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DIST. 4 REGION

W.P. No. 199-77-19

CONT. No. 93-43

W. O. No.

STR. SITE No. 10-227

HWY. No. 403

LOCATION Hwy 403 & Guelph line Underpass

No of PAGES -

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FOUNDATION INVESTIGATION REPORT

CONTRACT NO. 93-43



Ministry of
Transportation

INDEX

<u>Page No:</u>	<u>DESCRIPTION</u>
1	Index
2	Abbreviations & Symbols
3-41	Foundation Investigation Report for Guelph Line Underpass W.P. 199-77-19, Site 10-227 Hwy 403, District 4 Burlington Hwy 5 Underpass W.P. 199-77-21, Site 10-477 Hwy 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 project.

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

FOUNDATION INVESTIGATION REPORT
For
Bridge Structure
Hwy. 403 - Guelph Line Underpass
W.P. 199-77-19, Site No. 10-227
District 4, Burlington

INTRODUCTION

This report summarizes the information obtained from a foundation investigation carried out at the above mentioned site where four span twin structures are proposed to carry the existing Guelph Line over the proposed Hwy. 403.

The fieldwork was carried out between 90 04 20 and 90 04 24. Seven boreholes (BH 1 to BH 7) were advanced and sampled as part of this project by means of hollow stem augers with a conventional diamond drill (NW casing and NQ core barrel) adopted for rock sampling purposes. These boreholes extended down to depths of 11.9 and 15.4 m below the existing ground surface.

This report contains factual information obtained from this investigation.

SITE DESCRIPTION AND GEOLOGY

The site is located on the proposed alignment of Hwy. 403 where it crosses the existing Guelph Line in the City of Burlington, Regional Municipality of Halton. The proposed structure is located approximately 800 m south of the existing Hwy. 5. The topography in the area is generally flat to gently undulating with ground surface sloping to the southeast. Land use in the vicinity of the site is primarily residential and commercial subdivision development.

Physiographically, the site is located in the "Peel Plain" region (Ref. Chapman and Putnam, 1984) which is characterized by a glacial till containing large amount of Paleozoic shale. Underlying the glacial deposit are the red Queenston shale from which the till's reddish colour is derived.

SUBSURFACE CONDITIONS

The subsoil conditions are generally uniform across the site. The overburden consists of a deposit of cohesive glacial till composed of a heterogeneous mixture of clayey silt, sand and gravel underlain by shale and siltstone bedrock. The maximum thickness of this deposit was found to be about 12.2 m at BH 6. A thin layer of non-cohesive glacial till composed of a heterogeneous mixture of sandy silt, gravel and clay was encountered in two boreholes (BH's 2, and 7) within the cohesive till deposit. The maximum thickness of this deposit was found to be about 2.4 m at BH 7.

The upper portion of the shale was found to be weathered down to approximate El. 151.0 m with a maximum thickness of about 2.2 m at BH 1.

Thin layers of road fill materials and clayey silt topsoils were encountered at all seven borehole locations.

The boundaries between the various soil types, in situ and laboratory test results are shown on the attached Record of Borehole sheets in the Appendix. The locations and elevations of the boreholes, along with a profile and sections showing soil stratigraphy based on borehole data, are shown on Dwg. No. 1997719-A.*

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

Fill Material

All seven boreholes encountered some 1.9 m of fill material whose composition ranged from a brown reworked clayey silt to sand and gravel or Granular 'A' material.

A Grain Size Distribution analysis was carried out on sand and gravel as shown on Figure 1. Through visual observation and a Grain Size Distribution Analysis, it is apparent that the fill material can be classified as a clayey silt to sand and gravel or Granular 'A' material.

* DWG NO 2 OF THE CONTRACT DWG'S

Topsoil

Topsoil was encountered at six borehole locations. The thickness of this layer is about 0.7 m at BH's 2 and 3. Grain Size Distribution analysis was carried out on this material. Through the visual observation, the material can be classified as a clayey silt.

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

This stratum encountered underneath the fill material or topsoil. This deposit consists of a heterogeneous mixture of clayey silt of low plasticity with varying amounts of sand and gravel. The thickness of this layer was found to be the maximum 12.2 m at BH 6.

Atterberg Limit tests were performed on these samples and the results are plotted on Figure 2 and summarized as follows:

<u>Property</u>	<u>Range (%)</u>	<u>Average (%)</u>
Natural Moisture Content (w)	6.5-14.0	8.9
Liquid Limit (w_L)	17.5-28.5	21.2
Plastic Limit (w_p)	10.0-14.0	12.5
Plasticity Index (I_p)	5.5-15.0	8.7

From the plasticity chart, it is evident that the layer can be classified as a heterogeneous mixture of clayey silt, sand and gravel with low plasticity (CL or CL-ML).

Grain Size Distribution tests were carried out on this cohesive glacial till material. Figure 3 in the Appendix shows the results. An increasing frequency of fragments of weathered shale was encountered within the lower portion of this till.

In this stratum, the 'N' value ranges from 28 to over 100 blows/0.3 m indicating the consistency of this deposit described as very stiff to hard.

Heterogeneous Mixture of Sandy Silt, Gravel and Clay (Glacial Till)

A thin layer of non-cohesive glacial till composed of a heterogeneous mixture of sandy silt, gravel and clay was encountered within the cohesive till deposit at two borehole locations (BH's 2, and 7). The thickness of this layer ranges from 1.5 m at BH 2 to 2.4 m at BH 7.

Atterberg Limit tests were performed on this material and the results are plotted on Figure 4 and summarized as follows:

<u>Property</u>	<u>Range (%)</u>	<u>Average (%)</u>
Natural Moisture Content (w)	7.0-10.0	8.7
Liquid Limit (w_L)	14.5-16.0	15.3
Plastic Limit (w_p)	11.5-12.5	12.0
Plasticity Index (I_p)	3.0-3.5	3.3

From the plasticity chart, it is evident that the layer can be classified as a heterogeneous mixture of sandy silt, gravel and clay (ML).

Grain Size Distribution tests were carried out on this material. Figure 5 in the Appendix shows the results. This layer is basically non-plastic. In this stratum, the 'N' values ranges from 64 to over 100 blows/0.3 m indicating a state of compaction described as very dense.

Bedrock

In each of the borings, split spoon samples of the weathered portion of the bedrock were recovered before augering was terminated. Sound bedrock was proven in three boreholes by obtaining up to 1.5 m of NQ rock cores. The top of the bedrock ranged from El. 151.2 to 153.4 m which are corresponded to 13.7 m and 10.1 m below the existing ground surface. The upper 0.7 m to 2.2 m is in a highly weathered state, with layers of broken shale and red clayey silt.

The bedrock is a red shale with green siltstone (approximately 80% shale, 20% siltstone) of the Queenston formation. Detailed description of the rock are attached in the Appendix entitled "Rock Core Description".

The Core Recovery (CR) and Rock Quality Designation (RQD) values were determined in situ and also in the laboratory to evaluate the competence and integrity of the rock. Core Recoveries (RC) range between 73 and 100 percent and Rock Quality Designation (RQD) values range from 23 to 62 percent. Based on these results, the rock can be classified as weak to very weak and slightly to highly weathered.

GROUNDWATER CONDITIONS

Groundwater conditions were observed through the measurements of water levels in the open boreholes. All boreholes were dry or the water levels were close to the boundary between the till and weathered bedrock surface at the time of site investigation. However, groundwater level in BH 1 and BH 4 after a couple of hours later was found to be higher than that of others with approximate El. 158.1 m at BH 1 and 160.9 m at BH 4 which correspond to depths of 5.1 m and 3.3 m below the existing ground surface. These high groundwater levels are probably attributed to some water bearing sand layers within cohesive glacial till. One piezometer was installed at BH 2. Upon completion of rock coring, the induced drill water remained perched within the borehole, indicating a low permeability both for the till and shale strata.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of Tae C. Kim, Sr. Foundation Engineer, and Frank Reynolds, Technician for Northwestern Region. The equipment was owned and operated by Marathon Drilling Co. Ltd. and Master Soil Investigation Co. Ltd., Toronto.

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

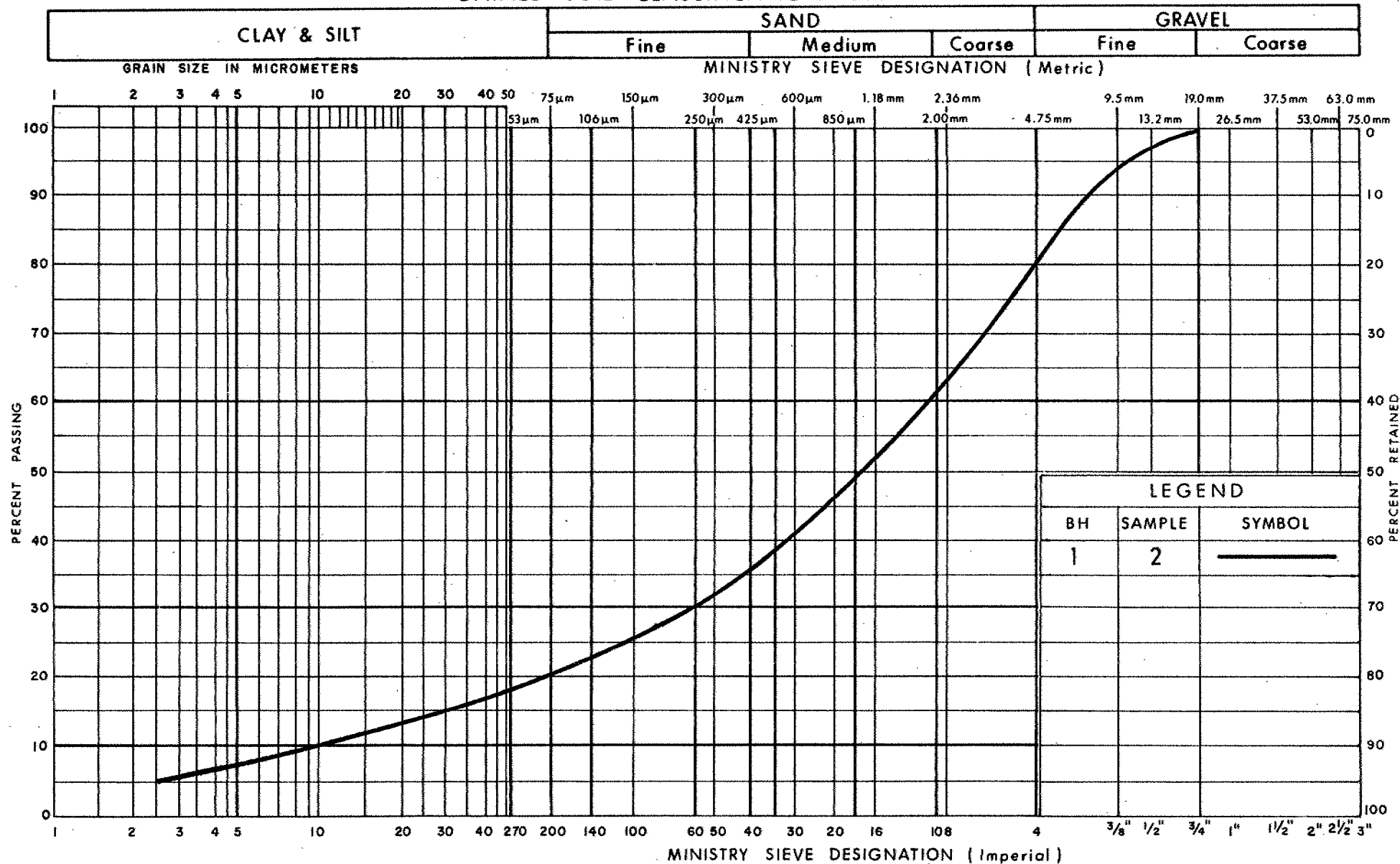


Tae C. Kim
Tae C. Kim, P.Eng.
Sr. Foundation Engineer

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

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM

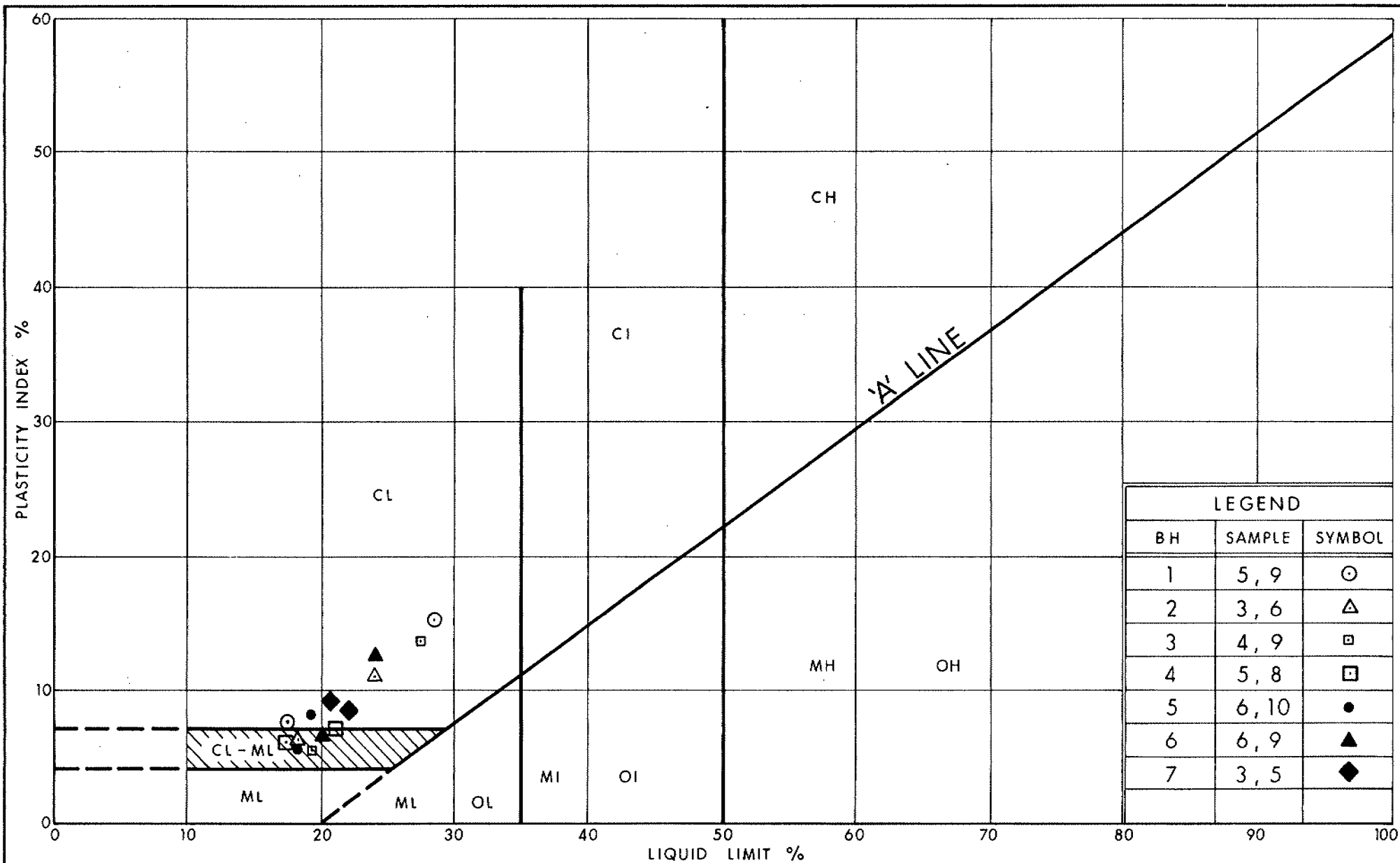


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GRAIN SIZE DISTRIBUTION SAND AND GRAVEL (FILL)

FIG No 1

W P 199-77-19

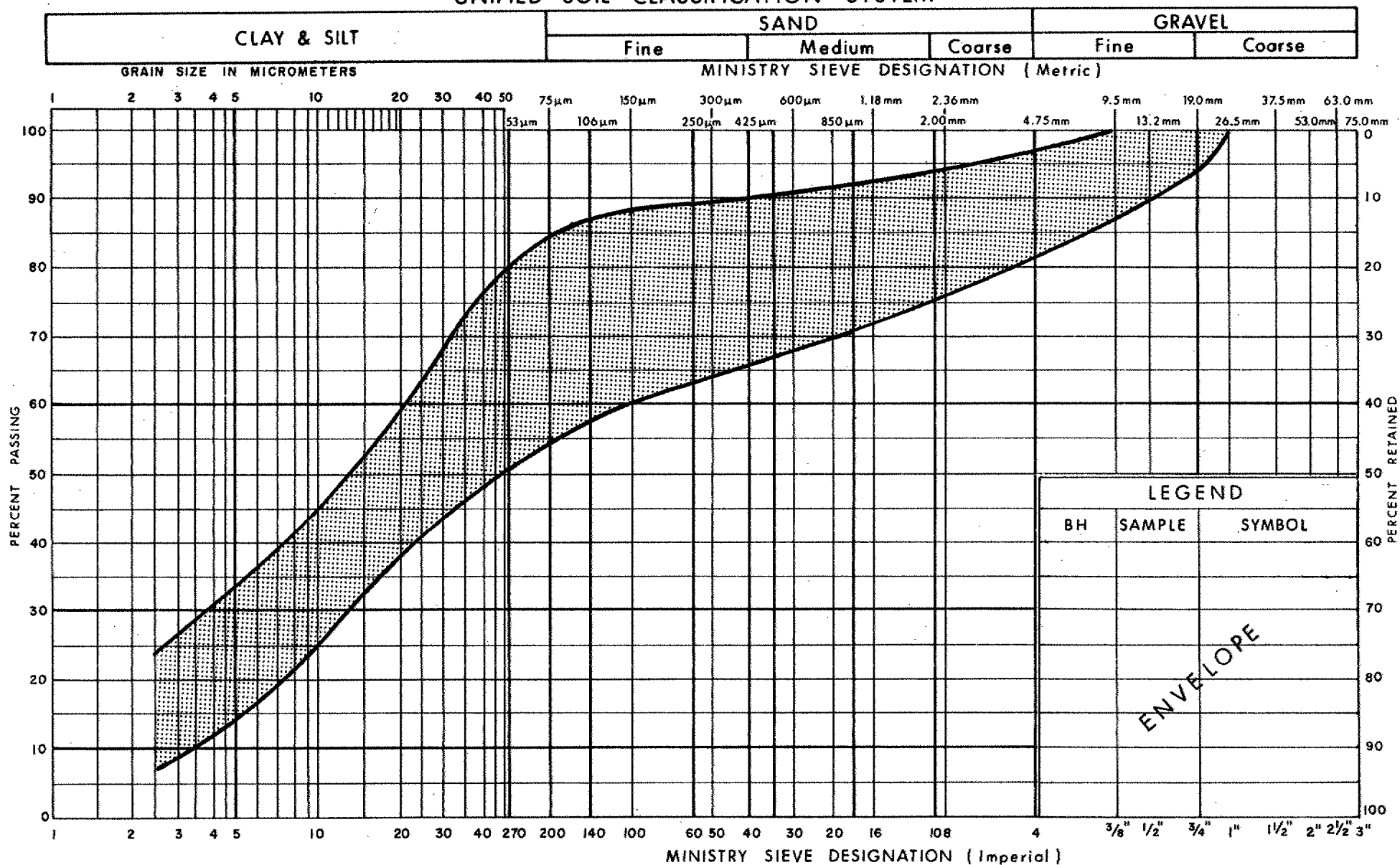


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PLASTICITY CHART HETEROGENEOUS MIXTURE OF CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 2

