

FOUNDATION INVESTIGATION REPORT

CONTRACT NO. 92-06



Ministry of
Transportation

INDEX

<u>Page No:</u>	<u>DESCRIPTION</u>
1	Index
2	Abbreviations & Symbols
3 - 112	Foundation Investigation Report for

Reynolds Creek
W.P. 100-90-01, Site 19-305
Hwy. 401, District 2 London

H.M.L. at Culloden Rd. & Hwy. 401
W.P. 479-89-01, Site -
Hwy. 401, District 2 London

Putman Rd. & C.P.R.
W.P. 479-89-02, Site 19-306
Hwy. 401, District 2 London

Dereham Townline
W.P. 479-89-03, Site 19-316
Hwy. 401, District 2 London

Culloden Rd.
W.P. 479-89-04, Site 23-208
Hwy. 401, District 2 London

C.P.R. Overhead
W.P. 479-89-05, Site 23-209
Hwy. 401, District 2 London

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

2

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

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

W.P. 100-90-01 , Bridge Site No: 19-305

Proposed Culvert Extension or New Structure

Hwy. 401 and Reynolds Creek

District 2, London

Ministry of Transportation, Ontario

1.0 INTRODUCTION

Strata Engineering Corp. has been retained by the Foundation Design Section of the Ministry of Transportation, Ontario, under Consultant Agreement No: 4240-9190-090, to conduct a foundation investigation for a proposed extension to the reinforced concrete arch slab culvert across Reynolds Creek. The terms of reference were to investigate the site by means of sampled boreholes and dynamic cone penetration tests, and to provide a full geotechnical report in advance of the issuance of E-Plans for the site.

2.0 SITE AND GEOLOGY

The site is located on Highway 401 at Interchange No. 208, in North Oxford Township, County of Middlesex, about 21km east of London.

The terrain in this area is flat to gently undulating. The banks and shoreline areas beyond the creek channel itself have developed marshes and swampy conditions. The boundaries around some of the interchange ramp loops are heavily wooded. Both of these site specific features made access to proposed drilling locations extremely difficult, and in a few instances, virtually impossible. Access to specific site locations near the proposed culvert extension limits is possible only in winter when the ground has frozen sufficiently to support drilling machinery. Also, some major trees would need to be clear-cut to enable access into the open areas near the existing culvert.

This site lies in an area where two physiographic regions of southern Ontario intersect, namely the Mount Elgin Ridges and the Oxford Till Plain.

The dominant geomorphological feature of the site is a north-south tending spillway breached into the east-west tending Ingersoll Moraine. Outwash flow occurred from south to north through the breached channel. The major soil types in this area are therefore ice-contact stratified drift related to the Ingersoll and Westminster Moraines, and the outwash materials through the spillway.

The spillway formed a broad valley which became infilled with fluvio-lacustrine cohesive sediments. The infilled spillway valley now forms the drainage channel for Reynolds Creek, which flows northerly to join the Thames River near Putnam. It follows a circuitous route through the St. Thomas Moraine, and is believed to have performed very little recent dissection (Chapman and Putnam, 1984)¹.

Drift thickness and bedrock topography maps indicate a depth to bedrock in this area of some 30m below ground surface. The bedrock has been mapped as dolomites and limestones of the Detroit River Group of Middle Devonian Age.

3.0 FIELD AND LABORATORY WORK

At the time of assignment of the project, an ETR plan was supplied showing the proposed culvert extensions on the north and south sides of Highway 401, together with an option to replace the culvert with a bridge on new foundations. After clearing all underground utilities, boreholes were laid out to coincide with the ends of the proposed extensions, and/or new footings, wherever feasible.

Lack of access to many of the proposed structure footing locations (due to reasons given earlier) necessitated the drilling of boreholes some distance away from these intended locations, as shown on Drawing 2.*

The field investigation was conducted from 1990 07 31 to 1990 08 03, using a bombardier mounted CME 55 hollow stem drilling machine. At certain depths in some boreholes, washboring techniques were employed, along with tri-cone drilling, to advance the boreholes through very dense or hard strata. On 1990 07 24, hand auger boreholes were attempted in areas not accessible to the drilling machine.

1. Physiography of Southern Ontario, 3rd ed. OGS Special Vol. 2, p. 93

A total of seven sampled boreholes were drilled (BH's: 2, 3, 4, 5, 6, 8, 9). Boreholes 1 and 7 were drilled by means of a hand auger, and sampled with a small diameter piston sampler. Near Boreholes 2 and 6, dynamic cone penetration resistance tests were performed. Within Borehole 8, a dynamic cone test was attempted when the borehole could not be advanced due to artesian pressure related problems.

Borehole 3 was drilled to determine the soil conditions for the proposed Reynolds Creek channel re-alignment. Boreholes 8 and 9 were drilled from the existing interchange ramp loop fills because access to the east side of the culvert, both north and south of Highway 401, was impossible given the heavy tree growth and soft terrain conditions at the time of this investigation. Boreholes 4 and 5 were drilled to determine the soil conditions below the proposed interchange ramp fills. The end result is that only Boreholes 2 and 6 are located close to the existing culvert, and only on its west side. However, the soil conditions across the valley are uniform; therefore, reliable interpolations of the soil conditions on the east side of the culvert may be made from representative cross-sections across the creek channel.

Samples of the overburden were obtained in the split-barrel sampler, the N values being noted for the Standard Penetration Test in blows/0.3m. Where feasible, thin walled tube samples were obtained in cohesive portions of the overburden. An MTO specification field vane was used with fish scales to apply a coupled torque for the measurement of undrained in situ shear strength in cohesive strata.

Bedrock was not reached in any of the boreholes.

In the laboratory, all soil samples were examined visually. Index property tests, such as moisture contents, Atterberg limits and grain size distributions were conducted on selected specimens. Some thin walled samples were extruded. Tests were conducted on some of the extruded specimens for consolidation and undrained shear strength characterization of the cohesive stratum.

The laboratory test results are shown in Figures 1 to 5 and on the Borehole Log Sheets in the Appendix.

Groundwater levels were monitored on a daily basis and a week after completion of drilling. The last recorded levels are shown on the Borehole Log Sheets.

In Borehole 2, a sealed perforated standpipe was installed to measure an artesian head condition.

4.0 SUBSURFACE CONDITIONS

4.1 General

Below fill or surficial organics, the predominant soil of concern is a laminated clayey silt stratum which is underlain by a silty sand glacial till overlying a sandy gravel deposit. Artesian groundwater conditions were encountered within the silty sand and underlying strata. Details follow.

4.2 Organics and Fill Materials

Organic soils were encountered in Boreholes 1, 4, 5, 6, and 7 at the surface. They range from peat (at Borehole 7) to topsoil and surficial sandy, flood plain type of deposits, mixed with vegetative organics. The thickness of these surficial organic materials ranged from 2.9m at Borehole 7 to 1.0m at Borehole 6.

Moisture content determinations show a range in values, depending on organic matter content. The values range from 119 per cent for the peat to 15 per cent for the organically contaminated sandy soils.

N values ranged between 5 and 14 blows/0.3m, indicating a loose to compact relative density for the organic sandy soils. The peaty soils are of generally soft consistency.

In Boreholes 8 and 9 which were drilled through the existing interchange ramp fills, the fill material consists of a medium to fine sand (Figure 1), with N values ranging from 4 to over 65 blows/0.3m. In Borehole 8, the fill was found to be underlain, at a depth of 9.4m, by a compressed peat deposit of 700mm thickness, with a moisture content of 26 per cent.

A fill type of material was also encountered in Borehole 2, close to the west side of the north portion of the existing culvert. This material may have originated as a result of construction of the existing culvert. Its thickness was 2.9m, with N values ranging between 5 and 12 blows/0.3m, and moisture contents approaching 30 per cent.

4.3 Clayey Silt

The major soil deposit at this site, from a design viewpoint, is a clayey silt stratum. The stratum was encountered in all machine drilled boreholes at elevations ranging between 259.7m and 260.9m. This uniformity in upper surface elevation indicates the deposit is widespread and of likely lacustrine origin. Therefore, its existence is suspected also on the east side of the culvert, at about elevation ± 260 m.

This cohesive deposit consists of a clayey silt. The soil has a distinct laminar feature, consisting of fine sand or silt seams of 1mm to 2mm thickness, spaced regularly to irregularly at 25mm to 40mm spacings. In some samples, the laminates appear to have been replaced with pockets of fine sand. This shows that the depositional conditions were not constant, and that turbidity was a major factor during genesis of the stratum.

The total thickness of the deposit ranged between 3.0m at Borehole 2 and 6.6m at Borehole 8, averaging about 5.5m in all boreholes through which the deposit was fully penetrated.

The moisture content of the soil was found to range between 16 and 27 per cent. The moisture content shows a tendency to increase with depth in Boreholes 3, 5, and 8 and a slight tendency to decrease with depth in Borehole 6. The observed moisture contents are all above the plastic limit of the soil, and in some cases are equal to the liquid limit, indicating a liquidity index of unity. The plasticity characteristics of the soil are shown in Figures 2A and 2B. The soil is classified as a clayey silt to silt of low plasticity (CL-ML soil).

Standard Penetration Resistance N values generally decreased with depth, ranging between 7 and 20 blows/0.3m in boreholes positioned at prevailing ground surface level. In Boreholes 8 and 9, below the ramp fills, the N values ranged between 15 and 42 blows/0.3m, showing the effects of consolidation over time. Also, the average moisture content of the soil in Boreholes 8 and 9 was a few percentage points below the average moisture content in the other boreholes.

Undrained in situ vane shear testing was attempted in Boreholes 6 and 8. In Borehole 6, a field vane undrained shear strength value of just over 40kPa was measured near the middle of the stratum, some 4.5m below ground surface. At approximately the same elevation in Borehole 8, the field vane could not be turned. In Borehole 6, an unconfined compression test gave an undrained shear strength of 30kPa near mid-thickness. At the same elevation in Borehole 8, the unconfined undrained shear strength was over 70kPa. Near the base of the deposit in Boreholes 6 and 8, the field vane could not be turned. Unconfined compression tests yielded values of the undrained shear strength of between 80kPa and 190kPa.

The result of one oedometer test is shown in Figure 3. The test shows a possible pre-consolidation value of the soil of about between 100kPa and 120kPa. The compression index, C_c , is 0.122. The coefficient of consolidation, c_v , was found to be about 0.5 cm²/min. at stresses ranging between 100kPa and 200kPa.

Based on the above field observations and laboratory tests, the overall consistency of the deposit is estimated to range between firm and very stiff, being generally firm near the middle of the deposit, except below ramp fills, where it is very stiff to hard.

4.4 Silty Sand (Glacial Till)

The clayey silt stratum is underlain by a silty sand deposit (glacial till) occurring between elevations 256.8m at Borehole 2, and 252.5m at Borehole 6. This stratum was not found at Borehole 3 below the clayey silt deposit.

The soil consists of a silty sand, with gravel. Some typical grain size distribution curves are shown in Figure 4, and indicate a range in gravel content of between 3 and 30 per cent. The silt content is generally less than 15 per cent. However, silty zones are present within the deposit, and occur more or less at random.

The thickness of this stratum was found to be between 1.5m and 1.9m in locations where it was fully penetrated (Boreholes 9 and 2 respectively), and over 3.9m at Borehole 6, where the deposit was not fully penetrated.

The moisture content of the stratum ranged between 7 and 14 per cent, being over 25 per cent in a clayey silt contaminated transition zone in Borehole 9.

N values of 43 to over 100 blows/0.3m indicate the deposit is generally dense to very dense. Some low recorded N values are suspected to be the result of "boiling" during sampling due to unbalanced hydrostatic heads and artesian pressure.

4.5 Sandy Gravel

A deposit of sandy gravel was encountered below the silty sand glacial till deposit in Boreholes 2 and 9 at an elevation of about ± 255 m. Typical grain size curves for representative samples are shown in Figure 5. The moisture content of this soil varied between 6 and 12 per cent. N values were generally over 100 blows/0.3m, indicating the deposit to be very dense.

5.0 GROUNDWATER CONDITIONS

Groundwater level observations were made in open boreholes at time of drilling or in piezometers and open standpipes after completion of drilling. These observations show the general phreatic level to be at about elevation ± 260 m.

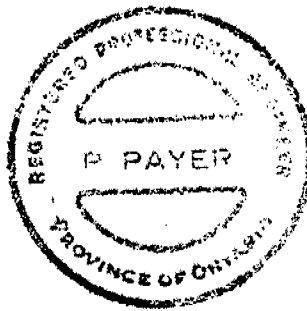
However, artesian heads, reaching up to 2.5m above prevailing ground level were measured at Borehole 2, and are suspected to be the cause of an elevation observation of over 262m at Borehole 8.

CLOSURE

The field work for this investigation was carried out by Ms. Andrea C. Abel, assisted by Mr. Justin Klodner.

The drilling equipment and crew were rented from Atcost Soil Drilling Limited of Concord, Ontario.

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

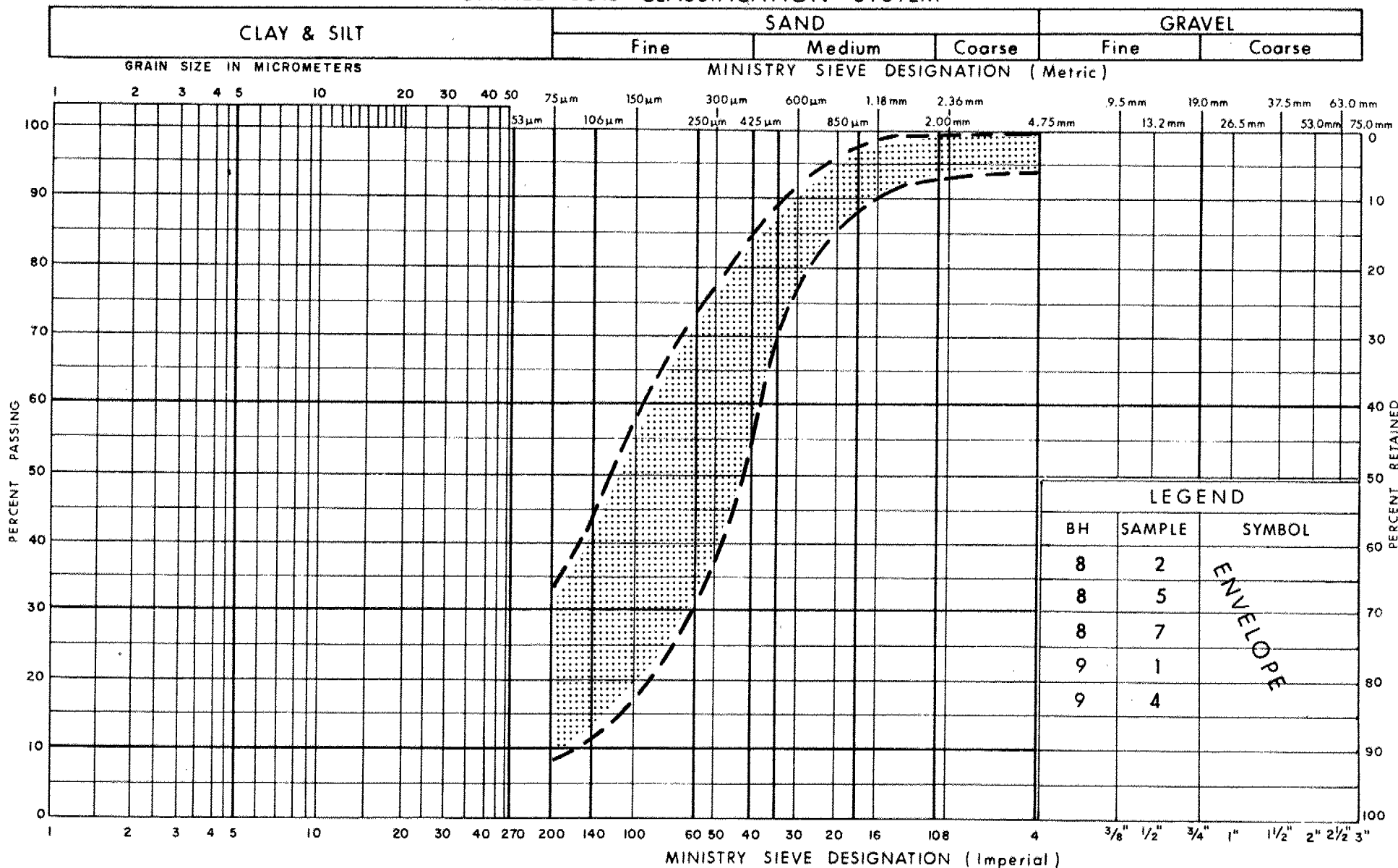


P. Payer, P. Eng.
Senior Foundation Engineer

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

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

Ministry of
Transportation

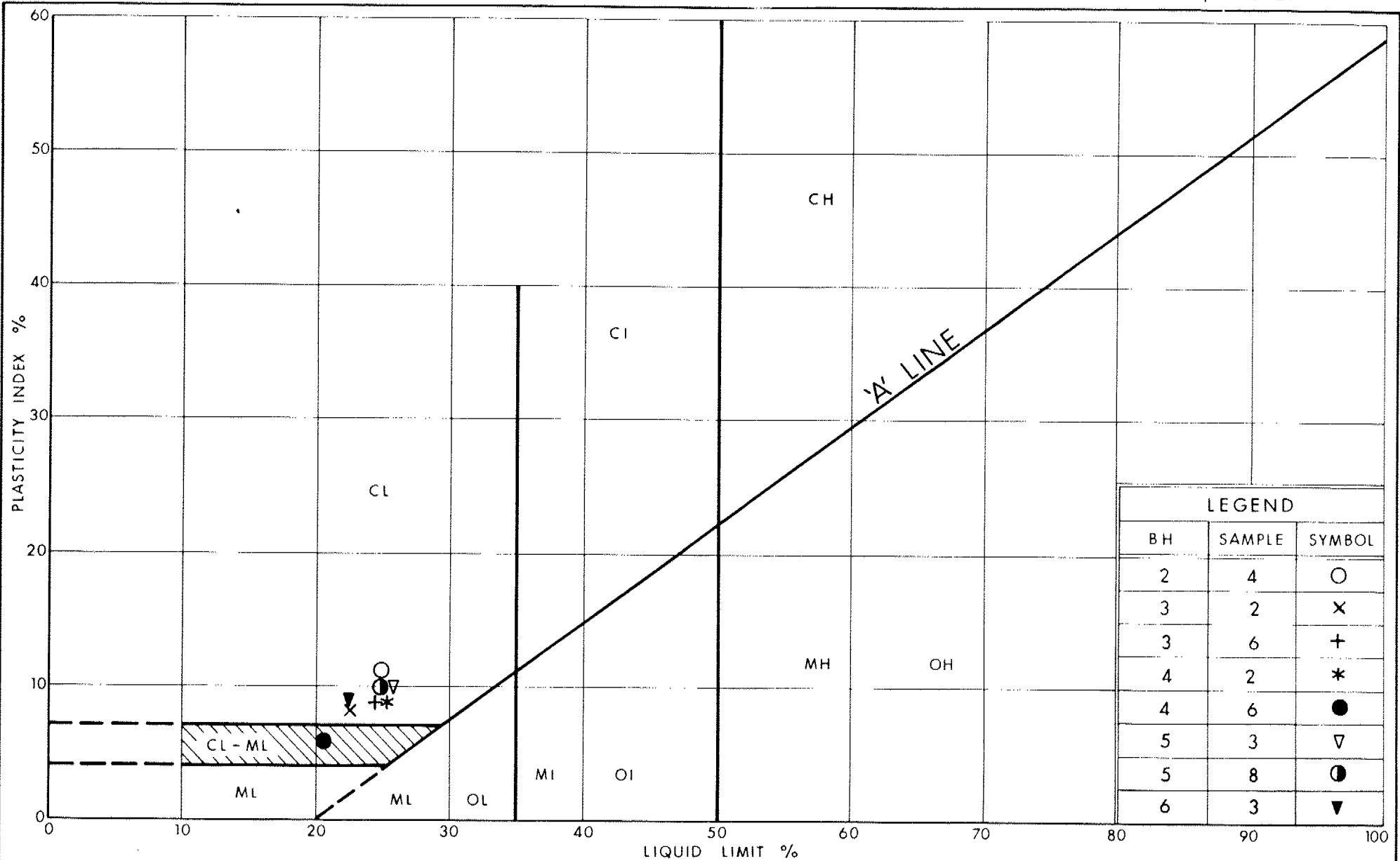
GRAIN SIZE DISTRIBUTION

Sand to Silty Sand (Ramp Fill)

