravel and boulders (Till)		4	CS			104		○		
103.1	Grey-Brown										
3.9	End of Test PIt					Test Pit dry following excavation					
							102				

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20 / 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF TEST PIT No. 6

METRIC

W P 199-77-08 LOCATION N4,799,642 E277,925.5 ORIGINATED BY VCH

DIST 4 HWY 403/QEW BOREHOLE TYPE John Deere 690 - Backhoe Dug COMPILED BY MHW

DATUM Geodetic DATE August 16, 1990 CHECKED BY JGM

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
106.2	Ground Surface										
105.9	Clayey Topsoil & Fill						106				
0.3	Granular Fill		1	CS					○		
0.5	Clayey Topsoil occ. rocks and rootlets										
105.0	(Fill) Brown		2	CS					○		
1.2	Clayey silt, trace sand (Till) occasional gravel.										
103.7			3	CS			104		○		
2.5	End of Test Pit					Test Pit dry following excavation					
							102				

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 (20/10) 5 (%) STRAIN AT FAILURE

DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. 30M5-174

DIST. 4 REGION

W.P. No. 199-77-02

CONT. No. 93-89

W. O. No.

STR. SITE No. 10-332

HWY. No. 403

LOCATION Ramp 403/W - Q.E.W./E over Ramp 403/E - Q.E.W./S

No of PAGES - (Bridge #37)

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

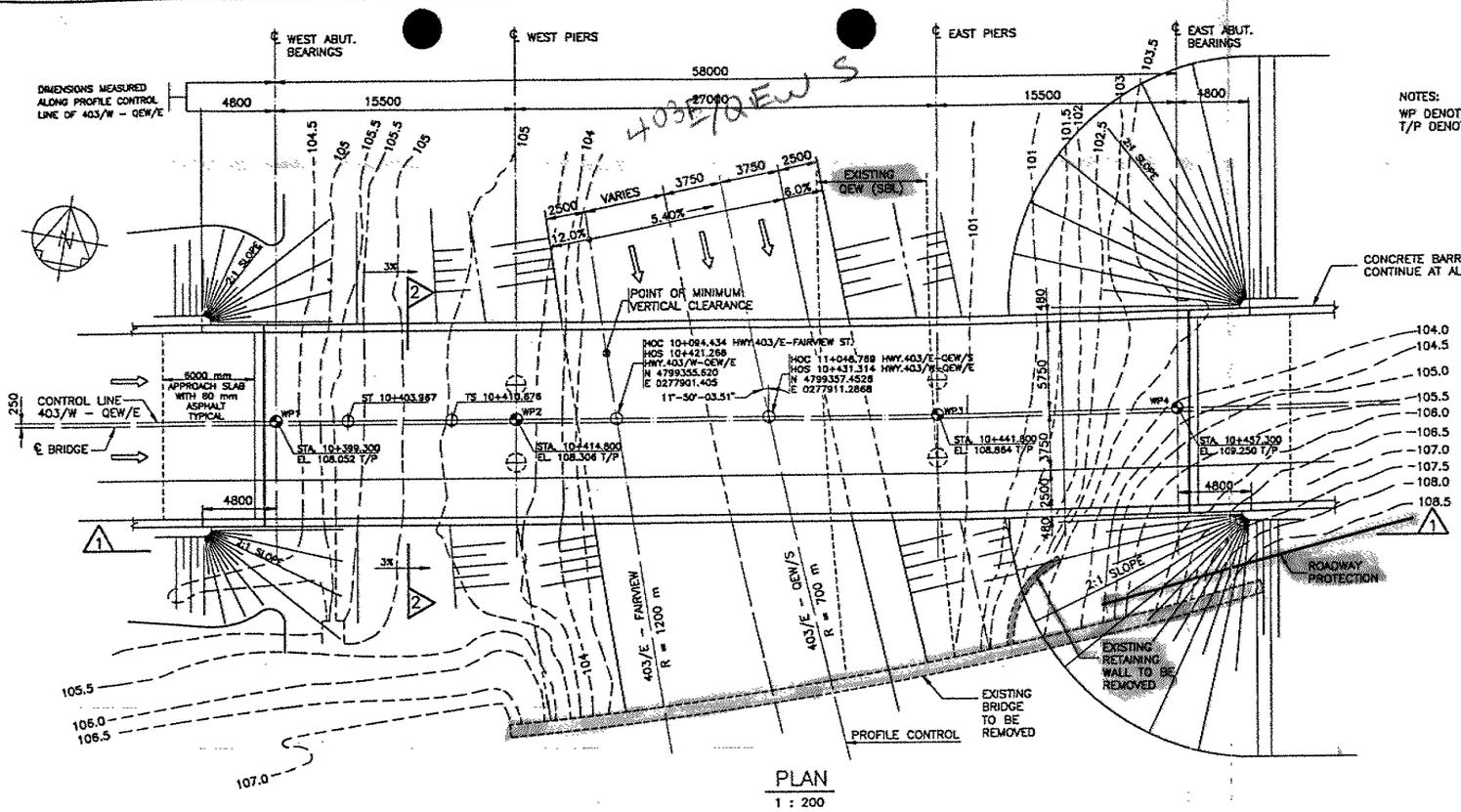
DIST No 4
CONT No
WP No 199-77-02

RAMP 403/W - QEW/E
OVER
RAMP 403/E - QEW/S
GENERAL ARRANGEMENT

SHEET

Gregg and Edens Limited
consulting engineers & planners

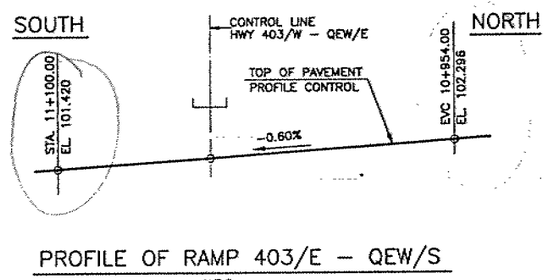
403E/QEW S



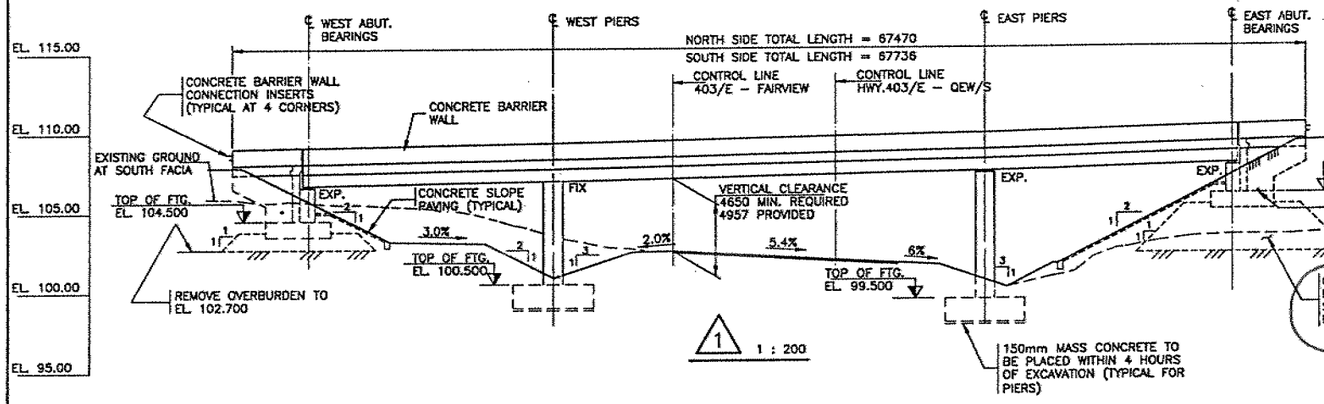
PLAN
1 : 200

NOTES:
WP DENOTES WORKING POINT
T/P DENOTES TOP OF PAVEMENT

403 W/QEW East Ramp



PROFILE OF RAMP 403/E - QEW/S
N.T.S.



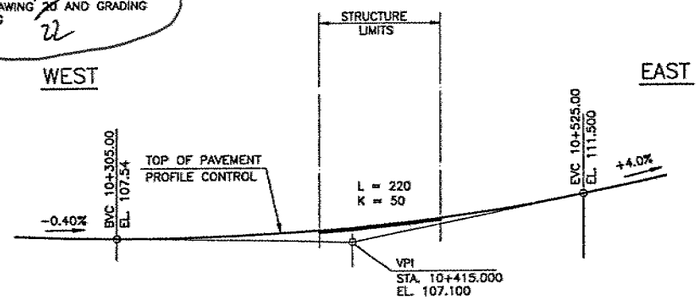
1 1 : 200

* Please confirm subsoil at this elevation. K

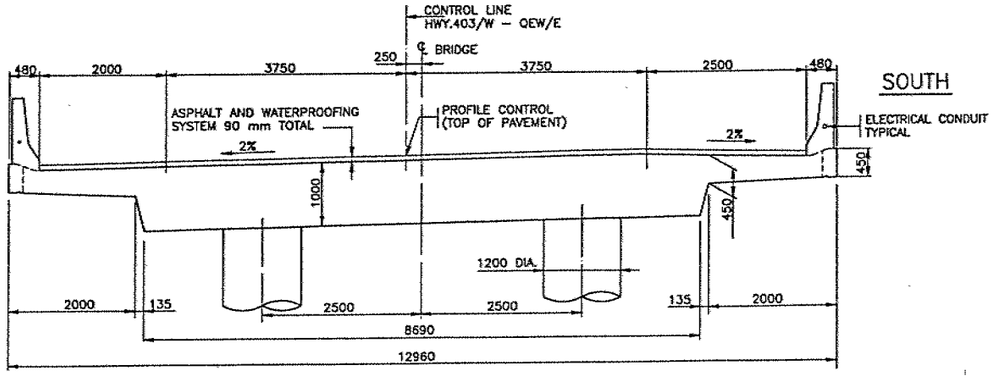
?

WEST

EAST



PROFILE OF RAMP 403/W - QEW/E
N.T.S.



2 1 : 50

MTO BM 838011
EL 102.394 m
CONCRETE BASE OF SIGNAL TOWER ON SOUTH SIDE OF CANADIAN NATIONAL RAILWAY, 93.5 m WEST OF KING ROAD. BENCH MARK IS SET VERTICALLY IN TOP OF CONCRETE BASE AT THE NORTHWEST CORNER, 2.40 m SOUTH OF THE MOST SOUTHERLY RAIL OF MAIN LINE.