W P 199-77-19

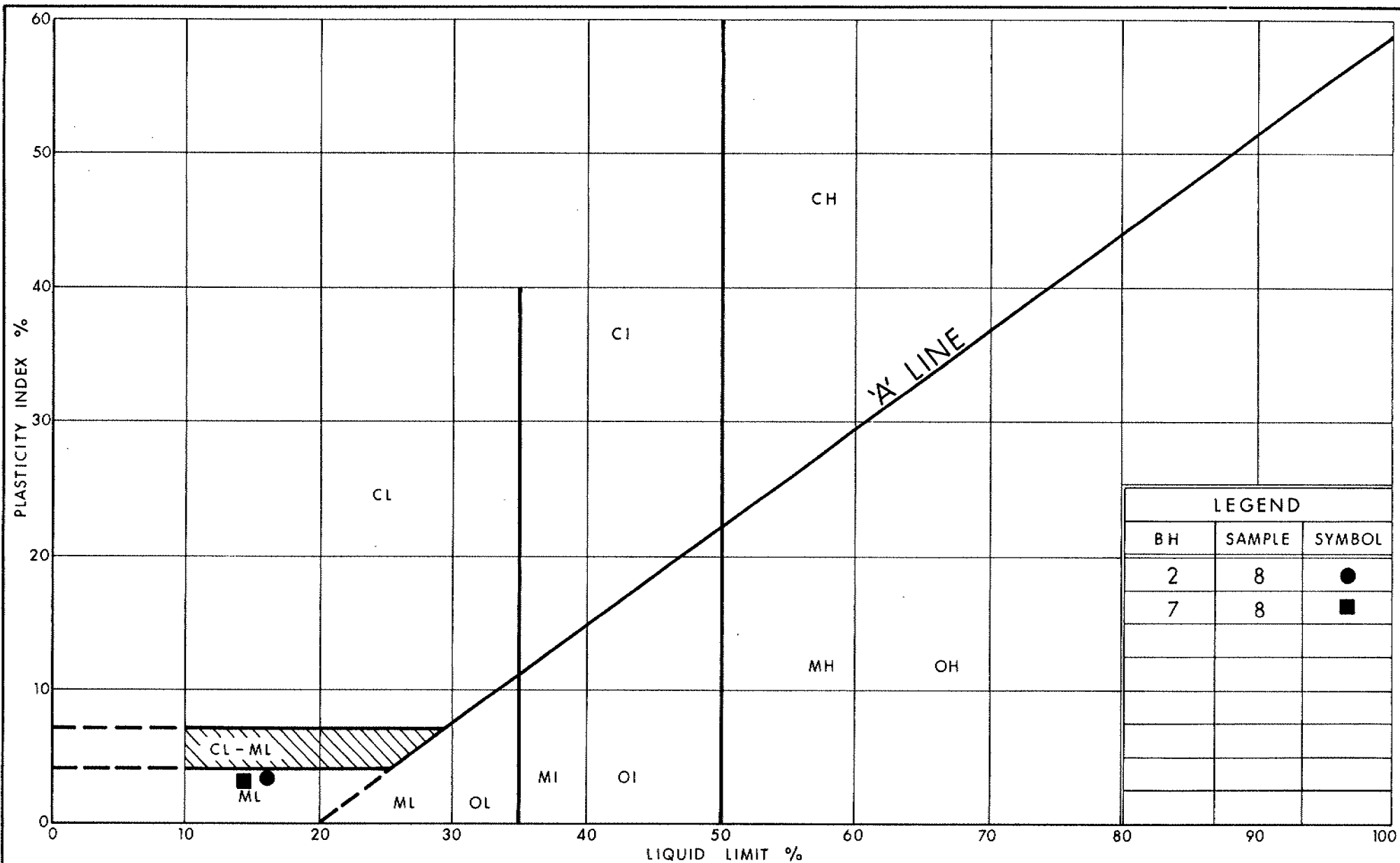
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GRAIN SIZE DISTRIBUTION HETEROGENEOUS MIXTURE OF CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 3

W P 199-77-19



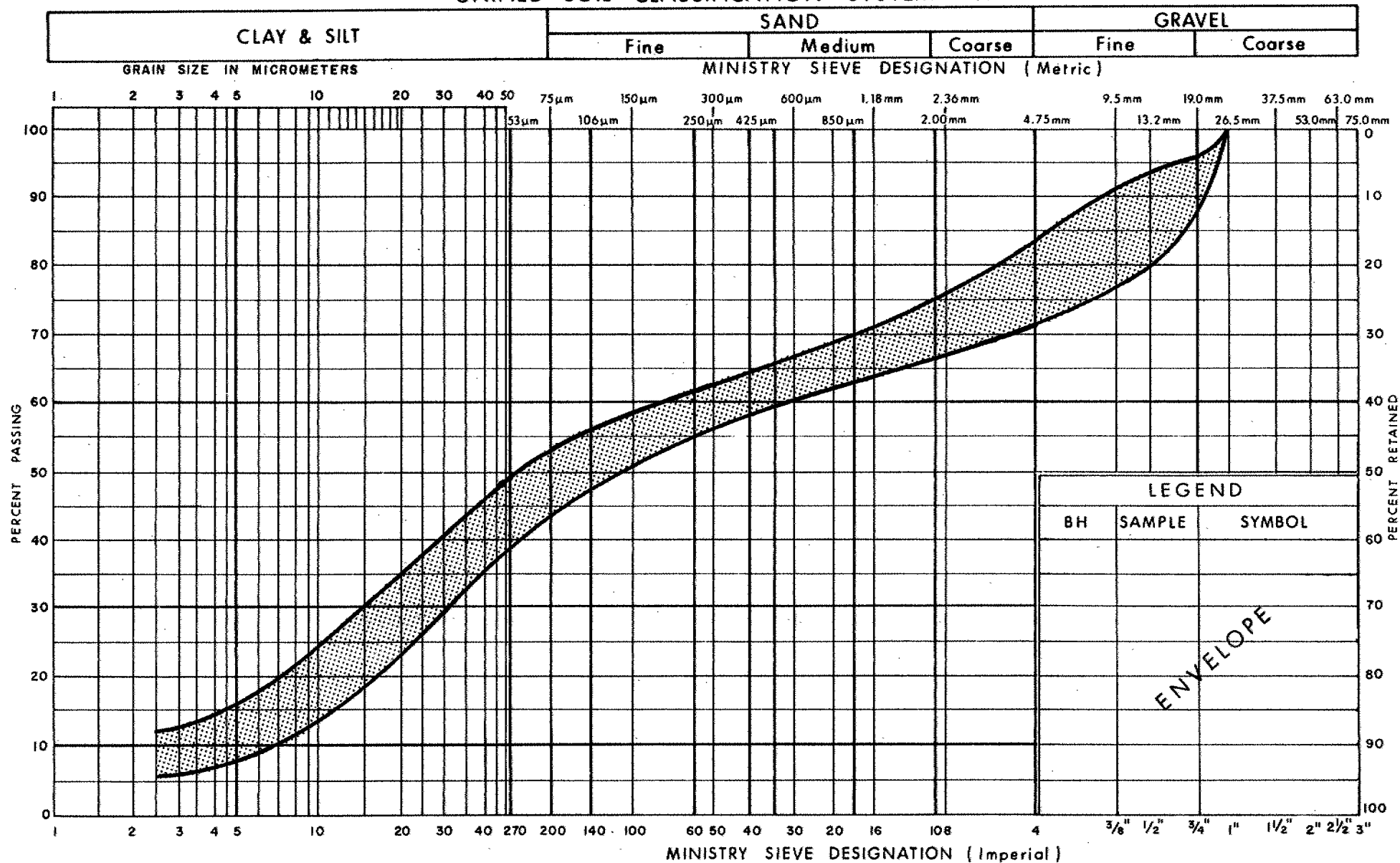
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PLASTICITY CHART
HETEROGENEOUS MIXTURE OF
SANDY SILT, GRAVEL & CLAY (Glacial Till)

FIG No 4

W P 199-77-19

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION
HETEROGENEOUS MIXTURE OF
SANDY SILT, GRAVEL & CLAY (Glacial Till)

FIG No 5

WP 199-77-19

ROCK CORE DESCRIPTION **WP 199-77-19**

Page 1 of 1

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	12	12.27-13.74	100	43	12.27-13.74	SHALE , dark reddish brown, interbedded with greyish green SILTSTONE (14%); very fine grained; weak to very weak rock; unweathered to slightly weathered; close to very close spaced fractures.
2						SHALE , expected as above (no core recovered).
3						SHALE , expected as above (no core recovered).
4	10	12.50-14.02	73	20	12.50-14.02	SHALE , dark reddish brown, interbedded with greyish green SILTSTONE (18%); very fine grained; weak to very weak rock; unweathered to slightly weathered; close to very close spaced fractures.
5						SHALE , expected as above (no core recovered).
6						SHALE , expected as above (no core recovered).
7	10	13.87-15.32	84	8	13.87-15.32	SHALE , dark reddish brown, interbedded with greyish green SILTSTONE (16%); very fine grained; weak to very weak rock; unweathered to slightly weathered; close to very close spaced fractures.

*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. 199-77-19 LOCATION Co-ord: N 4803 493.3 E 277 799.1 ORIGINATED BY F.L.R.
DIST 4 HWY 403 BOREHOLE TYPE H.S. Auger, and NQ Core COMPILED BY J.L.
DATUM Geodetic DATE April 20, 1990 CHECKED BY T.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
163.3	Ground Surface																
0.0	Clayey Silt (Topsoil)						163										
	Granular 'A'																
	(Fill)																
162.1		Grey	1	SS	7		162										
1.2		Brown															
	Sand and Gravel																
	(Fill)																
161.2		Brown	2	SS	13												21 58 16 5
		Reddish Brown					161										
2.1			3	SS	33												
			4	SS	36		160										
			5	SS	91		159										
			6	SS	120	/20cm	158										
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel																
	Hard																
	(Glacial Till)						157										11 22 51 16
			7	SS	120	/20cm	156										
			8	SS	120	/23cm	155										
							154										
			9	SS	104	/15cm	153										6 15 72 7
153.2		Reddish Brown					152										
		Red					151										
10.1			10	SS	139		150										
	Bedrock																
	Queenston Shale																
		Weathered	11	SS	180	/8cm											
		Sound															
			12	RC	REC												RQD 62%
					100%												
149.6																	
13.7	End of Borehole																

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 199-77-19 LOCATION Co-ord: N 4803 469.5 E 277 794.3 ORIGINATED BY T.K.
DIST 4 HWY 403 BOREHOLE TYPE Cone Test, and H.S. Auger COMPILED BY J.L.
DATUM Geodetic DATE April 24, 1990 CHECKED BY T.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
163.5	Ground Surface													
0.0	Clayey Silt (Topsoil)					DRY	163							
162.7	Granular A (Fill)						162							
0.8	Clayey Silt (Fill)		1	SS	13		161							
161.7			2	SS	9		160							
1.8	Clayey Silt w / Organics (Topsoil)		3	SS	62		159							
161.0			4	SS	35		158							
2.5			5	SS	110		157							
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel Hard (Glacial Till)		6	SS	118		156							
			7	SS	115		155							
154.9			8	SS	120		154							
8.6	Heterogeneous Mixture of Sandy Silt, Gravel and Clayey Very Dense (Glacial Till)		9	SS	88		153							
153.4			10	SS	100		152							
10.1	Bedrock Queenston Shale													
151.6	Weathered Sand													
11.9	End of Borehole													
* GROUND WATER CONDITIONS														
PIEZO. NO.	GROUND WATER ELEVATION (Metres)													
1	Dry													

+3, x5. Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 3

1 OF 1 METRIC

W.P. 199-77-19 LOCATION Co-ord: N 4803 451.1 E 277 812.3 ORIGINATED BY F.L.R.
DIST 4 HWY 403 BOREHOLE TYPE H.S. Auger COMPILED BY J.L.
DATUM Geodetic DATE April 24, 1990 CHECKED BY T.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	W _p	W	W _L		
163.9	Ground Surface																
0.0	Clayey Silt (Topsoil)																
163.1	Sand and Gravel (Fill)																
0.8	Clayey Silt (Topsoil)																
162.4																	
1.5	Firm Brown Reddish Brown		1	SS	7		163										
			2	SS	30		162										
			3	SS	126		161										
			4	SS	44		160										11 20 47 22
			5	SS	120	/15cm	159										
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel						158										
	Hard		6	SS	150	/23cm	157										
	(Glacial Till)		7	SS	126		156										
			8	SS	120	/15cm	155										
			9	SS	100	/15cm	154										
							153										4 10 79 7
152.3	Bedrock Queenston Shale						152										
151.6	Weathered Sound		10	SS	120	/13cm											
12.3	End of Borehole																
	* Borehole Dry During the Site Investigation and Charged with Water Later																

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 199-77-19 LOCATION Co-ord: N 4803 450.4 E 277 841.1 ORIGINATED BY T.K.
 DIST 4 HWY 403 BOREHOLE TYPE H.S. Auger, and NQ Core COMPILED BY J.L.
 DATUM Geodetic DATE April 20, 1990 CHECKED BY T.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
164.3	Ground Surface																
0.0	Clayey Silt (Topsoil)						164										
163.4	Granular ' A '																
	(Fill)																
0.9	Clayey Silt						163										
	(Fill)																
162.5	Brown																
1.8	Reddish Brown						162										
	Reddish Brown		1	SS	28												
	Reddish Brown		2	SS	50		161										
	Brown		3	SS	77		160										
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel Hard (Glacial Till)		4	SS	120	/20cm	159										
	Brown		5	SS	170		158										10 30 47 13
	Reddish Brown		6	SS	71		157										
			7	SS	64		156										
			8	SS	144		155										28 23 38 11
152.6	Reddish Brown						154										
	Red						153										6 18 70 6
11.7	Weathered Sound		9	SS	100	/8cm	152										
	Bedrock Queenston Shale		10	RC	REC 73%		151										RQD 47%
150.3																	
14.0	End of Borehole • Borehole Dry During the Site Investigation and Charged with Water Later																

RECORD OF BOREHOLE No 5

1 OF 1

METRIC

W.P. 199-77-19 LOCATION Co-ord: N 4803 397.3 E 277 864.4 ORIGINATED BY F.L.R.
DIST 4 HWY 403 BOREHOLE TYPE Cone Test, and H.S. Auger COMPILED BY J.L.
DATUM Geodetic DATE April 24, 1990 CHECKED BY T.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT 7 KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
164.8	Ground Surface													
0.0	Clayey Silt (Topsoil)					DRY								
163.3	Clayey Silt (Fill)													
1.5	Reddish Brown		1	SS	41									
			2	SS	45									
			3	SS	47									
			4	SS	81									
			5	SS	70									
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel Hard (Glacial Till)		6	SS	81									15 26 46 13
			7	SS	130									
			8	SS	120	/15cm								
			9	SS	92									
			10	SS	110	/15cm								28 28 36 8
151.7	Reddish Brown													
13.1	Bedrock Queenston Shale													
151.0	Weathered		11	SS	120	/5cm								
13.8	End of Borehole * Borehole Dry During Site Investigation													

+3, x5: Numbers refer to
Sensitivity

20
15-5 (x) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 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.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100					
164.9	Ground Surface																
0.0	Clayey Silt (Topsoil)																
	Clayey Silt (Fill)																
163.4	Brown																
1.5	Reddish Brown		1	SS	41												
			2	SS	50												
			3	SS	83												
			4	SS	82												
			5	SS	115												
			6	SS	150	/25cm											
			7	SS	131												
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel Hard (Glacial Till)		8	SS	150	/25cm											
			9	SS	152												
			10	SS	94												
			11	SS	120	/8cm											
151.1	Reddish Brown																
13.8	End of Borehole Red Weathered Shale																

+3, x5, Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 7

1 OF 1

METRIC

W.P. 199-77-19 LOCATION Co-ord: N 4803 379.4 E 277 881.9 ORIGINATED BY T.K.
DIST 4 HWY 403 BOREHOLE TYPE H.S. Auger, and NO Core COMPILED BY J.L.
DATUM Geodetic DATE April 23, 1990 CHECKED BY T.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
164.9	Ground Surface																
0.0	Clayey Silt (Fill)	Brown				DRY *											
164.3																	
0.6	Reddish Brown																
			1	SS	33		164										
			2	SS	106		163										
			3	SS	102		162										13 22 50 15
			4	SS	72		161										
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel						160										
	Hard (Glacial Till)						159										
			5	SS	95		158										13 28 43 15
			6	SS	118		157										
			7	SS	127	/23cm	156										
							155										
154.1							154										
10.8	Heterogeneous Mixture of Sandy Silt, Gravel and Clay						153										
	Very Dense (Glacial Till)		8	SS	88		152										17 39 39 5
151.7	Reddish Brown						151										
13.2	Red						150										
	Weathered		9	SS	101	/15cm											
	Bedrock																
	Queenston Shale		10	RC	REC 84%												RQD 23%
149.7																	

15.2 End of Borehole
* Borehole Dry During the Site
Investigation

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

FOUNDATION INVESTIGATION REPORT
For
Bridge Structure
Hwy. 403 - Hwy. 5 Underpass
W.P. 199-77-21, Site No. 10-477
District 4, Burlington

INTRODUCTION

This report summarizes the information obtained from a foundation investigation carried out at the above mentioned site where four span twin structures are proposed to carry the existing Hwy. 5 over the proposed Hwy. 403.