FIG No 1

W P 100-90-01

Site No. 19-305



Ministry of
Transportation
Ontario

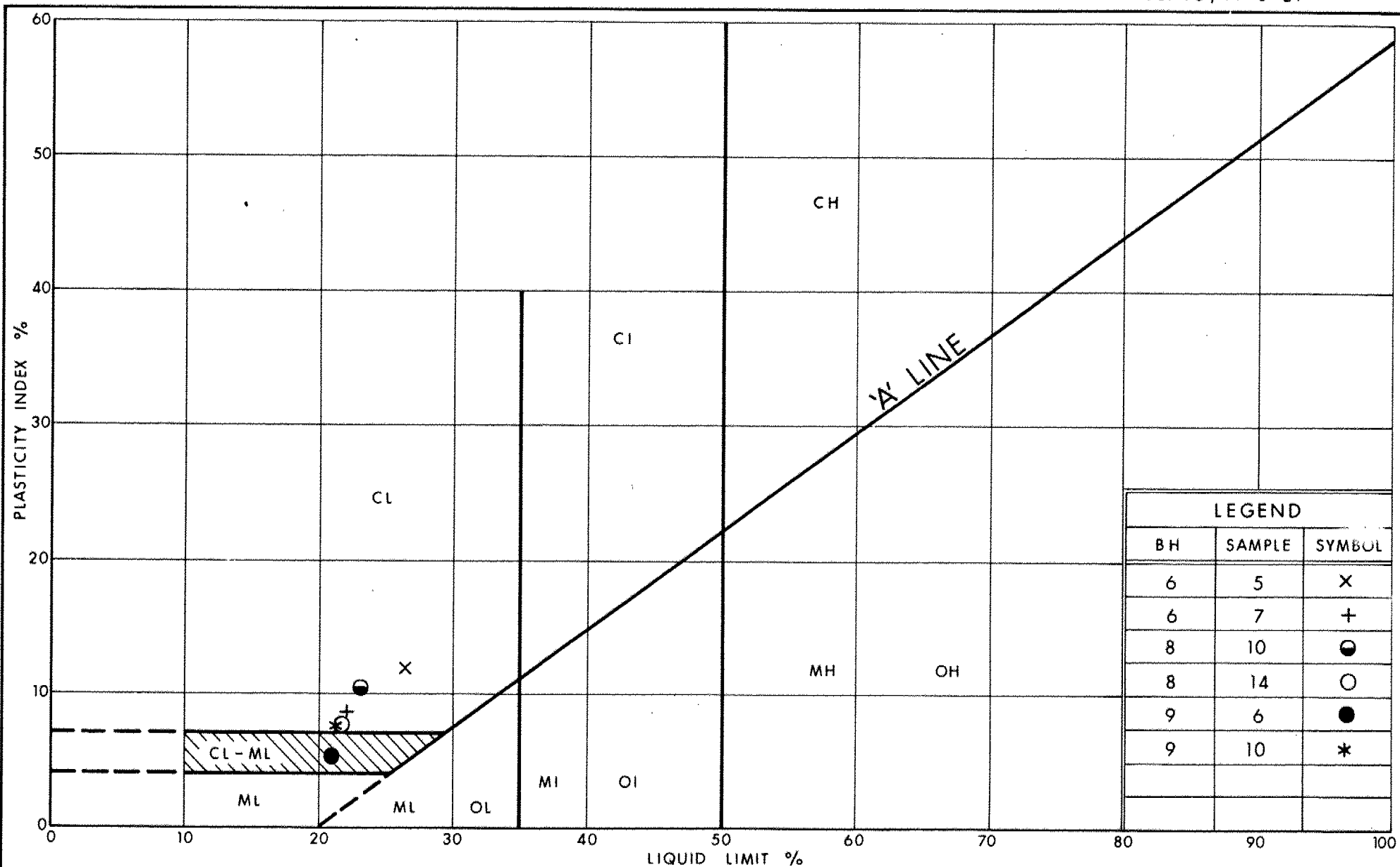
PLASTICITY CHART

Clayey Silt

FIG No 2A

W P 100-90-01

Site No. 19-305



Ministry of
Transportation
Ontario

PLASTICITY CHART Clayey Silt

FIG No 2B

W P 100-90-01

Site No. 19-305

VOID RATIO - PRESSURE CURVES

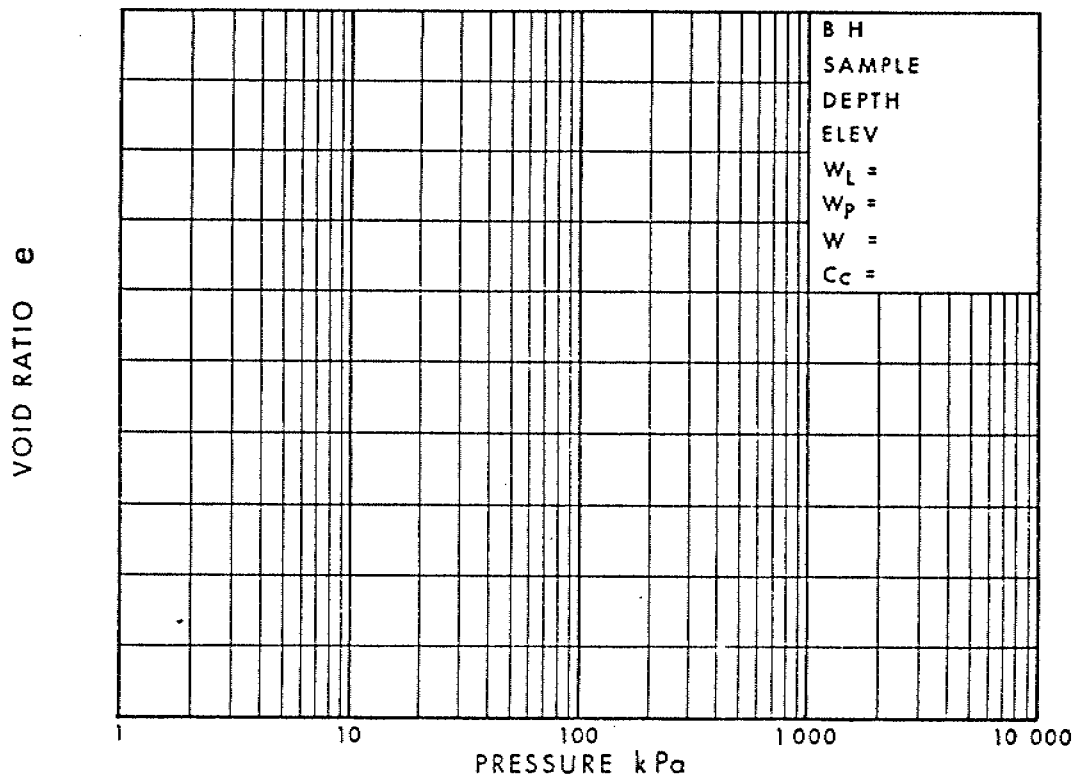
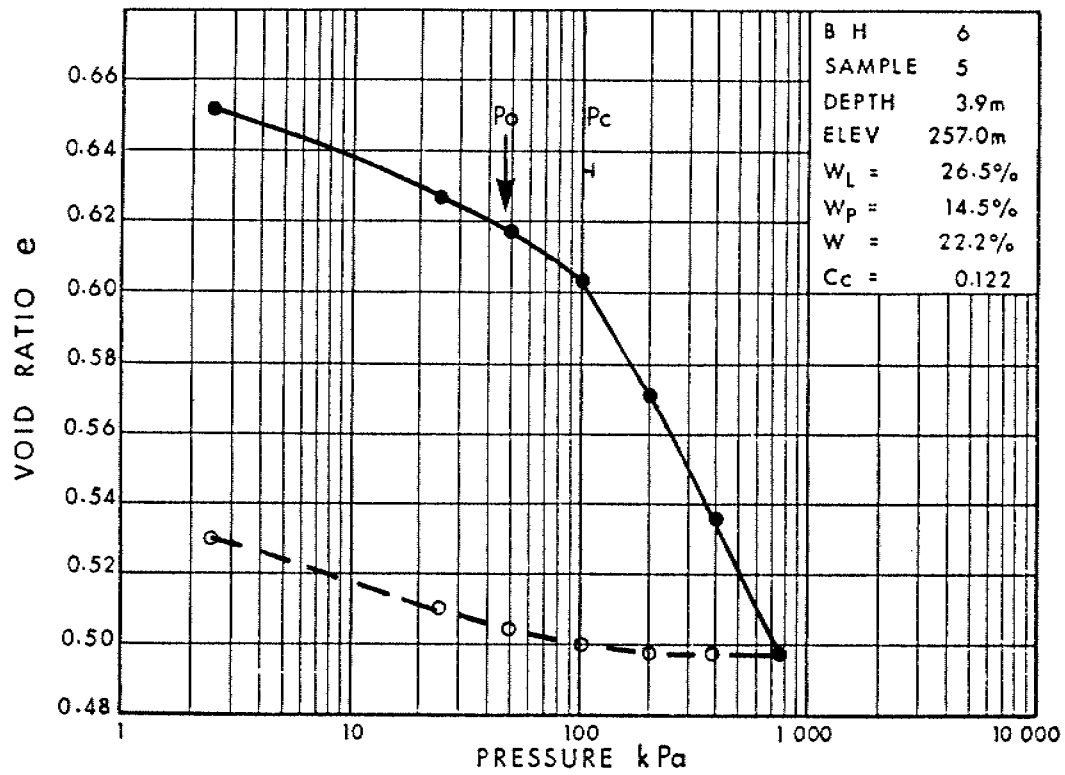
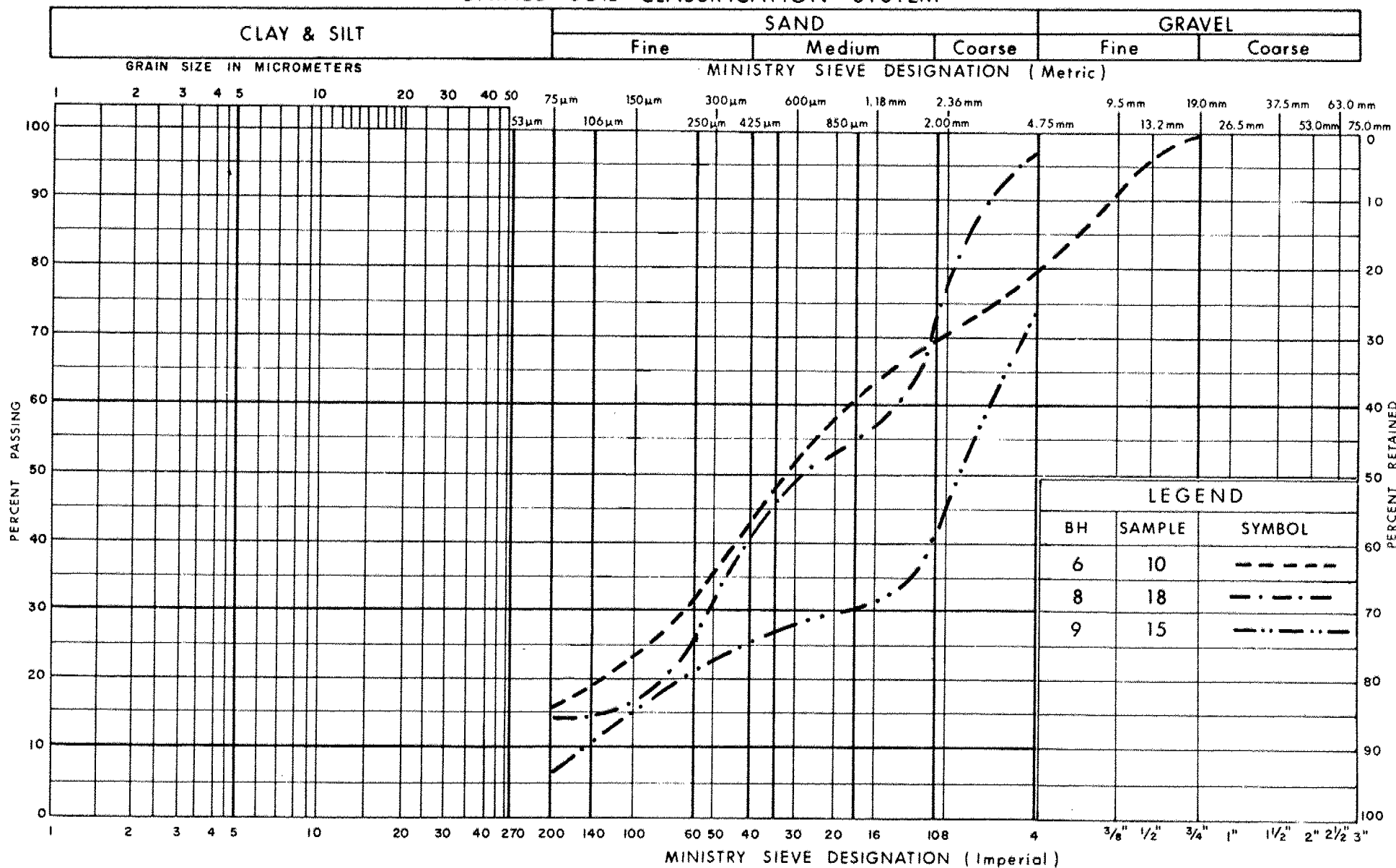


Fig 3

W P 100-90-01

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

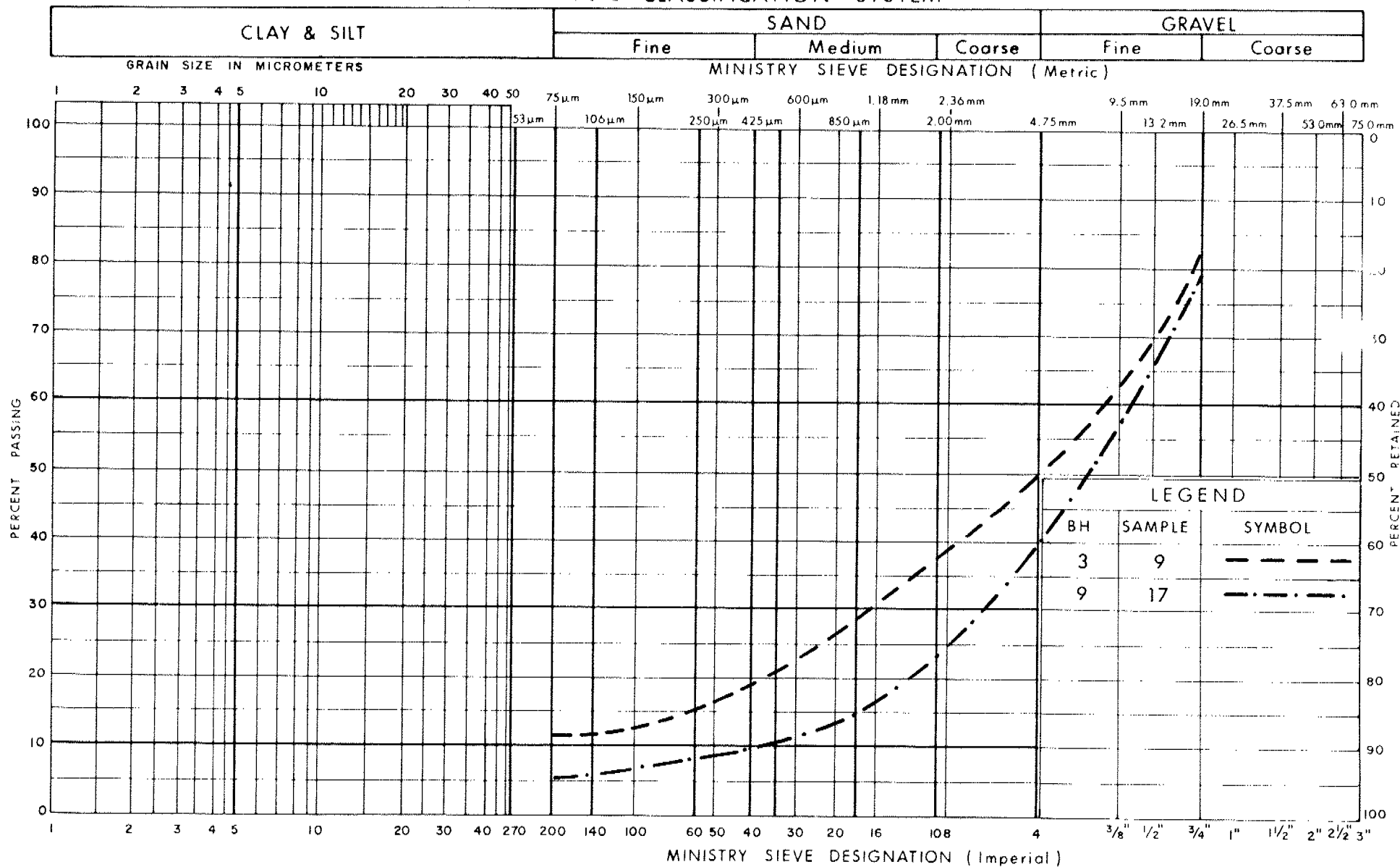
Silty Sand with Gravel
(Glacial till)

FIG No 4

W P 100-90-01

Site No. 19-305

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

Sandy Gravel

FIG No 5

W P 100-90-01

Site No. 19-305

RECORD OF BOREHOLE No1

METRIC 17

W P 100-90-91 LOCATION Co-ords. 4,760,448 N; 186,269 E ORIGINATED BY AA
 DIST 2 HWY 401 BOREHOLE TYPE Hand Auger COMPILED BY AK
 DATUM Geodetic DATE 1990 07 24 CHECKED BY CM

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					
262.1	Ground surface																
0.0	Organic Clayey Silt Brown some sand, Tr. Grav. Soft		1	TP	PM		262										
260.7			2	TP	PM		261										
1.4	Clayey Silt with sand and Occ. gravel - Grey Soft		3	TP	PM		260										
2.6	End of Borehole No further penetration possible with hand auger. * Borehole dry upon completion																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No2

METRIC 18

W P 100-90-01 LOCATION Co-ords. 4,760,373 N; 186,252 E ORIGINATED BY AA
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Test & washboring COMPILED BY AK
 DATUM Geodetic DATE 1990 08 01 CHECKED BY CM

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								
262.7	Ground surface												
0.0	Organic Clayey Silt and Topsoil incl. Firm (Fill)		1	SS	5		262						Water Levels on 1990 08 10
	with Gravel		2	SS	12		261						43 41 (16)
	Stiff		3	SS	11		260						
259.8	Clayey Silt (Laminated)		4	SS	8		259						
2.9	Stiff to Firm		5	SS	7		258						
	Grey		6	SS	7		257						
256.8	Silty Sand to Silt Occ. gravel Tr. clay (Glacial Till) Very Dense Grey		7	SS	100		256						
			8	SS	110		255						Wash casing installed and sampling conducted by triconing to desired depth.
254.9	Sandy Gravel Very Dense Grey		9	SS	101		254						
7.8	End of Borehole												
253.3	Artesian pressure controlled by sealing with "Benseal".												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No3

METRIC 19

W P 100-90-01 LOCATION Co-ords. 4,760,437 N; 186,264 E ORIGINATED BY AA
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AK
 DATUM Geodetic DATE 1990 08 01 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

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	SHEAR STRENGTH kPa					
262.6	Ground surface							○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE					GR SA SI CL
0.0	Sandy Silt with gravel						262							
261.4	Compact Rusty Brown		1	SS	13									
1.2	Clayey Silt (Laminated)		2	SS	18		261							
	Stiff to Very Stiff		3	SS	16		260							
			4	SS	15									
			5	SS	12		259							
			6	SS	12		258							
	Grey		7	SS	8		257							
			8	SS	11									
256.0	Sandy Gravel with silt (Glacial Till)						256							WL on 1990 08 01
255.3	Very Dense - Grey		9	SS	71									52 37 (11)
7.3	End of Borehole													

WL on
1990 08 01

52 37 (11)

RECORD OF BOREHOLE No 4

METRIC 20

W P 100-90-01 LOCATION Co-ords. 4,760,348 N; 186,212 E ORIGINATED BY JK
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AK
 DATUM Geodetic DATE 1990 08 01 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								20 40 60 80 100										10 20 30		
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE													
262.2	Ground surface															GR SA SI C				
0.0	Topsoil & Clayey Silt with organics						262													
261.1	Soft - Firm		1	SS	14															
1.1	Clayey Silt (Laminated)		2	SS	20		261													
	V. Stiff - Stiff		3	SS	14		260													
	Grey		4	SS	17		259													
			5	SS	15		258													
			6	SS	12															
	with Fine Sand partings		7	SS	11		257									WL on 1990 08 01 (not stabili- zed)				
255.9			8	SS	105		256													
6.3	Silty Sand Occ. gravel (Glacial Till) Very Dense Grey						255													
254.3			9	SS	160/	23cm														
7.9	End of Borehole																			

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

RECORD OF BOREHOLE No 5

METRIC 21

W P 100-90-01 LOCATION Co-ords. 4,760,292 N; 186,223 E ORIGINATED BY JK
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AK
 DATUM Geodetic DATE 1990 07 31 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

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					
261.8	Ground surface																
0.0	Silty Sand with organics Compact to Loose Brown		1	SS	11		261										
259.7			2	SS	9		260										
2.1	Clayey Silt (Laminated) Fine Sand Partings at random Stiff - Firm Grey		3	SS	12		259										
			4	SS	12		258										
			5	SS	10		257										
			6	SS	9		256										
			7	SS	9		255										
			8	SS	9		254										
255.0	Silty Sand Occ. gravel (Glacial Till) Very Dense - Grey		9	SS	80/	30cm	254										
253.9																	
7.9	End of Borehole																

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

RECORD OF BOREHOLE No6

METRIC 22

W P 100-90-01 LOCATION Co-ords. 4,760,282 N; 186,268 E ORIGINATED BY JK
DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger and Dynamic Cone Test, Washboring COMPILED BY AK
DATUM Geodetic DATE 1990 07 31 CHECKED BY CM

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					
260.9	Ground surface													GR SA SI CL
0.0	Sandy Silt with organics Topsoil													
259.9			1	SS	13		260							WL on 1990 07 31
1.0	Clayey Silt (Laminated)		2	SS	8		259							
			3	SS	8		258							
	Firm		4	SS	8		257							
			5	TW	PH		256							
	Grey		6	SS	7		255							
	becoming stiff to very stiff with depth		7	SS	8		254							
			8	TW	PH		253							
253.5	Clayey Silt with sand and gravel (Glacial Till) Hard - Grey [Transition Zone]		9	SS	55		252							
252.5							251							
8.4	Silty Sand with gravel (Glacial Till)		10	SS	62		250							
	Very Dense						249							
	Grey		11	SS	181/30cm									20 65 (15)
248.6			12	SS	140/15cm									Wash casing installed Borehole advanced by triconing.
12.3	End of Borehole													



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

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No7

METRIC 23

W P 100-90-01 LOCATION Co-ords. 4,760,205 N; 186,327 E ORIGINATED BY JK
 DIST 2 HWY 401 BOREHOLE TYPE Hand Auger COMPILED BY AK
 DATUM Geodetic DATE 1990 08 01 CHECKED BY CM

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					
260.8	Ground surface																GR SA SI CL
0.0	Peat		1	TP	PM	*	260									87.50	
	Black																
	V. Soft - Soft		2	TP	PM		259									119.0	
	with gravel																
257.9	Firm		3	TP	PM		258									50.30	
2.9	End of Borehole Borehole dry upon completion Further penetration not possible.																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 8

METRIC 24

W P 100-90-01 LOCATION Co-ords. 4,760,385 N; 186,321 E
DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger and Cone Test
DATUM Geodetic DATE 1990 08 02
ORIGINATED BY AA
COMPILED BY AK
CHECKED BY CM

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					
271.0	Ground surface																
0.0																	
	Medium Sand (Fill)		1	SS	33		270										
			2	SS	44		269										1 90 (9)
	Dense to Very Dense																
	Brown		3	SS	33		268										
							267										
			4	SS	101		266										
							265										0 88 (12)
	Silty Sand		6	SS	44		264										
	Occ. gravel		7	SS	68		263										3 63 (34)
	Compact to Very Dense																
	Grey		8	SS	23		262										
261.6			9	SS	34		261										
9.4	Peat Stiff Black		10	SS	42		260										
260.9							259										
10.1	Clayey Silt		11	SS	28		258										
	Occ. Fine Sand Partings		12	SS	24		257										
	Hard to Very Stiff		13	SS	27		256										
	Grey		14	SS	15												
			15	TW	PH												
			16	SS	15												
256.0																	
15.0	Borehole continued...																

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 8 cont'd

METRIC 25

W P 100-90-01 LOCATION Co-ords. 4,760,385 N; 186,321 E ORIGINATED BY AA
DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY AK
DATUM Geodetic DATE 1990 08 02 CHECKED BY CM

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					
256.0	cont. from page 1																
15.0	Clayey Silt occ. Fine Sand Partings Stiff - V. Stiff		17	TW	PH		255									21.0	
254.5																	
16.5	Silty Sand, Occ. gravel (Glacial Till) Compact - Grey		18	SS	25	Artesian Pressure encountered	254										3 83 (14)
253.7																	
17.3	End of Borehole and Cone Test Cone Test conducted since augers were sinking and sand was coming up in them.																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No9

METRIC 26

W P 100-90-01 LOCATION Co-ords. 4,760,261 N; 186,347 E ORIGINATED BY JK
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AK
 DATUM Geodetic DATE 1990 08 03 CHECKED BY CM

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	SHEAR STRENGTH kPa
270.8	Ground surface															GR SA SI CL		
0.0	Medium Sand (Fill) Compact to Very Dense						270											
			1	SS	42		269										4 84 (12)	
							268											
				2	SS	11		267										
								266										
	Brown						265											
							264											
				3	SS	65		263										
							262											
							261											
262.7	Tr. Organics		5	SS	4		260											
8.1	Clayey Silt (Laminated) V. Stiff Occ. fine sand partings						259											
							258											
				6	SS	23		257										
							256											
							255											
	Grey						254											
							253											
				7	SS	21		252										
							251											
							250											
	Stiff						249											
							248											
				8	SS	25		247										
							246											
							245											
258.2	Silty Sand Occ. silty clay zones (Glacial Till) Loose to Compact						244											
12.6							243											
							242											
				9	SS	19		241										
							240											
	Grey						239											
							238											
				10	SS	14		237										
							236											
							235											
255.8	with some gravel		14	SS	19		234											

15.0 Borehole continued...

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 9 cont'd

METRIC 27

W P 100-90-01 LOCATION Co-ords. 4,760,261 N; 186,347 E ORIGINATED BY JK
DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AK
DATUM Geodetic DATE 1990 08 03 CHECKED BY CM

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
255.8	cont. from page 1																
15.0	Silty Sand		15	SS	43		255										26 67 (7)
255.3	Dense (Glacial Till)																
15.5	Sandy Gravel		16	SS	78												
	Very Dense																
	Grey																
253.8			17	SS	130	25cm	254										60 35 (5)
17.0	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

FOUNDATION INVESTIGATION REPORT
For
High Mast Lighting
Highway 401 and Culloden Road Interchange
W.P. 479-89-01, Highway 401
District 2, London

INTRODUCTION

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

The fieldwork for this project was carried out between 91 08 26 and 91 08 28, and comprised of eight sampled boreholes and Dynamic Cone Penetration Test adjacent to these holes.

All the boreholes, with the exception of BH 5, were advanced at the proposed pole locations. However, the boring for pole No. 5 was carried out 5 m northeast of the original location to avoid underground service. Boreholes were advanced to a maximum depth of 14.2 m (Elevation 272.2 m) below the existing ground level using a continuous flight hollow stem auger. However, Dynamic Cone Penetration Test was carried out to a maximum depth of 17.8 m.

SITE DESCRIPTION

The site under investigation is located at the crossing of Highway 401 and Culloden Road in the Township of Southwest Oxford.

The topography of the site, with the exception of the existing crossing (embankment fill) is generally undulating with ridges to the east and northwest.

The ridges are moraines of calcareous clay or silty clay while in the valley, it is common to find alluvium of gravel, sand or silt. Physiographically the area is located in the region known as the "Mount Elgin Ridges".

SUBSURFACE CONDITIONS

General

The extent of the area investigated covers more than 800 m in length and 500 m in width. The subsoil conditions encountered at this site varies from location to location and it is not practical to give detail description for the individual strata. Reference should be made to the Record of Borehole sheets where details of the stratification at a particular boring location are given. However, for classification purposes, the soils encountered at this site can be divided into seven different zones.

- a) Fill
- b) Silty Sand to Sandy Silt Trace/Some Gravel
- c) Gravelly Sand, Trace of Silt
- d) Organic Silt
- e) Clayey Silt to Silty Clay
- f) Sandy Gravel
- g) Sand, Trace of Silt

The subsurface conditions encountered during the course of the investigation, together with the field and laboratory test results are shown on the Record of Borehole sheets contained in the Appendix of this report. The Gradation Test results for sandy or silty material are shown on Figure No.s 1, 2, 3 & 4. The results of the Atterberg Limit Test carried out on clayey soils are shown on Figure No.'s 5 & 6. The location of the boreholes are shown on Drawing No. 4798901-A.*

Groundwater Conditions

The groundwater level measurements were taken in open boreholes during investigation and was observed about 1.9 m to 6.0 m (Elevation 285.3 m to 281.7 m) below the existing ground level. The groundwater level at each borehole is as follows:

* SHEET NO 362-1 OF THE CONTRACT DWG'S

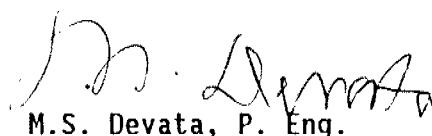
<u>Borehole No.</u>	<u>Elevation</u>	<u>Remarks</u>
1	283.3	Water level after 24 hours
2	284.5	Water level after 24 hours
3	-	Dry on Completion
4	285.3	Water level after 24 hours
5	282.4	Water level after 3 hours
6	281.7	Water level after 24 hours
7	283.1	Water level after 4 hours
8	282.8	Water level after 1 hour

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of M. Vasavithasan. The equipment used was owned and operated by Master Soil Investigation Ltd. This report was prepared by M. Vasavithasan, Foundation Engineer, reviewed by Mr. P. Payer, Senior Foundation Engineer and approved by M. Devata, Chief Foundation Engineer.



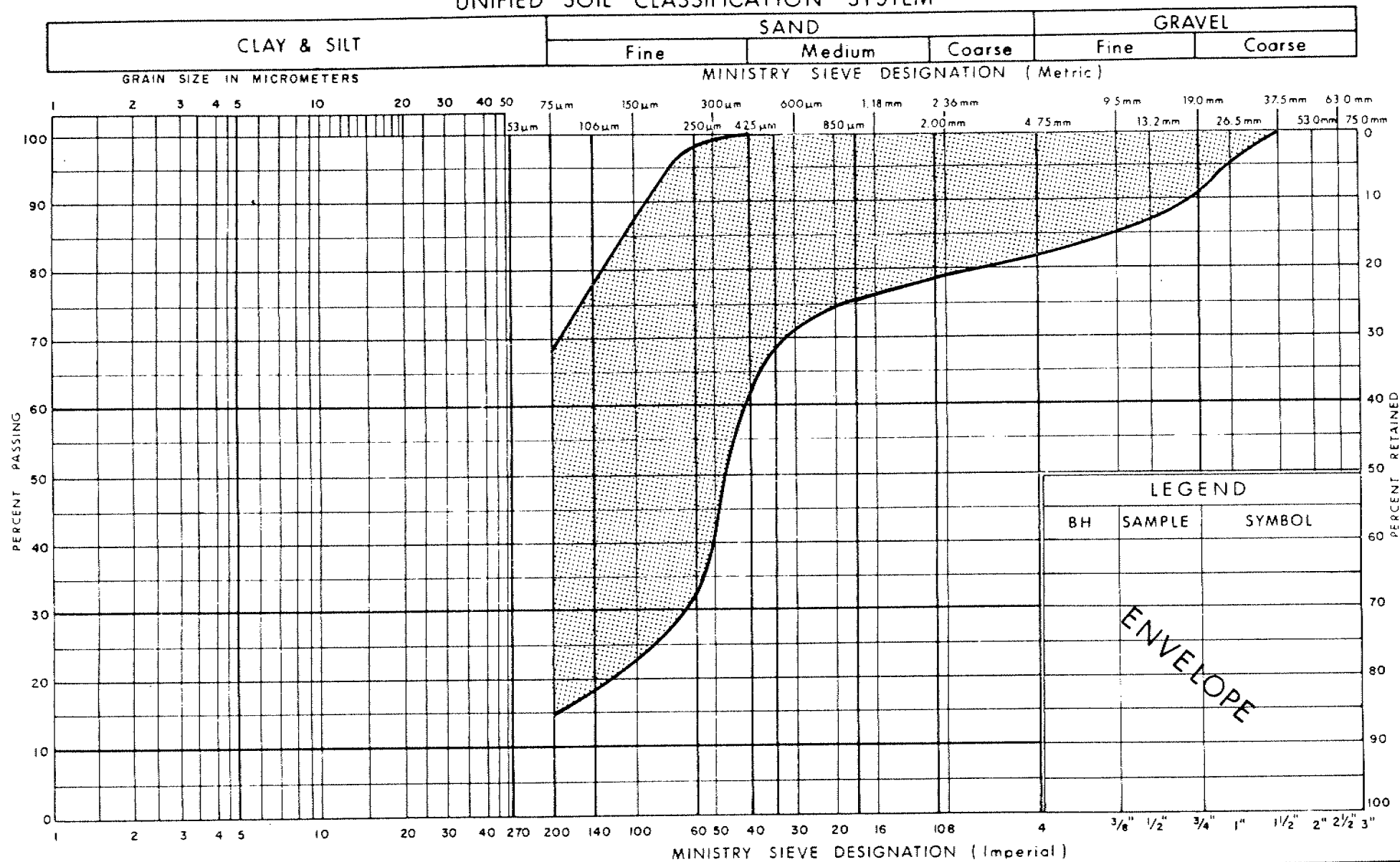
P. Payer, P. Eng.
Senior Foundation Engineer



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

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILTY SAND TO SANDY SILT
TRACE / SOME GRAVEL