GENERAL NOTES

1. CLASS OF CONCRETE

DECK AND PIER COLUMNS	35 MPa
REMAINDER	30 MPa

2. CLEAR COVER TO REINFORCING STEEL

FOOTINGS	100 ± 25
ABUTMENT AND WINGWALLS	
FRONT FACE	80 ± 20
BACK FACE	70 ± 20
PIERS	80 ± 20
DECK	
TOP	70 ± 20
BOTTOM	50 ± 10
SIDES	50 ± 10
REMAINDER	70 ± 20

UNLESS SPECIFIED OTHERWISE

3. REINFORCING STEEL SHALL BE GRADE 400 UNLESS OTHERWISE SPECIFIED. BAR MARKS WITH SUFFIX C DENOTE COATED BARS.
4. CONSTRUCTION NOTE:
   IF THE ACTUAL BEARING HEIGHTS ARE DIFFERENT FROM THE ASSUMED BEARING HEIGHTS GIVEN WITH THE BEARING DESIGN DATA, THE CONTRACTOR SHALL ADJUST THE BEARING SEAT ELEVATIONS AND THE REINFORCING STEEL TO SUIT THE ACTUAL HEIGHTS.

LIST OF DRAWINGS

APPLICABLE STANDARD DRAWINGS

DD 3503 - MINIMUM GRANULAR BACKFILL REQUIREMENTS

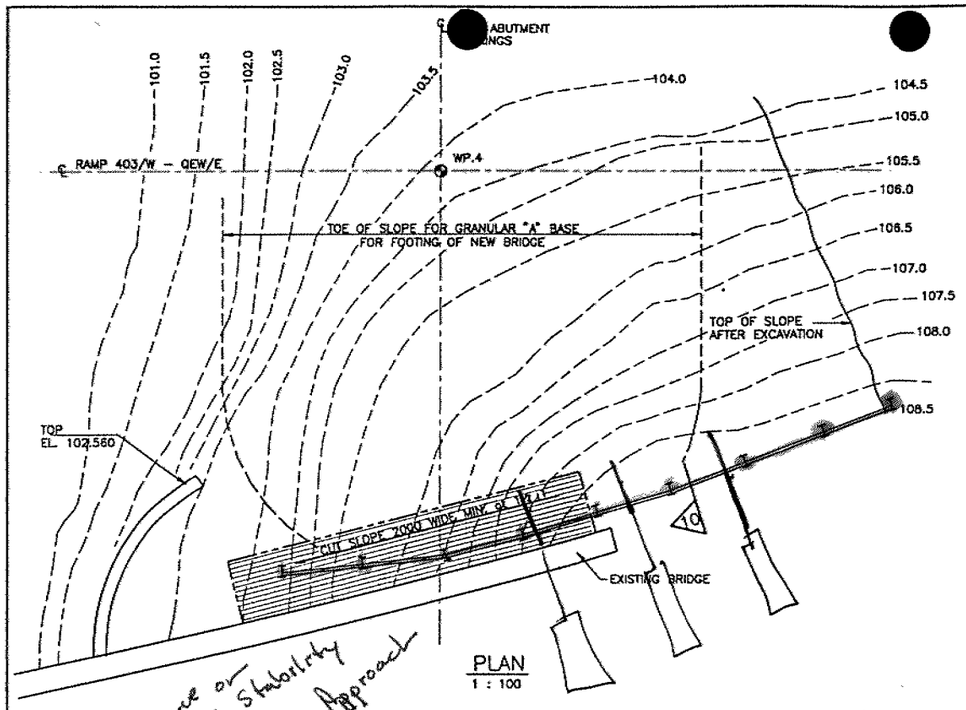
REGISTERED PROFESSIONAL ENGINEER J.T. GREGG PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER M.G. SHERLOCK PROVINCE OF ONTARIO

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

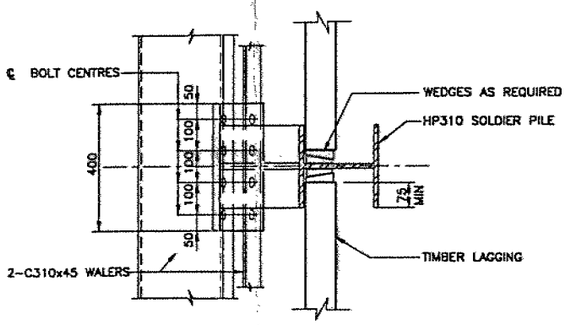
REVISIONS	DATE	BY	DESCRIPTION

DESIGN	M.G.S.	CHK J.T.G.	CODE - 1983-OHBDC	LOAD - CLASS A	DATE NOV. 1991
DRAWN	S.G.	CHK J.T.L.	SITE 10-332	STRUCT # 37	SCHEME	DWG 1

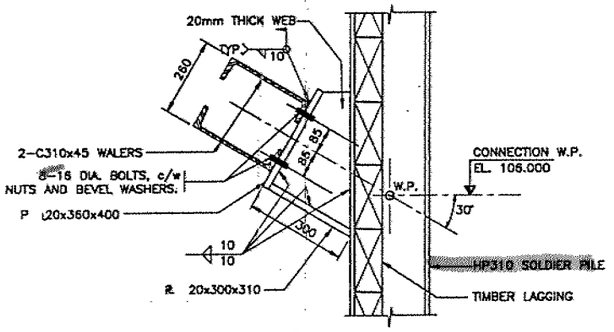


PLAN
1 : 100

Influence or Surficial Stability of existing Approach Embankment

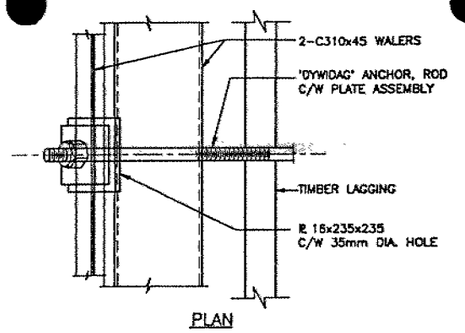


PLAN

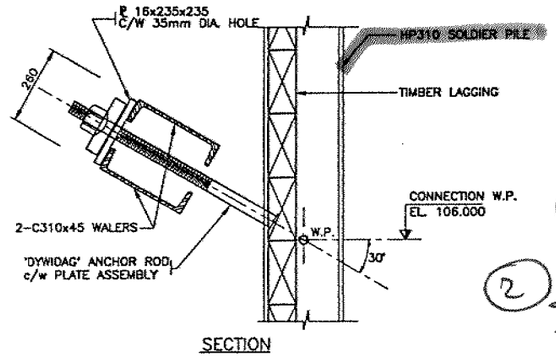


SECTION

WALER TO PILE CONNECTION DETAIL
1:10



PLAN



SECTION

WALER TO ANCHOR ROD CONNECTION DETAIL
1:10

Soldier Pile
① HP310 x ?
② Lagging
Thickness 50mm, 75mm, 100mm?

CONT No
WP No 199–77–02

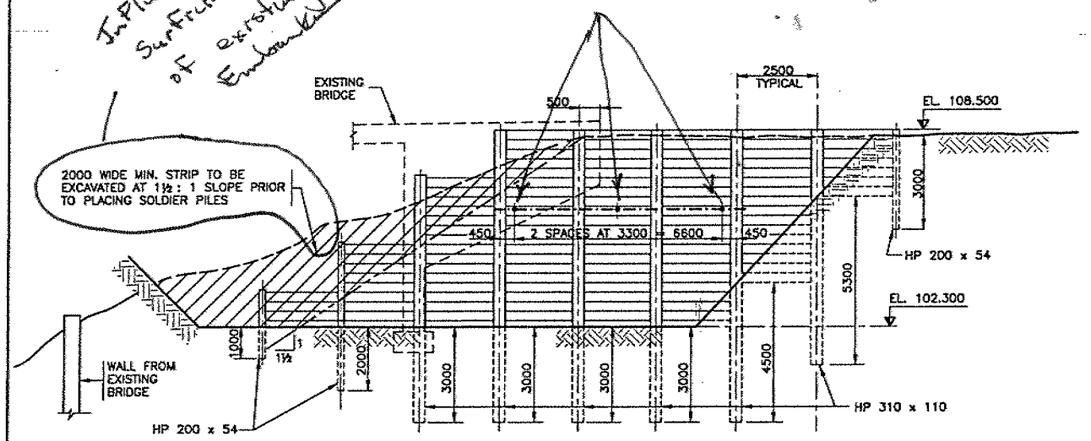
RAMP 403/W – QEW/E
OVER
RAMP 403/E – QEW/S
ROADWAY PROTECTION

SHEET

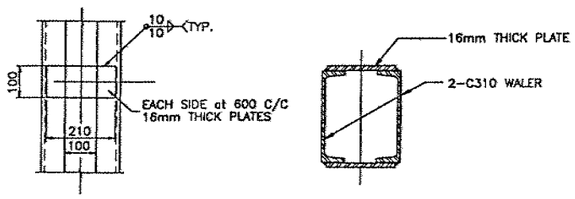
Gregg and Edens Limited
consulting engineers & planners

REGISTERED PROFESSIONAL ENGINEER J.T. GREGG PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER P. CEMAN PROVINCE OF ONTARIO

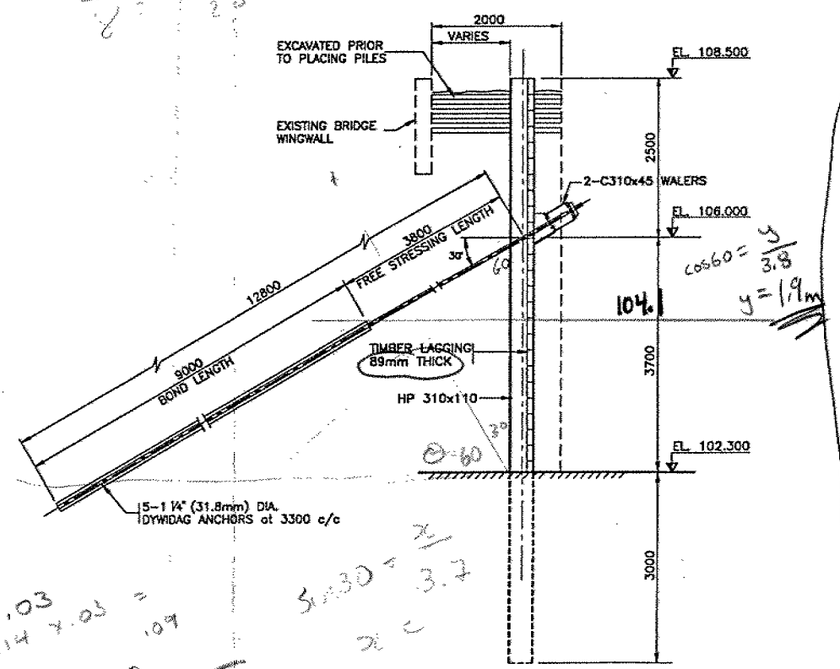


ELEVATION
1 : 100



PLAN SECTION

WALER SPACER PLATE DETAIL
1:10



10 1 : 50

NOTES:

1. STRUCTURAL STEEL

1.1 ALL STRUCTURAL STEEL AND ROLLED PLATES TO BE IN ACCORDANCE WITH CSA STANDARD G40.20–M AND CSA G40.21–M AND BE GRADE 350A

1.2 BEFORE FABRICATION AND INSTALLATION THE CONTRACTOR SHALL SUBMIT FOR APPROVAL OF THE ENGINEER SHOP AND FIELD ASSEMBLY DRAWINGS.