The fieldwork was carried out between 90 04 25 and 90 04 27. Seven boreholes (BH 1 to BH 7) were advanced and sampled as part of this project by means of hollow stem augers with a conventional diamond drill (NW casing and NQ core barrel) adopted for rock sampling purposes. These boreholes extended down to depths of 9.2 and 10.8 m below the existing ground surface.

This report contains factual information obtained from this investigation.

SITE DESCRIPTION AND GEOLOGY

The site is located on the proposed alignment of Hwy. 403 where it crosses the existing Hwy. 5 in the City of Burlington, Regional Municipality of Halton. The proposed structure is located approximately 800 m east of the existing Guelph Line. The topography in the area is generally flat to gently undulating with ground surface sloping to the southeast. Land use in the vicinity of the site is primarily residential subdivision development.

Physiographically, the site is located in the "Peel Plain" region (Ref. Chapman and Putnam, 1984) which is characterized by a glacial till containing large amount of paleozoic shale. Underlying the glacial deposit are the red Queenston shale from which the till's reddish colour is derived.

SUBSURFACE CONDITIONS

The subsoil conditions encountered across the site were generally uniform consisting primarily of two distinct deposits. The upper layer consists of a cohesive till with the maximum thickness of about 3.6 at BH's 3 and 5.

Underlying this stratum is a non-cohesive glacial till which can be described as a heterogeneous mixture of sandy silt, gravel and clay underlain by shale and siltstone bedrock. The maximum thickness of this deposit was found to be about 4.2 m at BH 6. These deposits are of glacial origins.

The upper portion of the shale was found to be weathered down to approximate El. 151.0 m with a maximum thickness of about 2.3 m at BH 3.

Thin layers of road fill materials and clayey silt topsoils were encountered at all seven borehole locations. However, it should be noted that at BH 7 a thin layer of sandy silt was found immediately underneath the topsoil with an approximate thickness of 0.8 m. This layer contains water bearing sand layers.

The boundaries between the various soil types, in situ and laboratory test results are shown on the attached Record of Borehole sheets in the Appendix. The locations and elevations of the boreholes, along with a profile and sections showing soil stratigraphy based on borehole data, are shown on Dwg. No. 1997721-A.*

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

Fill Material

All seven boreholes encountered some 1.4 m of fill material whose composition ranged from a brown reworked clayey silt to sand and gravel or Granular 'A' material.

An Atterberg Limit test and a Grain Size Distribution analysis were carried out on clayey silt as shown on Figures 1 and 2. Through visual observation and a Atterberg Limit test, it is apparent that the fill material can be classified as a clayey silt to sand and gravel or Granular 'A' material.

* DWG NO 2 OF THE CONTRACT DWG'S

Topsoil

Topsoil was encountered at five borehole locations. The thickness of this layer is about 0.7 m at BH's 4 and 6. An Atterberg Limit test and a Grain Size Distribution analysis were carried out on this material. Through the Atterberg Limit test and visual observation, the material can be classified as a clayey silt.

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

This stratum encountered underneath the fill material or topsoil. This deposit consists of a heterogeneous mixture of clayey silt of low plasticity with varying amounts of sand and gravel. The thickness of this layer was found to be the maximum 3.6 m at BH's 3 and 5.

Atterberg Limit tests were performed on these samples and the results are plotted on Figure 3 and summarized as follows:

<u>Property</u>	<u>Range (%)</u>	<u>Average (%)</u>
Natural Moisture Content (w)	10.0-23.0	14.8
Liquid Limit (w_L)	22.5-30.0	25.8
Plastic Limit (w_p)	12.5-18.5	15.6
Plasticity Index (I_p)	6.0-15.0	10.3

From the plasticity chart, it is evident that the layer can be classified as a heterogeneous mixture of clayey silt, sand and gravel with low plasticity (CL or CL-ML).

Grain Size Distribution tests were carried out on this cohesive glacial till material. Figure 4 in the Appendix shows the results. An increasing frequency of fragments of weathered shale was encountered within the lower portion of this till.

In this stratum, the 'N' value ranges from 5 to 74 blows/0.3 m indicating the consistency of this deposit described as firm to hard.

Heterogeneous Mixture of Sandy Silt, Gravel and Clay (Glacial Till)

This deposit was encountered immediately below the cohesive glacial till in all borehole locations. the thickness of this layer ranges from 2.6 m at BH 3 to 4.2 m at BH 6.

Atterberg Limit tests were performed on this material and the results are plotted on Figure 5 and summarized as follows:

<u>Property</u>	<u>Range (%)</u>	<u>Average (%)</u>
Natural Moisture Content (w)	7.5-10.5	8.8
Liquid Limit (w_L)	14.5-16.5	15.4
Plastic Limit (w_p)	12.0-14.0	13.3
Plasticity Index (I_p)	1.0-3.0	2.2

From the plasticity chart, it is evident that the layer can be classified as a heterogeneous mixture of sandy silt, gravel and clay (ML).

Grain Size Distribution tests were carried out on this material. Figure 6 in the Appendix shows the results. This layer is basically non-plastic. In this stratum, the 'N' values are over 100 blows/0.3 m indicating a state of compaction described as very dense.

Bedrock

In each of the borings, split spoon samples of the weathered portion of the bedrock were recovered before augering was terminated. Sound bedrock was proven in three boreholes by obtaining up to 3.0 m of NQ rock cores. The top of the bedrock ranged from El. 151.7 to 154.4 m which are corresponded to 8.6 m and 7.0 m below the existing ground surface. The upper 0.6 m to 2.3 m is in a highly weathered state, with layers of broken shale and red clayey silt.

The bedrock is a red shale with green siltstone (approximately 80% shale, 20% siltstone) of the Queenston formation. Detailed description of the rock are attached in the Appendix entitled "Rock Core Description".

The Core Recovery (CR) and Rock Quality Designation (RQD) values were determined in situ and also in the laboratory to evaluate the competence and integrity of the rock. Core Recoveries (RC) range between 48 and 95 percent and Rock Quality Designation (RQD) values range from 30 to 73 percent. Based on these results, the rock can be classified as weak to very weak and slightly weathered.

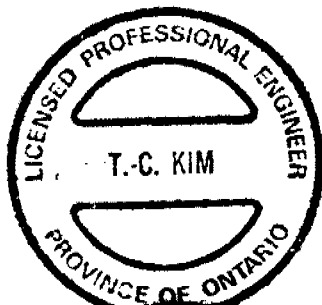
GROUNDWATER CONDITIONS

Groundwater conditions were observed through the measurements of water levels in the open boreholes. All boreholes were dry or the water levels were close to the boundary between the till and weathered bedrock surface at the time of site investigation. However, groundwater level in BH 2, BH 3 and BH 7 after a couple of hours later was found to be higher than that of others with approximate El. 157.4 m at BH 2 and 158.6 m at BH 3 which correspond to depths of 4.1 m and 2.4 m below the existing ground surface. These high groundwater levels are probably attributed to some water bearing sand layers within cohesive glacial till. Two piezometers were installed at BH's 1 and 5. Upon completion of rock coring, the induced drill water remained perched within the borehole, indicating a low permeability both for the till and shale strata.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of Tae C. Kim, Sr. Foundation Engineer, and Frank Reynolds, Technician for Northwestern Region. The equipment was owned and operated by Marathon Drilling Co. Ltd. and Master Soil Investigation Co. Ltd., Toronto.