FIG No 1

W P 479 - 89 - 01

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

Fine

Medium

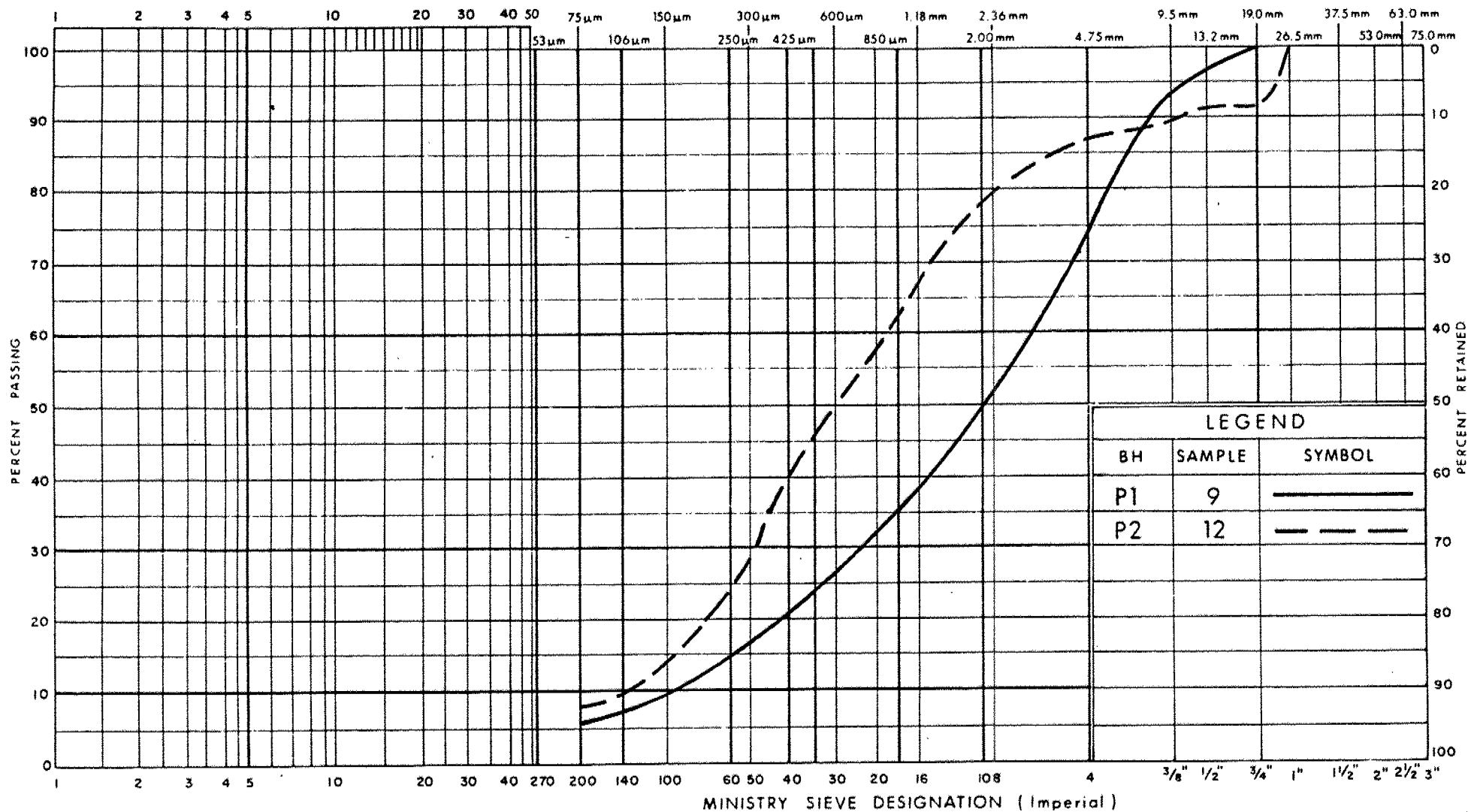
Coarse

Fine

Coarse

GRAIN SIZE IN MICROMETERS

MINISTRY SIEVE DESIGNATION (Metric)



LEGEND

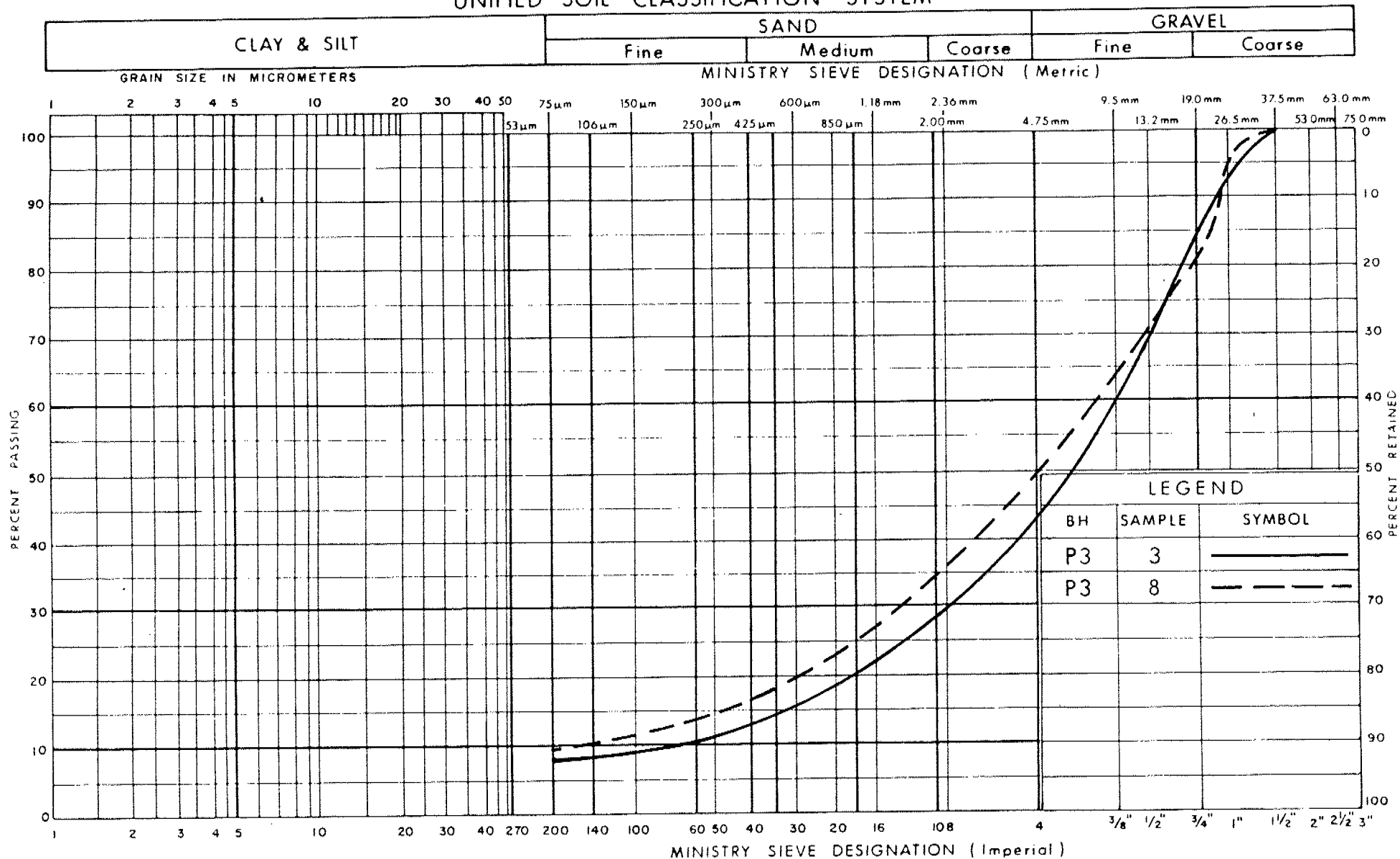
BH	SAMPLE	SYMBOL
P1	9	—————
P2	12	- - - - -

Ministry of
TransportationGRAIN SIZE DISTRIBUTION
GRAVELLY SAND, TRACE OF SILT

FIG No 2

W P 479-89-01

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

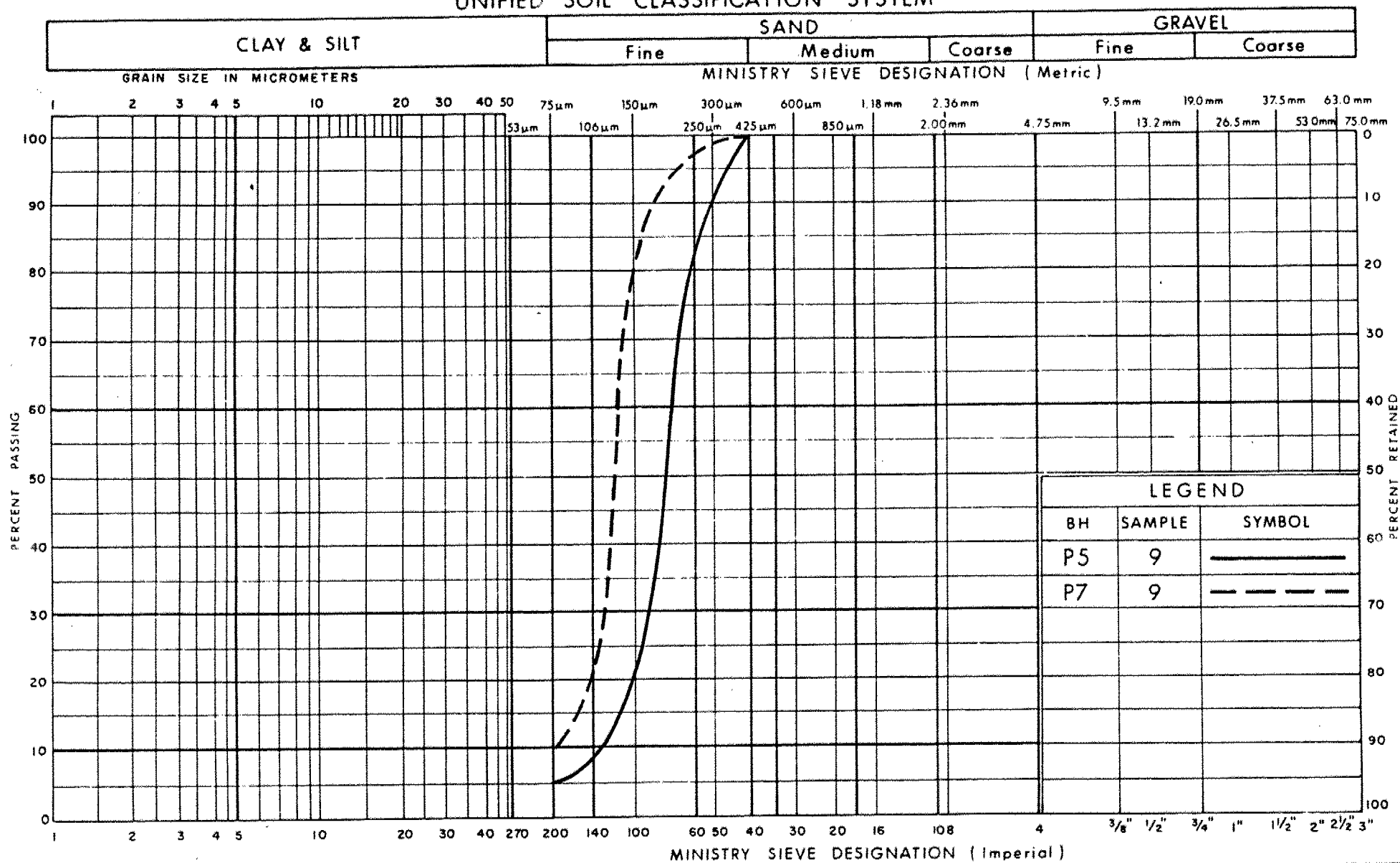
Ontario

GRAIN SIZE DISTRIBUTION
SANDY GRAVEL, TRACE OF SILT, COBBLES

FIG No 3

W P 479 - 89 - 01

UNIFIED SOIL CLASSIFICATION SYSTEM



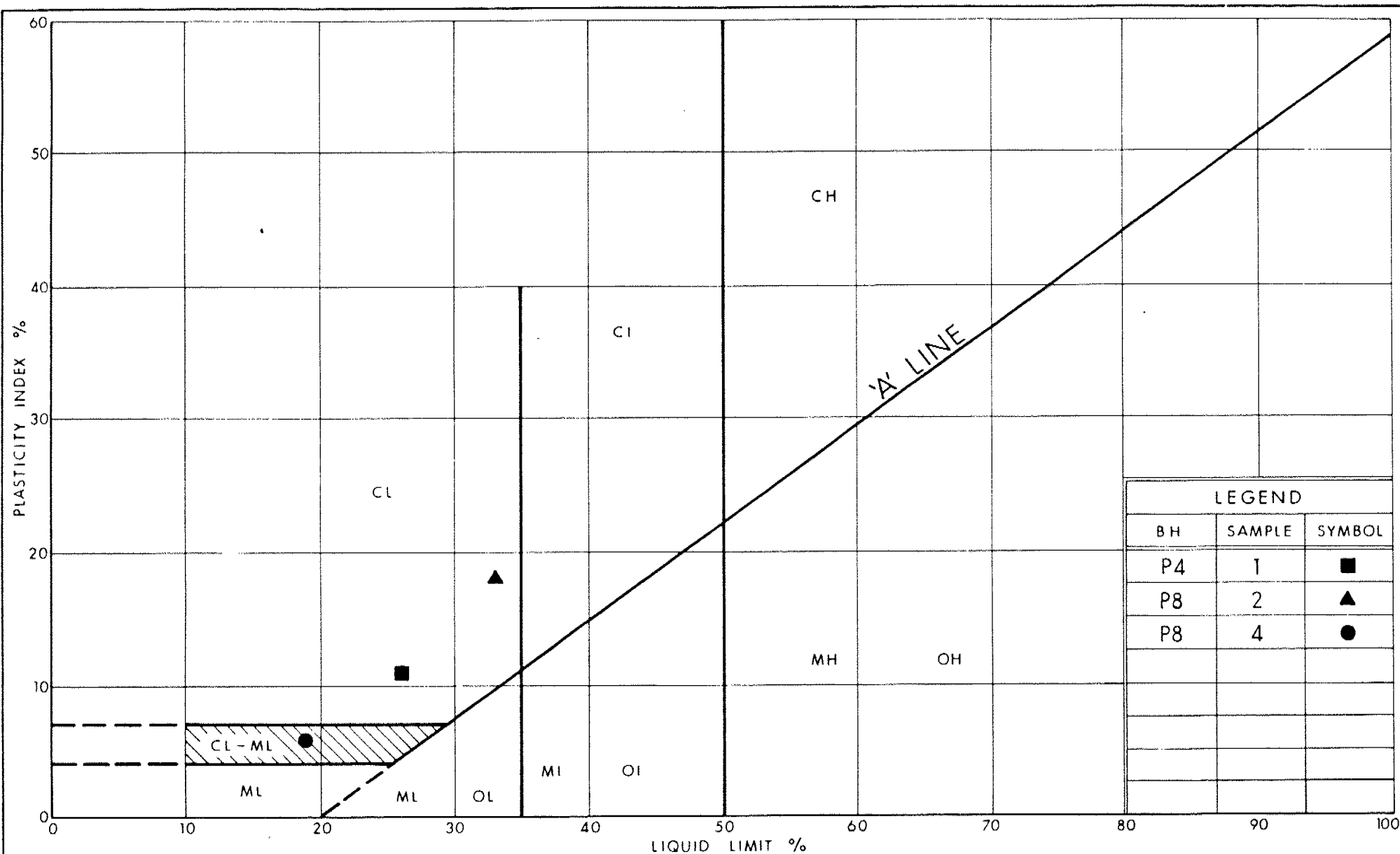
Ministry of
Transportation

Ontario

GRAIN SIZE DISTRIBUTION
SAND, TRACE OF SILT

FIG No 4

W P 479 - 89 - 01



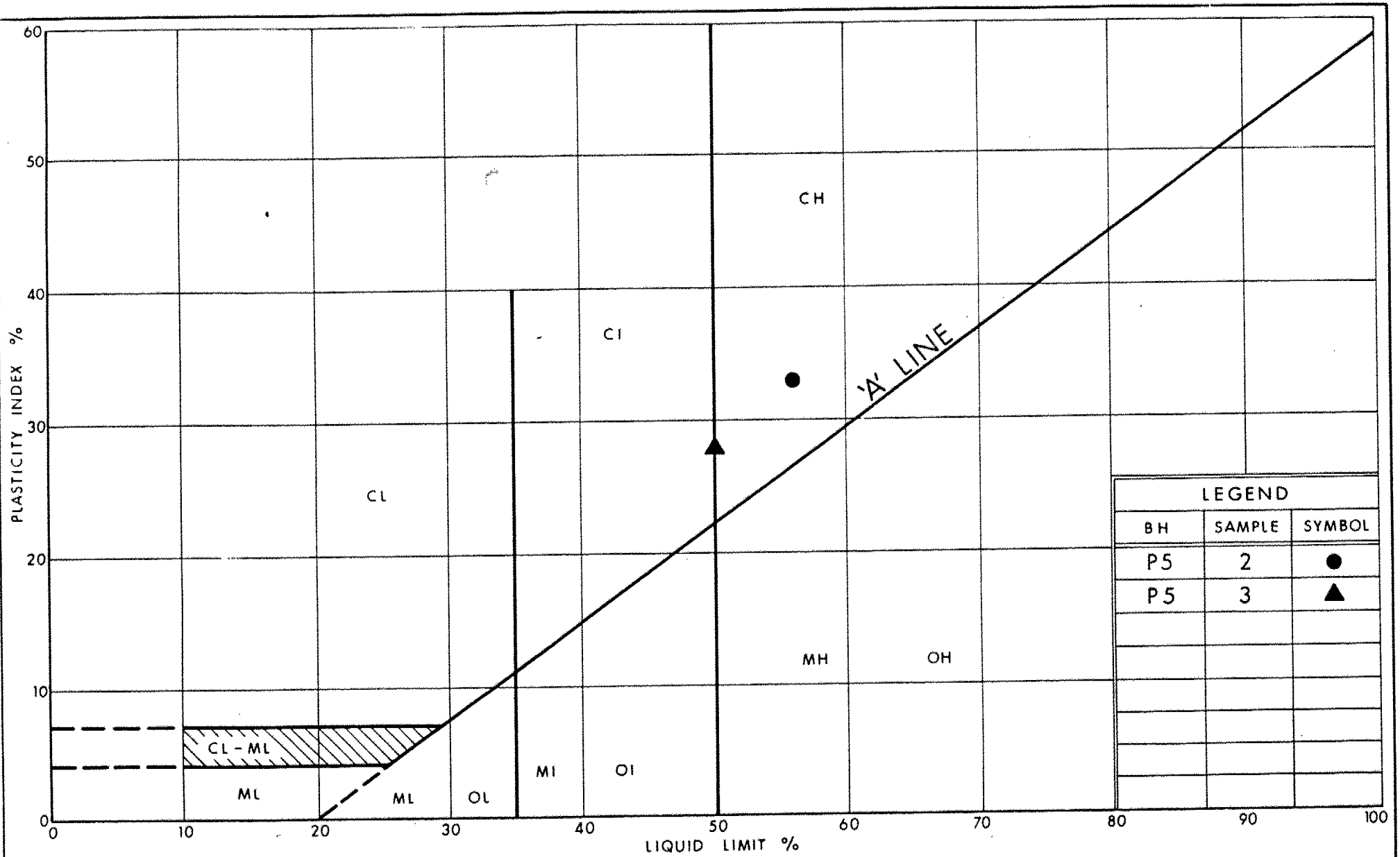
Ontario

Ministry of
Transportation

PLASTICITY CHART CLAYEY SILT

FIG No 5

W P 479-89-01



Ministry of
Transportation

Ontario

PLASTICITY CHART CLAY TO SILTY CLAY

FIG No 6

W P 479-89-01

RECORD OF BOREHOLE No P1

1 OF 1

METRIC 38

W.P. 479 - 89 - 01 LOCATION CO - ORDS. N 4 764 028; E 192 213 ORIGINATED BY M V
DIST 2 HWY 401 BOREHOLE TYPE CONE TEST & CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY M V
DATUM GEODETIC DATE 91 08 27 CHECKED BY P P

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					
285.9	Ground Surface																
0.0	SANDY SILT, Some Gravel, Trace of Organics, Compact, (FHL)		1	SS	11		285										
284.5			2	SS	8		284										0 54 (45)
1.4			3	SS	11		283										
	SILTY SAND to SANDY SILT, trace of Gravel, Loose to Compact		4	SS	18		282										
			5	SS	22		281										
			6	SS	21		280										
			7	SS	24		279										5 26 (69)
			8	SS	22		278										
278.4							277										
7.5	GRAVELLY SAND, Trace of Silt, Compact		9	SS	12												27 67 (6)
276.3			10	SS	-												
9.6	End of Borehole																
	Probable GRAVELLY SAND, Trace of Silt																
273.1																	
12.8	End of Cone Test																
	Note: Water Level 24 Hours After Completion of Drilling																

RECORD OF BOREHOLE No P2

1 OF 2

METRIC 39

W.P. 479 - 89 - 01 LOCATION CO - ORDS. N 4 764 134; E 192 337 ORIGINATED BY M V
DIST 2 HWY 401 BOREHOLE TYPE CONE TEST & CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY M V
DATUM GEODETIC DATE 91.08.27 CHECKED BY P P

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					
286.4	Ground Surface												
0.0	ORGANIC SILT, Some Sand, Trace of Gravel, Occasional Layers of Peat and Partially Decomposed Timber, Soft to Very Soft		1	SS	7								
			2	SS	4								
			3	SS	4								
			4	SS	3								
			5	SS	2								
281.8	SANDY SILT to SILTY SAND, Trace of Gravel, Loose to Compact		6	SS	3								
4.6			7	SS	10								6 44 (50)
			8	SS	6								
			9	SS	22								
			10	SS	30								
274.5	GRAVELLY SAND, Trace of Silt, Compact		11	SS	21								0 3 (87)
11.9			12	SS	-								13 79 (8)
			13	SS	-								
272.2	End of Borehole												
14.2													
271.2													

15.2

Continued

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE

Continued

RECORD OF BOREHOLE No P2

2 OF 2

METRIC

40

W.P. 479 - 89 - 01 LOCATION CO - ORDS. N 4 764 134; E 192 337 ORIGINATED BY M V
DIST 2 HWY 401 BOREHOLE TYPE CONE TEST & CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY M V
DATUM GEODETIC DATE 91 08 27 CHECKED BY P P

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			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	w _p	w		
271.2	Continued															
15.2	Probable GRAVELLY SAND, Trace of silt															
268.6																
17.8	End of Cone Test															
	Note: Water Level 24 Hours After Completion of Drilling															

RECORD OF BOREHOLE No P3

1 OF 1

METRIC 41

W.P. 479 - 89 - 01 LOCATION CO - ORDS. N 4 764 090; E 182 493 ORIGINATED BY M V
DIST 2 HWY 401 BOREHOLE TYPE CONE TEST & CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY M V
DATUM GEODETIC DATE 91 08 26 CHECKED BY P P

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
291.1	Ground Surface															
0.0	SAND, With Gravel, Some Silt, Compact, (Fill)					DRY										
0.7	Organics															
	SILTY SAND, Trace of Gravel, Compact		1	SS	14		290									
			2	SS	12											
289.0							289									
			3	SS	57											
			4	SS	88		288									
			5	SS	71	/15cm	287									
			6	SS	80	/13cm	286									
			7	SS	76	/10cm	285									
	SANDY GRAVEL, Trace of Silt, Cobbles, Very Dense		8	SS	107		284									
			9	SS	81		283									
281.9							282									
9.2	End of Borehole															
	Note: Borehole Dry on Completion															

RECORD OF BOREHOLE No P4

1 OF 1

METRIC 42

W.P. 479 - 89 - 01 LOCATION CO - ORDS. N 4 764 220; E 192 458 ORIGINATED BY M V
DIST 2 HWY 401 BOREHOLE TYPE CONE TEST & CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY M V
DATUM GEODETIC DATE 91 08 26 CHECKED BY P P

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	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								
287.3	Ground Surface												
0.0	Topsoil												
286.5	SANDY SILT, Trace of Gravel, Loose												
0.8	CLAYEY SILT, Tr. of Sand, Tr. of Gravel, Stiff		1	SS	10								
285.9													
1.4			2	SS	22								
			3	SS	12								
			4	SS	31								
			5	SS	16								
			6	SS	16								
			7	SS	21								
			8	SS	25								
			9	SS	26								
			10	SS	17								
277.7													
9.6	End of Borehole												
	* Note: Water Level 24 Hours After Completion of Drilling												

RECORD OF BOREHOLE No P5

1 OF 1

METRIC 43

W.P. 479 - 89 - 01 LOCATION CO - ORDS. N 4 764 402; E 192 519 ORIGINATED BY M V
DIST 2 HWY 401 BOREHOLE TYPE CONE TEST & CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY M V
DATUM GEODETIC DATE 91 08 28 CHECKED BY P P

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT		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	W _p W W _L	WATER CONTENT (%)		
287.0	Ground Surface												
0.0	SANDY SILT, Some Gravel, Trace of Organics, Loose to Compact		1	SS	16		286						
285.9			2	SS	16		285						
1.1	CLAY to SILTY CLAY, Some Sand, Trace of Gravel, Stiff to Very Stiff		3	SS	10		284						
283.7			4	SS	9		283						
3.3	SILTY SAND to SANDY SILT, Trace of Gravel, Compact		5	SS	13		282						
	Silt		6	SS	20		281						
			7	SS	2		280						
			8	SS	24		279						
279.5			9	SS	90								
7.5	SAND, Trace of Silt, Very Dense												
278.9													
8.1	End of Borehole												
278.5													
8.5	End of Cone Test												
	Note: Water Level 3 Hours After Completion of Drilling												

RECORD OF BOREHOLE No P6

1 OF 1

METRIC 44

W.P. 479 - 89 - 01 LOCATION CO - ORDS. N 4 764 562; E 192 475 ORIGINATED BY M V
DIST 2 HWY 401 BOREHOLE TYPE CONE TEST & CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY M V
DATUM GEODETIC DATE 91 08 27 CHECKED BY P P

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					
287.7	Ground Surface												
0.0	SANDY SILT, Some Gravel, Trace of Organics, Compact		1	SS	14								
286.6			2	SS	19								
1.1			3	SS	18								
			4	SS	37								
			5	SS	44								
	SILTY SAND, Some Gravel, Compact to Dense		6	SS	44								
			7	SS	46								
			8	SS	24								
			9	SS	85								
278.6													
9.1	End of Borehole												
278.3													
9.4	End of Cone Test												
	Note: Water Level 24 Hours After Completion of Drilling												

RECORD OF BOREHOLE No P7

1 OF 1

METRIC 45

W.P. 479 - 89 - 01 LOCATION CO - ORDS. N 4 764 496; E 192 643 ORIGINATED BY M.V.
DIST 2 HWY 401 BOREHOLE TYPE CONE TEST & CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY M.V.
DATUM GEODETIC DATE 91 08 28 CHECKED BY P.P.