1.3 ALL BOLTS, NUTS AND WASHERS TO BE GRADE A325M.

2. SOIL ANCHORS

2.1 THE ANCHORS TO BE AS SUPPLIED BY DYWIDAG SYSTEMS OR EQUAL.

2.2 ELEVATION OF ANCHOR POINT AT WALL AND ANCHOR SPACING TO BE AS INDICATED ON DRAWINGS OR AS DIRECTED BY THE ENGINEER.

2.3 THE ULTIMATE CAPACITY OF THE SOIL ANCHORS TO BE 828 kN.

2.4 SOIL ANCHORS TO BE PRESTRESSED AND HAVE AN ULTIMATE CAPACITY OF 828 kN.

2.5 PRESTRESSING PROCEDURE TO BE IN ACCORDANCE WITH THE SOIL ANCHOR SPECIFICATIONS.

2.6 ONE SOIL ANCHOR TO BE TESTESTED TO A TEST LOAD OF 600 kN.

3. TIMBER LAGGING

3.1 TIMBER LAGGING TO BE GRADE S–P–F ACCORDING TO CSA CAN3–086–M84.

4. PROCEDURE

4.1 SOLDIER PILES AND LAGGING TO BE INSTALLED ALONG THE EXISTING WINGWALL IN SUCH A WAY THAT AT ANY GIVEN TIME NOT MORE THAN 2.5m OF LENGTH IS EXCAVATED AND LEFT UNSUPPORTED.

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

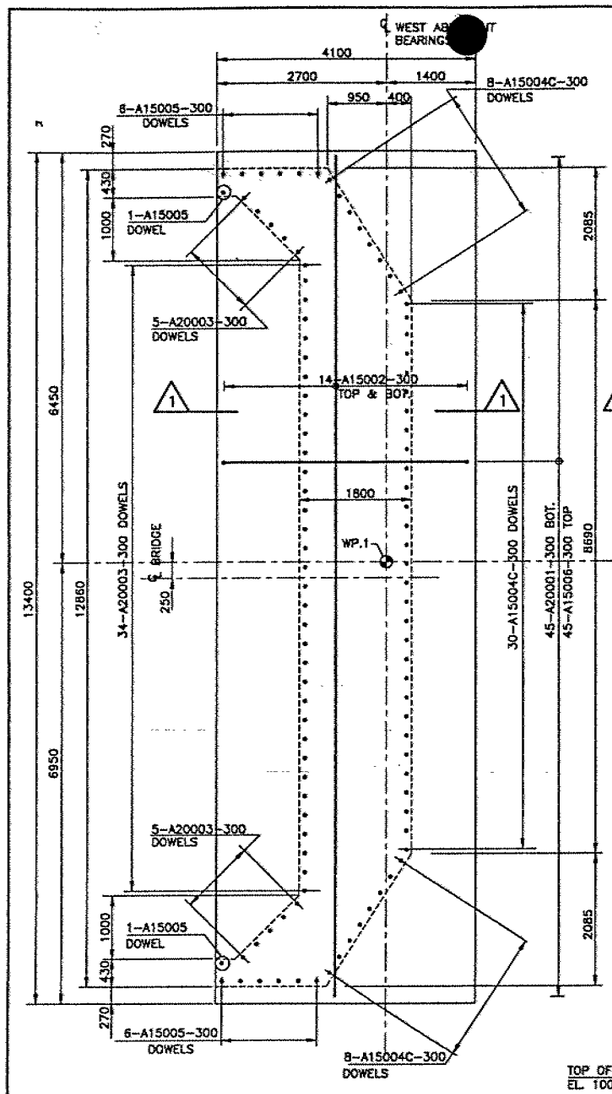
DESIGN P.C.	CHK J.T.G.	CODE – 1983–OHBDC	LOAD – CLASS A	DATE NOV. 1991		
DRAWN S.G.	CHK P.C.	SITE 10–332	STRUCT	SCHEME	DWG 3	

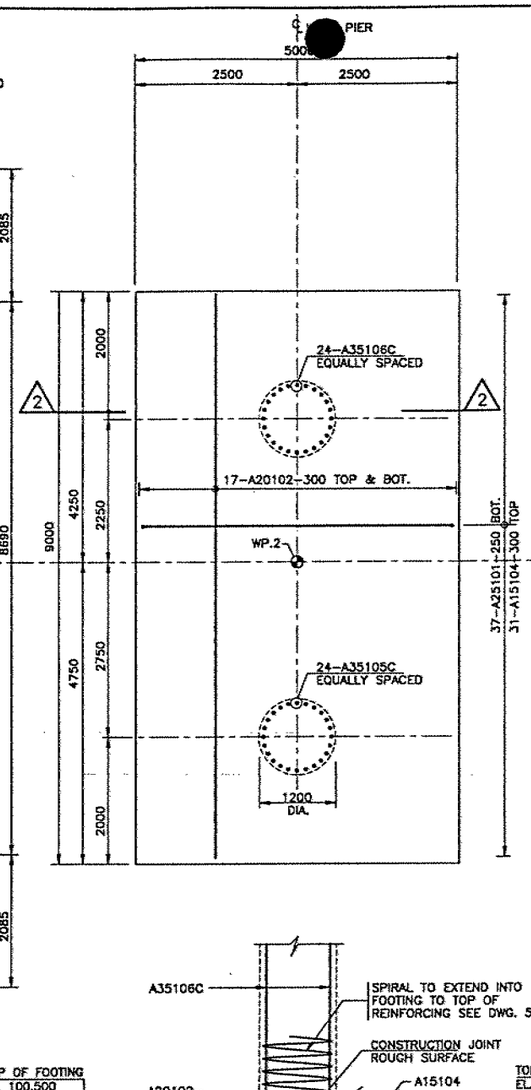
CONT No
WP No 199-77-02

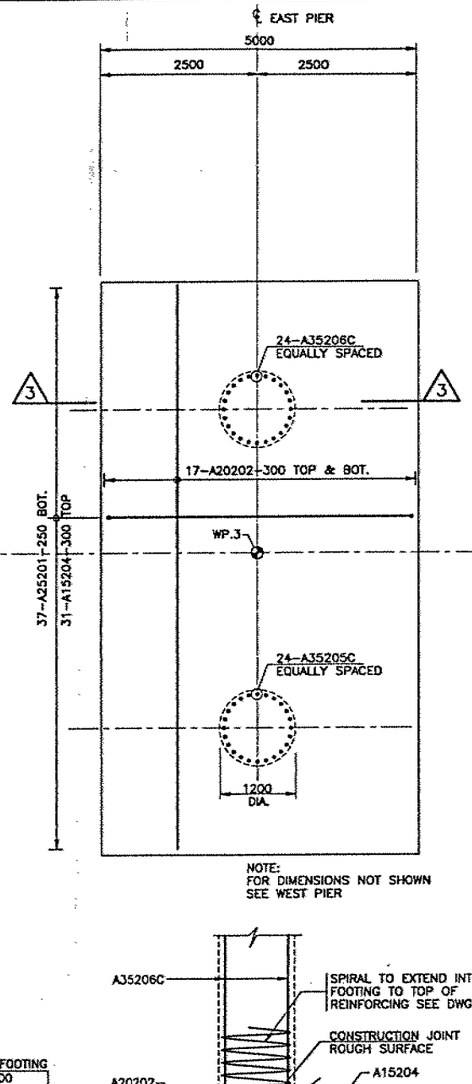
SHEET

RAMP 403/W - QEW/E
OVER
RAMP 403/E - QEW/S
FOOTING LAYOUT AND DETAILS

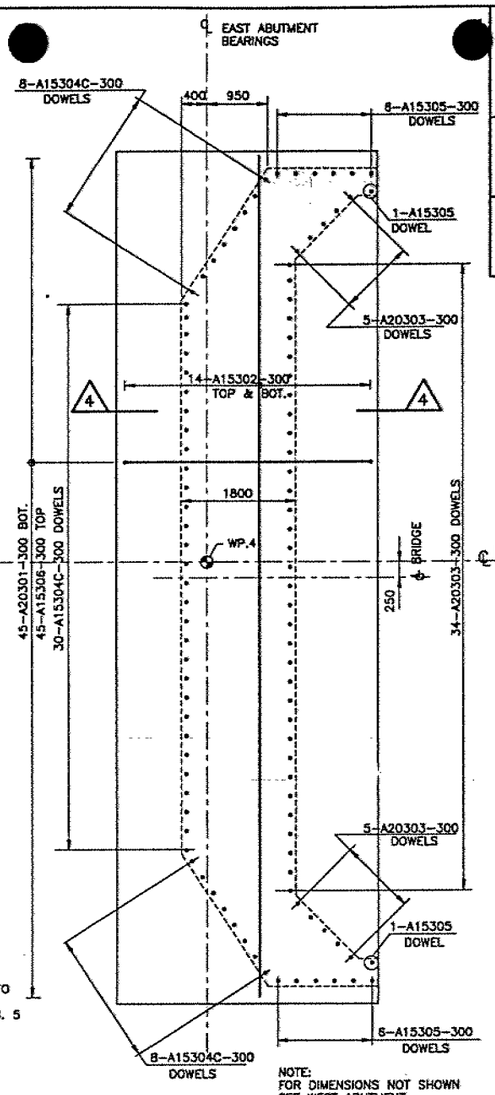
Gregg and Edens Limited
consulting engineers & planners