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

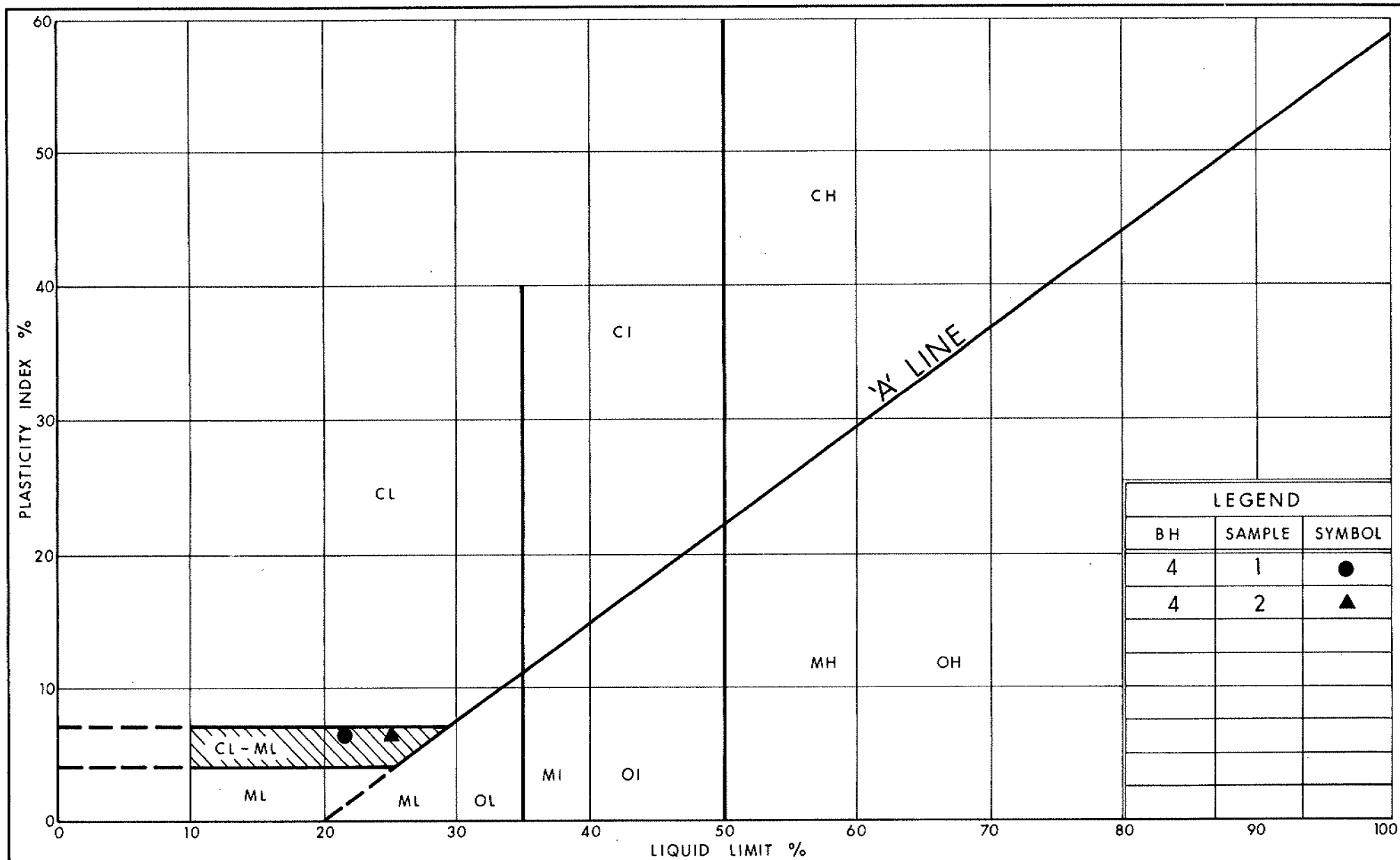


Tae C. Kim
Tae C. Kim, P.Eng.
Sr. Foundation Engineer



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

APPENDIX



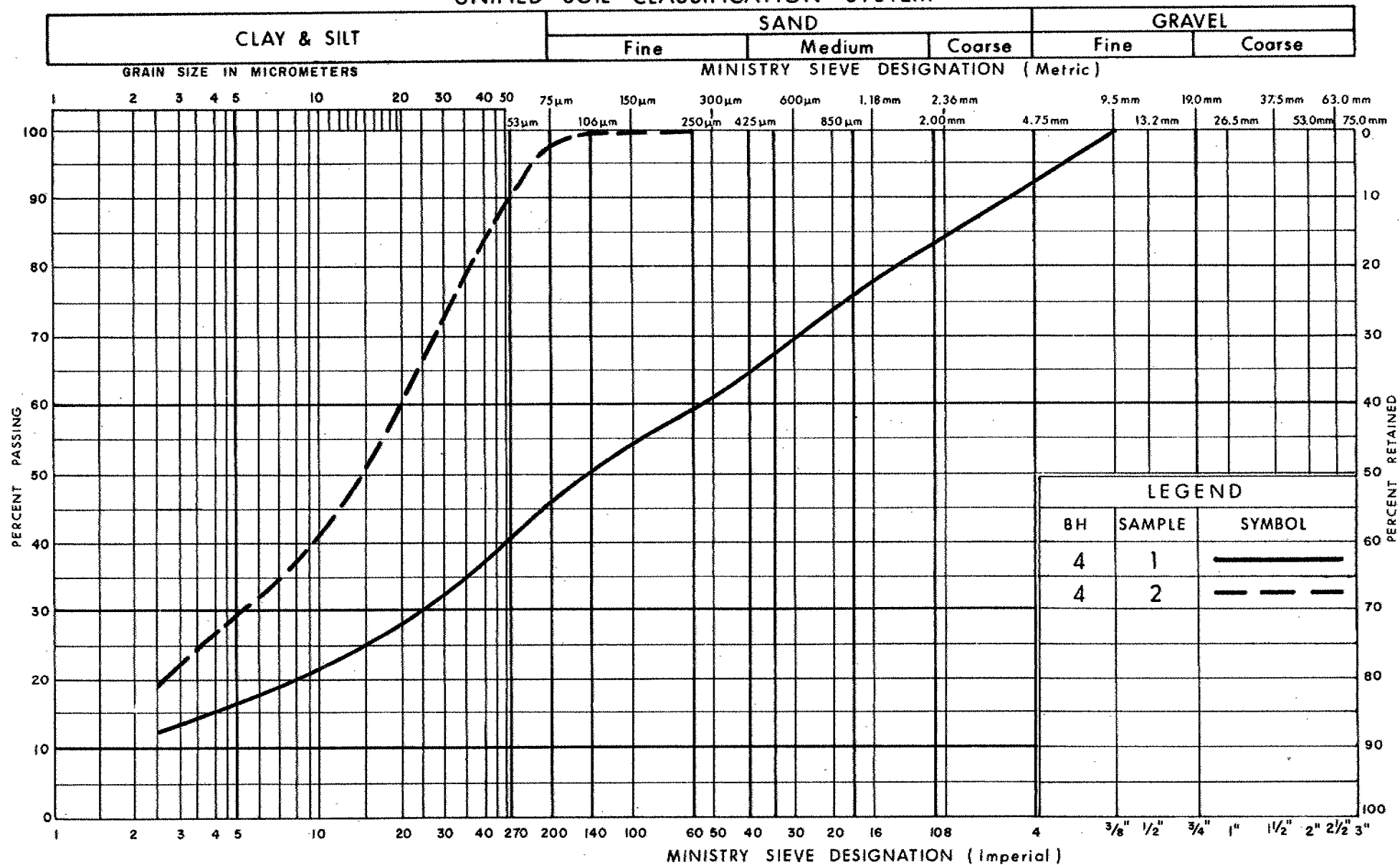
Ministry of
Transportation

PLASTICITY CHART CLAYEY SILT (FILL) AND TOPSOIL

FIG No 1

W P 199-77-21

UNIFIED SOIL CLASSIFICATION SYSTEM

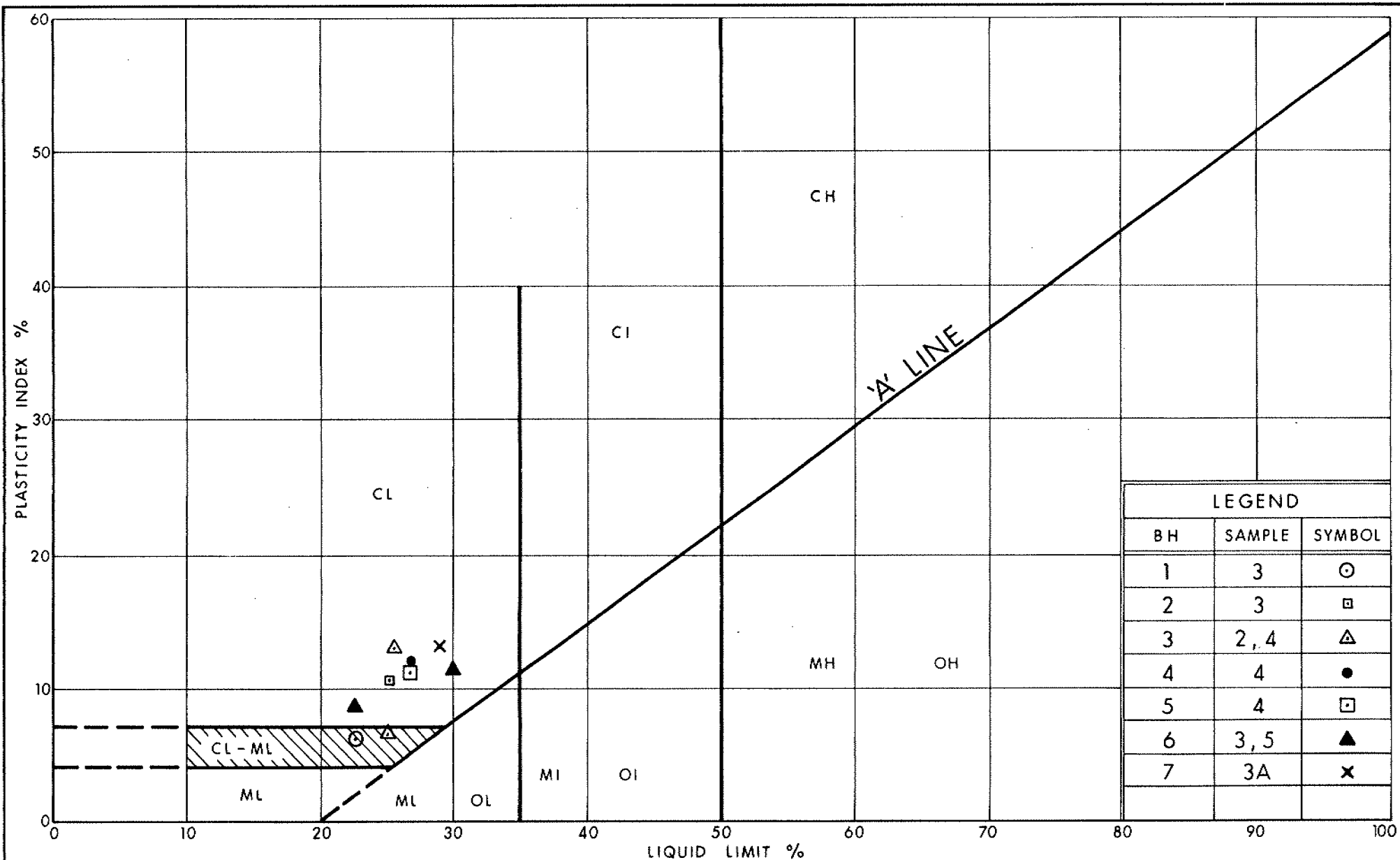


Ministry of
Transportation

GRAIN SIZE DISTRIBUTION CLAYEY SILT (FILL) AND TOPSOIL

FIG No 2

W P 199-77-21



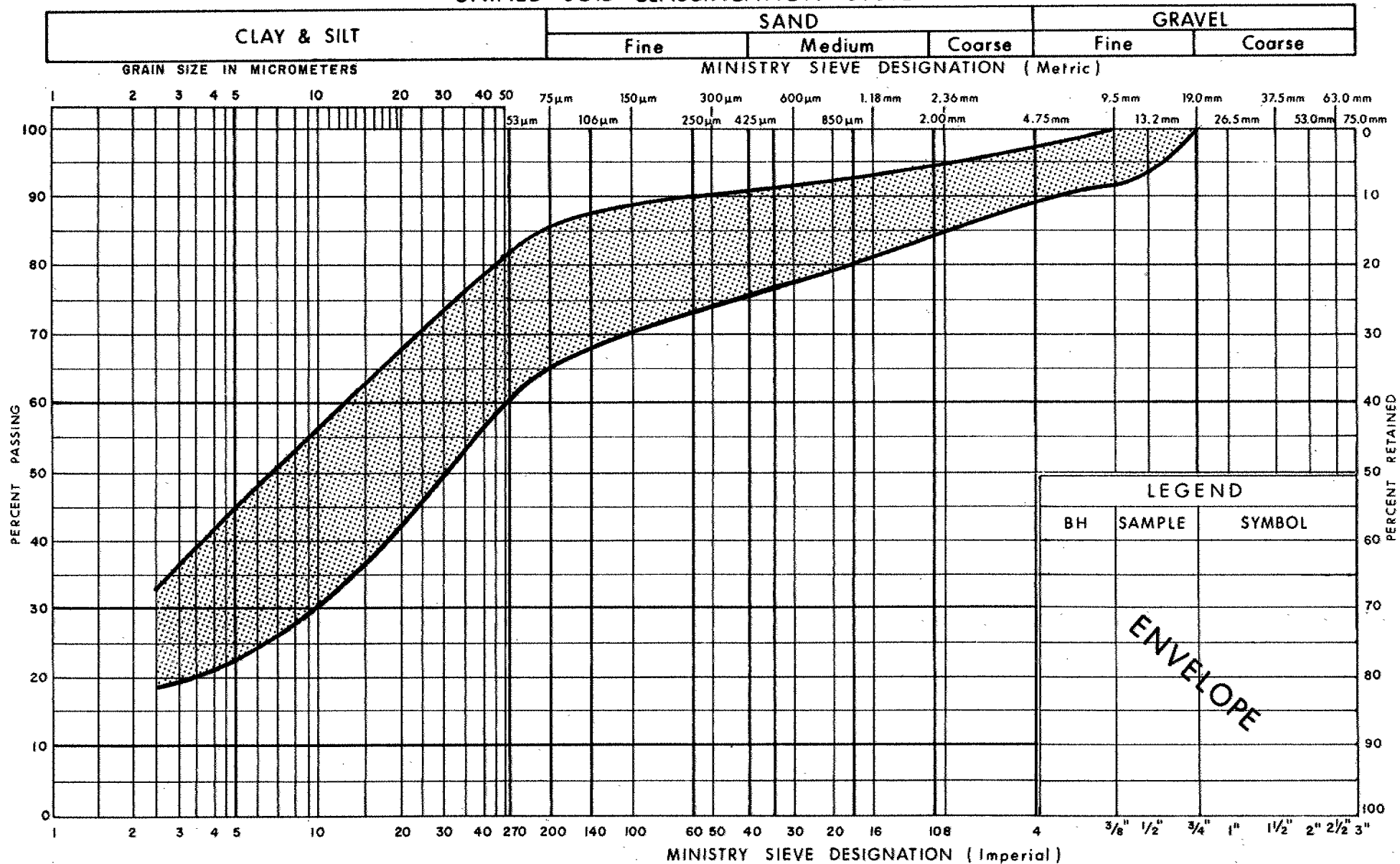
Ministry of
Transportation

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

FIG No 3

W P 199-77-21

UNIFIED SOIL CLASSIFICATION SYSTEM

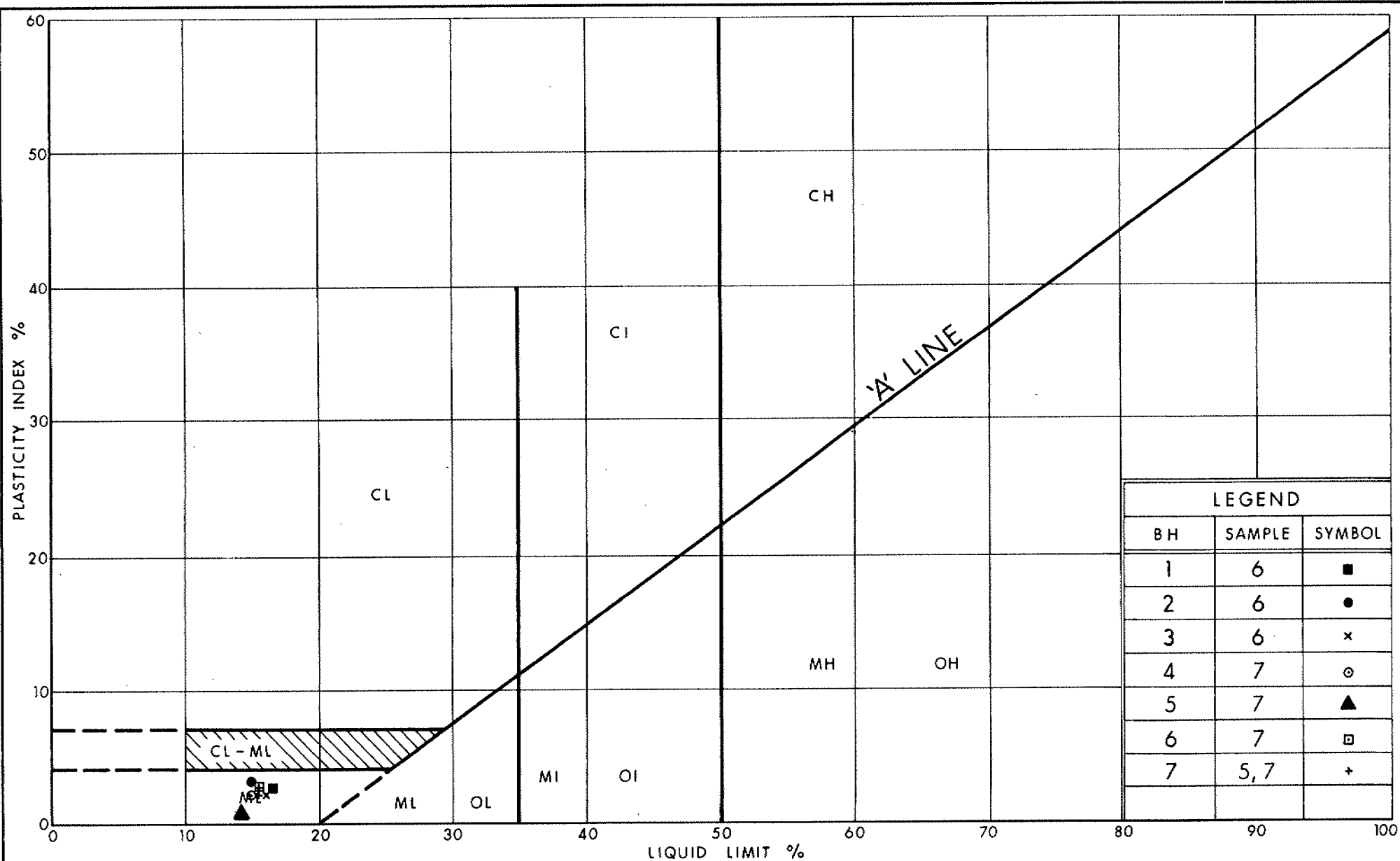


Ministry of
Transportation

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

FIG No 4

W P 199-77-21



Ministry of
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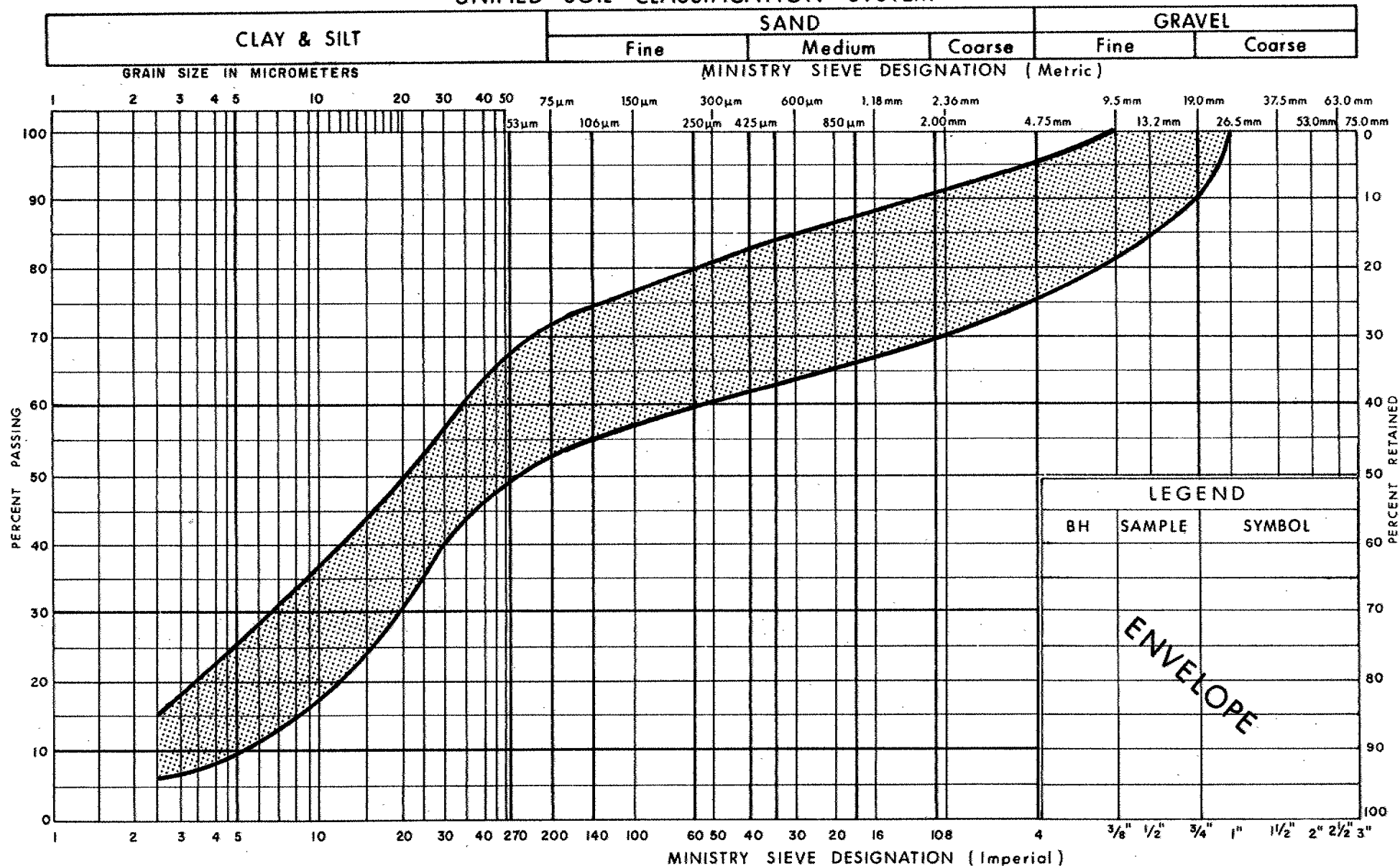
Ontario

PLASTICITY CHART
HETEROGENEOUS MIXTURE OF
SANDY SILT, GRAVEL & CLAY (Glacial Till)

FIG No 5

W P 199 - 77 - 21

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
HETEROGENEOUS MIXTURE OF
SANDY SILT, GRAVEL & CLAY (Glacial Till)

FIG No 6

W P 199-77-21

ROCK CORE DESCRIPTION **WP 199-77-21**

Page 1 of 1

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	9	7.80-9.24	48	18	7.80-10.80	SHALE , dark reddish brown, interbedded with greyish green SILTSTONE (26%); very fine grained; weak to very weak rock; unweathered to slightly weathered; close to very close spaced fractures.
	10	9.24-10.80	81	52		
2						SHALE , expected as above (no core recovered).
3						SHALE , expected as above (no core recovered).
4	10	9.14-10.67	95	59	9.14-10.67	SHALE , dark reddish brown, interbedded with greyish green SILTSTONE (24%); very fine grained; weak to very weak rock; unweathered to slightly weathered; close to very close spaced fractures.
5						SHALE , expected as above (no core recovered).
6						SHALE , expected as above (no core recovered).
7	9	8.08-9.60	75	10	8.08-9.60	SHALE , dark reddish brown, interbedded with greyish green SILTSTONE (5%); very fine grained; weak to very weak rock; unweathered to slightly weathered; close to very close spaced fractures.

*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. 199-77-21 LOCATION Co-ord: N 4804 607.9 E 277 719.1 ORIGINATED BY T.K.
DIST 4 HWY 403 BOREHOLE TYPE Cone Test, H.S. Auger, and NQ Core COMPILED BY J.L.
DATUM Geodetic DATE April 26 and 27, 1990 CHECKED BY T.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
161.4	Ground Surface													
0.0	Granular "A" Sand and Gravel (Fill)						161							
160.5														
0.8	Clayey Silt (Fill)		1	SS	8									
160.0	Clayey Silt (Topsoil) Brown													
1.4	Reddish Brown Heterogeneous Mixture of Clayey Silt, Sand and Gravel Very Stiff to Hard (Glacial Till)		2	SS	20									
			3	SS	29									8 21 46 25
157.7			4	SS	41									
3.7			5	SS	100 /13cm									
	Probable W.B.L. Heterogeneous Mixture of Sandy Silt, Gravel and Clay Very Dense (Glacial Till)		6	SS	120 /13cm									24 22 40 14
			7	SS	120 /10cm									
154.4	Reddish Brown Red													
7.0			8	SS	120 /15cm									
	Bedrock Weathered Queenston Shale Sound		9	RC	REC 48%									RQD 30%
			10	RC	REC 81%									RQD 52%
150.6														
10.8	End of Borehole													
	* W.B.L. = Water Bearing Layer													
	* GROUND WATER CONDITIONS													
	PIEZO. NO.													
	GROUND WATER ELEVATION (Metres)													
	1													
	154.4													

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 199-77-21 LOCATION Co-ord: N 4804 835.1 E 277 717.6 ORIGINATED BY F.L.R.
DIST 4 HWY 403 BOREHOLE TYPE Cone Test, and H.S. Auger COMPILED BY J.L.
DATUM Geodetic DATE April 25, 1990 CHECKED BY T.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
161.3	Ground Surface													
0.0	Clayey Silt (Fill)						161							
160.5														
0.8	Clayey Silt (Topsoil)		1	SS	23		160							
159.9	Brown													
1.4	Reddish Brown		2	SS	28									
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel Very Stiff to Hard (Glacial Till)		3	SS	30		159						8 22 46 24	
157.7			4	SS	46		158							
3.7			5	SS	120									
	Heterogeneous Mixture of Sandy Silt, Gravel and Clay Very Dense (Glacial Till)		6	SS	150	/23cm	157						10 27 54 9	
							156							
154.3	Reddish Brown		7	SS	100	/13cm	155							
7.0	Red						154							
	Bedrock Queenston Shale		8	SS	100	/13cm	153							
152.1	Weathered		9	SS	180	/10cm								
9.2	End of Borehole Sound • Borehole dry on completion, charged with water later													

METRIC

[illegible]

+3, x5: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 199-77-21 LOCATION Co-ord: N 4804 667.6 E 277 766.1 ORIGINATED BY F.L.R.
DIST 4 HWY 403 BOREHOLE TYPE Cone Test, H.S. Auger, and NQ Core COMPILED BY J.L.
DATUM Geodetic DATE April 25 and 26, 1990 CHECKED BY T.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
160.9	Ground Surface													
0.0	Clayey Silt (Fill)		1	SS	14									9 44 36 11
159.5														
1.4	Clayey Silt (Topsoil)		2	SS	5									0 2 83 15
158.8														
2.1	Heterogeneous Mixture of Clayey Silt, Sand and Gravel Very Stiff to Hard (Glacial Till)		3	SS	16									
			4	SS	24									4 17 49 30
			5	SS	61									
156.5			6	SS	150									
4.4	Heterogeneous Mixture of Sandy Silt, Gravel and Clay Very Dense (Glacial Till)		7	SS	120	/9cm								8 31 55 6
153.2			8	SS	177									
7.7	Bedrock Queenston Shale		9	SS	100	/5cm								
			10	RC	REC									RQD 73%
150.2														
10.7	End of Borehole													

RECORD OF BOREHOLE No 5

1 OF 1

METRIC

W.P. 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.