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					
287.1	Ground Surface													
0.0	SAND With Gravel, Some Silt, Loose to Very Loose (Fill)		1	SS	10									
285.0			2	SS	3									
2.1	CLAYEY SILT, Some Sand, Stiff		3	SS	10									
284.5			4	SS	25									
2.6	SILTY SAND, Some Gravel, Compact to Dense		5	SS	42									
			6	SS	36									
			7	SS	28									
280.9			8	SS	30									
6.2	SAND, Trace of Silt, Dense to Very Dense		9	SS	61									
279.0														0 90 (10)
8.1	End of Borehole Probable SAND													
278.1														
9.0	End of Cone Test													
	* Note: Water Level 4 Hours After Completion of Drilling													

RECORD OF BOREHOLE No P8

1 OF 1 METRIC 46

W.P. 479 - 89 - 01 LOCATION CO - ORDS. N 4 764 602; E 192 771 ORIGINATED BY M.V.
DIST 2 HWY 401 BOREHOLE TYPE CONE TEST & CONTINUOUS FLIGHT HOLLOW STEM AUGER COMPILED BY M.V.
DATUM GEODETIC DATE 91 08 28 CHECKED BY P.P.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	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								
287.7	Ground Surface												
0.0	SANDY SILT, Trace of Gravel, Loose		1	SS	6		287						
286.3							286						
1.4	CLAYEY SILT, Occasional Silt & Sand Seams, Stiff to Very Stiff		2	SS	10		285						
			3	SS	16		284						
284.3			4	SS	15		283						
3.4			5	SS	22		282						
			6	SS	11		281						
			7	SS	9		280						
			8	SS	16		279						
	SILTY SAND to SANDY SILT, Trace of Gravel, Loose to Compact		9	SS	18		278						
			10	SS	32		277						
			11	SS	25								
276.6													
11.1	End of Borehole												
276.1													
11.6	End of Cone Test												
	Note: Water Level 1 Hour After Completion of Drilling												

FOUNDATION INVESTIGATION REPORT

W.P. 479-89-02, Bridge Site No: 19-306

Proposed Structure Extension

Hwy. 401 - Putnam Road and CPR Overpass

District 2, London

Ministry of Transportation, Ontario

1.0 INTRODUCTION

Strata Engineering Corp. has been retained by the Foundation Design Section of the Ministry of Transportation, Ontario, under Consultant Agreement No: 4240-9190-090, to conduct a foundation investigation for a proposed extension to an existing overpass structure which carries Highway 401 across Putnam Road and a CPR siding track. The terms of reference were to investigate the site by means of sampled boreholes and dynamic cone penetration tests, and to provide a full geotechnical report in advance of the issuance of E-Plans for the site.

2.0 SITE AND GEOLOGY

The site is located on Highway 401 at Interchange No. 208, in North Oxford Township, County of Middlesex, about 21km east of London.

The terrain in this area is flat to gently undulating.

This site lies in an area where two physiographic regions of southern Ontario intersect, namely the Mount Elgin Ridges and the Oxford Till Plain.

The dominant geomorphological feature of the site is a north-south tending spillway breached into the east-west tending Ingersoll Moraine. Outwash flow occurred from south to north through the breached channel.

The major soil types in this area are therefore ice-contact stratified drift related to the Ingersoll and Westminster Moraines, and the outwash materials through the spillway.

Drift thickness and bedrock topography maps indicate a depth to bedrock in this area of some 30m below ground surface. The bedrock has been mapped as dolomites and limestones of the Detroit River Group of Middle Devonian Age.

3.0 FIELD AND LABORATORY WORK

At the time of assignment of the project, an ETR plan was supplied showing the proposed structure extensions on the north and south sides of Highway 401. After clearing all underground utilities, boreholes were laid out to coincide with the ends of the proposed extensions. Borehole locations are shown on Drawing 2.

The field investigation was conducted from 1990 07 25 to 1990 07 27, using a bombardier mounted CME 55 hollow stem auger drilling machine. At certain depths in some boreholes, washboring techniques were employed, along with tri-cone drilling, to advance the boreholes through very dense or hard strata.

A total of four sampled boreholes were drilled (Boreholes 1, 2, 3 and 6). Near Borehole 6, a dynamic cone penetration resistance test was conducted. Two additional cone tests were performed at locations shown as Boreholes 4 and 5 to supplement the soils data from the sampled boreholes.

Bedrock was not reached in any of the boreholes.

Samples of the overburden were obtained in the split-barrel sampler, the N values being noted for the Standard Penetration Test in blows/0.3m.

In the laboratory, all soil samples were examined visually. Index property tests, such as moisture contents, Atterberg limits and grain size distributions were conducted on selected specimens. The laboratory test results are shown in Figures 1 to 5, and on the Borehole Log Sheets in the Appendix.

Groundwater levels were monitored on a daily basis and a week after completion of drilling. The last recorded levels are shown on the Borehole Log Sheets.

Sealed perforated standpipes were installed to measure artesian head conditions in Boreholes 1 and 3, where artesian groundwater conditions were suspected to be the cause of blockage and seizure of the hollow stem augers.

4.0 SUBSURFACE CONDITIONS

4.1 General

Below road fill materials adjacent to Putnam Road and the CPR tracks, the predominant soil deposit is a silty sand to sandy silt which is underlain by very dense coarse sand. The details follow.

4.2 Fill Material

Fill material, comprising sand and gravel with some concrete debris, and ranging in thickness between 0.9m and 1.5m, was encountered from surface downwards in all sampled boreholes. It is inferred to be also present at the cone test locations. The moisture content of the fill material ranged between 4 and 8 per cent. N values varied between 13 and 53 blows/0.3m indicating a relative density of compact to very dense.

Typical grain size distribution curves of the fill material are given in Figure 1.

4.3 Sandy Silt to Silty Sand

The major soil deposit at this site is a sandy silt to silty sand stratum, which occurs at between elevations 259.4m and 265.0m across the site. The thickness of this deposit ranges at the sampled borehole locations between about 6 and 8 metres.

The moisture content of the soil was found to be quite variable, depending on position above or below the water table, silt content, and the presence of clayey silt lenses. Values obtained ranged between 4 and 30 per cent. The moisture content tends to increase with depth in Boreholes 2 and 3.

Grain size distribution curves for this deposit are given in envelope form in Figure 2.

The deposit has randomly occurring lenses or seams of slightly cohesive silt and clayey silt. The clayey silt was encountered only in Borehole 1 at a depth below ground surface of about 6m. It had a total thickness of about 1m. Atterberg Limits for the silt and clayey silt are given respectively in Figures 3 and 4.

Standard Penetration Resistance N values in this stratum generally decreased with depth, ranging between 53 and 11 blows/0.3m. On the basis of these N values the deposit is considered to be compact to very dense, being generally compact. The clayey silt layer in Borehole 1 is considered to be of stiff consistency, based on tactile examination of the recovered sample.

4.4 Coarse Sand

The sandy silt to silty sand stratum is underlain by a coarse sand deposit whose thickness was found to be 6m at Borehole 3 and over 7m at Borehole 1. The layer was not fully penetrated at all borehole locations, and therefore its thickness could not be established conclusively.

The moisture content of the stratum averages about 15 per cent. A grain size distribution envelope for the soil is given in Figure 5, and shows the presence of gravel in varying proportions in some samples.

The N values in this deposit increased with depth, ranging from 33 blows/0.3m near the upper horizon to over 100 blows/0.3m at depth. These observations indicate a compact to very dense deposit.

4.5 Sandy Silt (Glacial Till)

In Borehole 3 only, the coarse sand stratum was found to be underlain by a sandy silt with some clay (glacial till). This deposit may represent a discontinuous stratum present at random below or within the coarse sand outwash deposit. One N value of 90 blows/0.3m is indicative of the very dense character of this soil.

5.0 GROUNDWATER CONDITIONS

Groundwater level observations were made in open boreholes at time of drilling or in piezometers and open standpipes after completion of drilling. These observations show the general phreatic level to be at about elevation $\pm 264\text{m}$.

In the sealed perforated standpipes, the groundwater level was observed to be at elevation 263.6m.

During advancement of the boreholes, sand and fine gravel entered the hollow stem augers, even with the plug in place during advancement. Attempts to limit entry of sediment into the hollow stems with a positive head of water in the stem shaft did not prevent upward movement of the soil into the augers. From these observations, it is suspected that sub-artesian conditions may be prevalent within the lower coarse sand deposit.

CLOSURE

The field work for this investigation was carried out by Ms. Andrea C. Abel, assisted by Mr. Justin Klodner.

The drilling equipment and crew were rented from Atcost Soil Drilling Limited of Concord, Ontario.

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

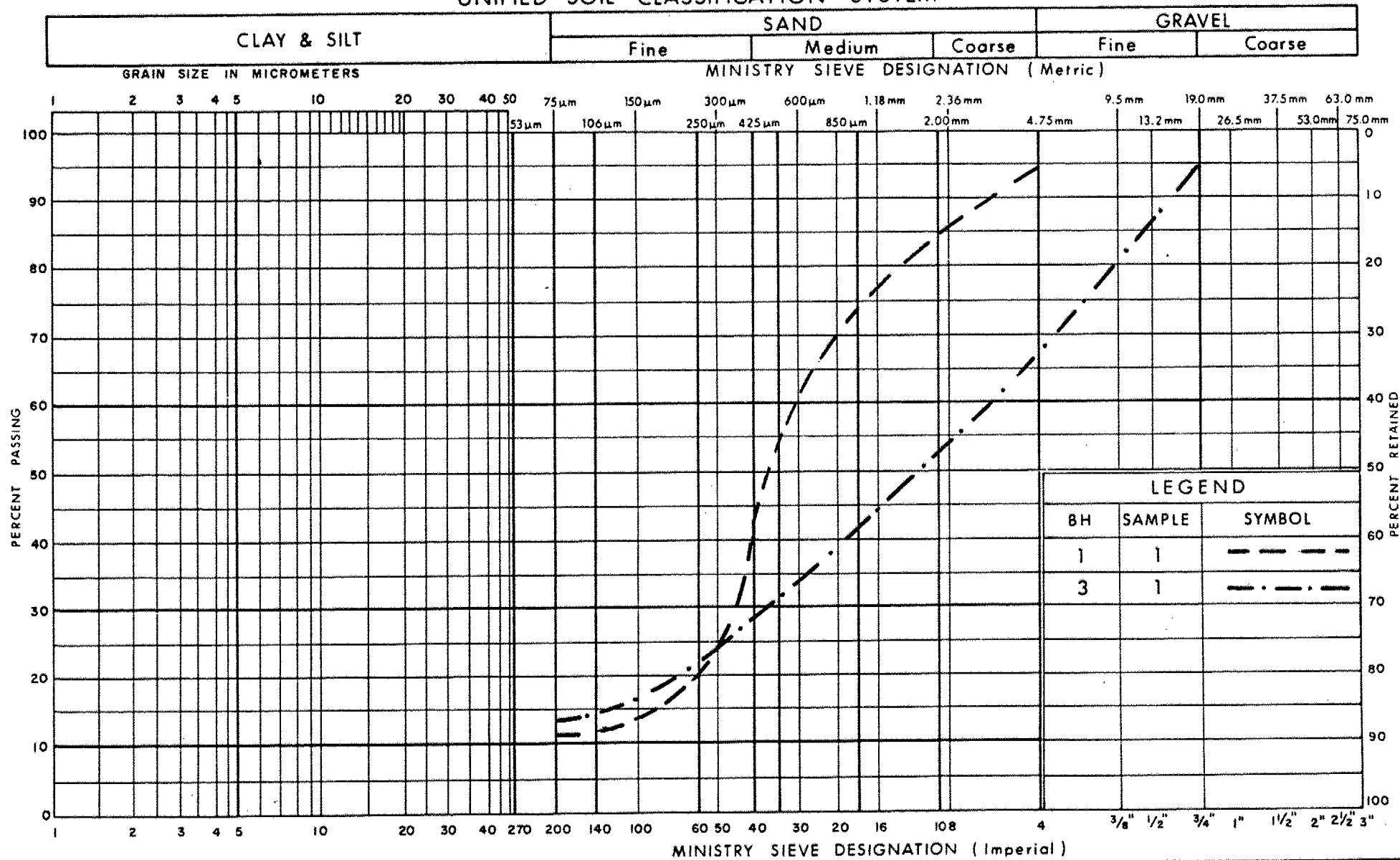


P. Payer
P. Payer, P. Eng.
Senior Foundation Engineer

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

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

Ontario

GRAIN SIZE DISTRIBUTION

Sand and Gravel (Road Fill)

FIG No 1

W P 479-89-02

SITE No: 19-306

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

Fine

Medium

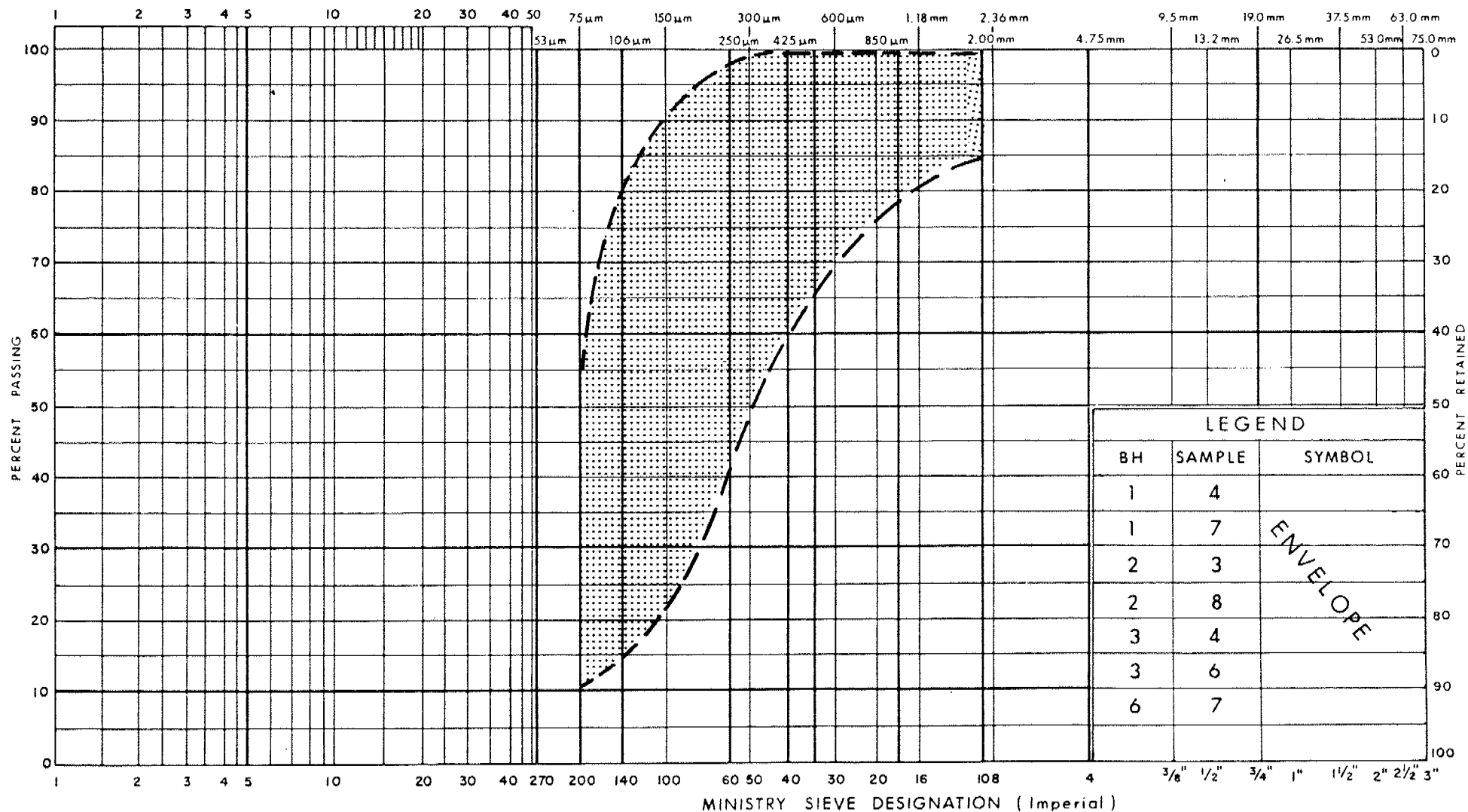
Coarse

Fine

Coarse

GRAIN SIZE IN MICROMETERS

MINISTRY SIEVE DESIGNATION (Metric)



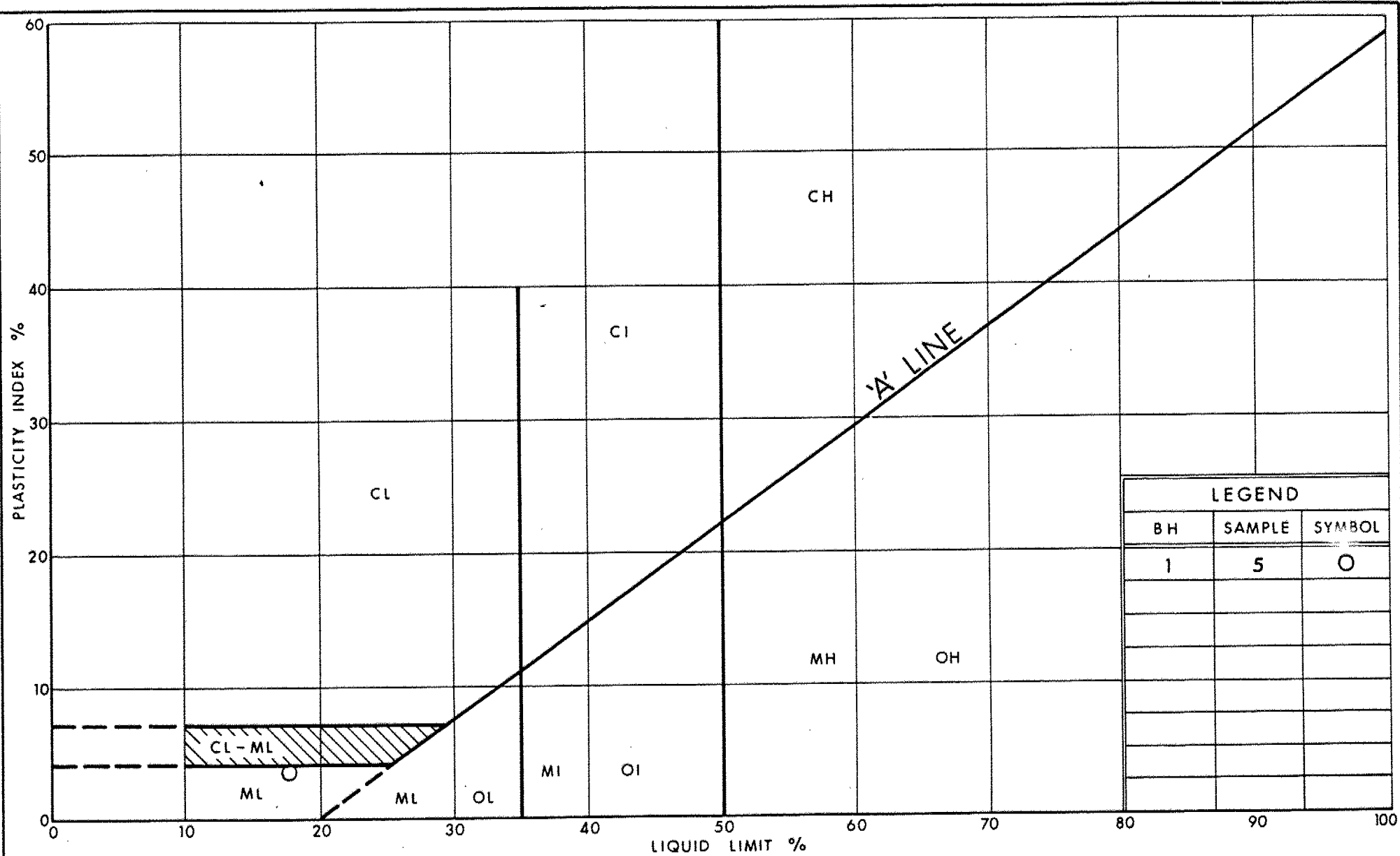
MINISTRY SIEVE DESIGNATION (Imperial)

Ministry of
TransportationGRAIN SIZE DISTRIBUTION
Sandy Silt to Silty Sand

FIG No 2

W P 479-89-02

Site No. 19-306



Ministry of
Transportation

Ontario

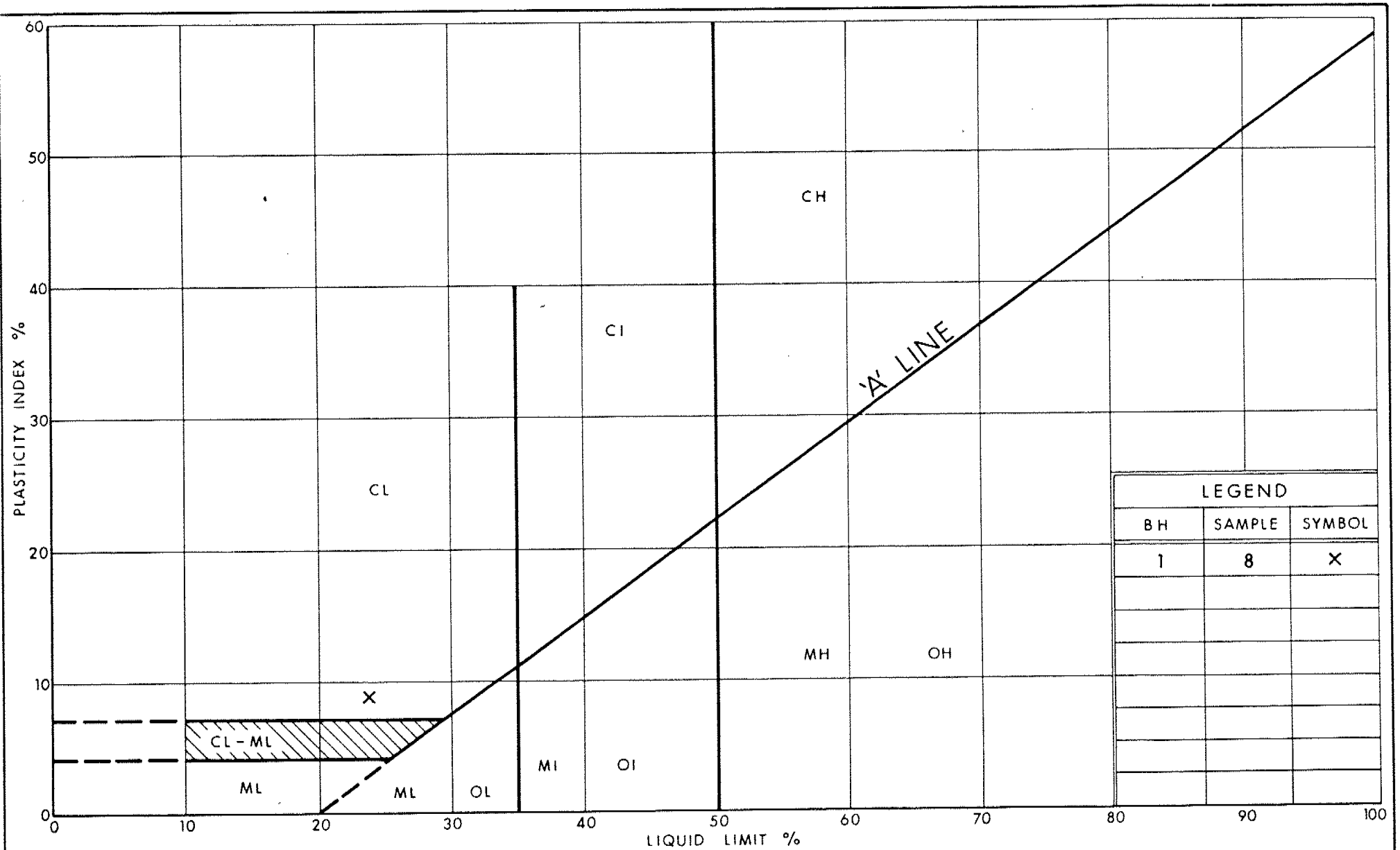
PLASTICITY CHART

Silt

FIG No 3

W P 479-89-02

Site No. 19-306



Ministry of
Transportation
Ontario

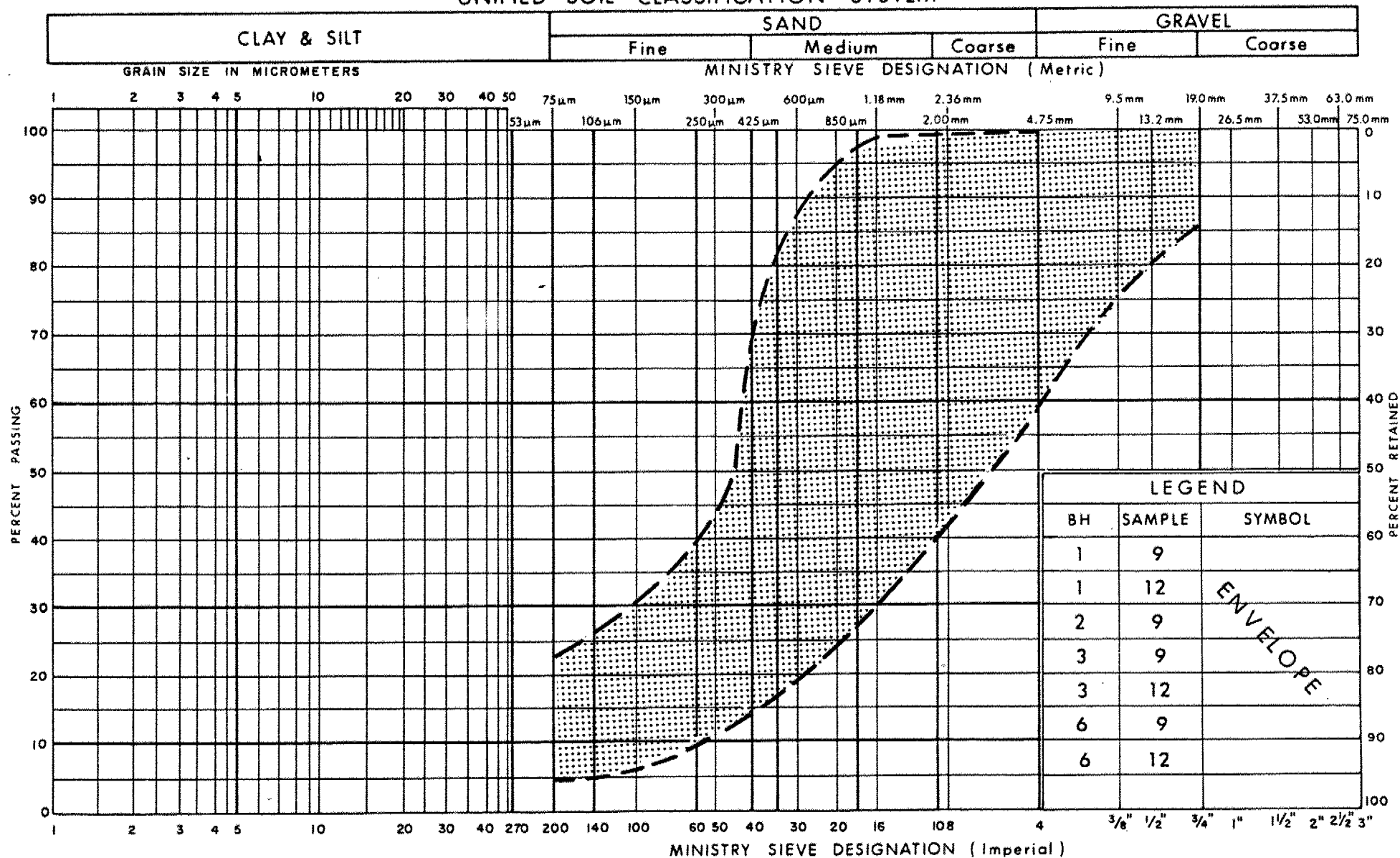
PLASTICITY CHART Clayey Silt

FIG No 4

W P 479-89-02

SITE No: 19-306

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

Coarse Sand with Gravel

FIG No 5

W P 479-89-02

Site No. 19-306

RECORD OF BOREHOLE No 1

METRIC

W P 479-89-02 LOCATION Co-ords. 4 760 392 N; 186 463 E ORIGINATED BY AA
DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger & Wash Boring & Tricone COMPILED BY AK
DATUM Geodetic DATE 1990 07 25 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa		W _p	W	W _L		
								20 40 60 80 100						
								○ UNCONFINED + FIELD VANE						
								● QUICK TRIAXIAL x LAB VANE						
265.8	Ground Surface													GR SA SI CL
0.0	Silty Sand with concrete debris (Road Fill)		1	SS	28		265							5 84 (11)
264.4														
1.4	Sandy Silt to Silty Sand		2	SS	20		264							WL on 1990 08 10
	Compact		3	SS	21		263							
	Brown													
	Grey to Brown		4	SS	23									0 9 (91)
	Brown		5	SS	13	Seal	262							
	Compact to Dense		6	SS	28		261							
			7	SS	53		260							0 61 (19)
260.0														
5.8	Clayey Silt some Sand		8	SS	17		259							
259.1	Very Stiff Grey													
6.7	Gravelly Sand						258							42 53 (5)
	Grey Dense		9	SS	37		257							
	Coarse Sand trace Silt Dense to Very Dense		10	SS	35		256							
	Grey													
			11	SS	80	Seal	255							Wash casing installed
							254							
			12	SS	81		253							0 96 (4)
							252							
250.8			13	SS	115	Standpipe	251							