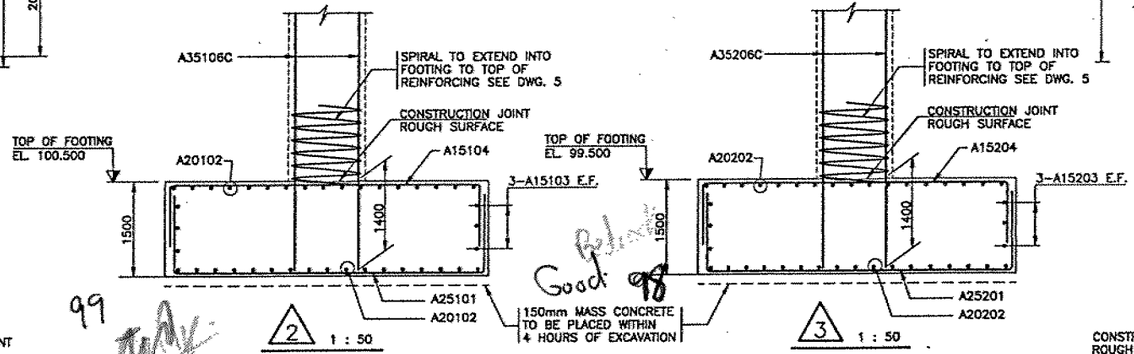
NOTE:
FOR DIMENSIONS NOT SHOWN
SEE WEST PIER

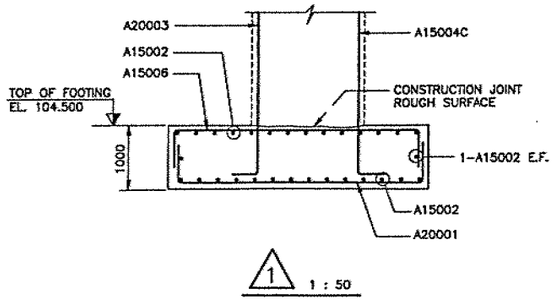


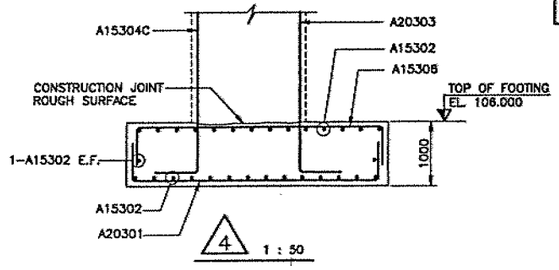
NOTE:
FOR DIMENSIONS NOT SHOWN
SEE WEST ABUTMENT

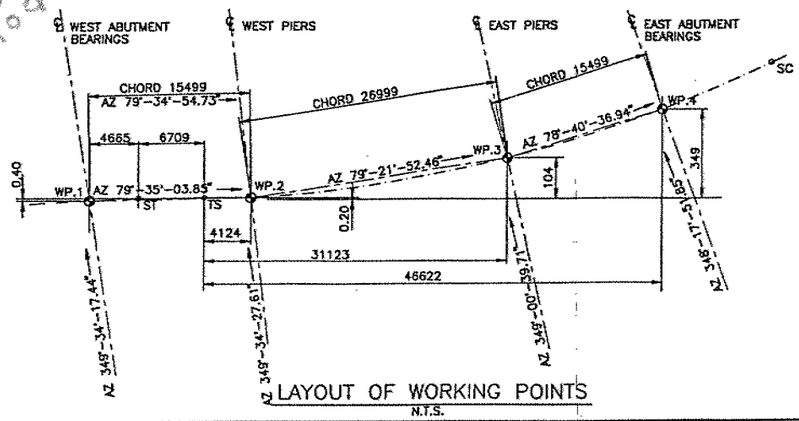
PROVINCIAL CO-ORDINATES OF WORKING POINTS

W.P.	STATION	NORTHING	EASTING
1	10+403.967	4799351.643	0277879.803
2	10+414.800	4799354.446	0277895.046
3	10+441.800	4799359.429	0277921.582
4	10+457.300	4799362.472	0277938.782









LAYOUT OF WORKING POINTS
N.T.S.

J.T. GREGG
PROVINCE OF ONTARIO

P. CEMAN
PROVINCE OF ONTARIO

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

DESIGN P.C.	CHK J.T.G.	CODE - 1983-OHBDC	LOAD - CLASS A	DATE NOV. 1991	
DRAWN S.G.	CHK M.A-H	SITE 10-332	STRUCT # 37	SCHEME	DWG. 4

memorandum

Ontario

To: K. Bassi
Head, Structural Section
7th Floor, Atrium Tower

Date: 1992 05 26

Attn: G. Al-Bazi
Design Engineer

From: Foundation Design Section
Room 315, Central Bldg.

Re: Highway 403 Advance Structures
Bridge No. 37
W.P. 199-77-02, Site 10-332

The revised drawing illustrating the roadway protection scheme for the above mentioned project has been reviewed by this office. The drawing correctly illustrates the anchor bond zone within the native material and beyond the fill material. However, the nomenclature "soil anchors" is still being used to identify these anchors, although it appears that the bond length also exists within the shale bedrock. In such a case, the anchor type shall reflect both the soil and rock bond zone and hence the anchors should be identified as "soil/rock" anchors. Any NSSP shall be revised accordingly.

If you have any questions regarding the above comments, please do not hesitate to contact this office.

T. Sangiuliano, P. Eng.
Foundation Engineer

for

M. Devata, P. Eng.
Chief Foundation Engineer

MD/TS/jb

memorandum

Ontario

To: K. Bassi
Head, Structural Office
7th Floor, Atrium Tower

Date: April 22, 1992

Attn: G. Al Bazi
Design Engineer

From: Foundation Design Section
Room 315, Central Building

Re: Final Design Revised Drawings Review
W.P. 199-77-02, Site 10-332
- Ramp 403/W-QEW/E over Ramp 403/E-QEW/S
W.P. 199-77-03, Site 10-333
- Ramp 403/W - QEW/E over QEW and
Ramp QEW/S - 403/E

The revised final design drawings and NSSP for the above mentioned projects have been reviewed by this office and the following responses are provided.

I - W.P. 199-77-02 - BRIDGE 37

Section 1 on drawing 3 continues to illustrate anchor bond zones located within the fill material. As discussed in previous correspondence, anchor bond zones shall NOT be located within the fill material of the existing road embankment. Bond zones of the anchors, rather, shall be within the competent clayey silt till material and/or shale bedrock. Anchor nomenclature, in turn, shall reflect the composition of the material within which the bond zones are installed (soil or rock anchors). The NSSP shall be modified if necessary to accurately identify the anchor type.

Specifications regarding the type of secondary grout shall also be included in the NSSP.

A forward excavation slope at approximately 1H:1V is shown on the elevation drawing of the shoring scheme on drawing 3. A forward slope of this steepness, as discussed in previous correspondence, will reduce the internal stability of the existing approach embankment. To ensure the internal stability of the approach embankment in the longitudinal direction, it is recommended that the forward slope be excavated at 2H:1V.

II - W.P. 199-77-03, BRIDGE 41

Structure Foundations

Subexcavation to an elevation of 101.7 m and not 107.7 m is recommended at the east abutment structure location.

Roadway Protection

The conventional cantilever timber lagging-soldier pile shoring schemes proposed at the east and west abutments are acceptable. It is reminded that lateral earth pressures at the east pier shall reflect the sloping surface behind the temporary shoring wall.

If you have any questions regarding the above review comments, please do not hesitate to contact this office.

T. Sangiuliano, P. Eng.
Foundation Engineer

for

M. Devata, P. Eng.
Chief Foundation Engineer

MD/TS/jb

cc: M. Bendayan

memorandum

Ontario

To: K. Bassi
Head, Structural Office
7th Floor, Atrium Tower

Date: March 27, 1992

Attn: G. Al Bazi
Design Engineer

From: Foundation Design Section
Room 315, Central Building

Re: Hwy. 403 Advance Structures, District 4
W.P. 199-77-02, Site 10-332
- Ramp 403/W-QEW/E over Ramp 403/E-QEW/S
W.P. 199-77-03, Site 10-333
- Ramp 403/W - QEW/E over QEW and
Ramp QEW/S - 403/E

The comments and solutions proposed by the consultant Gregg and Edens concerning the foundation and roadway protection design at the above named projects have been reviewed and the following responses are provided.

I - W.P. 199-77-02 - BRIDGE 37

1.1 Roadway Protection

The earth pressure coefficients given are valid for the fill material. The designer may want to consider applying an unfactored angle of internal friction of 35° for the cohesive clayey silt till material because the resulting earth pressure coefficients may lead to a more economical design. A saturated unit weight of 20 kN/m^3 is deemed acceptable for the clayey silt till material, but buoyant unit weights must be used in the earth pressure computation beneath the groundwater table.

All other design parameters are considered acceptable.

It is recommended that the bond zones of all anchors be located within the competent clayey silt till material and/or shale bedrock. Anchor bond zones shall **NOT** be located within the fill material of the existing road embankment as revealed in the consultant letter.

Anchor inclination has not been discussed. As indicated in my letter dated February 2, 1992, an anchor installation at 45° should be considered provided of course, that interference with the adjacent structure is avoided.

A forward excavation slope at 1H:1V is shown on the elevation drawing of the shoring scheme. A forward slope of this steepness, as discussed in previous correspondence, will reduce the internal stability of the existing approach embankment. To ensure the internal stability of the approach embankment in the

longitudinal direction, it is recommended that the forward slope be excavated at 2H:1V.

II - W.P. 199-77-03, BRIDGE 41

2.3 Roadway Protection

The comments given above for bridge 37 addressing shoring design parameters and anchor design are also applicable for the roadway protection for the piers at bridge 41.

If you have any questions regarding the above review comments or require further information, please do not hesitate to contact this office.

T. Sangiuliano, P. Eng.
Foundation Engineer

for

P. Payer, P. Eng.
Senior Foundation Engineer

cc. M. Bendayan

PP/TS/ts

Gregg & Edens Limited

CONSULTING ENGINEERS AND PLANNERS

MAR 18 1992

March 16, 1992

McCormick, Rankin & Assoc. Ltd.
Consulting Engineers
2655 North Sheridan Way
Mississauga, Ontario
L5K 2P8

Attention: Dr. Roy Skelton

Gentlemen:

Re: Highway 403 Structures, Freeman Interchange
Structure No. 41, W.P. 199-77-03
Structure No. 37, W.P. 199-77-02

Further to our recent discussion concerning the design of foundations and road protection for the above two structures we wish to report as follows:

1. Bridge No. 37

1.1 Road Protection

We suggest that the design of the east abutment be retained as is, rather than revise using more expensive caissons for support. We further suggest that the roadway protection be revised, still using a soldier pile/ground anchor arrangement as indicated on the accompanying sketch. The MTO Geotechnical section may wish to review our assumed design criteria for the anchors which is:

Active Earth Pressure Coeff. Ka = 0.33 at SLS
$(Ka)_f$ = 0.41 at ULS

Passive Earth Pressure Coeff. Kp = 3.0 at SLS
$(Kb)_f$ = 2.44 at ULS

Soil Unit Weight = 20 kN/m^3

Live Load surcharge = 600 mm of Earth

Anchor Allowable Bond Stress = 100 kPa

Anchor Grout Strength = 35 MPa

65 THE EAST MALL, TORONTO, ONTARIO CANADA M8Z 5W3 TELEPHONE (416) 259-4279 FAX (416) 259-7191

The previously 2m wide strip excavation at 1:1 1/2 slope is now eliminated. The soldier piles would be installed in pre-augered holes with the tips encased in 20 MPa concrete. The suggested redesign ensures that all anchors are embedded in original soil or in the well compacted fill of the existing road embankment. We believe the suggested design parameters to be reasonably conservative

1.2 Pier Footings

A soil bearing capacity of 1000 kPa at ULS and 500 kPa at SLS will reduce the footing sizes for the two piers. The west pier footing would reduce from 9 x 5 x 1.5 m to 7 x 4.5 x 1.5 m, saving 25.5 m^3 of concrete. In all, approximately 45.75 m^3 of concrete would be saved. Assuming a unit price of $200/per m^3, the total saving in concrete alone is estimated at $9,150.00, plus excavation savings.