SOIL PROFILE			SAMPLES			GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)									
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40						60	80	100	20	40	60	80	100	10
160.4	Ground Surface																						
0.0	Clayey Silt (Fill)						DRY																
159.7								160															
0.8			1	SS	5																		
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel Firm to Hard (Glacial Till)		2	SS	7			159															
			3	SS	29			158															
	Brown Reddish Brown		4	SS	21			157															
			5	SS	51			156															
156.0			6	SS	122			155															
4.4	Heterogeneous Mixture of Sandy Silt, Gravel and Clay Very Dense (Glacial Till)				/23cm			154															
			7	SS	120			153															
					/15cm			152															
152.5	Reddish Brown Red		8	SS	166																		
7.9	Bedrock Queenston Shale																						
151.2	Weathered Sound		9	SS	120																		
					/8cm																		
9.2	End of Borehole																						
* GROUND WATER CONDITIONS																							
PIEZO. NO.		GROUND WATER ELEVATION (Metres)																					
1		Dry																					

RECORD OF BOREHOLE No 6

1 OF 1

METRIC

W.P. 199-77-21 LOCATION Co-ord: N 4804 727.3 E 277 813.1 ORIGINATED BY F.L.R.
DIST 4 HWY 403 BOREHOLE TYPE Cone Test, and H.S. Auger COMPILED BY J.L.
DATUM Geodetic DATE April 26, 1990 CHECKED BY T.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
160.3	Ground Surface																
0.0	Clayey Silt (Fill)		1	SS	16	DRY	160										
158.9							159										
1.4	Clayey Silt (Topsoil)		2	SS	17												
158.1							158										
2.1	Brown Reddish Brown Heterogeneous Mixture of Clayey Silt, Sand and Gravel Very Stiff to Hard (Glacial Till)		3	SS	13		157										9 13 48 30
			4	SS	24		156										
155.8			5	SS	51		155										10 22 49 19
4.4			6	SS	106		154										
	Heterogeneous Mixture of Sandy Silt, Gravel and Clay Very Dense (Glacial Till)		7	SS	120	/13cm	153										4 28 50 8
			8	SS	150	/23cm	152										
151.7	Bedrock Reddish Brown Red																
8.6	Queenston Shale Weathered Sound		9	SS	120	/10cm											
151.0																	
9.2	End of Borehole																

RECORD OF BOREHOLE No 7

1 OF 1

METRIC

W.P. 199-77-21 LOCATION Co-ord: N 4804 754.6 E 277 811.6 ORIGINATED BY T.K.
DIST 4 HWY 403 BOREHOLE TYPE Cone Test, H.S. Auger, and NQ Core COMPILED BY J.L.
DATUM Geodetic DATE April 25, 1990 CHECKED BY T.K.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100	20 40 60 80 100					
160.1	Ground Surface												
0.0	Sand and Gravel (Fill)		1	SS	6								
158.8	Clayey Silt (Topsoil)		2	SS	7								
1.4	Reddish Brown Sandy Silt w/ some Clay and Gravel		3	SS	2								
157.6			3-A	SS	2								
2.5	Heterogeneous Mixture of Clayey Silt, Sand and Gravel Soft to Very Stiff		4	SS	17								
156.4	(Glacial Till)		5	SS	101								
3.7	Heterogeneous Mixture of Sandy Silt, Gravel and Clay Very Dense		6	SS	120	/15cm							
152.5	Reddish Brown Red Weathered Bedrock Queenston Shale		7	SS	120	/8cm							
7.7			8	SS	143								
150.5			9	RC	REC 75%								
9.6	End of Borehole * Borehole dry on completion, charged with water later.												

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

CONT. 93-43

WP 199-77-19 DIST 4
HWY 403 STR SITE 10-227

Hwy. 403 - Guelph Line Underpass

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FOUNDATION INVESTIGATION REPORT
For
Bridge Structure
Hwy. 403 - Guelph Line Underpass
W.P. 199-77-19, Site No. 10-227
District 4, Burlington

INTRODUCTION

This report summarizes the information obtained from a foundation investigation carried out at the above mentioned site where four span twin structures are proposed to carry the existing Guelph Line over the proposed Hwy. 403.

The fieldwork was carried out between 90 04 20 and 90 04 24. Seven boreholes (BH 1 to BH 7) were advanced and sampled as part of this project by means of hollow stem augers with a conventional diamond drill (NW casing and NQ core barrel) adopted for rock sampling purposes. These boreholes extended down to depths of 11.9 and 15.4 m below the existing ground surface.

This report contains factual information obtained from this investigation pertaining to structure foundations, approach embankments and related earthworks for the bridge structure as shown on Dwg. No. 1997719-A.

SITE DESCRIPTION AND GEOLOGY

The site is located on the proposed alignment of Hwy. 403 where it crosses the existing Guelph Line in the City of Burlington, Regional Municipality of Halton. The proposed structure is located approximately 800 m south of the existing Hwy. 5. The topography in the area is generally flat to gently undulating with ground surface sloping to the southeast. Land use in the vicinity of the site is primarily residential and commercial subdivision development.

Physiographically, the site is located in the "Peel Plain" region (Ref. Chapman and Putnam, 1984) which is characterized by a glacial till containing large amount of Paleozoic shale. Underlying the glacial deposit are the red Queenston shale from which the till's reddish colour is derived.

SUBSURFACE CONDITIONS

The subsoil conditions are generally uniform across the site. The overburden consists of a deposit of cohesive glacial till composed of a heterogeneous mixture of clayey silt, sand and gravel underlain by shale and siltstone bedrock. The maximum thickness of this deposit was found to be about 12.2 m at BH 6. A thin layer of non-cohesive glacial till composed of a heterogeneous mixture of sandy silt, gravel and clay was encountered in two boreholes (BH's 2, and 7) within the cohesive till deposit. The maximum thickness of this deposit was found to be about 2.4 m at BH 7.

The upper portion of the shale was found to be weathered down to approximate El. 151.0 m with a maximum thickness of about 2.2 m at BH 1.

Thin layers of road fill materials and clayey silt topsoils were encountered at all seven borehole locations.

The boundaries between the various soil types, in situ and laboratory test results are shown on the attached Record of Borehole sheets in the Appendix. The locations and elevations of the boreholes, along with a profile and sections showing soil stratigraphy based on borehole data, are shown on Dwg. No. 1997719-A.

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

Fill Material

All seven boreholes encountered some 1.9 m of fill material whose composition ranged from a brown reworked clayey silt to sand and gravel or Granular 'A' material.

A Grain Size Distribution analysis was carried out on sand and gravel as shown on Figure 1. Through visual observation and a Grain Size Distribution Analysis, it is apparent that the fill material can be classified as a clayey silt to sand and gravel or Granular 'A' material.

Topsoil

Topsoil was encountered at six borehole locations. The thickness of this layer is about 0.7 m at BH's 2 and 3. Grain Size Distribution analysis was carried out on this material. Through the visual observation, the material can be classified as a clayey silt.

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

This stratum encountered underneath the fill material or topsoil. This deposit consists of a heterogeneous mixture of clayey silt of low plasticity with varying amounts of sand and gravel. The thickness of this layer was found to be the maximum 12.2 m at BH 6.

Atterberg Limit tests were performed on these samples and the results are plotted on Figure 2 and summarized as follows:

<u>Property</u>	<u>Range (%)</u>	<u>Average (%)</u>
Natural Moisture Content (w)	6.5-14.0	8.9
Liquid Limit (w _L)	17.5-28.5	21.2
Plastic Limit (w _p)	10.0-14.0	12.5
Plasticity Index (I _p)	5.5-15.0	8.7

From the plasticity chart, it is evident that the layer can be classified as a heterogeneous mixture of clayey silt, sand and gravel with low plasticity (CL or CL-ML).

Grain Size Distribution tests were carried out on this cohesive glacial till material. Figure 3 in the Appendix shows the results. An increasing frequency of fragments of weathered shale was encountered within the lower portion of this till.

In this stratum, the 'N' value ranges from 28 to over 100 blows/0.3 m indicating the consistency of this deposit described as very stiff to hard.

Heterogeneous Mixture of Sandy Silt, Gravel and Clay (Glacial Till)

A thin layer of non-cohesive glacial till composed of a heterogeneous mixture of sandy silt, gravel and clay was encountered within the cohesive till deposit at two borehole locations (BH's 2, and 7). The thickness of this layer ranges from 1.5 m at BH 2 to 2.4 m at BH 7.

Atterberg Limit tests were performed on this material and the results are plotted on Figure 4 and summarized as follows:

<u>Property</u>	<u>Range (%)</u>	<u>Average (%)</u>
Natural Moisture Content (w)	7.0-10.0	8.7
Liquid Limit (w _L)	14.5-16.0	15.3
Plastic Limit (w _p)	11.5-12.5	12.0
Plasticity Index (I _p)	3.0-3.5	3.3

From the plasticity chart, it is evident that the layer can be classified as a heterogeneous mixture of sandy silt, gravel and clay (ML).

Grain Size Distribution tests were carried out on this material. Figure 5 in the Appendix shows the results. This layer is basically non-plastic. In this stratum, the 'N' values ranges from 64 to over 100 blows/0.3 m indicating a state of compaction described as very dense.

Bedrock

In each of the borings, split spoon samples of the weathered portion of the bedrock were recovered before augering was terminated. Sound bedrock was proven in three boreholes by obtaining up to 1.5 m of NQ rock cores. The top of the bedrock ranged from El. 151.2 to 153.4 m which are corresponded to 13.7 m and 10.1 m below the existing ground surface. The upper 0.7 m to 2.2 m is in a highly weathered state, with layers of broken shale and red clayey silt.

The bedrock is a red shale with green siltstone (approximately 80% shale, 20% siltstone) of the Queenston formation. Detailed description of the rock are attached in the Appendix entitled "Rock Core Description".

The Core Recovery (CR) and Rock Quality Designation (RQD) values were determined in situ and also in the laboratory to evaluate the competence and integrity of the rock. Core Recoveries (RC) range between 73 and 100 percent and Rock Quality Designation (RQD) values range from 23 to 62 percent. Based on these results, the rock can be classified as weak to very weak and slightly to highly weathered.

GROUNDWATER CONDITIONS

Groundwater conditions were observed through the measurements of water levels in the open boreholes. All boreholes were dry or the water levels were close to the boundary between the till and weathered bedrock surface at the time of site investigation. However, groundwater level in BH 1 and BH 4 after a couple of hours later was found to be higher than that of others with approximate El. 158.1 m at BH 1 and 160.9 m at BH 4 which correspond to depths of 5.1 m and 3.3 m below the existing ground surface. These high groundwater levels are probably attributed to some water bearing sand layers within cohesive glacial till. One piezometer was installed at BH 2. Upon completion of rock coring, the induced drill water remained perched within the borehole, indicating a low permeability both for the till and shale strata.

DISCUSSION AND RECOMMENDATIONS

The recommendations in this report apply to the bridge structure and related approaches.

It is proposed to construct overpass structure that will carry the existing Guelph Line over the proposed Hwy. 403 eastbound and westbound lanes. The proposed structure is a twin four span bridge. A proposed Guelph Line profile grade, ranging from 165.4 m at north abutment to 166.4 m at south abutment with a proposed Hwy. 403 profile grade of about 159.0 m, will necessitate minimum approach cuts in the order of 6.6 m at north abutment and 6.4 m at south abutment with 1.4 to 1.6 m fill above the existing ground surface.

Recommendations pertaining to the foundations of the new structure, and retaining walls and related earth works are summarized as follows.

Structure Foundations

Abutments and Piers, and Retaining Walls

In consideration of the competent nature of the subsoils, a perched-type abutment founded on spread footings as high as possible within the glacial till. For spread footings founded on native glacial till, the following design parameters are recommended.

	Factored Bearing Capacity at U.L.S. (kPa)	Allowable Capacity S.L.S. Type II (kPa)	Proposed Footing Elevation (m)
North Abutment	700 1,000	450 -	161 (at or below) <159(at or below)
North Piers	1,000	-	<157
Centre Piers	950	600	<157
South Piers	1,000	-	<158
South Abutment	700 1,000	450 -	163 (at or below) <160(at or below)

Alternatively, the closed-type of abutments can be supported on spread footings within hard glacial till for a factored capacity at the U.L.S. of 1,000 kPa below the elevation of 157.0 m.

For the retaining walls between the two structures, footing can be supported on shallow spread footings located within the glacial till for the following design parameters:

	Factored Bearing Capacity at U.L.S. (kPa)	Allowable Capacity S.L.S. Type II (kPa)	Proposed Footing Elevation (m)
North Abutment	700	450	161
South Abutment	700	450	163

A footing width of 2.5 m with an embedded depth of 1.2 m was used in the calculation of the above capacities. The magnitude of the differential settlement of the footings is anticipated to be within 25 mm, provided the subsoil is not disturbed by construction activities.

Sliding resistance may be computed by assuming a coefficient of friction of 0.57 to apply between the underside of footings and the founding soil.

The design of shallow foundation founded on an unyielding type of medium such as glacial till, will be not governed by settlement since the bearing capacity at S.L.S. Type II is much larger than the factored bearing capacity at the U.L.S.

Other Considerations

Lateral Earth Pressures on Structures

Free draining material such as Granular 'A' or Granular 'B' is recommended as appropriate backfill to the abutments to prevent hydrostatic pressure build-up.

Design parameters of the soil are given below for purpose of the O.H.B.C.D.

	Granular 'A'	Granular 'B'
Angle of Internal Friction, ϕ	35°	30°
Unit Weight (kN/m ³), γ	22.8	21.2
Coefficient of Active Earth Pressure (K_a)	0.27	0.33
Coefficient of Earth Pressure at Rest (K_0)	0.43	0.50

The earth pressure coefficient at rest is to be used in design of the abutment walls are rigid and unyielding. Weep holes in the abutment walls should be designed to drain any accumulation of water in the backfill.

Dewatering

No major dewatering difficulties are anticipated for footing excavations in consideration of the relatively low permeability of the glacial till. However, if localized seepage or surface water is to accumulate in excavations, it can be controlled by perimeter ditches and pumping from corner sumps.

Frost Protection

The footings should be placed so as to have a minimum earth cover of 1.2 m to allow for frost protection.

Approaches and Excavations

The base of all footing excavations should be covered immediately upon exposure with a working slab of lean concrete to protect the exposed glacial till from disturbing and softening within 4 hours of exposure. All organic and softened material should be stripped from within the plan limits of the immediate approach embankments prior to placement of any fill. The site should be properly graded and ditched to allow for free drainage in order to prevent ponding of water around the structure and possible softening of the founding till.

No stability problems are anticipated for permanent embankment and cut slopes constructed to a 2:1 geometry. However, the slope surface should be protected from erosion of the glacial till by a thin layer of top soil.

Temporary cut slopes will stand at a 2.0:1 geometry, however, these slopes will weather rapidly and show signs of surficial distress if not protected in a reasonable length of time.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of Tae C. Kim, Sr. Foundation Engineer, and Frank Reynolds, Technician for Northwestern Region. The equipment was owned and operated by Marathon Drilling Co. Ltd. and Master Soil Investigation Co. Ltd., Toronto.