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

RECORD OF BOREHOLE No2

METRIC

W P 479-89-02 LOCATION Co-ords. 4 760 398 N; 186 498 E ORIGINATED BY JK
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger and Wash Boring COMPILED BY AK
 DATUM Geodetic DATE 1990 07 26 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								20	40						
266.2	Ground surface														
0.0	Sand, Gravel Tr. asphaltic concrete (Road Fill)		1	SS	30		266								
264.9							265								
1.3	Sandy Silt to Silty Sand		2	SS	30										
			3	SS	25		264								
	Compact to Dense		4	SS	38		263								
			5	SS	37		262								
	Brown		6	SS	26										
			7	SS	24		261								
			8	SS	24		260								
259.4							259								
6.8	Coarse Sand Tr. gravel		9	SS	38		258								
	Dense to Very Dense						257								
			10	SS	56		256								
	Grey						255								
			11	SS	73		254								
	Occ. clayey silt seams throughout														
253.5			12	SS	101										
12.7	End of borehole														

+3, x5: Numbers refer to
Sensitivity

20
15 \div 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No3

METRIC

W P 479-89-02 LOCATION Co-ords. 4 760 345 N; 186 507 E ORIGINATED BY AA
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger, Wash Boring and Dynamic Cone COMPILED BY AK
 DATUM Geodetic DATE 1990 07 27 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100		
266.4	Ground surface												
0.0	Sand and Gravel (Road Fill)												Concrete ob- struction to 1.1m depth
265.0	Very Dense Brown		1	SS	53								33 54 (13)
1.4	Sandy Silt to Silty Sand		2	SS	24								
	Occ. gravel		3	SS	28								WL on 1990 08 10
	Compact to Dense		4	SS	25								4 85 (11)
	Compact		5	SS	49								
	Brown		6	SS	30								0 67 (33)
			7	SS	12								
			8	SS	12								
259.4	Coarse Sand with gravel		9	SS	48								15 79 (6)
7.0	Dense to Very Dense		10	SS	107								
	Grey		11	SS	45/10 cm								
			12	SS	122								0 89 (11)
253.5	Sandy Silt some clay Occ. gravel (Glacial Till)												
12.9	Very Dense Grey		13	SS	90								
252.2	End of borehole												
14.2													

+3, x5: Numbers refer to
Sensitivity

20
15 \div 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4

METRIC

W P 479-89-02 LOCATION Co-ords. 4 760 338 N; 186 472 E ORIGINATED BY JK
 DIST 2 HWY 401 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AA
 DATUM Geodetic DATE 1990 07 26 CHECKED BY CH

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
266.4	Ground surface													
0.0	Probable Road Fill													
265.2 1.2	Probable Sandy Silt to Silty Sand													
259.0 7.4	Probable Coarse Sand													
255.4	End of Cone Test													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No5

METRIC

W P 479-89-02 LOCATION Co-ords. 4 760 392 N. 186 480 E ORIGINATED BY AA
 DIST 2 HWY 401 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY AK
 DATUM Geodetic DATE 1990 07 26 CHECKED BY CM

SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	'N' VALUES	20 40 60 80 100	W _p	W		
266.0	Ground surface											GR SA SI CL
0.0	Probable Road Fill											
265.1	Probable				265							
0.9	Sandy Silt to Silty Sand				264							
					263							
					262							
261.4	End of Cone Test											
4.6												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 6

METRIC

W P 479-89-02 LOCATION Co-ords. 4 760 343 N; 186 489 E ORIGINATED BY AA
DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger, Wash Boring and Tricone COMPILED BY AK
DATUM Geodetic DATE 1990 07 27 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
266.1	Ground surface						266										
0.0	Sand, Gravel (Road Fill)																
	Compact		1	SS	13		265										
264.6	Brown																
1.5	Sandy Silt to Silty Sand		2	SS	29		264										
	Compact to Dense		3	SS	23												
	Brown		4	SS	29		263										
			5	SS	27		262										
	Grey		6	SS	20		261										
			7	SS	11		260										
259.4			8	SS	36		259										
6.7	Coarse Sand some clay																
	Tr. gravel		9	SS	33		258										
	Dense to Very Dense						257										
	Grey		10	SS	80		256										
			11	SS	99		255										
253.4			12	SS	103		254										
12.7	End of Borehole																

+3, x³ : Numbers refer to Sensitivity 20 15 10 (5) (%) STRAIN AT FAILURE

WL on 1990 07 27
0 62 (38)
5 72 (23)
Wash casing installed Borehole advanced by triconing 1 83 (16)

FOUNDATION INVESTIGATION REPORT

For

Dereham Townline Overpass

W.P. 479-89-03, Site 19-316

Hwy. 401, District 2, LondonINTRODUCTION

This report contains the results of a soil investigation carried out at the above mentioned site to provide information for the design and construction of the proposed widening of Dereham Townline overpass.

The field work for this project was carried out between 90 07 23 and 90 07 26, and comprised of four sampled boreholes and Dynamic Cone Penetration Test adjacent to these holes.

Boreholes were advanced to a maximum depth of 21.8 m (El. 273.7 m) below the existing ground level using a continuous flight hollow stem auger.

SITE DESCRIPTION

The site under investigation is located at the crossing of Hwy. 401 and Dereham Townline Road in the Township of Southwest Oxford.

The terrain is gradually sloping in the northeast to southwest direction with undulations and ridges to the north and south. It appears that the site in question is located on a ridge which was modified to the present condition by the construction of the existing bridge.

The ridges are moraines of calcareous clay or silty clay while in the valley it is common to find alluvium of gravel, sand or silt. Physiographically the area is located in the region known as the "Mount Elgin Ridges".

SUBSURFACE CONDITIONS

General

The underlying subsoil at this site consists of stiff to hard clayey silt underlain by dense to very dense non-cohesive glacial till which overlies very dense sand with varying proportions of silt sized particles. For classification purposes, the soils encountered at this site can be divided into three different zones.

- a) Clayey Silt, trace Sand and trace Gravel
- b) Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till)
- c) Sand, some Silt

The subsurface conditions encountered during the course of the investigation, together with the field and laboratory test results are shown on the Record of Borehole sheets contained in the Appendix of this report. Two stratigraphical sections are shown on Drwg. No. 2. This drawing also shows the locations and elevations of the borings. Description of the strata encountered are given below.

a) Clayey Silt, trace Sand, and Trace Gravel

This clayey silt layer was encountered immediately below the topsoil. The thickness of this layer varies from 9.8 m to 12.0 m and extends to El. 285.9 m to 283.5 m. The natural moisture content varies from 14.5% to 18.0% with an average value of 15.6%. The results of the Atterberg Limit Test carried out on representative soil samples are shown on Figure 1. The liquid limit varies between 27 and 29 with the plasticity index varying from 13 to 16. The Standard Penetration Test results were observed to vary widely ('N' values 9 blows/30 cm to 59 blows/30 cm) indicating stiff to hard consistency.

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

The clayey silt layer is underlain by this non-cohesive glacial till deposit. The thickness of this deposit varies between 5.4 m and 6.7 m, and extends to El. 279.2 m to 278.1 m. The Gradation Test results are shown on Figure 2 in an envelope form. These results indicate 1% to 14% gravel, 35% to 75% sand and 26% to 52% silt. The natural moisture content varies from 3% to 10.5% with an average value of 7.0%. The Standard Penetration Test results in this deposit vary from 23 blows/30 cm to over 100 blows/30 cm indicating compact to very dense state of compaction.

c) Sand, some Silt

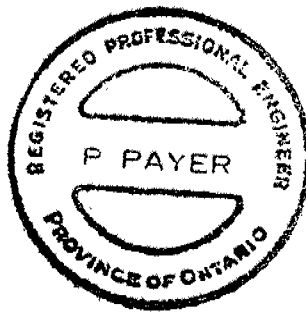
This sandy deposit was encountered in all the boreholes immediately below the glacial till deposit. The Gradation Test results are shown on Figure 3 in an envelope form. These test results indicate that this deposit is predominantly composed of sand with varying proportions of silt sized particles (sand 84% to 91%, silt 8% to 16%). The Standard Penetration Test results were observed to vary from 72 blows/30 cm to over 100 blows/ 30 cm indicating very dense state of compaction. This layer extends to the depth probed (i.e. El. 273.7 m), however, the full extent of this deposit was not proven.

Groundwater Conditions

The groundwater level was not encountered in any of the boreholes and the boreholes were observed to be dry. However, the observation made at the well close to site in question indicate that the groundwater level may be expected at about 27 m (approximately El. 268.5 m) below the existing ground level.

MISCELLANEOUS

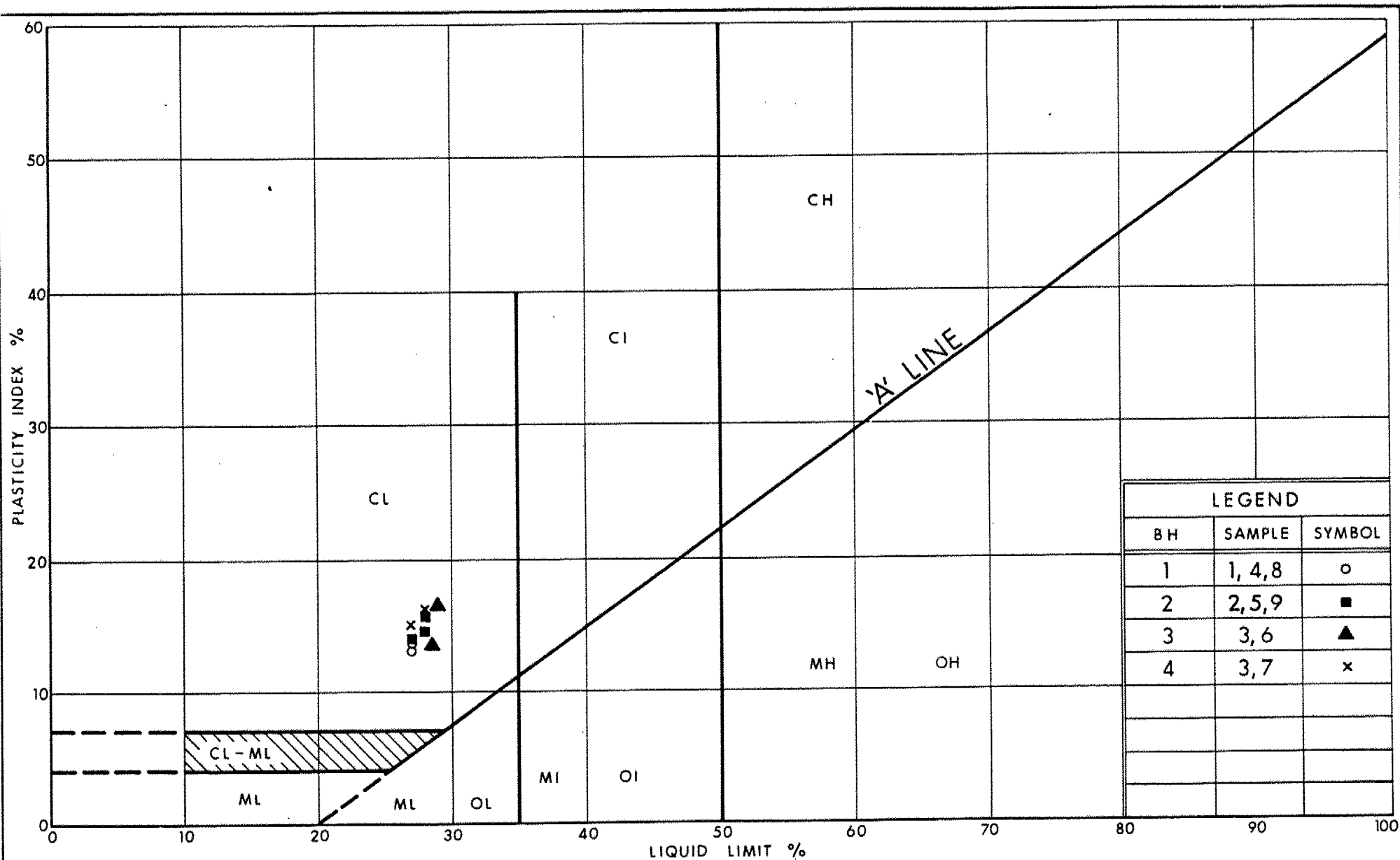
The field work for this investigation was carried out under the supervision of M. Vasavithasan, Foundation Engineer, and J. LeMessurier, Student Engineer trainee. The equipment used was owned and operated by Master Soil Investigation Ltd. This report was prepared by M. Vasavithasan, reviewed by P. Payer, Senior Foundation Engineer, and approved by M. Devata, Chief Foundation Engineer.



P. Payer
P. Payer, P. Eng.
Senior Foundation Engineer

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

APPENDIX



Ministry of
Transportation

Ontario

PLASTICITY CHART
CLAYEY SILT, TRACE OF SAND & GRAVEL

FIG No 1

W P 479-89-03

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

Fine

Medium

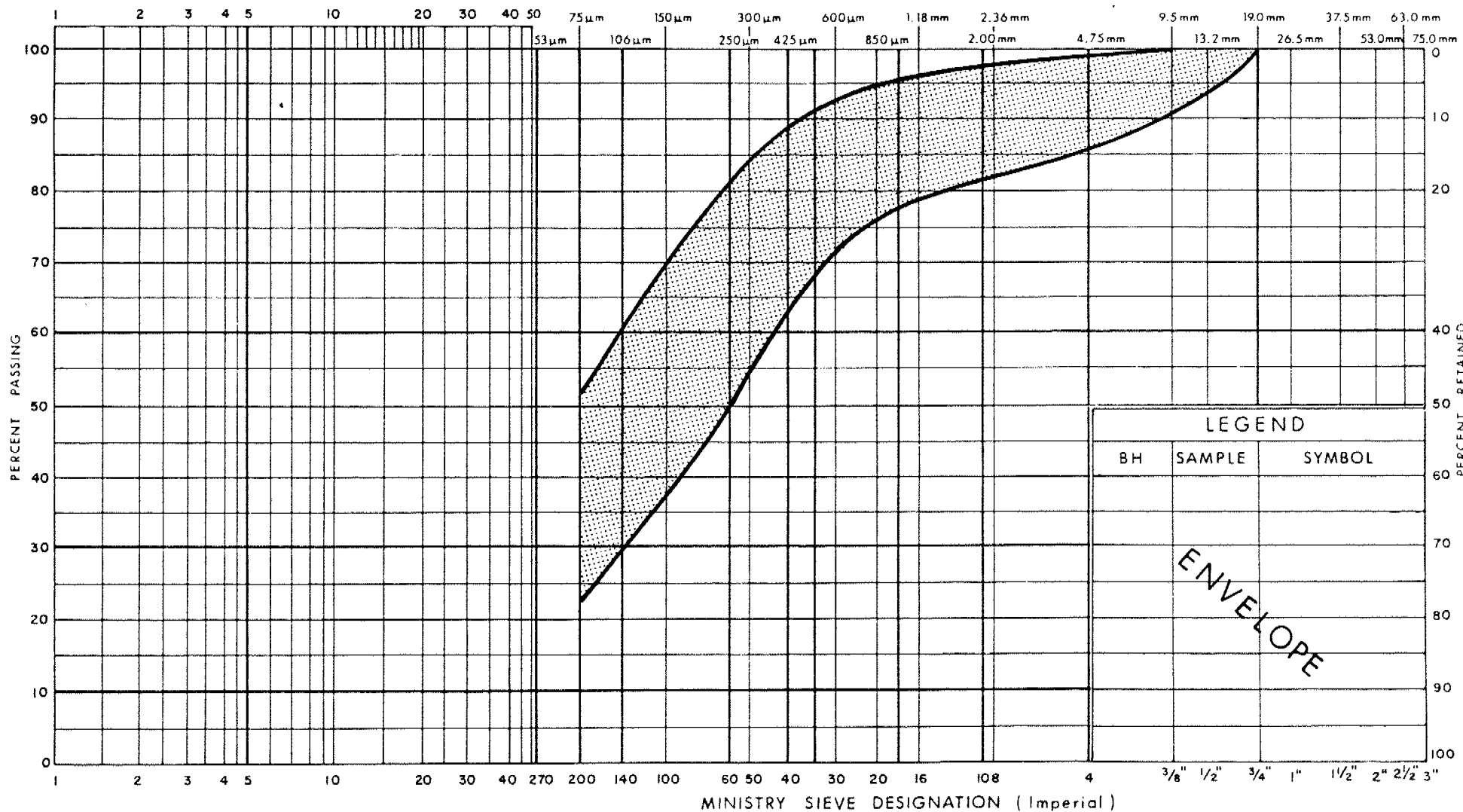
Coarse

Fine

Coarse

GRAIN SIZE IN MICROMETERS

MINISTRY SIEVE DESIGNATION (Metric)



LEGEND

BH

SAMPLE

SYMBOL

ENVELOPE

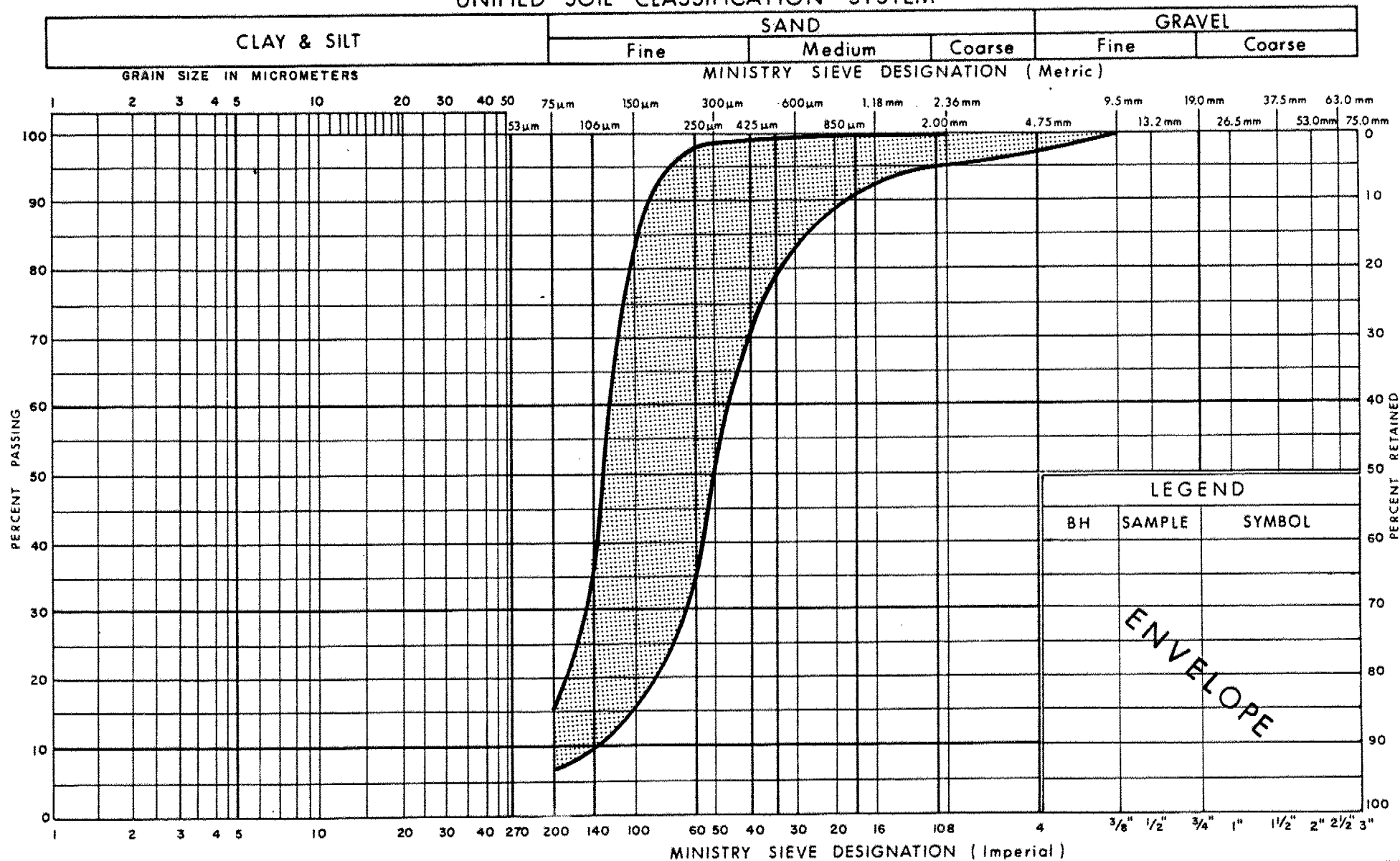
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
HET. MIX. OF GRAVEL, SAND & SILT
(Glacial Till)

FIG No 2

W P 479 89 03

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SAND, TRACE TO SOME SILT

FIG No 3

W P 479-89-03

RECORD OF BOREHOLE No 1

1 OF 1

METRIC 72

W.P. 479 - 89 - 03 LOCATION CO - ORDS. N 4 761 149.8; E 189 200.6 ORIGINATED BY M V&J L
DIST 2 HWY 401 BOREHOLE TYPE CONE TEST & HOLLOW STEM AUGER COMPILED BY M V
DATUM GEODETIC DATE 90 07 23 & 90 07 24 CHECKED BY P P

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					
296.2	Ground Surface													
0.0	Topsoil					DRY	296							
			1	SS	20		294							
			2	SS	9		292							
	CLAYEY SILT, Trace of Sand, Trace of Gravel, Stiff to Very Stiff		3	SS	12		290							
			4	SS	16		288							
			5	SS	19		286							
			6	SS	25		284							
			7	SS	24		282							
			8	SS	28		280							
			9	SS	26		278							
285.2			10	SS	82		276							
11.0			11	SS	120									
			12	SS	117									
	Heterogeneous Mixture of GRAVEL, SAND and SILT, Very Dense (Glacial Till)		13	SS	52									4 49 (47)
			14	SS	115									3 71 (26)
			15	SS	111									
278.6			16	SS	95									0 91 (9)
17.6														
	SAND, Trace of Silt, Very Dense													
274.5			17	SS	120	/25cm								
21.7	End of Borehole													

RECORD OF BOREHOLE No 2 1 OF 1 METRIC 73

W.P. 479 - 89 - 03 LOCATION CO - ORDS. N 4 761 123.6; E 189 171.1 ORIGINATED BY M V&J L
 DIST 2 HWY 401 BOREHOLE TYPE CONE TEST & HOLLOW STEM AUGER COMPILED BY M V
 DATUM GEODETIC DATE 90 07 24 & 90 07 25 CHECKED BY P P

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	20 40 60 80 100					
295.5	Ground Surface													
0.0	Topsoil					DRY								
			1	SS	36		294							
			2	SS	26		292							
			3	SS	29		290							
	CLAYEY SILT, Trace of Sand, Trace of Gravel, Very Stiff to Hard		4	SS	22		288							
			5	SS	29		286							
			6	SS	20		284							
			7	SS	46		282							
			8	SS	30		280							
			9	SS	34		278							
			10	SS	33									
283.5			11	SS	42									
12.0			12	SS	70									
			13	SS	116									
	Heterogeneous Mixture of GRAVEL, SAND and SILT, Dense to Very Dense (Glacial Till)		14	SS	39									
			15	SS	74									
278.1			16	SS	120	13cm								
17.4	SAND, Trace of Silt,													
277.1	Very Dense													
18.4	End of Borehole													

RECORD OF BOREHOLE No 3

1 OF 1 METRIC 74

W.P. 479 - 89 - 03 LOCATION CO - ORDS. N 4 761 087.2; E 189 202.4 ORIGINATED BY M V&J L
 DIST 2 HWY 401 BOREHOLE TYPE CONE TEST & HOLLOW STEM AUGER COMPILED BY M V
 DATUM GEODETIC DATE 90 07 25 & 90 07 26 CHECKED BY P P

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	20 40 60 80 100					
295.5	Ground Surface													
0.0	Topsoil					DRY								
			1	SS	28		294							
			2	SS	30		292							
	CLAYEY SILT, Trace of Sand, Trace of Gravel, Very Stiff to Hard		3	SS	27		290							
			4	SS	20		288							
			5	SS	23		286							
			6	SS	29		284							
			7	SS	59		282							
285.7			8	SS	34		280							
9.8			9	SS	55		278							
			10	SS	55		276							
	Heterogeneous Mixture of GRAVEL, SAND and SILT, Dense to Very Dense (Glacial Till)		11	SS	51		274							
			12	SS	35		272							
			13	SS	42		270							
			14	SS	70		268							
279.1			15	SS	72		266							
16.4			16	SS	120	/23cm	264							
	SAND, Some Silt, Very Dense		17	SS	147		262							
273.7							260							
21.8	End of Borehole						258							

RECORD OF BOREHOLE No 4 1 OF 1 METRIC 75

W.P. 479 - 89 - 03 LOCATION CO - ORDS. N 4 761 118.7; E 189 233.6 ORIGINATED BY M. V&J L
 DIST 2 HWY 401 BOREHOLE TYPE CONE TEST & HOLLOW STEM AUGER COMPILED BY M V
 DATUM GEODETIC DATE 90 07 25 & 90 07 26 CHECKED BY P P

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					
297.0	Ground Surface																
0.0	Topsoil					DRY											
			1	SS	24												
			2	SS	13												
	CLAYEY SILT, Trace of Sand, Trace of Gravel, Stiff to Very Stiff		3	SS	13												
			4	SS	18												
			5	SS	18												
			6	SS	18												
			7	SS	22												
			8	SS	25												
			9	SS	23												
285.9			10	SS	41												
11.1			11	SS	98												10 59 (31)
			12	SS	91												
	Heterogeneous Mixture of GRAVEL, SAND and SILT, Compact to Very Dense (Glacial Till)		13	SS	23												12 36 (52)
			14	SS	120												
279.2			15	SS	120	/18cm											
17.8			16	SS	120	/28cm											0 87 (13)
	SAND, Some Silt, Trace of Gravel, Very Dense																
275.2			17	SS	120	/28cm											
21.8	End of Borehole																

GEOTECHNICAL INVESTIGATION
CULLODEN ROAD NEW UNDERPASS
DISTRICT 2 (LONDON)
SOUTHWESTERN REGION
FOR
MINISTRY OF TRANSPORTATION, ONTARIO
W.P. 479-89-04
SITE 23-208 (NEW STRUCTURE)

1. INTRODUCTION

Peto MacCallum Ltd. was authorized by The Ministry of Transportation, Ontario, Agreement number 4240-9190-092 dated September 4, 1990, to carry out a geotechnical investigation at the site of the proposed bridge structure at Highway 401 and Culloden Road interchange in District 2 (London), Ontario.