We recommend that these footings be revised using the new design bearing capacities for the soil.

2. BRIDGE NO. 41

2.1 West Abutment

The elevation of sub-excavation for Granular 'A' at the west abutment has been raised to 102.000. This in effect reduces the extent of Granular 'A' material and eliminates the need for roadway protection at this location.

2.2 Pier Footings

The pier footing sizes must remain as they are despite the higher calculated soil capacity of ULS. The east and west footings are the same size because different limit state conditions govern. The west pier footing size is controlled by ULS, whereas the east pier footing size is controlled by SLS and the effect of horizontal forces on the pier. No change in footing design is recommended.

2.3 Roadway Protection

A revised roadway protection scheme at the excavation for the pier footings is suggested using soldier piles and lagging. The design would be based on parameters similar to those for Bridge #37 described above.

Any comments you have will be appreciated and we are proceeding to revise the drawings as discussed during our meeting of Thursday, February 27, 1992. It is planned that these revisions will be completed by Monday, March 23, 1992.

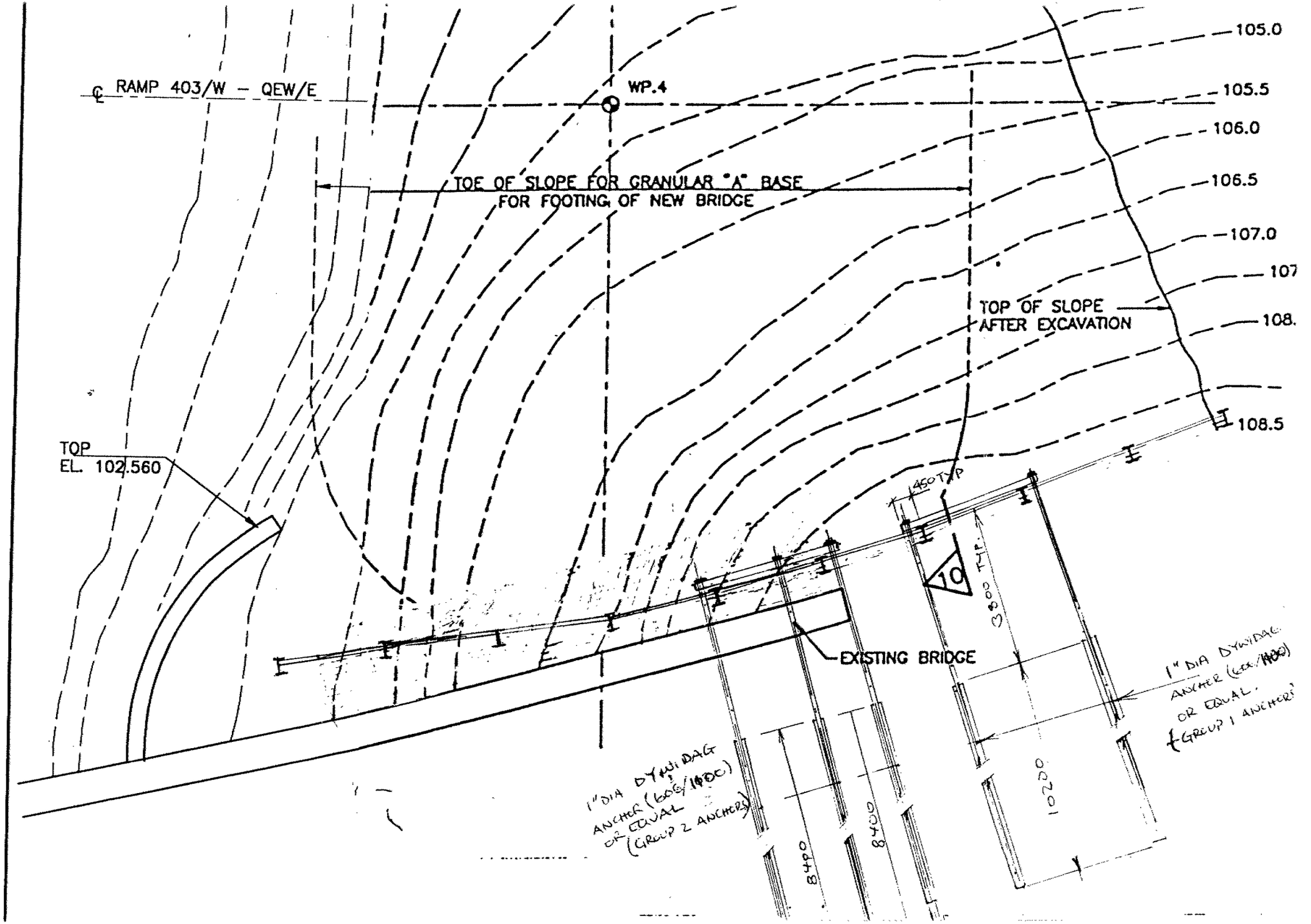
Yours truly,

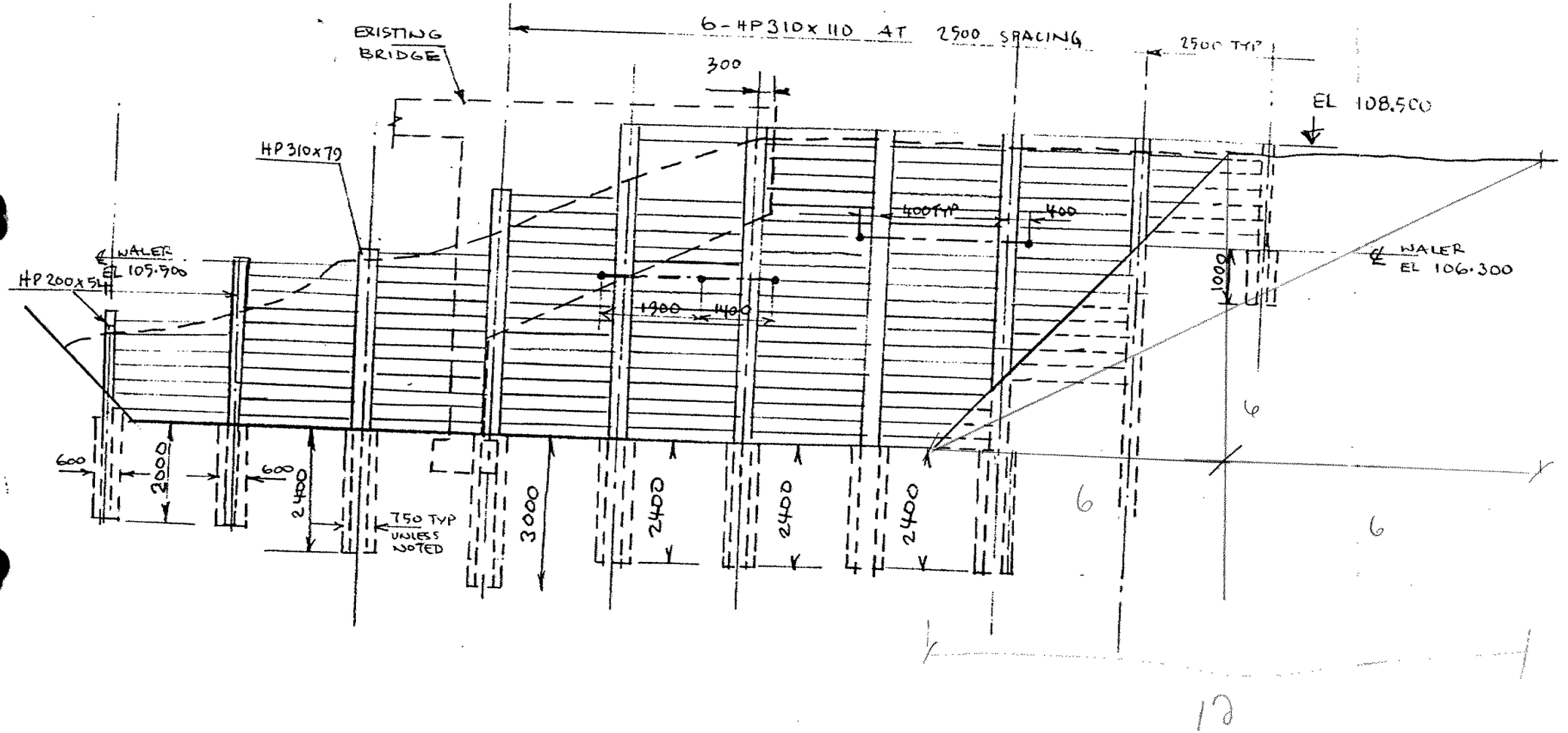
GREGG AND EDENS LIMITED

J T. Gregg, P.Eng.
President
/jm

File No. 9017 & 9025

cc: M. Bendayen, P.Eng.


℄ RAMP 403/W – QEW/E
WP.4
TOE OF SLOPE FOR GRANULAR "A" BASE
FOR FOOTING OF NEW BRIDGE
TOP OF SLOPE
AFTER EXCAVATION
TOP
EL. 102.560
105.0
105.5
106.0
106.5
107.0
107
108.
108.5
450 TYP
10
3500 TYP.
EXISTING BRIDGE
1" DIA DYWIDAG
ANCHOR (600/1000)
OR EQUAL
(GROUP 2 ANCHORS)
1" DIA DYWIDAG
ANCHOR (600/1000)
OR EQUAL.
(GROUP 1 ANCHORS)
8400
8400
10200


EXISTING BRIDGE
6-HP310x110 AT 2500 SPACING
2500 TYP
300
EL 108.500
HP310x79
400 TYP
400
WALER
EL 105.900
HP200x54
WALER
EL 106.300
1900
1400
1000
600
2000
600
2400
750 TYP
UNLESS NOTED
3000
2400
2400
2400
6
6
6
12

memorandum

Ontario

To:

K.G. Bassi
Head, Design Section
7th Floor, Atrium Tower

Date: 1992 02 20

Atten: G. Al-Bazi

From: Foundation Design Office
Room 315, Central Bldg.

Re: Bearing Capacity Values
Freeman Interchange
W.P. 199-77-02
W.P. 199-77-03
W.P. 199-77-04
W.P. 199-77-05
W.P. 199-77-07
W.P. 199-77-08
District #4 (Burlington)

As per our discussion on 92 02 11 the spread footings may be placed on the undisturbed hard lower glacial till or on the underlying bedrock, using a factored bearing capacity of 1000 kPa at ultimate limit states and 500 kPa at serviceability limit states.