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

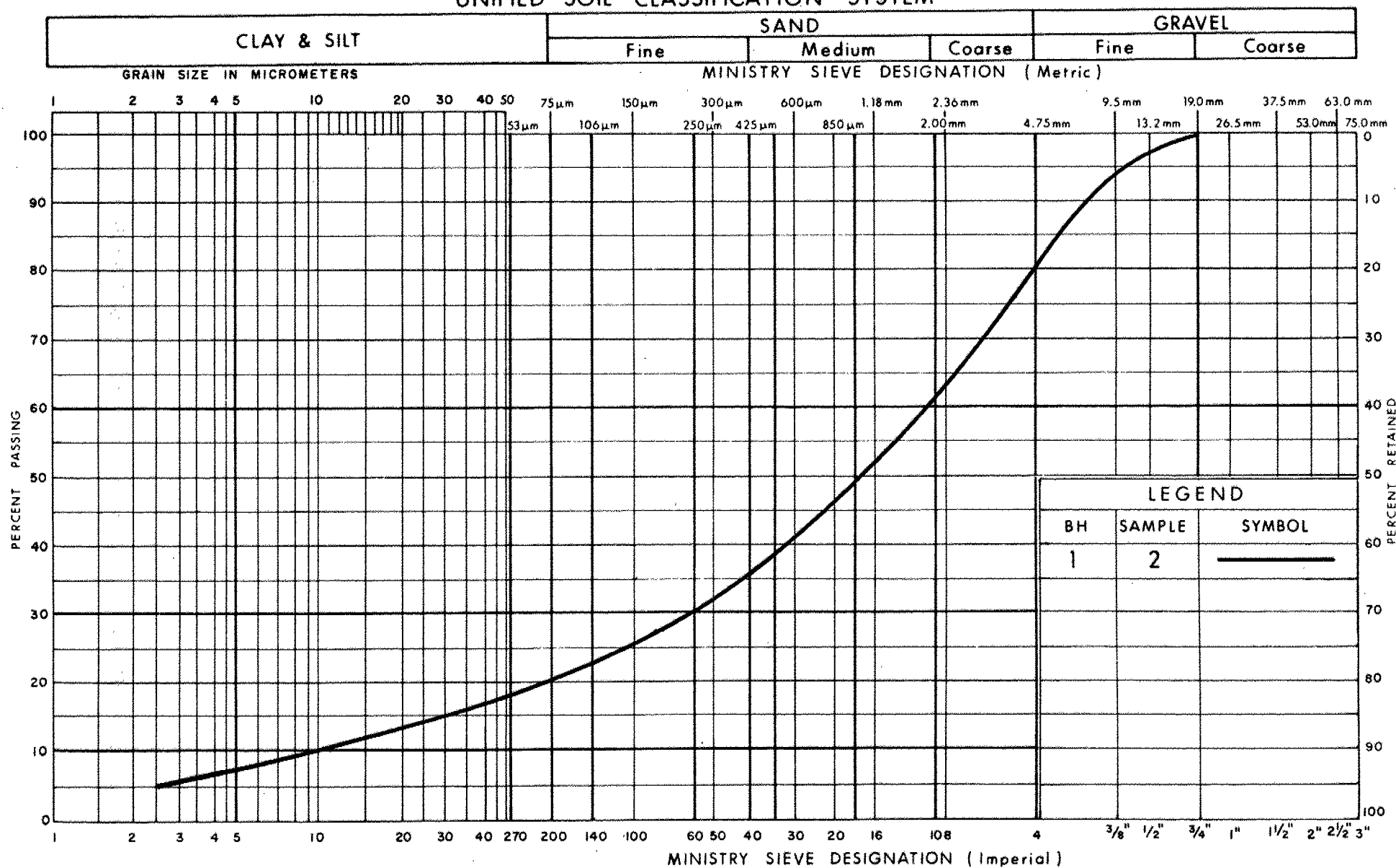


Tae C. Kim
Tae C. Kim, P.Eng.
Sr. Foundation Engineer

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

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM

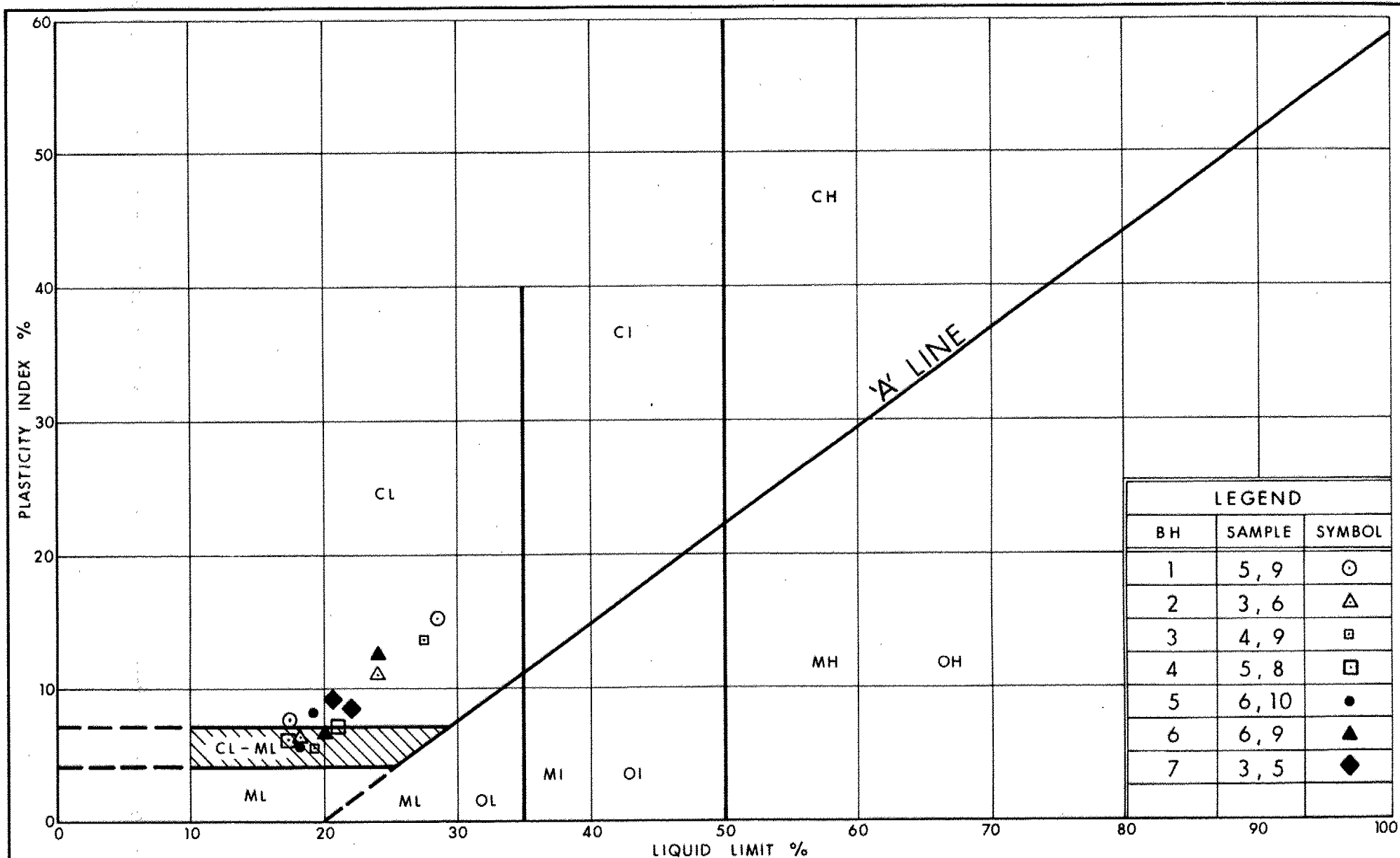


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Transportation

GRAIN SIZE DISTRIBUTION SAND AND GRAVEL (FILL)

FIG No 1

W P 199-77-19



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

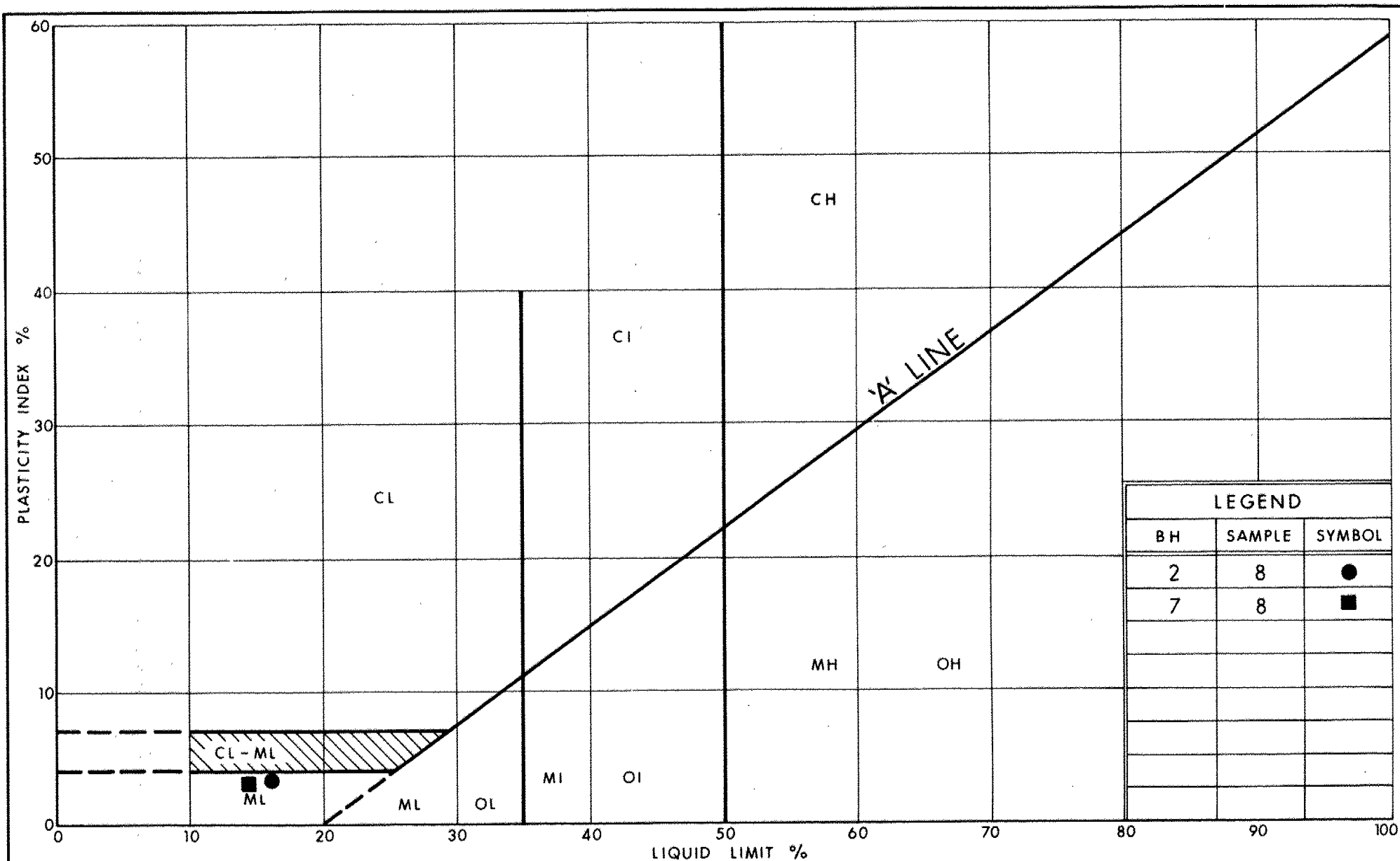
FIG No 2

W P 199 - 77-19



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

W P 199-77-19



Ministry of
Transportation

Ontario

PLASTICITY CHART
HETEROGENEOUS MIXTURE OF
SANDY SILT, GRAVEL & CLAY (Glacial Till)

FIG No 4

W P 199-77-19



GRAIN SIZE DISTRIBUTION
HETEROGENEOUS MIXTURE OF
SANDY SILT, GRAVEL & CLAY (Glacial Till)

FIG No 5

W P 199-77-19

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

MECHANICAL PROPERTIES OF SOIL

m_v	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'_{v0}	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_f	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

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

PHYSICAL PROPERTIES OF SOIL

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

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 199-77-19 LOCATION Co-ord: N 4803 493.3 E 277 799.1 ORIGINATED BY F.L.R.
DIST 4 HWY 403 BOREHOLE TYPE H.S. Auger, and NQ Core COMPILED BY J.L.
DATUM Geodetic DATE April 20, 1990 CHECKED BY T.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	WATER CONTENT (%)	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100						
163.3	Ground Surface																	
0.0	Clayey Silt (Topsoil)						163											
	Granular ' A '																	
	(Fill)																	
162.1		Grey	1	SS	7		162											
1.2		Brown																
	Sand and Gravel																	
	(Fill)																	
161.2		Brown	2	SS	13													21 58 16 5
		Reddish Brown					161											
2.1			3	SS	33													
			4	SS	36		160											
			5	SS	91		159											
			6	SS	120	/20cm	158											
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel																	
	Hard																	
	(Glacial Till)		7	SS	120	/20cm	157											
			8	SS	120	/23cm	156											
			9	SS	104	/15cm	154											
153.2		Reddish Brown					153											
10.1		Red	10	SS	139		152											
	Bedrock																	
	Queenston Shale																	
	Weathered		11	SS	180	/8cm	151											
	Sound		12	RC	REC		150											
					100%													RQD 62%
149.6																		
13.7	End of Borehole																	

+3, x5 : Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 199-77-19 LOCATION Co-ord: N 4803 469.5 E 277 794.3 ORIGINATED BY T.K.
 DIST 4 HWY 403 BOREHOLE TYPE Cone Test, and H.S. Auger COMPILED BY J.L.
 DATUM Geodetic DATE April 24, 1990 CHECKED BY T.K.

SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIMIT MOISTURE CONTENT		UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100	20 40 60 80 100	W _p W W _L	WATER CONTENT (%)		
163.5	Ground Surface											
0.0	Clayey Silt (Topsoil)				DRY	163						
162.7	Granular 'A' (Fill)	Grey Brown				162						
0.8	Clayey Silt (Fill)		1	SS	13							
161.7			2	SS	9							
1.8	Clayey Silt w / Organics (Topsoil)	Brown				161						12 16 52 20
161.0		Reddish Brown	3	SS	62							
2.5			4	SS	35							
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel		5	SS	110							
	Hard (Glacial Till)		6	SS	118							19 26 43 12
			7	SS	115							
154.9			8	SS	120							17 29 44 10
8.6	Heterogeneous Mixture of Sandy Silt, Gravel and Clayey Very Dense (Glacial Till)	Reddish Brown Red				154						
153.4			9	SS	88							
10.1	Bedrock					153						
	Queenston Shale					152						
151.6		Weathered Sound	10	SS	100							
11.9	End of Borehole											
* GROUND WATER CONDITIONS												
	PIEZO. NO.	GROUND WATER ELEVATION (Metres)										
	1	Dry										

RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W.P. 199-77-19 LOCATION Co-ord: N 4803 451.1 E 277 812.3 ORIGINATED BY F.L.R.
DIST 4 HWY 403 BOREHOLE TYPE H.S. Auger COMPILED BY J.L.
DATUM Geodetic DATE April 24, 1990 CHECKED BY T.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
163.9	Ground Surface																
0.0	Clayey Silt (Topsoil)																
163.1	Sand and Gravel (Fill)																
0.8	Clayey Silt (Topsoil)																
162.4																	
1.5	Firm Brown Reddish Brown		1	SS	7		162										
			2	SS	30		161										
			3	SS	126		160										
			4	SS	44		159										
			5	SS	120	/15cm	158										
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel						157										
	Hard (Glacial Till)		6	SS	150	/23cm	156										
			7	SS	126		155										
			8	SS	120	/15cm	154										
			9	SS	100	/15cm	153										
152.3	Reddish Brown						152										
11.6	Bedrock Queenston Shale																
151.8	Weathered Sound		10	SS	120	/13cm											
12.3	End of Borehole																
	* Borehole Dry During the Site Investigation and Charged with Water Later																

+3, x⁵: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 199-77-19 LOCATION Co-ord: N 4803 450.4 E 277 841.1 ORIGINATED BY T.K.
 DIST 4 HWY 403 BOREHOLE TYPE H.S. Auger, and NQ Core COMPILED BY J.L.
 DATUM Geodetic DATE April 20, 1990 CHECKED BY T.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	WATER CONTENT (%)	UNIF WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100						
164.3	Ground Surface																	
0.0	Clayey Silt (Topsoil)						164											
163.4	Granular ' A ' (Fill)																	
0.9	Clayey Silt (Fill)						163											
162.5	Brown																	
1.8	Reddish Brown						162											
	Reddish Brown		1	SS	28		161											
	Brown		2	SS	50		160											
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel Hard (Glacial Till)		3	SS	77		159											
	Brown		4	SS	120	/20cm	158											
	Reddish Brown						157											
			5	SS	170		156											
			6	SS	71		155											
			7	SS	64		154											
			8	SS	144		153											
152.6	Reddish Brown Red						152											
11.7	Weathered Sound		9	SS	100	/8cm	151											
	Bedrock																	
	Queenston Shale		10	RC	REC	73%												
150.3																		
14.0	End of Borehole																	
	Borehole Dry During the Site Investigation and Charged with Water Later																	

RECORD OF BOREHOLE No 5

1 OF 1 METRIC

W.P. 199-77-19 LOCATION Co-ord: N 4803 397.3 E 277 854.4 ORIGINATED BY F.L.R.
DIST 4 HWY 403 BOREHOLE TYPE Cone Test, and H.S. Auger COMPILED BY J.L.
DATUM Geodetic DATE April 24, 1990 CHECKED BY T.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
164.8	Ground Surface													
0.0	Clayey Silt (Topsoil)					DRY								
163.3	Clayey Silt (Fill)													
1.5	Brown Reddish Brown		1	SS	41									
			2	SS	45									
			3	SS	47									
			4	SS	81									
			5	SS	70									
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel Hard (Glacial Till)		6	SS	81								15 26 46 13	
			7	SS	130									
			8	SS	120	/15cm								
			9	SS	92									
			10	SS	110	/15cm							28 28 36 8	
151.7	Reddish Brown													
13.1	Bedrock Queenston Shale													
151.0	Weathered Sound													
13.8	End of Borehole • Borehole Dry During Site Investigation													

+3, x³: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 6

1 OF 1 METRIC

W.P. 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.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
164.9	Ground Surface																
0.0	Clayey Silt (Topsoil)																
	Clayey Silt (Fill)																
163.4	Brown																
1.5	Reddish Brown		1	SS	41												
			2	SS	50												
			3	SS	83												
			4	SS	82												
			5	SS	115												
			6	SS	150	/25cm											
			7	SS	131												
	Heterogeneous Mixture of Clayey Silt, Sand and Gravel Hard (Glacial Till)		8	SS	150	/25cm											
			9	SS	152												
			10	SS	94												
			11	SS	120	/8cm											
151.1	Reddish Brown																
13.8	End of Borehole Red Weathered Shale																

METRIC

[illegible]

20
15-5 (%) STRAIN AT FAILURE
10

ROCK CORE DESCRIPTION

WP 199-77-19

Page 1 of 1

CORE RECOVERY					CORE DESCRIPTION	
BH#	RC#	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	12	12.27-13.74	100	43	12.27-13.74	SHALE, dark reddish brown, interbedded with greyish green SILTSTONE (14%); very fine grained; weak to very weak rock; unweathered to slightly weathered; close to very close spaced fractures.
2						SHALE, expected as above (no core recovered).
3						SHALE, expected as above (no core recovered).
4	10	12.50-14.02	73	20	12.50-14.02	SHALE, dark reddish brown, interbedded with greyish green SILTSTONE (18%); very fine grained; weak to very weak rock; unweathered to slightly weathered; close to very close spaced fractures.
5						SHALE, expected as above (no core recovered).
6						SHALE, expected as above (no core recovered).
7	10	13.87-15.32	84	8	13.87-15.32	SHALE, dark reddish brown, interbedded with greyish green SILTSTONE (16%); very fine grained; weak to very weak rock; unweathered to slightly weathered; close to very close spaced fractures.