The proposed bridge will be a four (4) span structure, approximately 129 m long and will be located on the west side of the existing bridge structure which will not remain in service. Construction of approach fills to the bridge is also required.

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

2. FIELDWORK

The fieldwork for the investigation was carried out during the period August 27 to 30, 1990, and comprised four (4) sampled boreholes and four (4) dynamic cone penetration tests put down to depths of 14.85 to 18.50 m below existing grade as shown on the appended plan.

The boreholes were advanced using a CT-150 track mounted drillrig equipped with continuous flight hollow stem augers. The drillrig was supplied and operated by London Soil Test.

Representative samples of the overburden were secured at regular intervals throughout the depth explored. Standard penetration resistance tests were carried out during sampling operations using conventional split spoon equipment.

The groundwater conditions in the open boreholes were monitored during and after the completion of drilling. A piezometer was installed in borehole 4 for monitoring the stabilized groundwater conditions.

The fieldwork was supervised throughout by a member of our engineering staff who directed the drilling and sampling operations, documented the soil stratigraphy encountered, monitored groundwater conditions and processed the recovered samples.

The locations and ground surface elevations of the boreholes were established in the field by Peto MacCallum Ltd. The ground surface elevations have been referred to the following benchmark (B.M.), as shown on Ministry of Transport, Ontario Plan E-90-401-1.

B.M.: Department of Highways, Ontario
Benchmark number 252-67; circular brass
plaque on southeast corner of the
existing bridge wall facing north.

Elevation: 288.790 (Geodetic, metric)

3. LABORATORY TESTING PROGRAMME

All recovered samples were brought to our laboratory for detailed visual examination and testing to confirm field classification. The following tests were carried out:

- i) Natural moisture content determinations on all recovered samples, with results shown on the appended Record of Borehole sheets;
- ii) Nine (9) grain size analyses with results illustrated on Figures 1 through 3 and the appended Record of Borehole sheets;
- iii) Two (2) Atterberg limits with results presented on Table 1, Figure 4 and the appended Record of Borehole sheets;
- iv) Five (5) unit weight determinations on representative soil samples and the results are shown on the appended Record of Borehole sheets.

4. SITE DESCRIPTION

The site is located on the existing Highway 401 approximately 2.7 km west of Highway 19 in the Township of Southwest Oxford in Oxford County. The natural ground surface at the site is relatively flat, ranging from elevation 287.55 to 288.46 at the borehole locations.

Based on the available geological mapping, the surficial material at the site comprises Port Stanley Till. This Port Stanley Till sheet overlies Erie Interstadial glaciolacustrine sediments.

5. SUMMARIZED SUBSURFACE CONDITIONS

5.1 General

Reference is made to the appended Record of Borehole sheets for details of the fieldwork, including soil classification, inferred stratigraphy, standard penetration 'N' values, dynamic cone penetration tests, moisture content determinations and Atterberg limit test results, together with groundwater observations in the open boreholes and installed piezometer. Ground surface elevations and locations are also marked on the Record of Borehole sheets.

The summarized subsurface conditions are presented on a profile .

The stratigraphy at the site, as revealed in the boreholes, generally comprised surficial topsoil overlying a clayey silt fill material. The fill material was underlain by a discontinuous sand deposit over major deposits of sandy silt glacial till, lower sand and lower sandy silt glacial till.

5.2 Overburden

5.2.1 Topsoil

Surficially, 600 to 900 mm of brown clayey silt topsoil with organic content was contacted throughout the site.

5.2.2 Clayey Silt (Fill)

Underlying the surficial topsoil at the site, a clayey silt fill material was contacted to depths of 2.70 to 3.70 m. The fill typically comprised

brown clayey silt with trace sand and gravel. Scattered topsoil inclusions were noted at borehole 1. Moisture contents ranged between 9 and 28%.

Based on standard penetration 'N' values, the consistency of the fill stratum was typically stiff.

5.2.3 Sand

At borehole 4, a discontinuous deposit of sand was contacted below the clayey silt fill, and extended to 6.10 m depth. The material comprised brown fine to medium sand, some silt and some gravel. A grain size distribution curve for a representative sample of the material is presented on Figure 1. Natural moisture contents ranged from 8 to 18%.

Based on standard penetration 'N' values, the denseness of the sand deposit was compact to very dense.

5.2.4 Sandy Silt (Glacial Till)

A major stratum of sandy silt glacial till was contacted in all the boreholes beneath the clayey silt fill or sand, and extended to depths of 9.00 to 12.95 m. This till stratum typically consisted of brown to grey sandy silt, some clay and trace to some gravel. Grain size distribution envelope for five (5) representative samples of the material are shown on Figure 2.

Atterberg limit tests were carried out on a representative sample of the stratum. Test results are summarized on Table 1 and illustrated on Figure 4. Atterberg limits gave values of 16 for the liquid limit and 11 for the plastic limit resulting in a plasticity index of 5. Moisture contents varied between 9 and 18% but were typically in the 12 to 15% range.

The denseness of the sandy silt glacial till stratum, as determined from the field standard penetration tests, varied from loose to very dense but was typically in the compact state.

5.2.5 Sand

The sandy silt glacial till was underlain throughout the site by a lower sand deposit which extended down to depths of 14.87 to 17.00 m. In general, the stratum was described as brown to grey fine to medium sand, trace to some silt, with some gravel. Grain size distribution curves for two (2) representative samples of the sand material are shown on Figures 1 and 3. Moisture contents ranged between 9 and 22% indicating wet to saturated conditions.

The denseness of the sand stratum, as determined from the field standard penetration tests, was typically compact to very dense. Boreholes 3 and 4 were terminated within the sand stratum at depths of 15.69 and 14.87 m respectively.

5.2.6 Sandy Silt (Glacial Till)

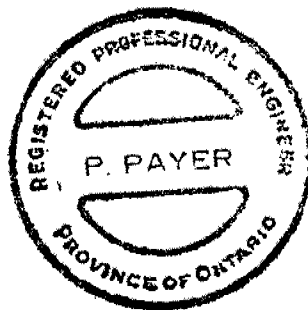
In boreholes 1 and 2, the sand stratum was fully penetrated at depths of 17.00 to 16.70 m, respectively, and was underlain by the second occurrence of the sandy silt glacial till sheet which extended down to the termination depth of the boreholes. A grain size distribution envelope for representative samples of the sandy silt glacial till material is provided on Figure 2. Atterberg limit tests results are shown on Table 1 and Figure 4. The material was typically very dense with moisture contents ranging between 7 and 9%.

5.3 Groundwater Conditions

Observations of groundwater in the boreholes during and upon completion of drilling, as well as piezometer readings are noted on the individual borehole records. Upon completion of drilling, groundwater was recorded at depths of about 3.0 to 7.6 m below existing grade (elevation 280.5 to 284.8) in all the boreholes. The piezometer installed in borehole 4 indicated the stabilized groundwater level lies about elevation 285.2. The water appeared to come from random wet sand layers within the sandy silt glacial till as well as the saturated sand deposit at depth. Seasonal fluctuations should be expected.

The results of pH and sulphate content determinations conducted on a groundwater sample showed a pH value of 7.3 and a sulphate content of 70 ppm as SO_4 . The measurements indicate a 'negligible' degree of sulphate attack on buried concrete structures. For information regarding the type of cement for concrete structure below water table, reference is made to CSA-A23.

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



P. Payer
P. Payer, P. Eng.
Senior Foundation Engineer

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

APPENDIX

TABLE I
ATTERBERG LIMIT TEST RESULTS

CULLODEN ROAD NEW UNDERPASS
DISTRICT 2 (LONDON), SOUTHWESTERN REGION

BOREHOLE NO.	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	REMARKS
		(m)	(w) %	(^w L)	(^w P)	(^I P)	
2	6	4.55-5.00	10.8	16	11	5	Sandy Silt Glacial Till (ML)
2	10	16.70-17.15	9.5	17	11	6	" "

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

Fine

Medium

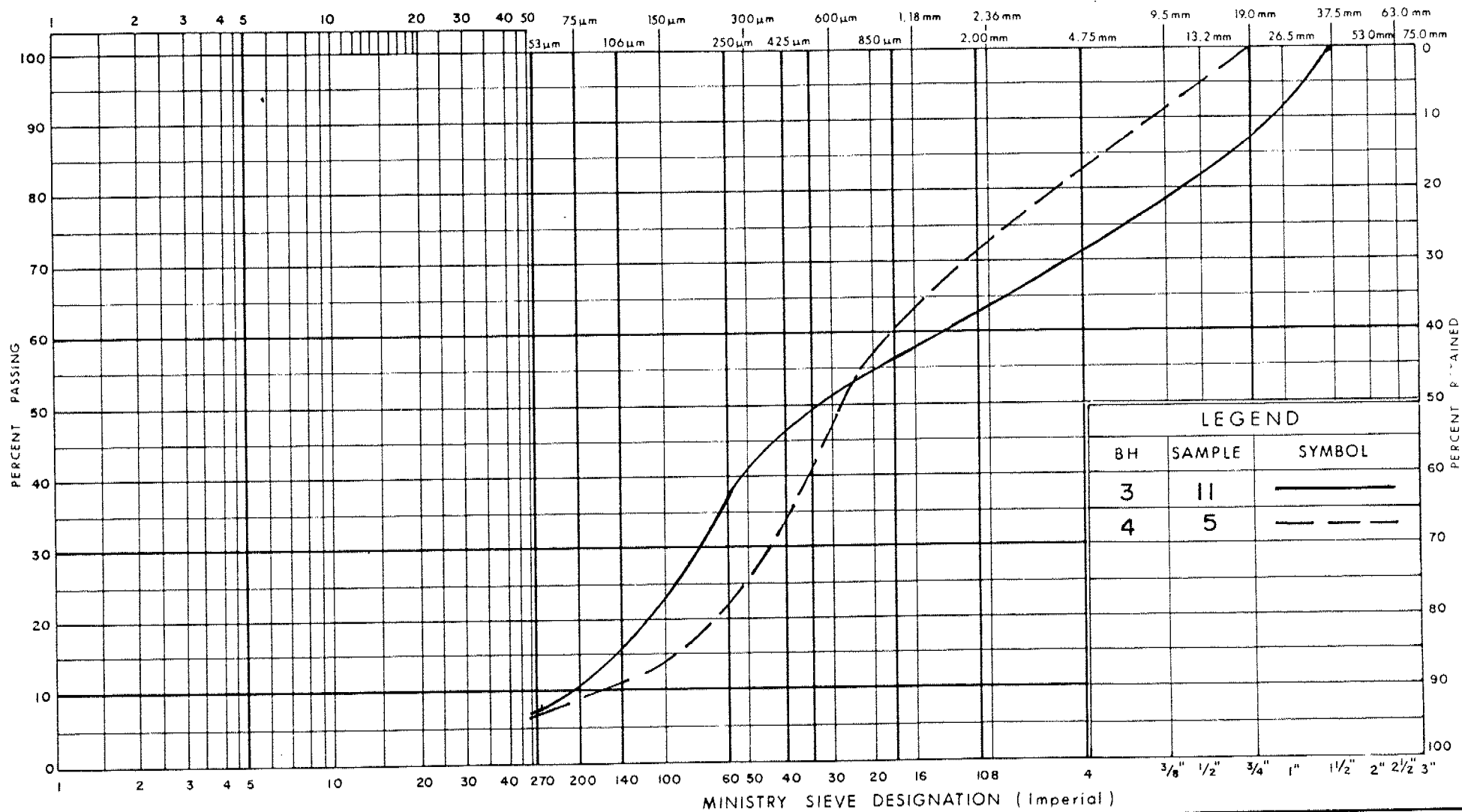
Coarse

Fine

Coarse

GRAIN SIZE IN MICROMETERS

MINISTRY SIEVE DESIGNATION (Metric)



LEGEND

BH	SAMPLE	SYMBOL
3	11	————
4	5	- - - - -

GRAIN SIZE DISTRIBUTION
SAND
SOME GRAVEL

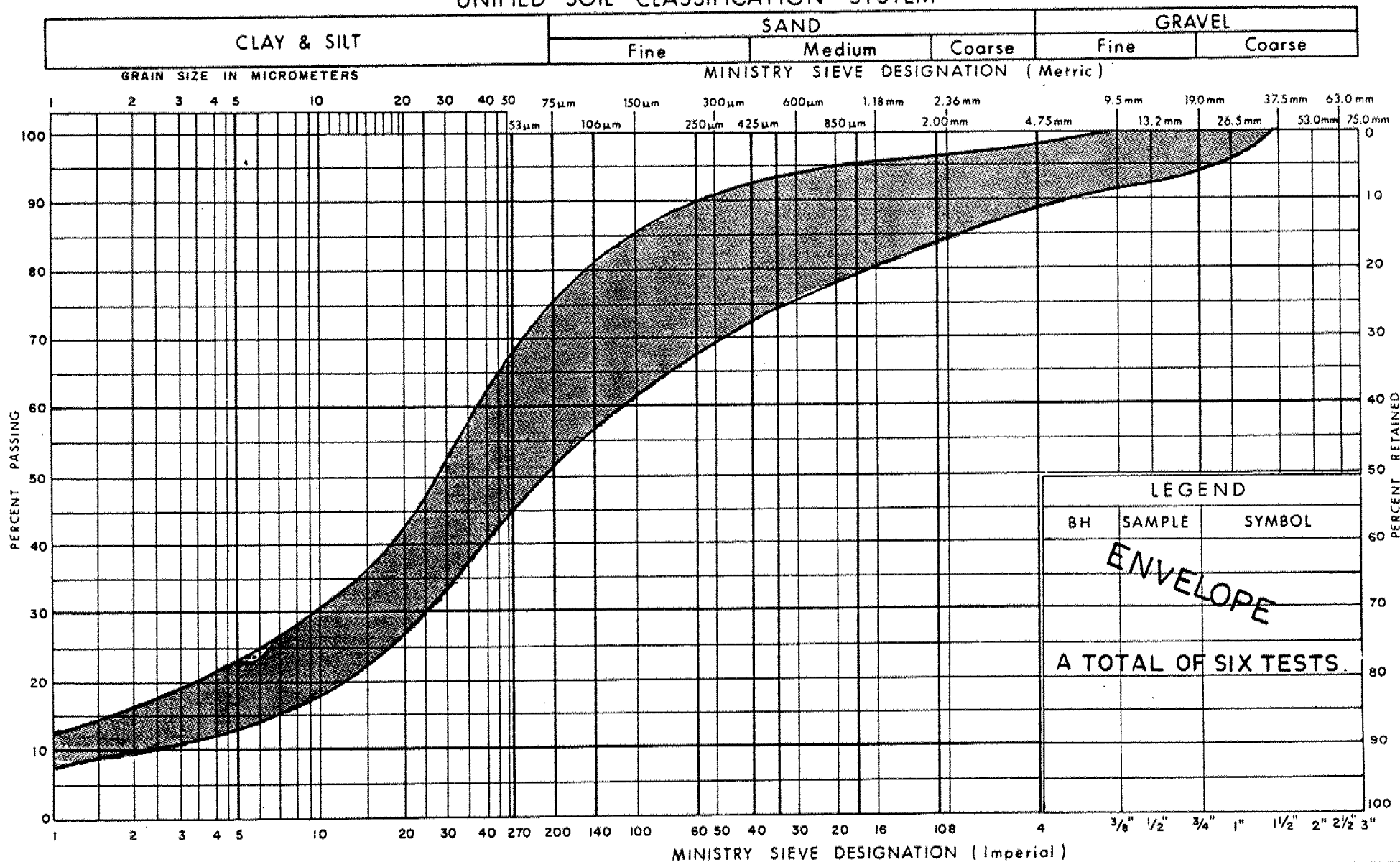
FIG No 1

W P 479 - 89 - 04



Ministry of
Transportation

UNIFIED SOIL CLASSIFICATION SYSTEM



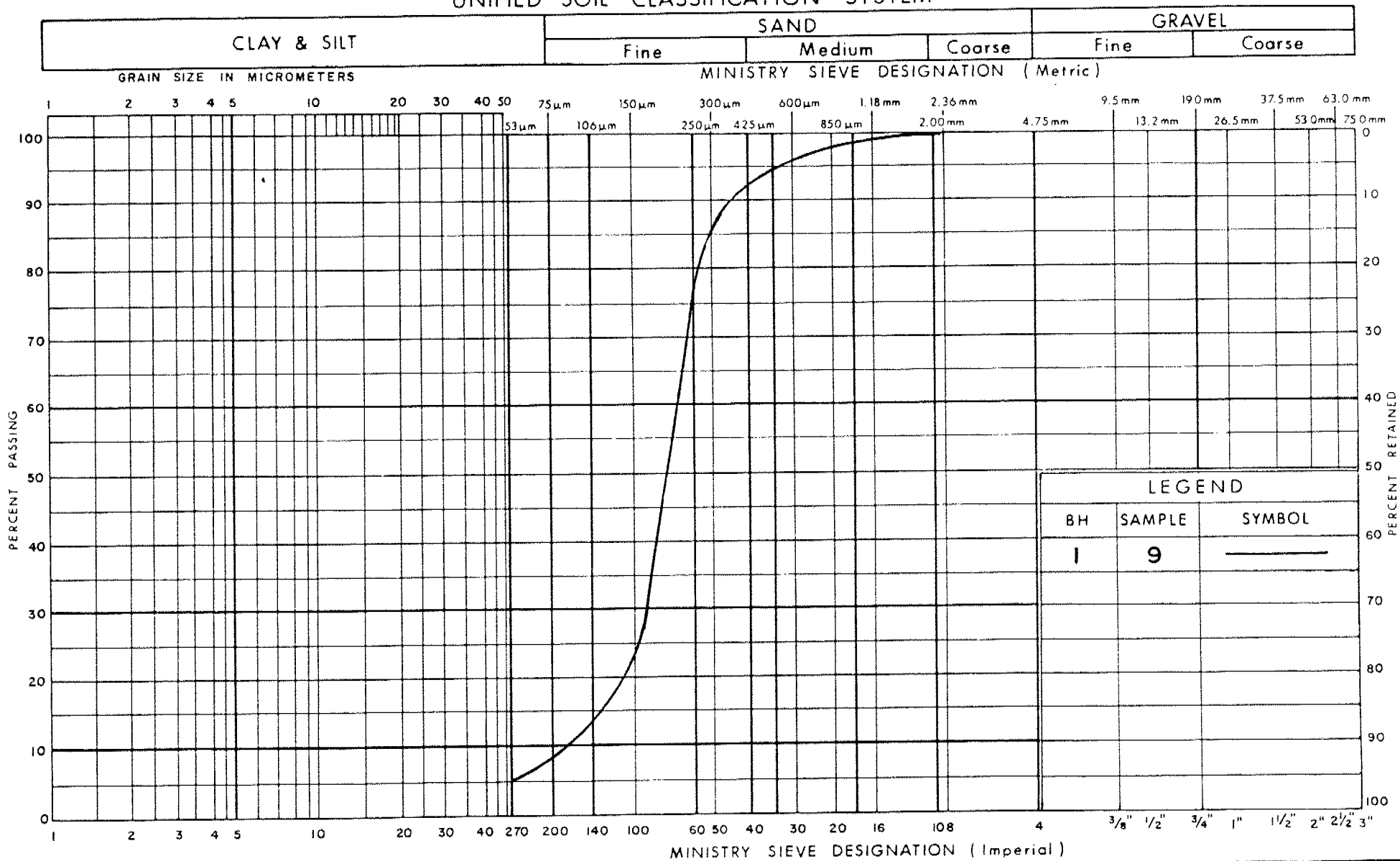
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SANDY SILT (GLACIAL TILL)
SOME CLAY, TRACE TO SOME GRAVEL

FIG No 2

W P 479 - 89 - 04

UNIFIED SOIL CLASSIFICATION SYSTEM

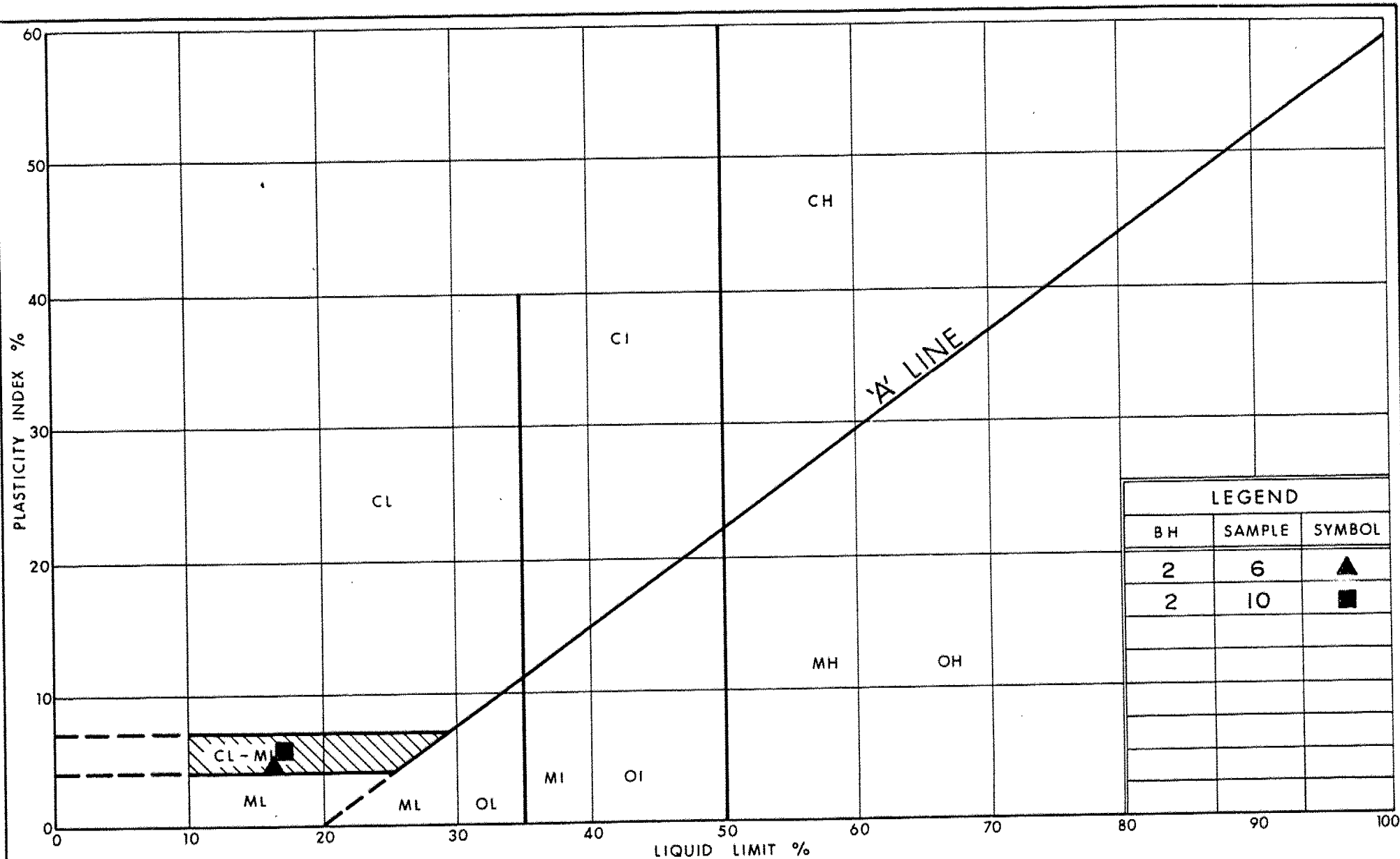


Ontario

Ministry of
TransportationGRAIN SIZE DISTRIBUTION
SAND

FIG No 3

W P 479 - 89 - 04



Ministry of
Transportation

PLASTICITY CHART
SANDY SILT (GLACIAL TILL)
SOME CLAY, TRACE TO SOME GRAVEL

FIG No 4

W P 479-89-04

RECORD OF BOREHOLE No 1

METRIC 90

W P 479 - 89 -04 LOCATION Co-ords, 4764.351.8 N: 192.467.5E ORIGINATED BY DS
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Augers and Dynamic Cone Penetration Test COMPILED BY GDP
 DATUM Geodetic DATE August 30/31, 1990 CHECKED BY PC

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	100					
288.46	Ground Level													
0.00	Topsoil, clayey silt, medium organic, brown		1	SS	9		288							
287.56	Clayey Silt (Fill) trace sand, trace gravel topsoil inclusions		2	SS	11									
0.90			3	SS	10									
			4	SS	17		286							
284.86	Brown Stiff		5	SS	9									
3.60	Sandy Silt, some gravel some clay, (Glacial Till)		6	SS	13		284							
	Brown		7	SS	10		282							9 39 42 10
	Fine sand seams		8	SS	5		280							0 95 5 0
279.46	Grey Compact		9	SS	87									
9.00	Sand, fine to medium, trace gravel, trace silt						278							
							276							
							274							
							272							
271.46	Brown Very Dense													
17.00	Sandy Silt (Glacial Till)		10	SS	167/150mm									
270.79	Grey Very Dense													
17.67	End of Borehole													
Note: Borehole at 10m, sand blow back inside hollow stem augers Upon completion of augering, water at elevation 280.84														

OFFICE REPORT ON SOIL EXPLORATION

Water level in open borehole

+³, x⁵: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

W P 479 - 89 - 04 LOCATION 4764,331.5 N., 192,479.35 ORIGINATED BY DS
DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Augers and Dynamic Cone Penetration Test COMPILED BY GDP
DATUM Geodetic DATE August 29, 1990 CHECKED BY PC

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					
287.55	Ground Level												
0.00	Topsoil, some sand , some gravel, medium organic, Brown		1	SS	8								
0.60	Clayey Silt, (Fill) with some sand, some gravel		2	SS	4								
			3	SS	9								
			4	SS	12								
283.85	Brown Stiff		5	SS	15								
3.70	Sandy Silt, some gravel some clay, (Glacial Till)		6	SS	18								
	Compact												
	Loose												
	Brown Gray		7	SS	9								
			8	SS	3								
			9	SS	10								
277.34	Sand, fine to medium, some gravel (From auger samples)												
10.21													
270.85	Grey Very Dense		10	SS	16	150mm							
16.70	Sandy Silt, some gravel some clay, (Glacial Till)												
269.05	Grey Very Dense		11	S	13	200mm							
18.50	End of borehole												
Note: After sample 9, water inside hollow stem augers at elevation 280.55 Borehole at elevation 277.34, sand blow back inside hollow stem augers Drove cone below. Borehole augered down without sampling to elevation 270.85													



Water level in open borehole

+3, x5 : Numbers refer to Sensitivity

20
15 ϕ S (%) STRAIN AT FAILURE
10

METRIC 92

W P 479 - 89 - 04 LOCATION Co-ords, 4764,331.5 N, 192,479.35 ORIGINATED BY D.S.
DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger and Dynamic Cone Penetration Test COMPILED BY G.D.P.
DATUM Geodetic DATE August 29, 1990 CHECKED BY P.C.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20					
287.55	Ground Level												
0.00	(Pre - Augered)					286							
						284							
282.80						282							
4.75						280							
						278							
						276							
274.30													
13.25	End of Dynamic Cone Penetration Test										130/300mm		

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 3

METRIC

93

W P 479 - 89 -04

LOCATION Co-ords, 4764,291.4N; 192,486.8E

ORIGINATED BY DS

DIST 2 HWY 401

BOREHOLE TYPE Hollow Stem Augers and Dynamic Cone Penetration Test

COMPILED BY GDP

DATUM Geodetic

DATE August 27, 1990

CHECKED BY PC

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			SHEAR STRENGTH kPa							WATER CONTENT (%)			
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE										
287.85	Ground Level																	
0.00	Topsoil, clayey silt,																	
287.15	trace sand, medium organic, brown		1	SS	18													
0.70	Clayey Silt (Fill) with trace sand, trace gravel		2	SS	10													
284.95	Stiff Brown Firm		3	SS	5													
2.90	Sandy Silt, some gravel some clay, (Glacial Till)		4	SS	9													
			5	SS	16									6 44 35 15				
			6	SS	16													
	Brown																	
	Fine sand seam		7	SS	5									4 46 35 15				
			8	SS	14													
			9	SS	19													
276.12	Grey Compact																	
11.73	Sand, fine to medium some gravel, trace silt		10	SS	19													
			11	SS	18													
	Compact																	
272.16	Grey Dense		12	SS	40													
15.69	End of Borehole End of Dynamic Cone Penetration Test																	
	Note: Upon completion of auger. water at elevation 280.84																	

Water level in open borehole

+³, x⁵: Numbers refer to Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 4

METRIC 94

W P 479 - 89 -04 LOCATION Co-ords. 4764.258.4N: 192.491.6E ORIGINATED BY DS
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Augers and Dynamic Cone Penetration Test COMPILED BY GDP
 DATUM Geodetic DATE August 28, 1990 CHECKED BY PC

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				
287.86	Ground level															
0.00	Topsoil, clayey silt, medium organic, brown		1	SS	5											
287.26			2	SS	13											
0.60	Clayey Silt, (Fill) with trace sand, trace gravel		3	SS	15											
285.16	Brown Stiff		4	SS	20											
2.70	Sand, fine to medium some silt, some gravel		5	SS	16											
	Compact		6	SS	61											
281.76	Brown Very Dense		7	SS	53											
6.10	Sandy Silt, trace gravel, some clay		8	SS	40											
	Dense to Very Dense		9	SS	26											
	Brown		10	SS	22											
	Compact		11	SS	43											
274.91	Grey Dense		12	SS	27											
12.95	Sand, fine to medium, some gravel, some silt															
272.95	Grey Compact															
14.87	End of borehole															
	Note: Before sample 8 water at elevation 280.63 inside hollow stem augers. Upon completion of augering water at elevation 284.81. Piezometer installed with tip at elevation 272.92 with seals at elevations 283.28 and 287.80 DATE Water Elevation Aug. 28 286.13 Aug. 31 285.24															

OFFICE REPORT ON SOIL EXPLORATION

METRIC 95

W P 479 - 89 - 04

LOCATION Co-Ords. 4764,258.4N; 192,491.6E

ORIGINATED BY D.S.