P. Payer, P. Eng.
Sr. Foundation Engineer

for

M. Devata, P. Eng.
Chief Foundation Engineer

MD/PP/mmj

memorandum

Ontario

To: K. Bassi
Head, Structural Office
7th Floor, Atrium Tower

Date: February 2, 1992

Attn: G. Al Bazi
Design Engineer

From: Foundation Design Section
Room 315, Central Building

Re: Final Design Drawing Review
Hwy. 403 Advance Structures, District 4
W.P. 199-77-02, Site 10-332
- Ramp 403/W-QEW/E over Ramp 403/E-QEW/S
W.P. 199-77-03, Site 10-333
- Ramp 403/W - QEW/E over QEW and
Ramp QEW/S - 403/E

As requested, the Final Design Drawings and documents for the above mentioned projects have been reviewed and relevant foundation and geotechnical comments are provided. In addition, revised bearing capacities to facilitate the design of shallow foundations on the bedrock are also included.

I - FOUNDATION DESIGN

Spread footings on shale bedrock or competent cohesive glacial till at either site can be designed using a revised factored capacity at U.L.S. of 1000 kPa and the original capacity at S.L.S Type II of 500 kPa.

II - W.P. 199-77-02

STRUCTURE FOUNDATIONS

Shallow Foundation Alternative

A detailed drawing of the compacted Granular "A" pad applicable at the abutment structure foundations, shall be included in the Final Design Drawings. A note presently shown on Drawing 1 indicates that this drawing is to be shown on Drawing 20. Drawing 20, however, does not include the detailed drawing of the Granular "A" pad foundation.

Deep Foundation Alternative

Major consideration should be given to supporting the east abutment on deep foundation concrete caissons socketed into the bedrock as described on page 13 of the original foundation report. This option may eliminate the requirement for roadway protection and hence a cost effectiveness comparison is warranted.

Design parameters for the axial capacity of the caisson are given in the original foundation report. The lateral capacity of the caisson shall be computed in accordance with Section 6.8.3.8 of the OHBDC.

Pertinent unfactored soil/rock parameters to facilitate the design of the lateral pile capacity of vertical piles are given in Table 1 below.

Table 1 - Design Parameters

A. Soil

Type	Elevation (m)	Unconfined Compressive Strength (kPa)	Unit Weight ( ) (kN/m^3)
Clayey Silt (Till)	102.3 - 100.3	500	20
Clayey Silt (Till)	100.3 - 99	1000	20

B. Rock

Type	Elevation (m)	Unconfined Compressive Strength (kPa)	Unit Weight ( ) (kN/m^3)
Weathered Shale	99-96	1000	20
Unweathered Shale	<96	10,000	22

Alternatively, lateral capacities can be obtained by battered units. However, construction limitations restrict these batters to 1:4.

Caissons shall be socketed at least 1 metre into the bedrock.

Driven steel H-piles are not considered technically feasible at the site because of restricted embedment lengths.

ROADWAY PROTECTION

A number of concerns regarding the temporary shoring design have been identified and are summarized below.

(a) Design Parameters

In view of the fact that to the reviewer's awareness, shoring design parameters were never recommended from our office, there exists an uncertainty regarding pertinent shoring design parameter selection. Bond stresses, earth pressure coefficients and soil unit weights selected should be forwarded for review.

(b) Anchor Bond Zone and Inclination

Section 10 on Drawing 3 presently illustrates a nine (9) metre bond length, most of which is located within the existing structure's approach embankment fill material, a material which is of insufficient strength to provide any reasonable bond stress. The bond zone should be located in the competent clayey silt till deposit and the bedrock. A bond stress of 100 kPa can be used to facilitate the design of the anchor bond length.

An anchor inclination of 30^0 is presently also indicated on Section 10. The efficiency of anchor installation at a 45^0 inclination should be evaluated. Avoidance of a potential conflict between the anchors and the existing bridge substructure or superstructure should be confirmed.

(c) Existing Embankment Slope Excavation

The proposed scheme illustrates that the forward slope geometry is to be steepened to approximately 1H:1V and that a 2 m wide minimum strip excavation at 1-1/2H:1V is to precede the soldier pile installation. These two proposals will definitely reduce the internal stability of the existing approach embankment and this concern should be addressed.

(d) Specifications

The following specifications shall be included in the Contract Drawings and/or Special Provisions.

Soldier Piles

Soldier piles are to be installed in preaugered holes of a given diameter and soldier pile toes shall consist of concrete, typically of 20 MPa compressive strength. Furthermore, the annular space between the soldier pile HP 310 X ? (a unit weight should be specified) should be filled with a lean mix concrete (say 0.7 mPa) to facilitate timber lagging installation.

Anchors

Anchor bond zones shall consist of 35 MPa grout and free stressing zones shall consist of bentonite concrete mix or equivalent.

Shoring Installation Procedure

A general step by step procedure for soldier pile installation, timber lagging installation, anchor installation and excavation can be considered to be included on the drawings.

Anchor Testing

Any full scale testing or proof load testing procedures should be included in the Special Provisions of the contract documents.

III - W.P. 199-77-03

STRUCTURE FOUNDATIONS

Subexcavation to an elevation of 100.0 m is presently illustrated prior to the placement of the Granular "A" pads at both proposed abutment locations. Based on the competence and quality of the subsoil as determined during the foundation field investigation at these locations and as previously indicated in the foundation investigation report, subexcavation need only extend to 102 metres at the west abutment and 101.7 metres at the east abutment. The progress of MTO Contract 91-22 should be immediately investigated to determine if the east abutment granular pad has been constructed so that unnecessary subexcavation is avoided.

ROADWAY PROTECTION

(a) Design Parameters

As previously mentioned for project W.P. 199-77-03, shoring design parameters should have been issued from this office and since there has not been any record of such recommendation, there is uncertainty regarding the validity of shoring parameters applied in the design.

(b Sheet Piling Impenetrability

The roadway protection schemes identified at the west abutment, west pier and east pier locations illustrate an "Arbed" BZ32 sheet piling or equivalent installed to elevations of 96.3 m, 97.2 m and 97.2 m respectively. These elevations reflect penetrations of the piling up to 2.2 metres into bedrock, which in our opinion is totally unrealistic. Furthermore, the overlying clayey silt till deposit is of such a hard consistency, it is improbable and unlikely that any sheet piling will be able to penetrate this material. In view of this, it is recommended that the steel sheet piling system be replaced by a conventional soldier pile timber lagging system.

CONSTRUCTION SEQUENCING

Provided that the Granular "A" pad has not yet been constructed at the east abutment location, shoring requirements can be eliminated at the east pier by constructing this pier prior to the east abutment and hence prior to relocating the existing QEW/S - Hwy. 403/E ramp. Hence, this construction sequencing should

be considered.

BOX CULVERT DESIGN AND CONSTRUCTION AT WEST ABUTMENT LOCATION

The mutual influences of the concrete box culvert and west abutment foundation on the design and construction of either structure shall be considered. It is recommended that the box culvert be constructed prior to the Granular "A" pad and any additional loads on the culvert imposed by the abutment foundation be appropriately incorporated in the design of the culvert.

If you have any questions regarding the above review comments, please do not hesitate to contact this office.

T. Sangiuliano, P. Eng.
Foundation Engineer

for

M. Devata, P. Eng.
Chief Foundation Engineer

cc. V. Boehnke

MD/TS/jb

Ministry of Transportation Ontario
Ministère des Transports

Engineering Materials Office
Foundation Design Section
Room 315, Central Bldg.
1201 Wilson Avenue
Downsview, Ontario
M3M 1J8

Tel: (416) 235-3731

1991 07 31

McCormick Rankin
Consulting Engineers
2655 North Sheridan Way
Mississauga, Ontario
L5K 2P8

Attn: Mr. K. Woon-Fat, P. Eng.

Re: Review of Preliminary Drawing
Hwy. 403 Advance Structures
Bridge 37, W.P. 199-77-02, Site 10-332
Your File: W.O. 2204-90
District 4, Burlington

Further to your letter dated July 16, 1991, the General Arrangement Drawing P1 for the aforementioned structure has been reviewed by this office.

Based on our review, it is concluded that the design confirms to our recommendations. However, the following corrections and comments should be made on the details shown on the above mentioned drawing.

1) Unsuitable materials underneath the proposed embankment fill should be excavated before fill placement.

2) Slope surface should be protected from erosion of fill material as per M.T.O. standard.

3) Due to the existence of permeable layer within the fill adequate control of groundwater during construction is essential to minimize the deterioration of the founding soil.

We have no further comments. If you have any questions, please contact this office.

Taechul Kim
Tae C. Kim, P. Eng.
Sr. Foundation Engineer

TCK/me
cc: M. Bendayan

memorandum

Ontario

To: V.F. Boehnke (3)
Head, Structural Section
4th Floor, Atrium Tower

Date: 1991 05 02

From: Foundation Design Section
Room 315, Central Building

Re: Foundation Investigation Report for
Proposed Bridge 37
Freeman Interchange
Hwy. 403 & Q.E.W.
W.P. 199-77-02, Site 10-332
District 4 (Burlington)

The Foundation Design Section retained Golder Associates Limited, to carry out a foundation investigation for the above-noted project. The Foundation Investigation Report is forwarded under cover of this memo.

After preparing the consultant agreement, this office provided terms of reference and careful review of the consultant's proposals and progress at all stages of the project. Several meetings were held with the Consultant during which our comments were incorporated into his report. The Foundation Investigation (factual) portion of the report, drawings, record of borehole sheets and figures were reviewed only for format, and its accuracy and completeness are the responsibility of the Consultant. The Foundation Design (recommendation) portion of the report has been carefully reviewed by this office based on the subsurface information provided by the consultant.

We find the recommendations to be satisfactory.

If there are any questions during the detailed design phase, please contact our office.