*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

CONT No
WP No 199-77-19

GUELPH LINE

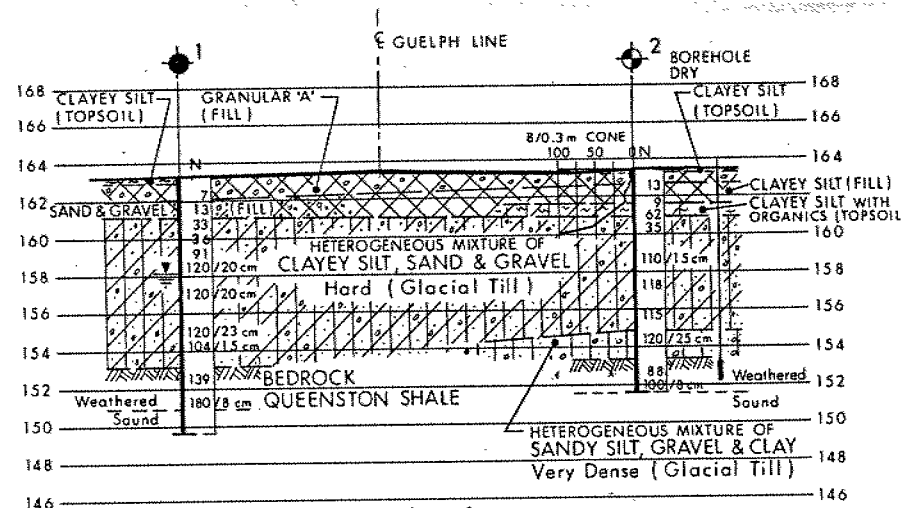
BORE HOLE LOCATIONS & SOIL STRATA



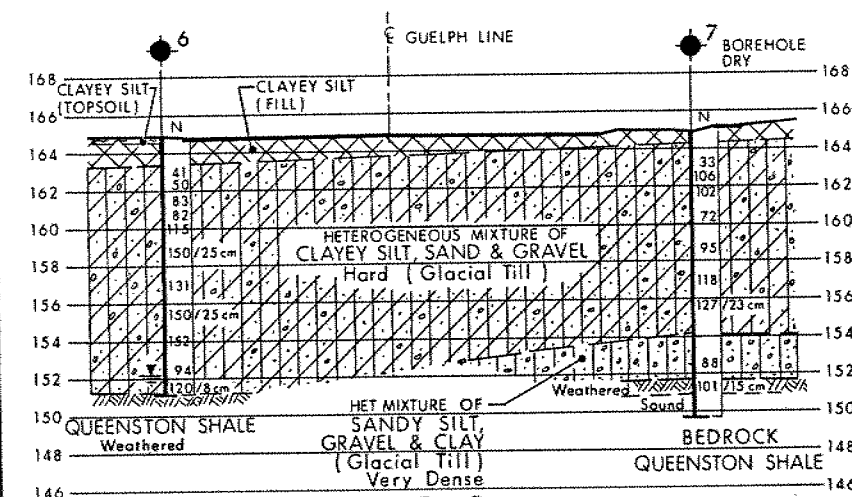
SHEET

METRIC

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

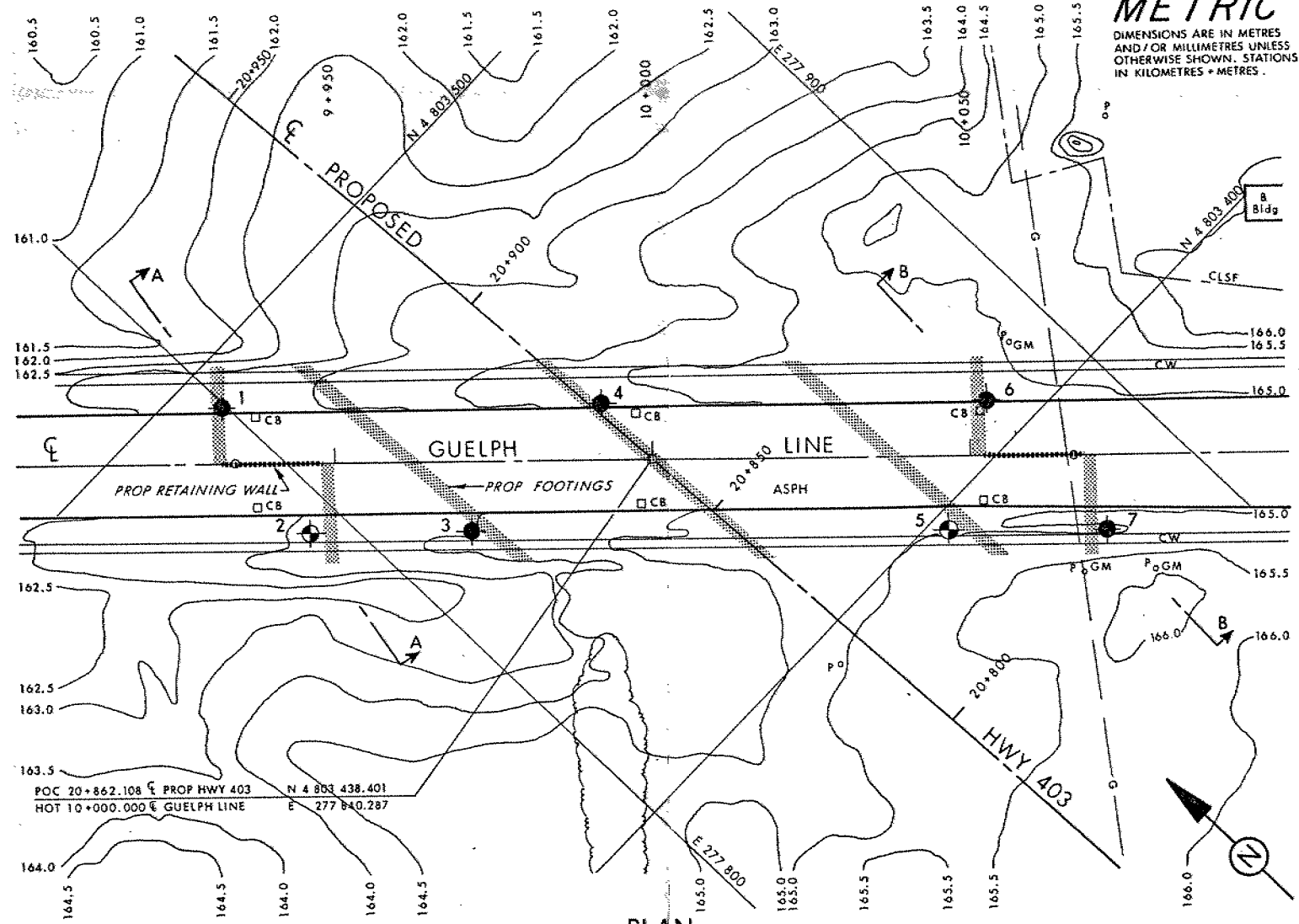


A - A



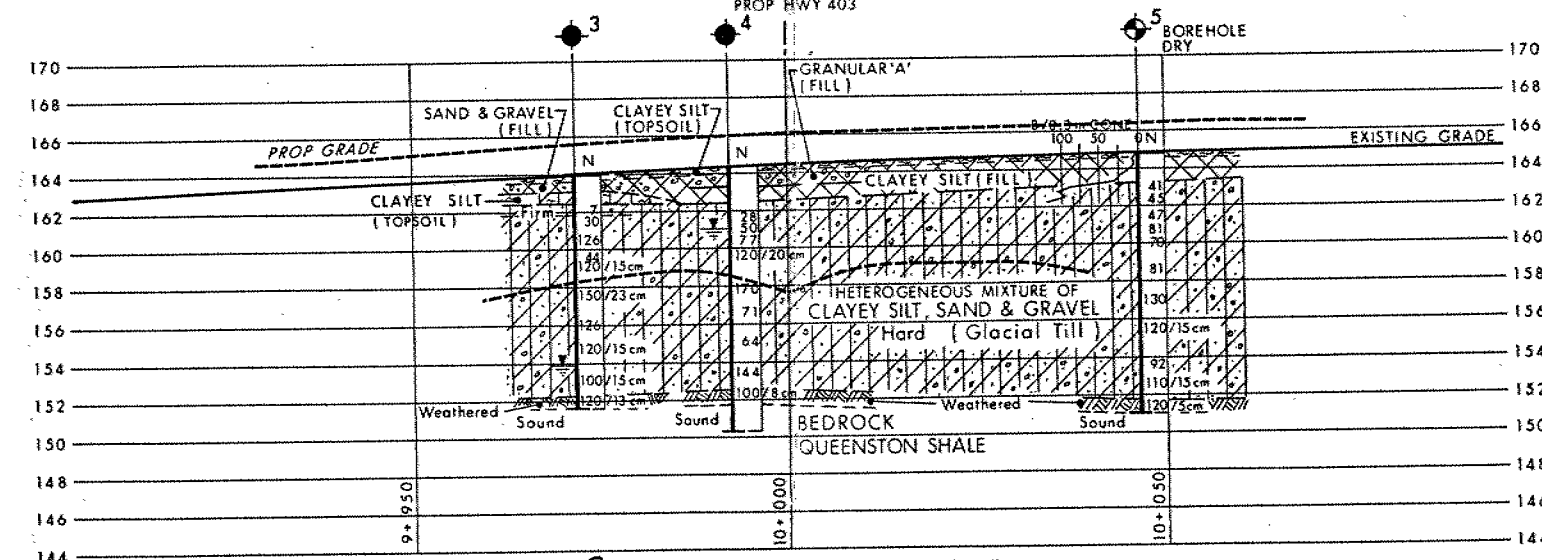
SECTIONS

SCALE
4m 2 0 4m



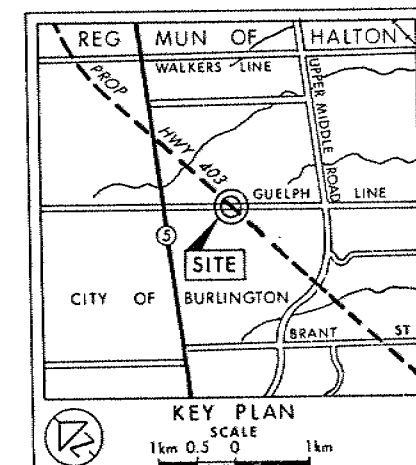
PLAN

SCALE
10m 5 0 10m



PROFILE - GUELPH LINE

SCALE
10m 5 0 10m HOR
4m 2 0 4m VERT



LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test [Cone]
- ⊙ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation 1990 04
- PIEZOMETER

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	163.3	4 803 493.3	277 799.1
2	163.5	4 803 469.5	277 794.3
3	163.9	4 803 451.1	277 812.3
4	164.3	4 803 450.4	277 841.1
5	164.8	4 803 397.3	277 864.4
6	164.9	4 803 407.2	277 883.5
7	164.9	4 803 379.4	277 881.9

NOTE

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

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

DATE	BY	DESCRIPTION
------	----	-------------

Geocres No 30M05-162

HWY No 403	CHECKED	DATE 90 10 03	DIST 4
SUBMIT	CHECKED	DATE 90 10 03	SITE 10-227
DRAWN RS	CHECKED	DATE 90 10 03	DWG 1997719-A

memorandum



To: G. Al-Bazi
Design Engineer
Structural Office
7th Floor, Atrium Tower

From: Foundation Design Section
Room 315, Central Building

Re: Final Drawing Review
Hwy. 403 - Guelphline Underpass
W.P. 199-77-19, Site 10-227
District 4, Burlington

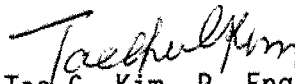
Date: 1991 02 13

Further to your memo dated January 22, 1991, this letter summarizes our review on the submitted final drawings and provisions.

Based on the above review, it is concluded that the design confirms to our recommendations and comments. However, the following comments should still be made on the details shown on the above-mentioned drawing.

1. As discussed in our previous memo (1990 08 10), foundation elevations for the central wingwalls between two bridges should be clearly indicated on the drawing.
2. It should be emphasized that the base of the wall footing excavations be covered with a working slab of lean concrete within 4 hours of exposure.
3. Unsuitable materials underneath the proposed embankment fill should be excavated before fill placement.
4. The slope surface should be protected from erosion of fill and cut slope as per M.T.O. Standard.

We have no further comments. If you have any questions, please contact this office.


Tae C. Kim, P. Eng.
Sr. Foundation Engineer

for

M. Devata P. Eng.
Chief Foundation Engineer

MD/mmj

UMA Engineering Ltd.
Engineers & Planners

• Pier Columns, Deck, Median & Sidewalks	35 MPa
• Remainder	30 MPa
<u>Clear Cover to Reinforcing Steel</u>	
• Abutments, Wingwalls & Retaining Walls	
- Front Face	80 ± 20
- Back Face	70 ± 20
• Pier Columns	80 ± 20
• Footings	100 ± 25
• Deck	
- Top	70 ± 20
- Bottom	50 ± 10
• Remainder (unless otherwise specified)	70 ± 20

1. GENERAL ARRANGEMENT
2. BOREHOLE LOCATIONS AND SOIL STRATA
3. FOOTING LAYOUT
4. FOOTING REINFORCING
5. N.E. AND S.W. ABUTMENTS
6. N.W. AND S.E. ABUTMENTS
7. WINGWALL DETAILS
8. NORTH AND SOUTH RETAINING WALL DETAILS
9. COLUMN AND BEARING DETAILS
10. DECK DETAILS
11. LONGITUDINAL TENDON DETAILS
12. TRANSVERSE TENDON DETAILS
13. DECK REINFORCING I
14. DECK REINFORCING II
15. JOINT ANCHORAGE AND ARMOURING
16. BARRIER WALL ON SIDEWALK
17. RAILING FOR BARRIER WALL
18. 6000 mm APPROACH SLAB
19. DETAILS OF CONC. SLOPE PAVING N.I.C.
20. ELECTRICAL EMBEDDED WORK
21. AS CONSTRUCTED ELEV. AND DIM.
22. STANDARD DETAILS
23. QUANTITIES - STRUCTURE I
24. QUANTITIES - STRUCTURE II

CONSTRUCTION NOTE
IF THE ACTUAL BEARING HEIGHTS
ARE DIFFERENT FROM THE ASSUMED
HEIGHTS GIVEN WITH THE DESIGN
DATA, THE CONTRACTOR SHALL
ADJUST THE BEARING SEAT ELEVATIONS
AND REINFORCING STEEL TO
SUIT THE ACTUAL HEIGHTS.

- W. P. DENOTES WORKING POINT
- T/ P DENOTES TOP OF PAVEMENT

Plan view of the bridge deck showing dimensions, centerline, and various components. The drawing is oriented with EAST on the left and WEST on the right. The centerline is labeled "GUELPH LINE (CONTROL LINE)".

Dimensions:

- Overall width: 15 655
- Segment widths from left to right: 455, 2950, 3750, 3750, 3750, 1000, 1000, 3750, 3750, 3750, 2950, 455.
- Segment widths from right to left: 400, 2550, 400.
- Segment widths from centerline to left edge: 2100, 5725, 5725, 2090, 2090, 5725, 5725, 2100.
- Segment widths from centerline to right edge: 800, 150 (TYP), 800, 150 (TYP), 800, 150 (TYP), 800, 150 (TYP).

Components and Notes:

- ASPHALT & WATERPROOFING SYSTEM - 20 mm TOTAL
- PROFILE CONTROL TOP OF PAVEMENT - 200 (TYP)
- 1-75 mm ϕ LIGHTING DUCT
- 1-100 mm ϕ CABLE NET DUCT
- 3-100 mm ϕ BELL DUCTS
- 2400 mm ϕ COLUMN
- 30 GAP
- 800 ϕ
- 150 (TYP)
- 2400 mm ϕ COLUMN
- 1-75 mm ϕ LIGHTING DUCT
- 1-100 mm ϕ CABLE NET DUCT
- 3-100 mm ϕ BELL DUCTS
- CAST IN PLACE POST TENSIONED VOIDED DECK

BM 164.378 m
GEODETIC DATUM

BM 164.378 m
 GEODETIC DATUM
 N & W in root of 0.3 Dia. Poplar
 41.9 Rt 9+993.7

TOP OF PAVEMENT
 PROFILE CONTROL
 AT GUELPH LINE

H.O.T. 10+000 GUELPH LINE
 P.O.C. 20+862.108 G HWY 403

B.V.C. 9+957.000
 ELEV. 165.349

VPI 10+039.000
 ELEV. 167.453

NORTH

2.566%

K = 25
 LVC = 164 m

BRIDGE LIMITS

PROFILE OF GUELPH LINE

N.T.S.