DIST 2 HWY 401

BOREHOLE TYPE Hollow Stem Auger and Dynamic Cone Penetration Test

COMPILED BY G.D:P

DATUM Geodetic

DATE August 31, 1990

CHECKED BY P.C.

[illegible]

OFFICE REPORT ON SOIL EXPLORATION

+³, x⁵: Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

FOUNDATION INVESTIGATION REPORT

For

C.P.R. Overhead

W.P. 479-89-05, Site 23-209

Hwy. 401, District 2, LondonINTRODUCTION

This report contains the results of a soil investigation carried out at the above mentioned site to provide information for the design and construction of the proposed widening of C.P.R. Overhead.

The field work for this project was carried out between 90 07 16 and 90 07 23, and comprised of six sampled boreholes and Dynamic Cone Penetration Test adjacent to four of the boreholes.

Boreholes were advanced to a maximum depth of 18.8 m (El. 264.3 m) below the existing ground level using a continuous flight hollow stem auger.

SITE DESCRIPTION

The site under investigation is located about 1.1 km west of Hwy. 19 at the crossing of Hwy. 401 and C.P.R. Overhead in the Township of Southwest Oxford.

The topography of the site with the exception of the existing crossing (embankment fill) is generally undulating with ridges to the east and northwest. The site in question is located in a valley and modified to the present condition by the construction of the existing C.P.R. Overhead.

The ridges are moraines of calcareous clay or silty clay while in the valley it is common to find alluvium of gravel, sand or silt. Physiographically the area is located in the region known as the "Mount Elgin Ridges".

SUBSURFACE CONDITIONS

General

The underlying subsoil at this site, with the exception of the embankment fill, consists of loose to compact sand with varying proportions of silt and gravel underlain by a thin layer of stiff to hard cohesive glacial till which overlies dense to very dense sand and gravel. The sand and gravel deposit is underlain by very dense non cohesive glacial till. For classification purposes, the soils encountered at this site can be divided into five different zones.

- a) Embankment Fill
- b) Sand with/some Silt
- c) Heterogeneous Mixture of Clayey Silt, Sand and Gravel (Glacial Till)
- d) Sand and Gravel, trace Silt
- e) Heterogeneous Mixture of Gravel, Sand and Silt (Glacial Till)

The subsurface conditions encountered during the course of the investigation, together with the field and laboratory test results are shown on the Record of Borehole sheets contained in the Appendix of this report. Two stratigraphical sections and a profile along median are shown on Drwg. No. 2.* This drawing also shows the locations and elevations of the borings. Description of the strata encountered are given below.

a) Embankment Fill

This fill which was placed to raise the finished grade of the Hwy. 401 consists mainly of Sandy material. The fill on the west side of the overhead bridge is about 5.6 m high and was observed to be in a compact to very dense state of compaction (N-values 20 blows/30 cm to 112 blows/30 cm). However, on the east side of the bridge, the fill is about 9.4 m high and consists of layers of sand and sandy silt with varying proportions of gravel and clay sized particles. The Standard Penetration Test results vary over a wide range (7 blows/30 cm to 45 blows/30 cm) indicating loose to dense state of compaction.

* DWG NO 2 OF THE CONTRACT DWG'S

b) Sand with/some Silt

This sandy deposit was encountered in all the boreholes immediately below the topsoil with the exception of boreholes located on Hwy. 401 shoulder. The thickness of this deposit varies from 1.4 m to 6.5 m and extends to El. 280.9 m to 279.4 m. However, the upper 0.5 m to 1.4 m is contaminated with organics. The results of the Gradation Tests carried out on representative soil samples are shown on Figure 1 in an envelope form. These test results indicate that this deposit in the southwestern corner is predominantly composed of sand (Sand 88% to 93%, Silt 7% to 12%), however, the samples from the north and east side of the bridge indicate higher silt content (Silt 30%, Sand 64%). The Standard Penetration Test results vary from 6 blows/30 cm to 19 blows/30 cm. These results indicate that this stratum is in a loose to compact state of compaction.

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

This cohesive glacial till deposit was encountered in all the boreholes, with the exception of boreholes located in the southwest corner in the depth range of 1.4 m to 2.2 m (El. 280.9 m to 279.4 m) below the existing ground level. The thickness of this till deposit varies from 0.8 m to 2.2 m and extends to elevation 280.1 m to 277.9 m. The Gradation Test results are shown on Figure 2 in an envelope form. These results indicate 21% to 72% clayey silt, 13% to 35% sand and 15% to 49% Gravel. The results of the Atterberg Limit Test are shown on Figure 3. The natural moisture content of this deposit varies from 7% to 13.5% with an average value of 10.3%. The Standard Penetration Test results indicate stiff to hard consistency (13 blows/30 cm to 82 blows/30 cm).

d) Sand and Gravel, trace Silt

This deposit was encountered immediately below the cohesive till layer. The thickness of this deposit was observed to vary from 4.6 m to 6.7 m and extends to El. 274.8 m to 272.7 m. The Gradation Test results are shown on Figure 4 in an envelope form. These test results indicate 28% to 56%

Gravel, 34% to 60% Sand and 3% to 12% Silt. The Standard Penetration Test results indicate that this stratum is in a compact to very dense state of compaction (N-values 22 blows/30 cm to over 100 blows/30 cm).

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

This non cohesive glacial till deposit underlies the sand and gravel layer. The Gradation Test results are shown on Figure 5 in an envelope form. These results indicate 16% to 50% gravel, 39% to 49% sand and 7% to 45% silt. The natural moisture content varies from 6.5% to 8% with an average value of 7.1%. This stratum is in a very dense state of compaction and complete refusal to Standard Penetration Test was observed (N-values over 100 blows/30 cm). This deposit extends to the depth probed (i.e. El. 264.3 m), however, the full extent of this glacial deposit was not proven.

Groundwater Conditions

The groundwater was encountered in all four boreholes located at the bottom of the embankment, and was observed between El. 279.8 m and 277.9 m. The groundwater level at each borehole location is as follows:

Borehole (No.)	Elevation (m)
1	278.9
2	277.9
3	279.3
4	279.8

MISCELLANEOUS

The field work for this investigation was carried out under the supervision of M. Vasavithasan, Foundation Engineer, and J. LeMessurier, Student Engineer Trainee. The equipment used was owned and operated by Master Soil Investigation Ltd. This report was prepared by M. Vasavithasan and reviewed by P. Payer, Senior Foundation Engineer and approved by M. Devata, Chief Foundation Engineer.



P. Payer, P. Eng.
Senior Foundation Engineer

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

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

Fine

Medium

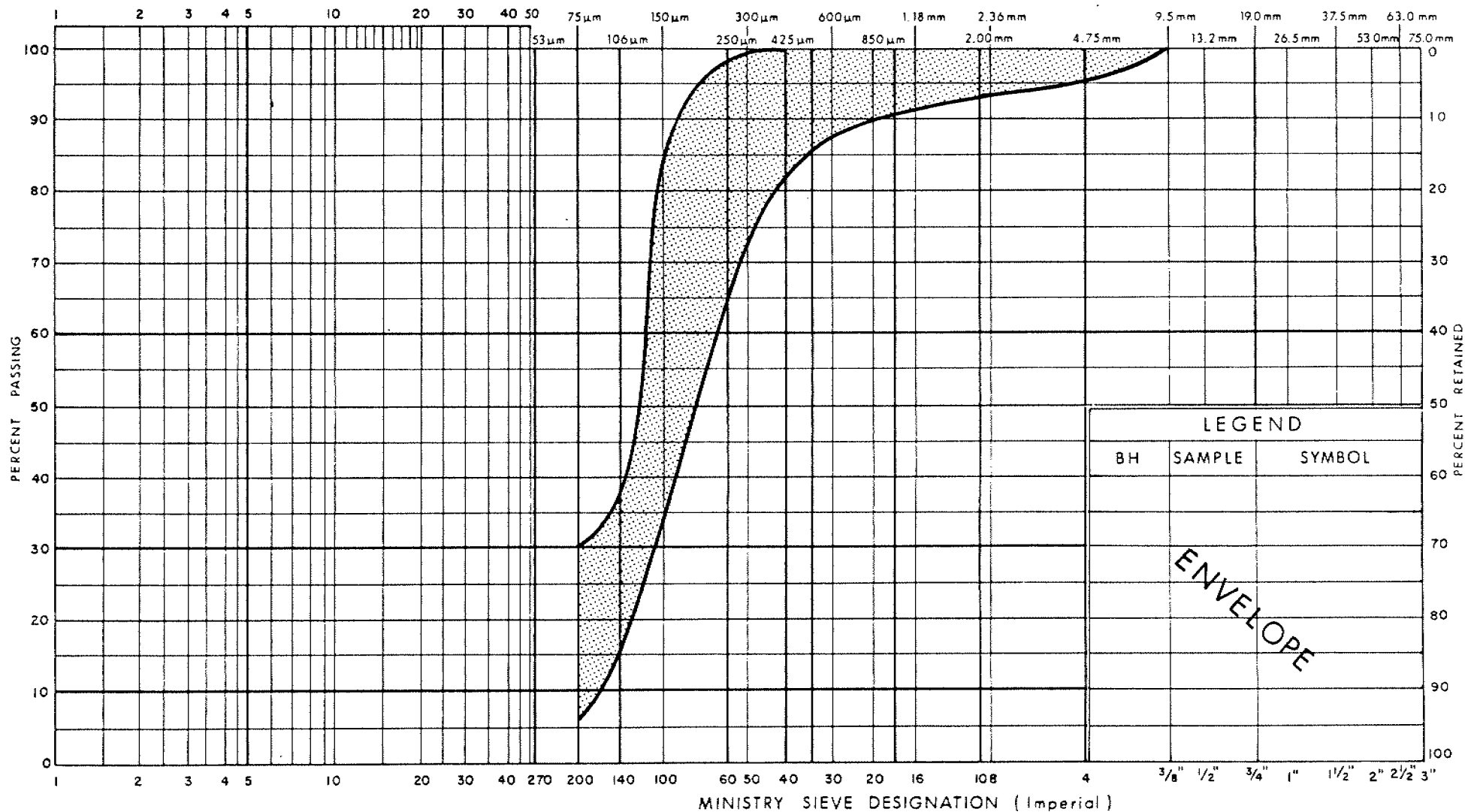
Coarse

Fine

Coarse

GRAIN SIZE IN MICROMETERS

MINISTRY SIEVE DESIGNATION (Metric)



LEGEND

BH SAMPLE SYMBOL

ENVELOPE

GRAIN SIZE DISTRIBUTION
SAND, SOME/WITH SILT, TRACE OF GRAVEL

FIG No 1

W P 479-89-05



Ministry of
Transportation

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

Fine

Medium

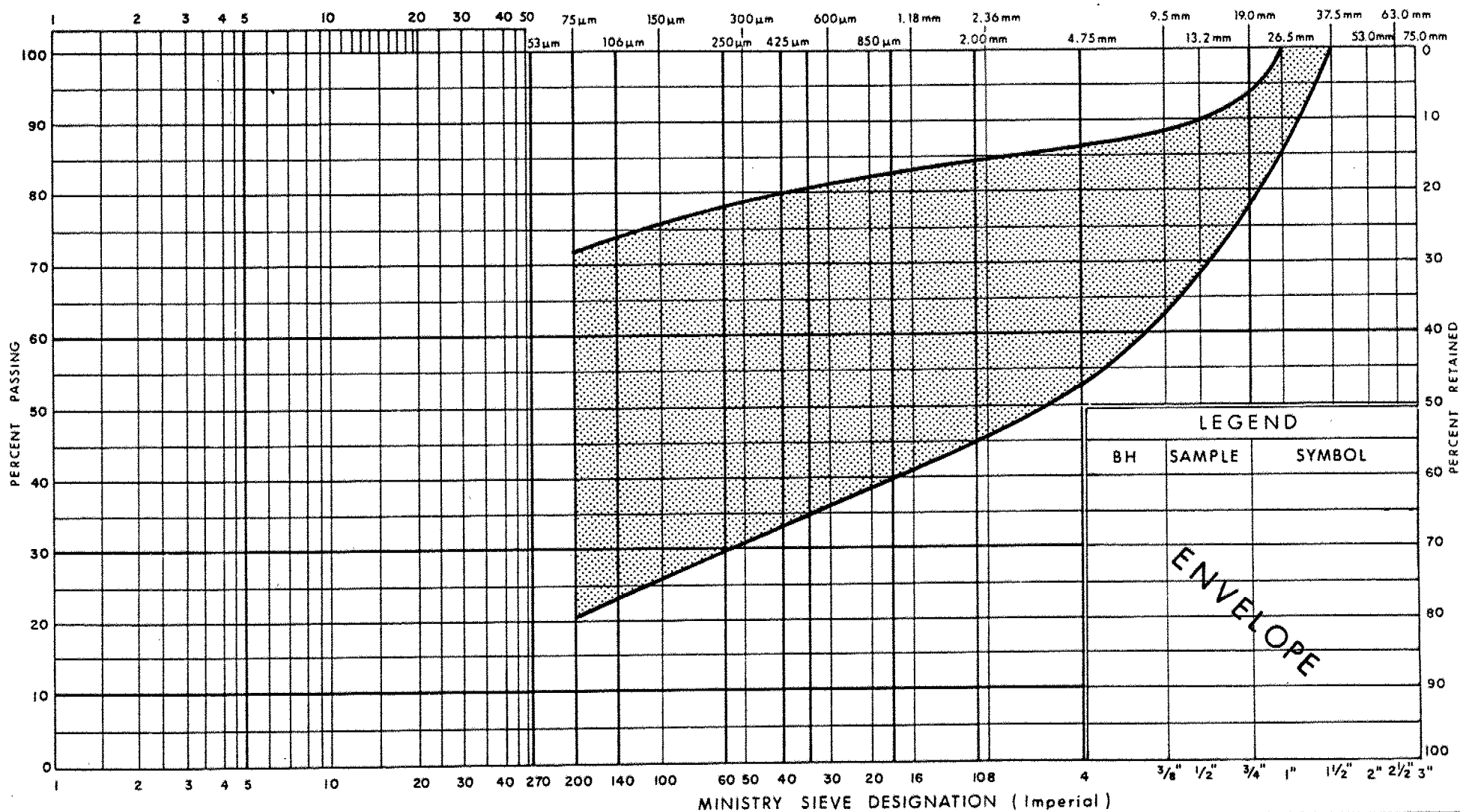
Coarse

Fine

Coarse

GRAIN SIZE IN MICROMETERS

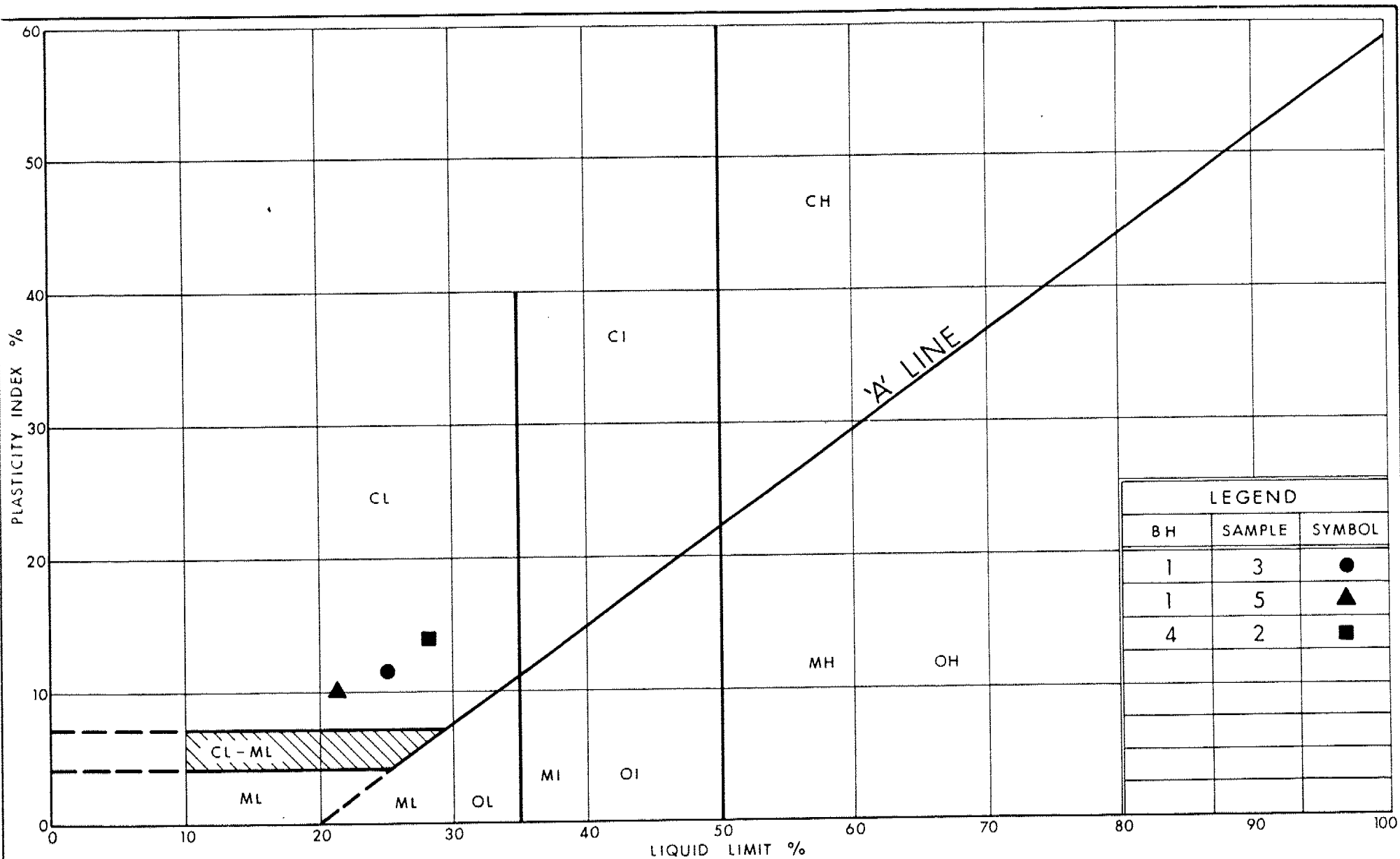
MINISTRY SIEVE DESIGNATION (Metric)

Ministry of
Transportation

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

FIG No 2

W P 479-89-05



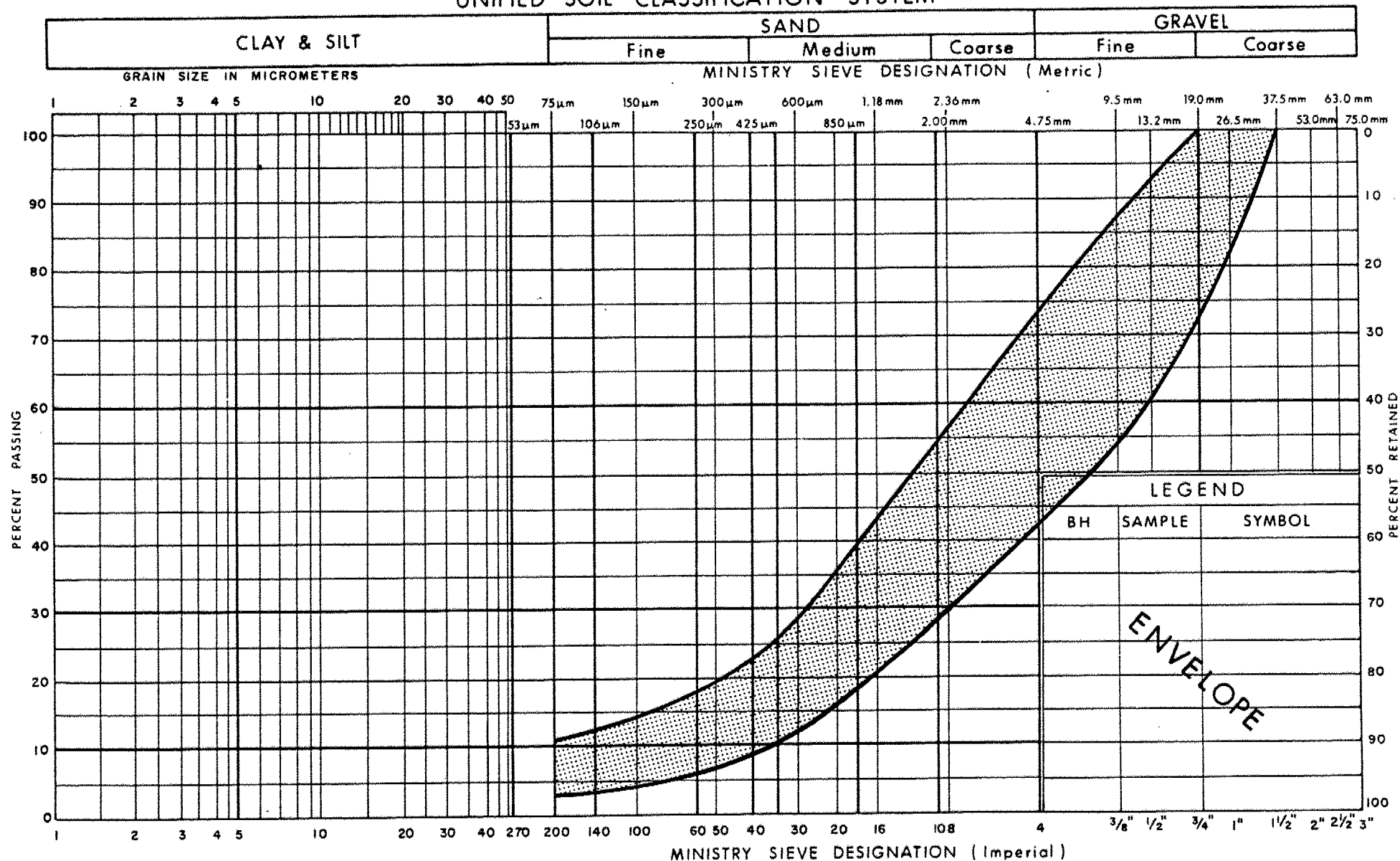
Ministry of
Transportation
Ontario

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

FIG No 3

W P 479-89-05

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SAND & GRAVEL, TRACE OF SILT

FIG No 4

W P 479-89-05

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

Fine

Medium

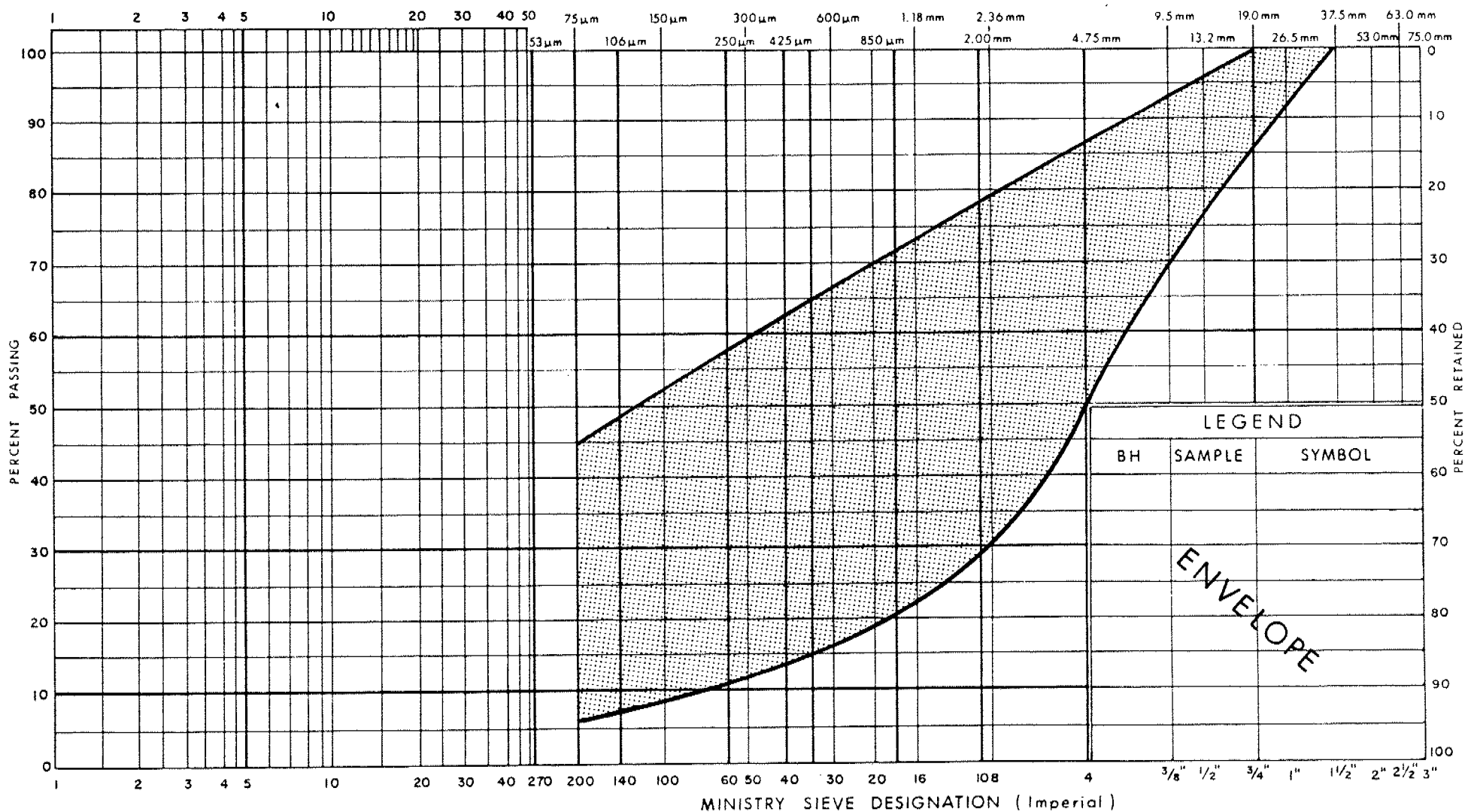
Coarse

Fine

Coarse

GRAIN SIZE IN MICROMETERS

MINISTRY SIEVE DESIGNATION (Metric)

Ministry of
Transportation

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

FIG No 5

W P 479-89-05

RECORD OF BOREHOLE No 1

1 OF 1

METRIC 107

W.P. 479 - 89 - 05 LOCATION CO - ORDS. N 4 765 225.2; E 193 527.8 ORIGINATED BY M. V&J. L.
DIST 2 HWY 401 BOREHOLE TYPE CONE TEST & HOLLOW STEM AUGER COMPILED BY M. V.
DATUM CEODETIC DATE 90 07 16 CHECKED BY P. P.