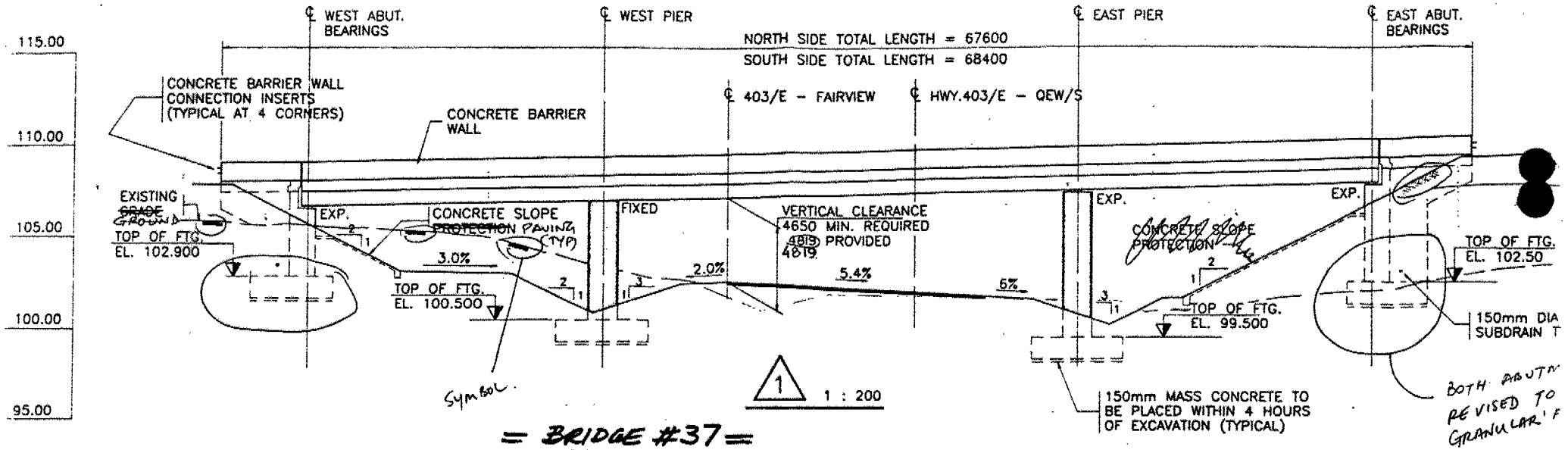
P. Payer, P. Eng.
Sr. Foundation Engineer

for

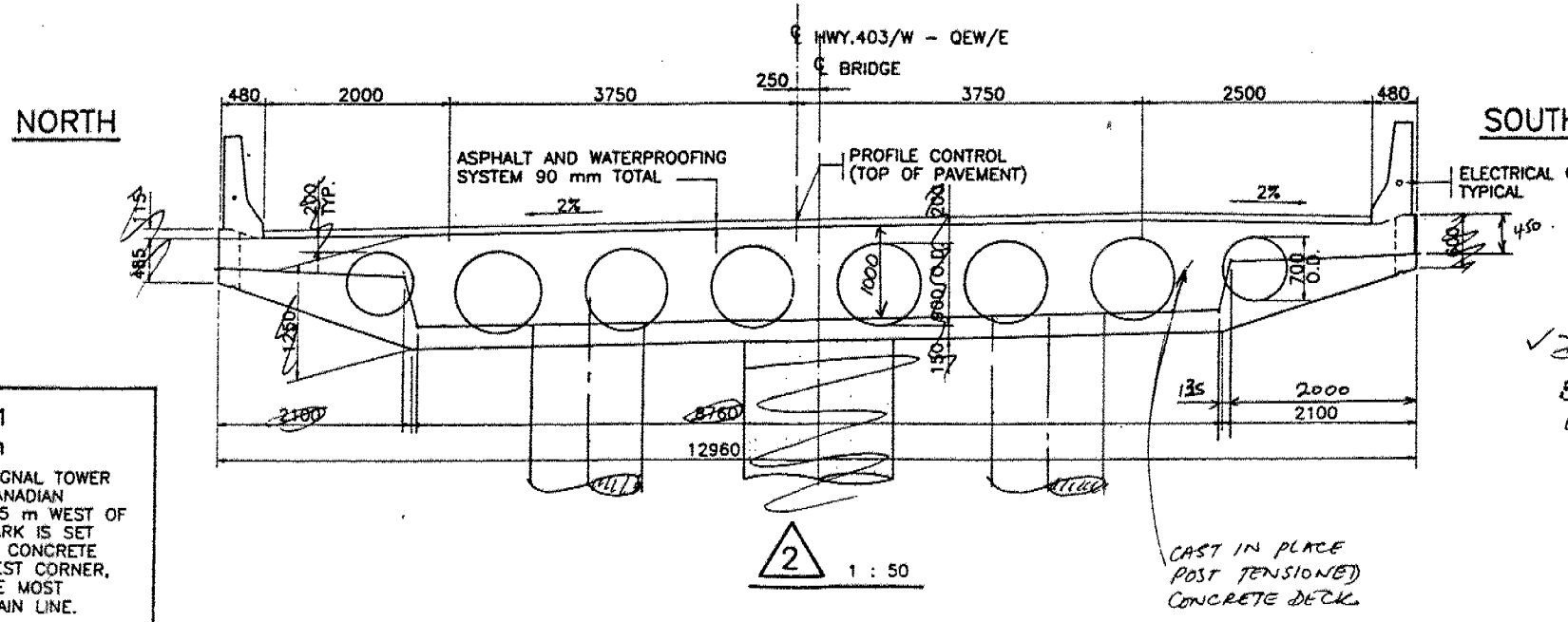
M. Devata, P. Eng.
Chief Foundation Engineer

MD/PP/jb

cc: G. Cautillo
J. Cullen (2)
A. Wittenberg
K.G. Bassi
S.J. Dunham
E.A. Joseph
File



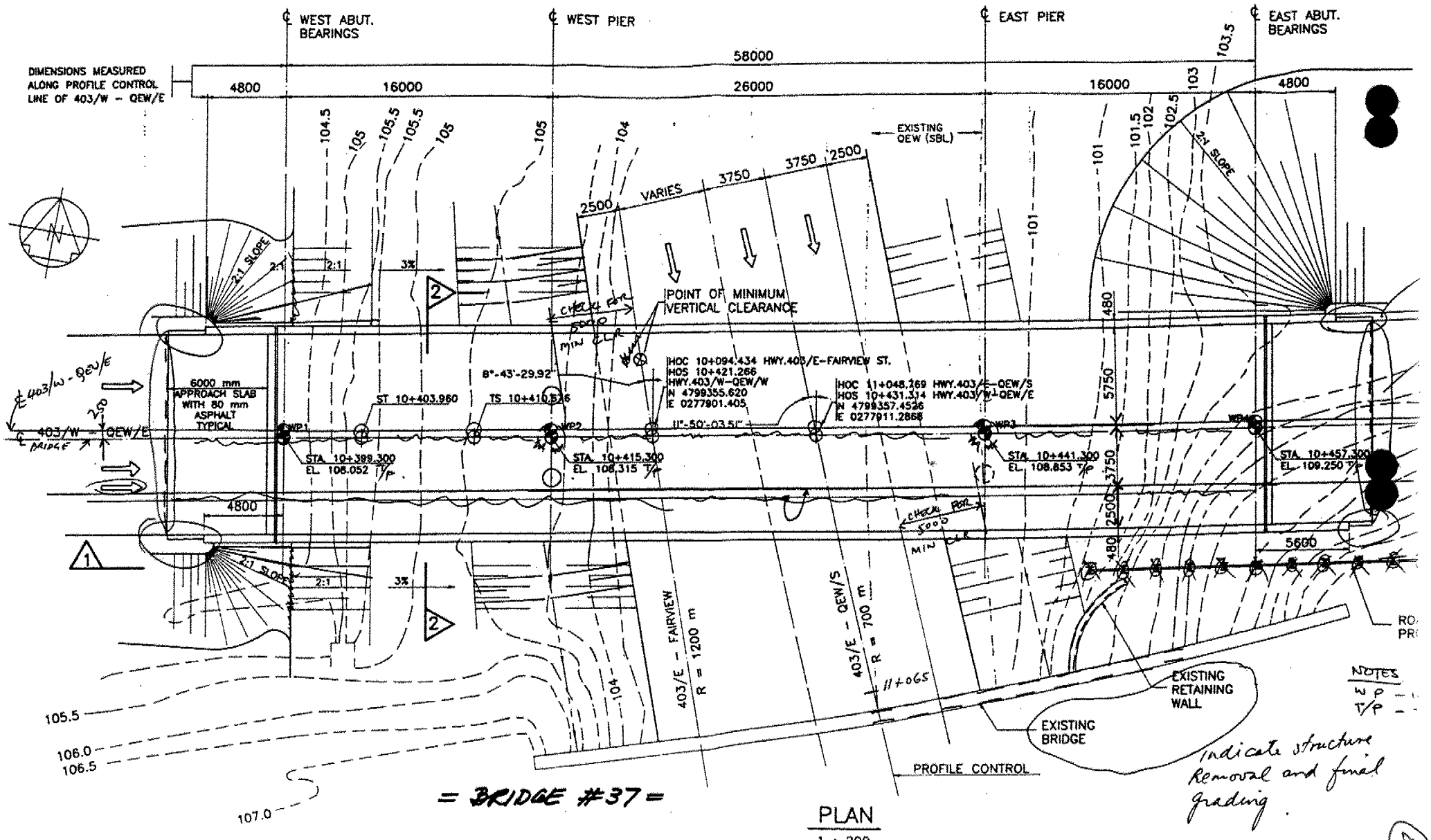
= BRIDGE #37 =



when started
✓ DESIGN TO BE BASED ON ONE LAYER OF CA

TO BM 838011
102.394 m
ONCRETE BASE OF SIGNAL TOWER
N SOUTH SIDE OF CANADIAN
ATIONAL RAILWAY, 93.5 m WEST OF
NG ROAD. BENCH MARK IS SET
RTICALLY IN TOP OF CONCRETE
SE AT THE NORTHWEST CORNER,
40 m SOUTH OF THE MOST
OUTHERLY RAIL OF MAIN LINE.

(3)