P.O.C. 20+862.108 @ HWY 403
H.O.T. 10+000 @ GUELPH LINE
V.P.I. 20+952.000
ELEV. 156.700
B.V.C. 20+842.000
ELEV. 159.381
ELEV. 157.044
TOP OF PAVEMENT
PROFILE CONTROL
(4.25 m. LT. & 4.25 m. RT.
OF @ HWY 403)
K=60
L.V.C. = 220m
0.312%
-2.437%
EAST WEST

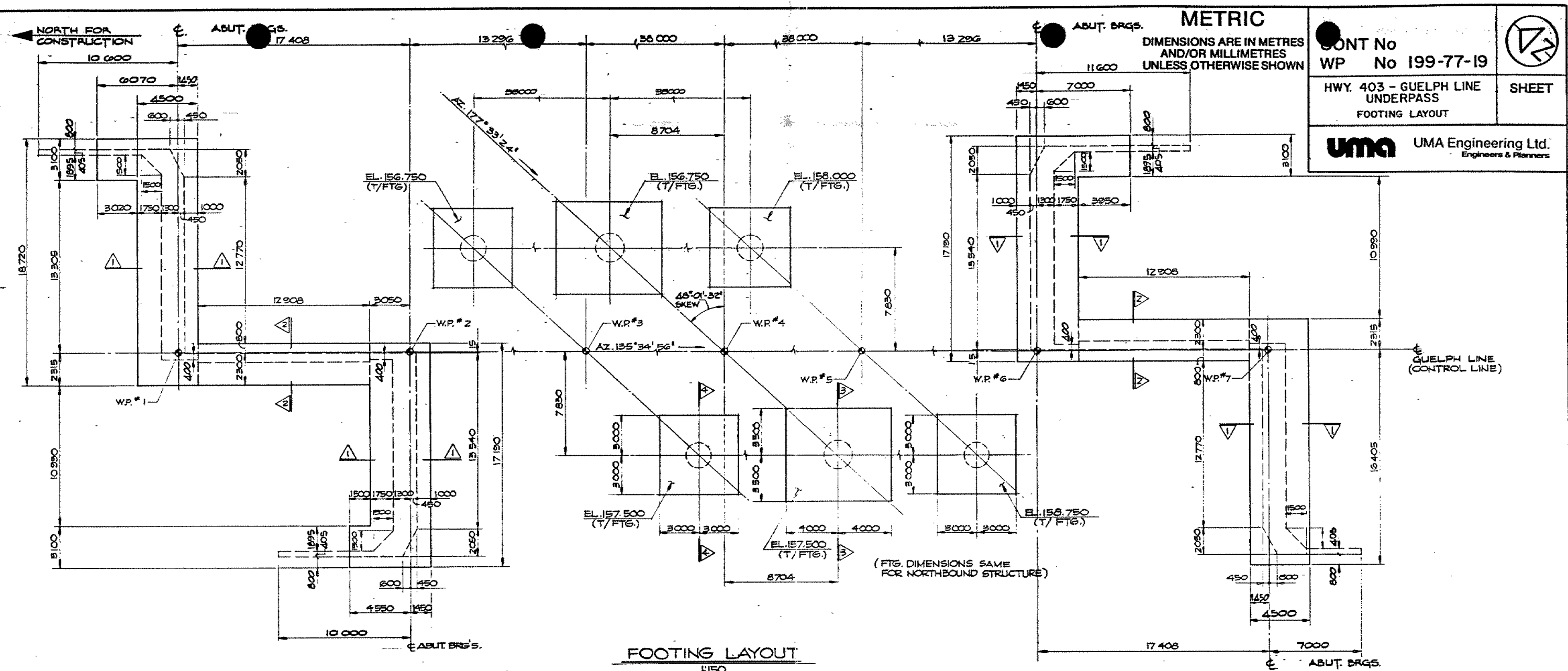
N.T.S.

DD-3502 MINIMUM GRANULAR BACKFILL
REQUIREMENTS

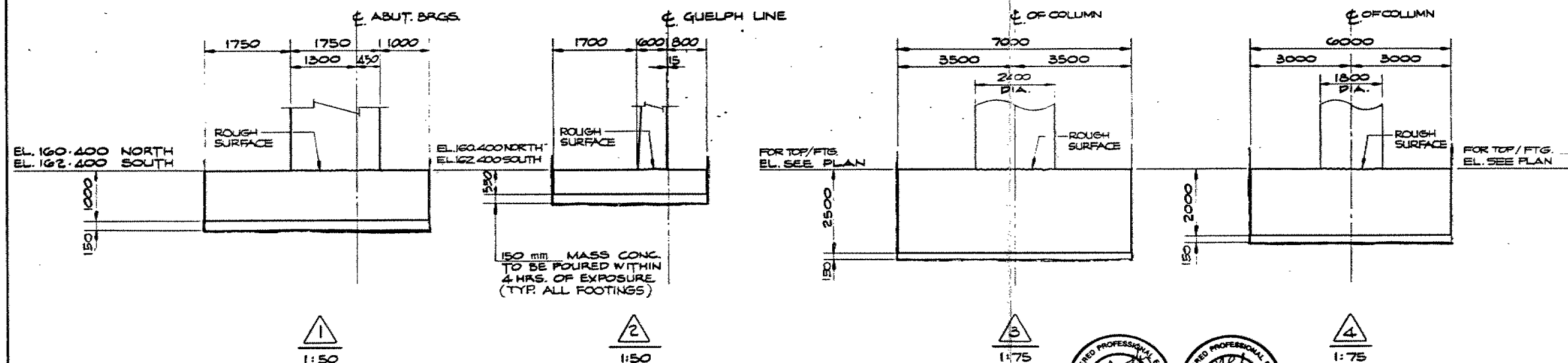
REVISIONS							
	DATE	BY	DESCRIPTION				
	DESIGN H.C. CHK K.A.	CODE	PROC-43	LOAD	CLASS A	DATE	JAN. 1991
	DRAWN F.M. CHK B.A.	SITE	K-227	STRUCT	SCHEME	DWG.	1

REGISTERED PROFESSIONAL
H. CHEN
91-1-18
PROVINCE OF ONTARIO

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING



FOOTING LAYOUT



CO-ORDINATES		
POINT	NORTHING	EASTING
WP#1	4 803 457.476	277 792.205
WP#2	475.042	804.588
WP#3	465.544	819.693
WP#4	438.401	840.257
WP#5	411.258	866.881
WP#6	401.763	876.188
WP#7	389.329	888.372



DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS					
	DATE	BY	DESCRIPTION		
	DESIGN H.C.	CHK K.A.	CODE 2452 - 63	LOAD CLASS A	DATE JAN. 1993
	DRAWN R.D.	CHK B.A.	SITE 10-227	ISCHUE	DWG 2

memorandum



To: Mr. G. Al-Bazi
Design Engineer
Structural Office
7th Floor, Atrium Tower

Date: 1990 08 10

Attn: I. Husain

From: Foundation Design Section
Room 315, Central Building

Re: Preliminary Drawing Review
Hwy. 403 U'Pass at Guelph Line
W.P. 199-77-19, Site 10-227
Hwy 403, District 4, Burlington

Further to your memo dated July 30, 1990, the General Arrangement Drawing 10-227-P1 for the aforementioned structure has been reviewed by this section.

Based on the above review, it is concluded that the design confirms to our recommendations and comments. However, the following comments should be made on the details shown on the above mentioned drawing.

1. Foundation elevations for the central wingwalls between two bridges should be clearly indicated on the drawing.
2. Unsuitable materials underneath the proposed embankment fill should be excavated before fill placement.
3. The slope surface (even temporary cut) should be protected from erosion of the glacial till by a thin layer of top soil.

We have no further comments.

If you have any questions, please contact this office.


Tae C. Kim, P. Eng.
Sr. Foundation Engineer

for

Murty Devata, P. Eng.
Chief Foundation Engineer

MD/TCK/jb

memorandum



235-3731

To: V.F. Boehnke
Head, Structural Section
Central Region
4th Floor, Atrium Tower

Date: 1990 05 25

Attn: Morris D. Bendayan
Senior Structural Engineer

From: Foundation Design Section
Room 315, Central Building

Subject: Hwy. 403 - Guelph Line Underpass
W.P. 199-77-19, Site 227
District 4, Burlington

The field work for the foundation investigation for the above-noted project has been completed. Due to the urgency of this report as per your request, we are herewith submitting our preliminary recommendations. This memo provides a summary of subsurface conditions and recommendations which will permit your office to proceed with design of the above structure.

The complete foundation investigation and design report will be forwarded to your Office at a later date upon the complete of laboratory tests and draftings. In the meantime, if additional information is required, please contact this office immediately.

SITE DESCRIPTION AND GEOLOGY

The site is located on the proposed alignment of Hwy. 403 where it crosses the existing Guelph Line in the City of Burlington, Regional Municipality of Halton. The proposed structure is located approximately 800 m south of the existing Hwy. 5. The topography in the area is generally flat to gently undulating with ground surface sloping to the southeast. Land use in the vicinity of the site is primarily residential and commercial subdivision development.

Physiographically, the site is located in the "Peel Plain" region (Ref.: Chapman and Putnam, 1984) which is characterized by a glacial till containing large amount of paleozoic shale. Underlying the glacial deposit are the red Queenston shale from which the till's reddish colour is derived.

SUBSURFACE CONDITIONS

The subsoil conditions are generally uniform across the site. The overburden consists of a deposit of cohesive glacial till

composed of a heterogeneous mixture of clayey silt to silt, sand and gravel. The maximum thickness of this deposit was found to be about 12.6 m at BH 7.

The upper portion of the shale was found to be weathered down to approximate elevation of 151.0 m with a maximum thickness of about 2.0 m at BH #6.

Thin layers of road fill materials and clay silt top soils were encountered at all seven borehole locations.

Groundwater conditions were observed through the measurements of water levels in the open boreholes. All boreholes were dry or the water levels were close to the boundary between the till and weathered bedrock surface at the time of site investigation. However, groundwater level in BH 1 and BH 4 after a couple of hours later was found to be higher than that of others with approximate elevation of 158.1 m at BH 1 and 160.9 m at BH 4 which correspond to depths of 5.1 m and 3.3 m below the existing ground surface. These high groundwater levels are probably attributed to some water bearing sand layers within cohesive glacial till. One piezometer was installed at BH 2. Upon completion of rock coring, the induced drill water remained perched within the borehole, indicating a low permeability both for the till and shale strata.

RECOMMENDATIONS

It is proposed to construct overpass structure that will carry the existing Guelph Line over the proposed Hwy. 403 eastbound and westbound lanes. The proposed structure is a twin four span bridge. A proposed Guelph line profile grade, ranging from 165.4 m at north abutment to 166.4 m at south abutment with a proposed Hwy. 403 profile grade of about 159.0 m, will necessitate minimum approach cuts in the order of 6.6 m at north abutment and 6.4 m at south abutment with 1.4 to 1.6 m fill above the existing ground surface.

Recommendations pertaining to the foundations of the new structure, and retaining walls and related earth works are summarized as follows.

Structure Foundations

Abutments and Piers, and Retaining Walls

In consideration of the competent nature of the subsoils, a perched-type abutment founded on spread footings as high as possible within the glacial till. For spread footings founded on native glacial till, the following design parameters are recommended.

	Factored Bearing Capacity at U.L.S. (kPa)	Allowable Capacity S.L.S. Type II (kPa)	Proposed Footing Elevation (m)
North	700	450	161 (at or below)
Abutment	1,000	-	<159(at or below)
North Piers	1,000	-	<157
Centre Piers	950	600	<157
South Piers	1,000	-	<158
South	700	450	163 (at or below)
Abutment	1,000	-	<160(at or below)

Alternatively, the closed-type of abutments can be supported on spread footings within hard glacial till for a factored capacity at the U.L.S. of 1,000 kPa below the elevation of 157.0 m.

For the retaining walls between two structures, footing can be supported on shallow spread footings located and designed with the glacial till for the following design parameters:

	Factored Bearing Capacity at U.L.S. (kPa)	Allowable Capacity S.L.S. Type II (kPa)	Proposed Footing Elevation (m)
North	700	450	161
Abutment			
South	700	450	163
Abutment			

Sliding resistance may be computed by assuming a coefficient of friction of 0.57 to apply between the underside of footings and the founding soil.

The design of shallow foundation founded on an unyielding type of medium such as glacial till, will be not governed by settlement since the bearing capacity at S.L.S. Type II is much larger than the factored bearing capacity at the U.L.S.

Other Considerations

Lateral Earth Pressures on Structures

Free draining material such as Granular 'A' or Granular 'B' is recommended as appropriate backfill to the abutments to prevent hydrostatic pressure build-up.

Design parameters of the soil are given below for purpose of the O.H.B.C.D.

	Granular 'A'	Granular 'A'
Angle of Internal Friction, ϕ	35°	30°
Unit Weight (kN/m^3), γ	22.8	21.2
Coefficient of Active Earth Pressure (K_a)	0.27	0.33
Coefficient of Earth Pressure at Rest (K_o)	0.43	0.50

The earth pressure coefficient at rest is to be used in design of the abutment walls are rigid and unyielding. Weep holes in the abutment walls should be designed to drain any accumulation of water in the backfill.

Dewatering

No major dewatering difficulties are anticipated for footing excavations in consideration of the relatively low permeability of the glacial till. However, if localized seepage or surface water to accumulate in excavations, it can be controlled by perimeter ditches and pumping from corner sumps.

Frost Protection

The footings should be placed so as to have a minimum earth cover of 1.2 m to allow for frost protection.

Approaches and Excavations

The base of all footing excavations should be covered immediately upon exposure with a working slab of lean concrete to protect the exposed glacial till from disturbing and softening within 4 hours of exposure. All organic and softened material should be stripped from within the plan limits of the immediate approach embankments prior to placement of any fill. The site should properly graded and ditched to allow for free drainage in order to prevent ponding of water around the structure and possible softening of the founding till.

No stability problems are anticipated for permanent embankment and cut slopes constructed to a 2:1 geometry. However, the slope surface should be protected from erosion of the glacial till by a thin layer of top soil.

Temporary cut slopes will also stand at a 2.0:1 geometry.

We believe that this memorandum meets with your present requirements.

If you have any questions, please contact us.

Tae C. Kim
Tae C. Kim, P.Eng.
Foundation Design Engineer

for

P. Payer, P.Eng.
Sr. Foundation Engineer

PP/TK/ms

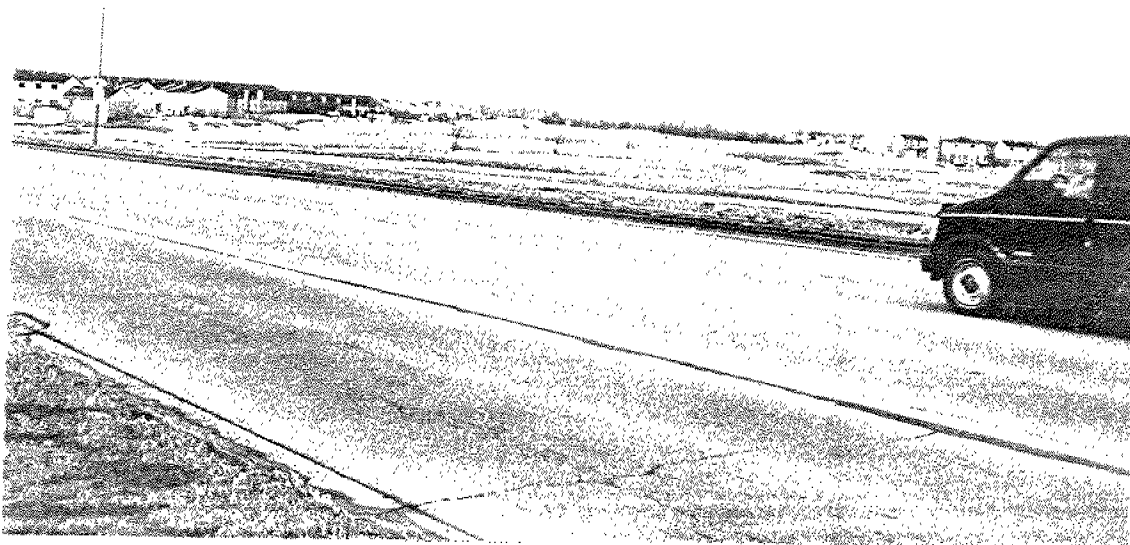
c.c.: K. Bassi

January 1990

Hwy. 403 - Guelph Line U'Pass
W.P. 199-77-19, Site 10-227
District 6, Toronto



North Side Looking South Along
Centre Line Hwy. 403



South Side Looking North Along
Centre Line Hwy. 403

January 1990

Hwy. 403 - Guelph Line U'Pass
W.P. 199-77-19, Site 10-227
District 6, Toronto



N. E. Side Guelph Line Looking N.W.



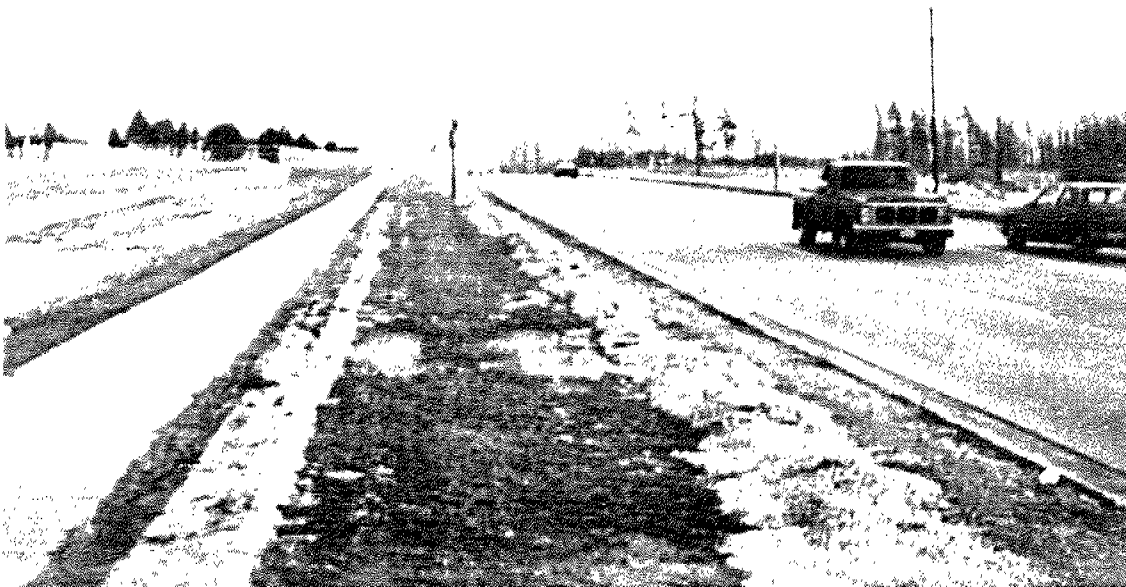
S.E. Side Guelph Line Looking N.W.

January 1990

Hwy. 403 - Guelph Line U'Pass
W.P. 199-77-19, Site 227
District 6, Toronto



Looking S.E. From North Side
Guelph Line



Looking S.E. from South Side
Guelph Line