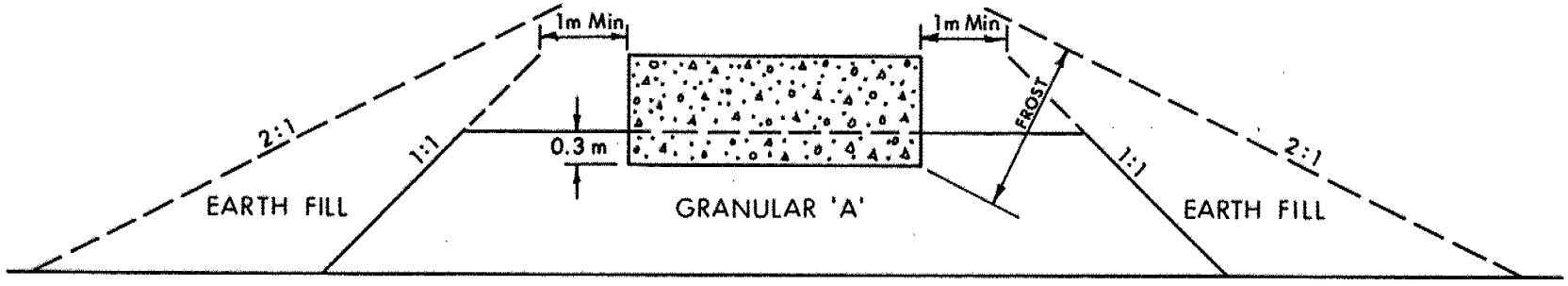


= BRIDGE #37 =

PLAN

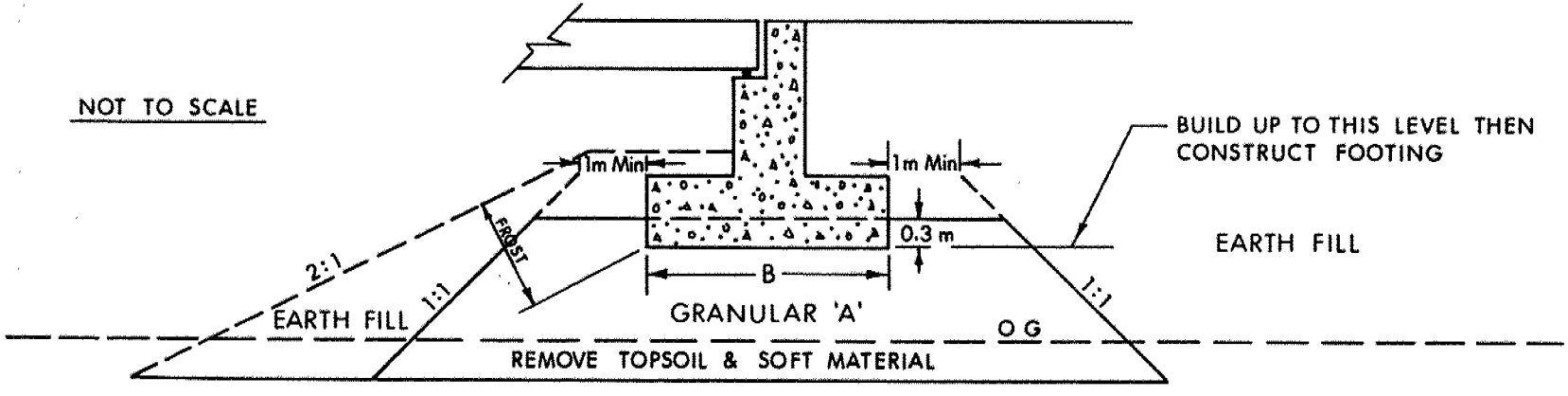
1 : 200

Indicate structure Removal and final grading.



X SECTION

NOT TO SCALE



LONGITUDINAL SECTION

NOTES:

1 - REMOVE TOPSOIL &/OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' & EARTH FILL.

2 - PLACE GRANULAR 'A' & EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO CURRENT M T O STANDARDS.

3 - CONSTRUCT CONCRETE FOOTING.

4 - PLACE REMAINDER OF GRANULAR 'A' & EARTH FILL AS REQUIRED.

Ministry of Transportation Ontario	ABUTMENT ON COMPACTED FILL SHOWING GRANULAR 'A' CORE	FIG No
		W P

Golder Associates Ltd.
CONSULTING ENGINEERS

January 31, 1991 Our ref: 901-6039-5

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

Attention: Mr. P. Payer, P. Eng.
Senior Foundation Engineer

RE: **W.P. 199-77-02, SITE 10-332**
BRIDGE 37, FREEMAN INTERCHANGE
DISTRICT 4, BURLINGTON

Dear Sir:

Further to your facsimile transmittal of January 30, 1991, this letter provides our comments on the perched abutment alternative suggested for the above site by Mr. M.D. Bendayan in his memorandum of January 25, 1991.

Based on a review of the results of the geotechnical investigation carried out at the above site, we concur that the perched abutment alternative as shown schematically in the MTO scematic provided to us, would be feasible.

However in preparation for constructing the engineered fill which would support the abutments it would be necessary to excavate all existing fill, topsoil and any loose material. Based on the results of boreholes 19 and 22 drilled at the west and east abutments respectively, some 1.1 to 1.9 metres of excavation may be required to expose a suitable subgrade to support the engineered fill.

We would suggest that for engineered fills constructed as outlined on the MTO schematic, design bearing pressures of 250 KPa SLS and 400 KPa ULS be considered.

Abutment footings placed on engineered fill resting on the native subsoil at the site will experience settlement with

...2

January 31, 1991 901-6039

time. The magnitude of the settlement will depend on the thickness of the embankment and engineered fills, the thickness of subsoil and the degree of compaction of the engineered fill. For preliminary design purposes total settlement of the order of several centimetres can be anticipated. This should be taken into consideration in the context of differential movements with respect to the adjoining pier foundations and the flexibility of the bridge span to accommodate these movements.

We trust that this letter is adequate for your present requirements. We will incorporate a discussion pertaining to the use of perched abutments for Bridge 37 in the final report. In the interim should your require additional information, please contact our office.

Yours truly,

GOLDER ASSOCIATES LTD.

J.G. Muckle, P. Eng.

JGM/apf

Golder Associates Ltd.
CONSULTING ENGINEERS

Our ref: 901-6039-5

October 29, 1990

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

Attention: Mr. P. Payer, P. Eng.

RE: GEOTECHNICAL INVESTIGATION
SITE 10-332 BRIDGE 37
FREEMAN INTERCHANGE
WP 199-77-02
BURLINGTON, ONTARIO

Dear Sir:

Further to our meeting of October 24, 1990, this letter provides preliminary geotechnical design information for the above site. We anticipate that the geotechnical report will be issued in draft format within a few weeks. The intent of this letter is to provide the design engineer with a brief summary of the subsurface conditions encountered together with preliminary geotechnical design recommendations in order that the design of the structure can proceed in the interim.

1. SITE DESCRIPTION

As presently proposed, Bridge 37 will carry the 403 West/QEW East Ramp traffic over the 403 East/QEW South traffic. The proposed alignment of the bridge is generally in an east west direction traversing an existing drainage course and the existing QEW south bound ramp. The bridge will consist of a three span structure with two abutments and two piers. The existing drainage course is situated between the proposed west abutment and west pier. The proposed east pier would be situated immediately adjacent to existing ramp. The existing ramp is understood to have been constructed in cut and is some 2 to 3 metres below the elevation of the existing ground surface at the proposed abutments and west pier.

2. PROCEDURE

Four boreholes and one test pit were put down at the site of Bridge 37. Bedrock was cored to a nominal depth of 3 metres in two of the boreholes while the remaining two boreholes were drilled to practical auger refusal. The test pit was terminated in glacial till.

3. SUBSURFACE CONDITIONS

The subsurface conditions encountered at the site generally consisted of fill and topsoil, and surficial sand strata overlying glacial till and completely to highly weathered shale underlain by more competent shale bedrock.

The glacial till encountered in the boreholes drilled at the west abutment, west pier and east abutment is characterized by an upper zone of hard brown to grey clayey silt and a lower zone of red brown clayey to sandy silt which was somewhat harder than the overlying till. The upper till was not encountered in the borehole drilled near the proposed east pier location.

The bedrock was characterized by a surficial highly weathered zone with more competent shale bedrock at depth in the two boreholes in which bedrock was cored.

Groundwater was generally encountered within the surficial sand strata overlying the less permeable clayey silt till. The groundwater level measured in a piezometer sealed into one of the boreholes was at about elevation 101.7 metres, within the upper till stratum.

4. DISCUSSION

It is understood that the proposed finished deck grade will vary from about elevation 107.9 metres at the west abutment to about elevation 109.5 metres at the east abutment. The finished pavement elevation beneath the bridge will vary from about 100.2 and 101.0 metres.

4.1 Foundations

Based on the above, it is anticipated that the foundations for the proposed piers would be founded at or below about elevation 99 and 100 metres to provide the minimum frost protection required, while the abutments could be founded somewhat higher in elevation.

Based on the results of the boreholes and test pit, it is considered that the abutments and piers could be founded on conventional spread footings bearing in the glacial till

between about elevations 100 and 102 metres. Alternatively the footings could be constructed on bedrock at the pier locations which exists at about elevation 97 metres. Recommended founding elevations and corresponding bearing pressures recommended for the design of the respective abutments and piers are provided in the attached Table I. Three bearing strata have been considered including, the upper till zone, the lower till zone and the moderately weathered bedrock. Due to the variable nature of the upper weathered zone of the bedrock and the difficulty of definitively distinguishing the lower till from the upper bedrock, the design parameters of the lower till are also recommended for the upper weathered bedrock at this site.

The shale bedrock is very susceptible to rapid deterioration on exposure to air and water necessitating that special precautions be taken during construction of the foundations. Effective control of groundwater seepage is essential to preserving the integrity of the bearing strata. In addition the use of concrete mud slabs to protect exposed bedrock is recommended.

It is considered that the use of deep foundations consisting of caissons socketed into the bedrock, may be considered as an alternative to spread footings. This alternative may be particularly advantageous for this bridge structure given the close proximity to the existing ramp which we understand will remain in service during construction. For preliminary consideration, caissons socketed at least 1 diameter into the moderately weathered shale may be designed using an end bearing pressure of 2800 kilopascals. The caissons should have a minimum diameter of 900 millimetres for inspection purposes.

4.2 Embankments

Approach fills of about 3 to 5 metres will be required at the abutment locations. The subgrade at the abutment locations consists of about 0.2 metres of topsoil overlying about a metre of silty clay fill. The in-situ water content of the existing fill is relatively high (30 percent) It is considered that some remedial work may therefore be required prior to placing the embankment fill. The remedial work will probably consist of stripping the topsoil, proofrolling the existing fill subgrade and potentially some subexcavation. The actual scope of the remedial work can best be determined during construction.

Provided that suitable subgrade preparation is carried out no deep seated stability problems are anticipated with the embankment heights proposed. Side slope inclinations of 2 horizontal to 1 vertical or flatter would be appropriate for

the embankments provided that the fill is homogenous in nature and constructed as an engineered fill.

We trust that this letter is sufficient for your present requirements. If additional information would be beneficial at this time or if any point requires clarification, please contact our office.

Yours truly,

GOLDER ASSOCIATES LTD.

J.G. Muckle, P. Eng.

JGM/apf

TABLE I

SUMMARY OF RECOMMENDED FOUNDATION DESIGN PARAMETERS

Bridge 37 Freeman Interchange
WP 199-77-01
Burlington, Ontario

	CASE I (Foundations on Upper Till)			CASE II (Foundations on Lower Till/Weathered Rock)			CASE III (Foundations on Bedrock)	
Foundation Unit	Elevation	Design Bearing Pressures (Kpa)		Elevation	Design Bearing Pressures (Kpa)		Elevation	Design Bearing Pressures (Kpa)
	(m)	ULS	SLS	(m)	ULS	SLS	(m)	ULS
East Abutment	101.9 or lower	450	300	100.0 or lower	750	500	97 or Lower	1400
Pier 1	-----	-----	-----	100.0 or lower	750	500	97 or lower	1400
Pier 2	102 or lower	450	300	100.0 or lower	750	500	98 or lower	1400
West Abutment	102.3 or lower	450	300	100.0 or lower	750	500	97 or lower	1400

Note: Table to be read in conjunction with accompanying letter dated October 29, 1990.

FOUNDATION REPORT
MISSING

FEB 4/97