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					
282.6														
0.0	Trace of Organics		1	SS	10		282							
280.4	SAND With Silt, Trace of Gravel, Loose		2	SS	7									6 64 (30)
2.2	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)		3	SS	39		280							21 35 (44)
278.2			4	SS	82									
			5	SS	52									49 30 (21)
4.4			6	SS	22		278							
			7	SS	28									
	SAND and GRAVEL Trace of Silt, Compact to Dense		8	SS	42		276							45 52 (3)
			9	SS	94									
272.7			10	SS	41		274							51 39 (10)
9.9			11	SS	60	/3cm	272							
			12	SS	100	/10cm	270							
	Heterogeneous Mixture of GRAVEL, SAND and SILT, Very Dense (Glacial Till)		13	SS	100	/10cm	268							30 49 (21)
264.3			14	SS	100	/3cm	266							
18.3	End of Borehole													

RECORD OF BOREHOLE No 2

1 OF 1

METRIC 108

W.P. 479 - 89 - 05 LOCATION CO - ORDS. N 4 765 240.5; E 193 545.9 ORIGINATED BY M V&J L
 DIST 2 HWY 401 BOREHOLE TYPE CONE TEST & HOLLOW STEM AUGER COMPILED BY M V
 DATUM GEODETIC DATE 90 07 16 & 90 07 17 CHECKED BY P P

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	W _p	W	W _L	
281.6	Ground Surface														
0.0	Trace of Organics		1	SS	19										
279.4	SAND With Silt, Trace of Gravel, Compact		2	SS	18										
2.7	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Very Stiff to Hard (Glacial Till)		3	SS	17										
277.9			4	SS	41										
3.7			5	SS	31										
			6	SS	47										
	SAND and GRAVEL, Trace of Silt, Dense		7	SS	36										
			8	SS	48										
273.3			9	SS	56										
8.3			10	SS	120	/23cm									
	Heterogeneous Mixture of GRAVEL, SAND and SILT, Very Dense (Glacial Till)		11	SS	120	/18cm									
			12	SS	120	/15cm									
267.7			13	SS	85	/8cm									
13.9	End of Borehole														

RECORD OF BOREHOLE No 3

1 OF 1

METRIC 109

W.P. 479 - 89 - 05 LOCATION CO - ORDS. N 4 765 167.3; E 193 574.8 ORIGINATED BY M. V&J L
 DIST 2 HWY 401 BOREHOLE TYPE CONE TEST & HOLLOW STEM AUGER COMPILED BY M V
 DATUM GEODETIC DATE 90 07 17 & 90 07 18 CHECKED BY P P

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			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	W _P	W	W _L		
286.3	Ground Surface													
0.0	Trace of Organics						286							
			1	SS	6		284							
	SAND, Some Silt, Loose to Compact		2	SS	12									
			3	SS	16		282							0 93 (7)
			4	SS	12									
279.8			5	SS	54		280							0 88 (12)
6.5			6	SS	105									
	SAND and GRAVEL, Trace of Silt, Very Dense		7	SS	66		278							33 56 (11)
			8	SS	74									
			9	SS	100	/8cm	276							56 36 (8)
			10	SS	79									
274.8			11	SS	76		274							
11.5			12	SS	101									
	Heterogeneous Mixture of GRAVEL, SAND and SILT, Very Dense (Glacial Till)		13	SS	87	/15cm	272							16 39 (45)
			14	SS	100	/9cm	270							
			15	SS	100	/10cm								
							268							
	Boulders													
267.5														
18.8	End of Borehole													
	Note: From 17.6 m to 18.8 m Borehole Was Advanced by Tri - Coning													

RECORD OF BOREHOLE No 4

1 OF 1

METRIC 110

W.P. 479 - 89 - 05 LOCATION CO - ORDS, N 4 765 182.7; E 193 594.6 ORIGINATED BY M V&J L
DIST 2 HWY 401 BOREHOLE TYPE CONE TEST & HOLLOW STEM AUGER COMPILED BY M V
DATUM GEODETIC DATE 90 07 17 TO 90 07 19 CHECKED BY P P

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					
282.3	Ground Surface												
0.0	SAND With Organic Silt, Loose		1	SS	7								
280.9			2	SS	13								15 13 (72)
1.4 280.1	Het. Mix. of CLAYEY SILT, SAND & GRAVEL, Stiff (Till)		3	SS	36								
2.2			4	SS	120	/23cm							
			5	SS	42								
			6	SS	55								48 48 (4)
	SAND and GRAVEL, Trace of Silt, Dense to Very Dense		7	SS	120	/23cm							
			8	SS	29								
			9	SS	91								28 60 (12)
273.4			10	SS	120	/23cm							
8.9	Heterogeneous Mixture of GRAVEL, SAND and SILT, Very Dense (Glacial Till)		11	SS	120	/10cm							
			12	SS	120	/15cm							
268.4			13	SS	120	/20cm							50 43 (7)
13.9	End of Borehole												

RECORD OF BOREHOLE No 5

1 of 1

METRIC 111

W.P. 479 - 89 - 05 LOCATION CO - ORDS. N 4 765 181.2; E 193 558.1 ORIGINATED BY M V&J L
 DIST 2 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGER COMPILED BY M V
 DATUM GEODETIC DATE 90 07 18 CHECKED BY P P

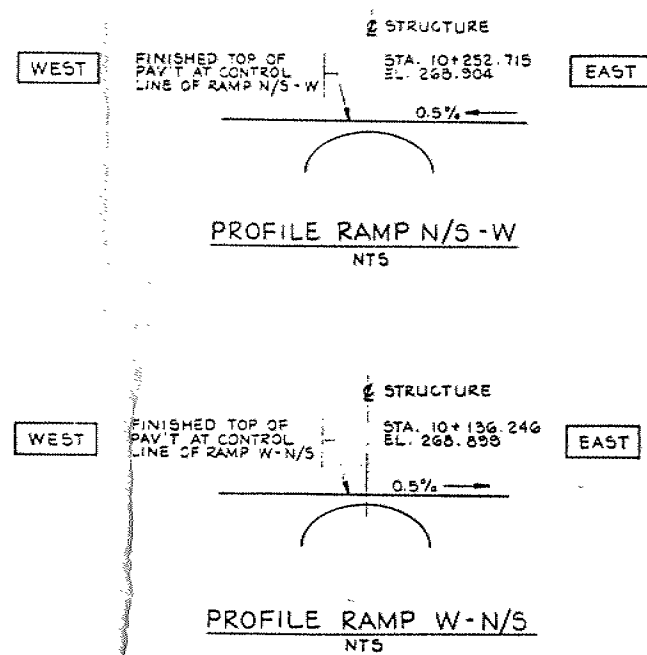
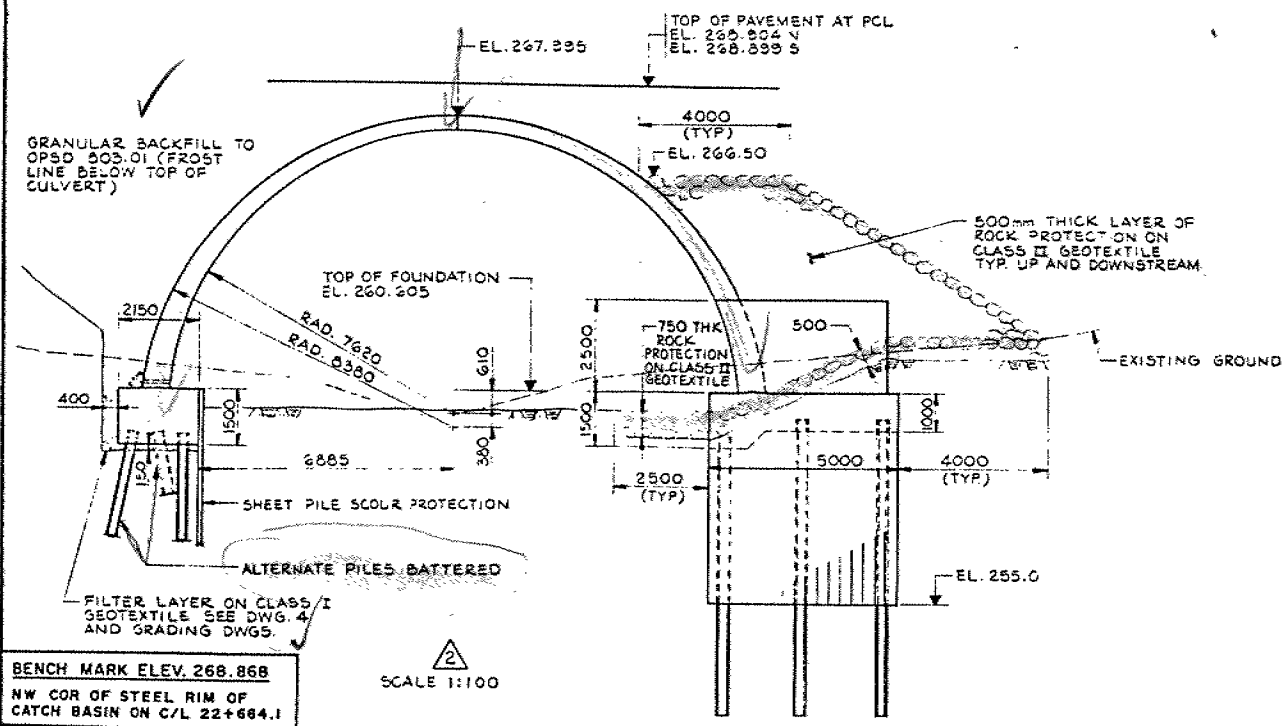
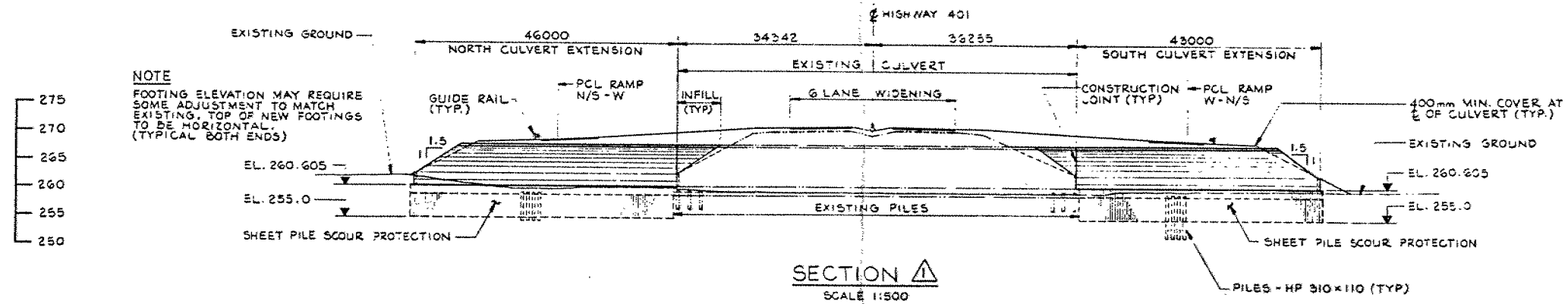
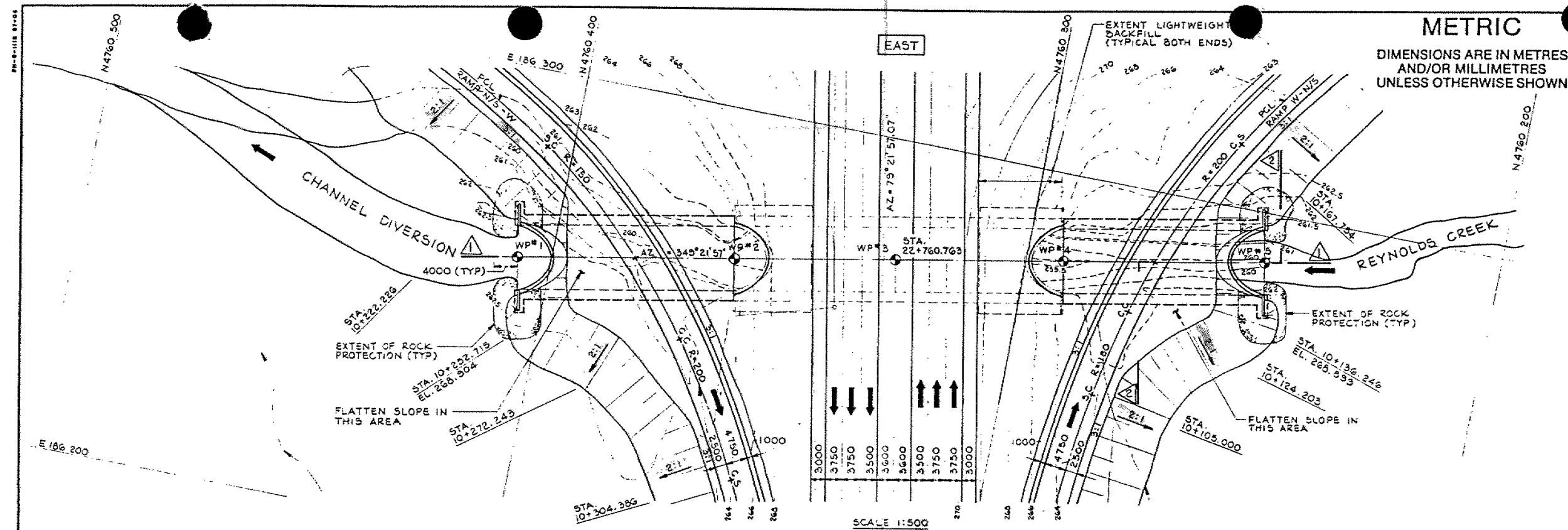
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80	100	W _p	W			W _L
291.0	Hwy. 401 Shoulder																
0.0	SAND With Gravel, Some Silt, Compact to Very Dense (Fill)		1	SS	30												
			2	SS	20												
			3	SS	34												
			4	SS	35												
			5	SS	112												
			6	SS	58												
285.4	Loose ----- SAND, Some Silt, Trace of Gravel, Very Dense		7	SS	5												
5.6			8	SS	62												
			9	SS	156												
281.4																	
9.6	End of Borehole																

RECORD OF BOREHOLE No 6

1 OF 1 METRIC 112

W.P. 479 - 89 - 05 LOCATION CO - ORDS. N 4 765 224.5; E 193 566.4 ORIGINATED BY M V&J L
 DIST 2 HWY 401 BOREHOLE TYPE HOLLOW STEM AUGER COMPILED BY M V
 DATUM GEODETIC DATE 90 07 19 & 90 07 23 CHECKED BY P P

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20	40	60	80	100	20	40	60		
290.8	Hwy. 401 Shoulder																
0.0	SANDY SILT, Some Gravel, Trace of Clay, Loose (Fill)		1	SS	8	DRY	290										
289.4			2	SS	44		288										
1.4	SAND With gravel, Some Silt, Dense to Loose (Fill)		3	SS	36		286										
			4	SS	27												
			5	SS	30												
			6	SS	7												
284.9																	
5.9	SANDY SILT, Trace of Clay, Compact to Dense (Fill)	7	SS	45	284												
		8	SS	20	282												
281.4	Trace of Organics	9	SS	18	280												
9.4	Heterogeneous Mixture of CLAYEY SILT, SAND and GRAVEL, Hard (Glacial Till)	10	SS	48													
278.2		11	SS	54													
12.6	End of Borehole																



WORK POINTS COORDINATES		
W.P.	NORTHING	EASTING
1	4 760 406.986	186 259.755
2	4 760 361.176	186 265.244
3	4 760 328.024	186 274.581
4	4 760 292.362	186 281.277
5	4 760 250.101	186 289.212



DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	DJR	CHK MW	CODE 0H00C-53 (LOAD CLASS A) DATE MAY 1991
DRAWN	AJV	CHK	SITE 19-305 STRUCT C SCHEME [DWG. 1]

METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No 100-90-01

REYNOLDS CREEK
CULVERT EXTENSION
FOUNDATIONS FOR NORTH
EXTENSION



SHEET

Sandwell Sandwell Inc.
Sandwell Swan Wooster Division

PILE DATA

LOCATION	BATTER	Nº REQ'D	LENGTH
EAST FOOTING	1:5	20	5.0
	1:5	21	5.0
	VERT.	24	5.0
WEST FOOTING	1:5	20	4.0
	1:5	21	4.0
	VERT.	24	4.0

MAX. COMB. FACTORED LOADS

U.L.S. 1250 kN
S.L.S. 800 kN

NOTES:

- ALL BEARING PILES TO BE HP 310x110
- PILE SPACING IS MEASURED FROM UNDERSIDE OF FOOTING
- PILE LENGTHS SHOWN IN TABLE ARE THEORETICAL LENGTHS BELOW CUT-OFF ELEVATION
- PILES TO BE DRIVEN IN ACCORDANCE WITH STANDARD SS-103-10 OR SS-03-11 USING ULTIMATE CAPACITY OF 3450 kN PER PILE
- SHEET PILES SHOWN ON THIS DRAWING ARE REQUIRED FOR SCOUR PROTECTION
- SHEET PILES TO HAVE SECTION MODULUS $\geq 200,000 \text{ cm}^3/\text{m}$ AND MIN. WALL THICKNESS 6mm
- QUANTITY OF ANCHORAGES ASSUMES ANCHORS ARE SPACED AT 1000 O.C. CONTRACTOR TO ADJUST QUANTITY TO SUIT ACTUAL PILE SHAPE

DRAINAGE BLANKET

- THE DRAINAGE/FILTER BLANKETS SHOULD BE IN PLACE PRIOR TO PILE DRIVING
- THE GEOTEXTILE SHOULD BE CUT WITH A 300mm x 300mm "X" AT LOCATIONS WHERE PILES WILL PENETRATE.
- IF BLANKET IS DISTURBED DURING PILE DRIVING, THE BLANKET SHOULD BE RESTORED TO THE DETAILS SHOWN AFTER COMPLETION OF PILE DRIVING.

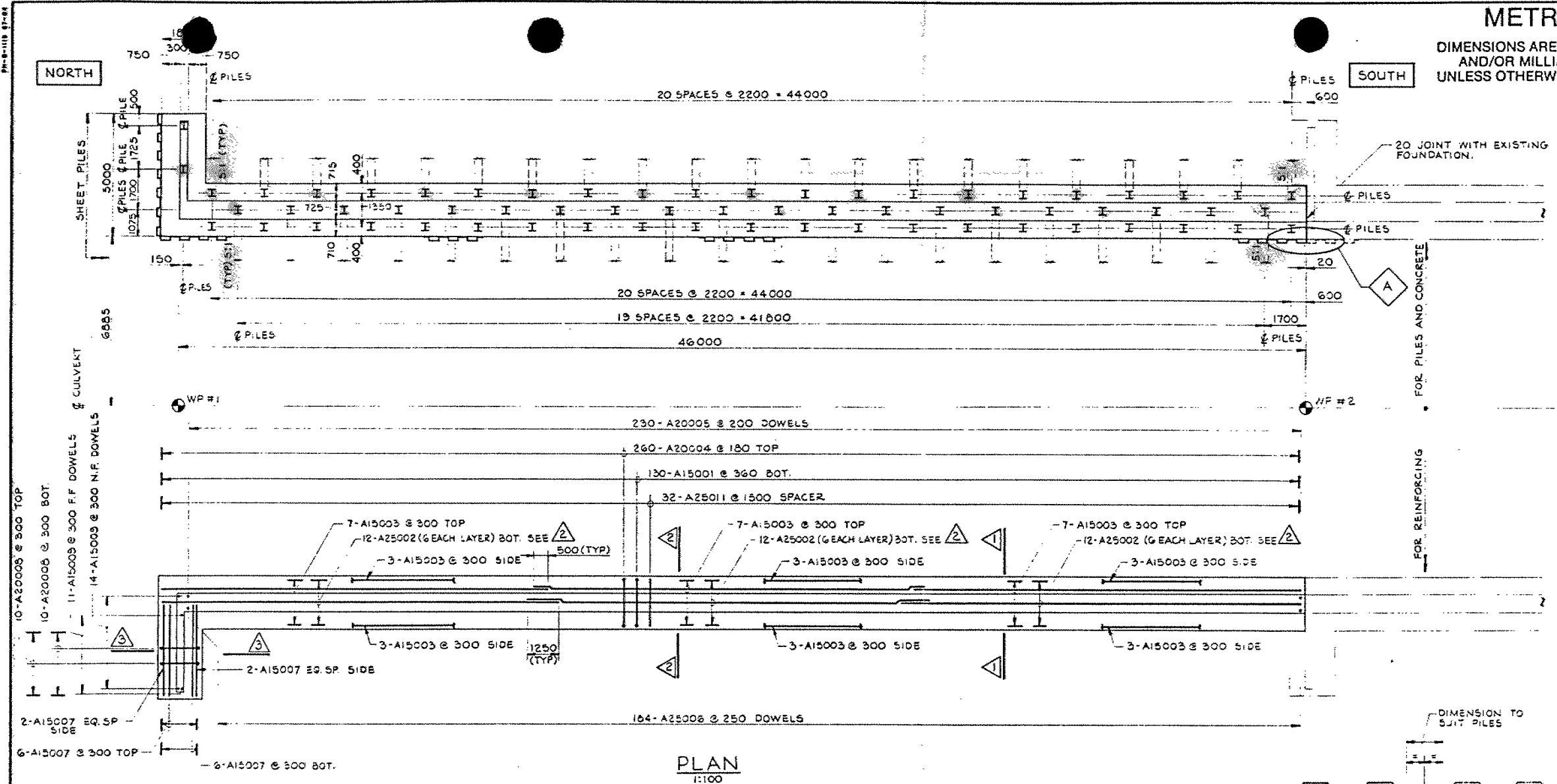
APPLICABLE STANDARD DRAWINGS

DD-3922 SUPPORTS FOR BOTTOM REINFORCING STEEL
DD-3920 STEEL SHEET PILES - ANCHORAGE DETAILS

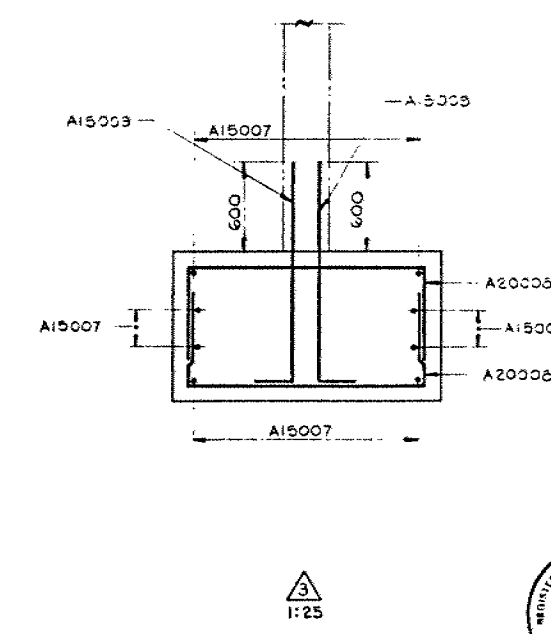
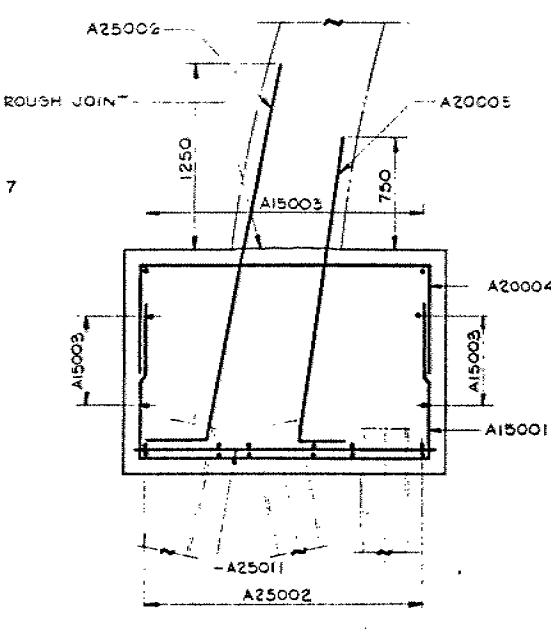
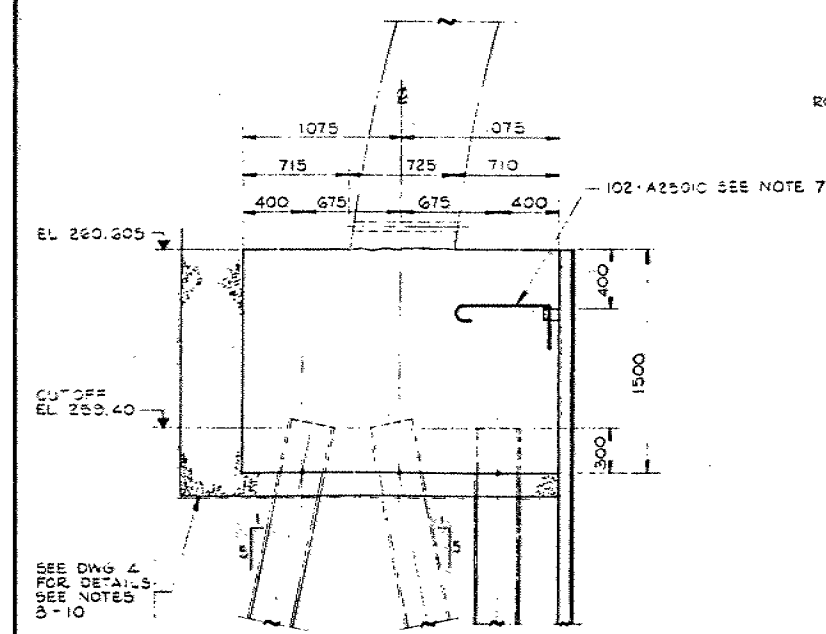


DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION



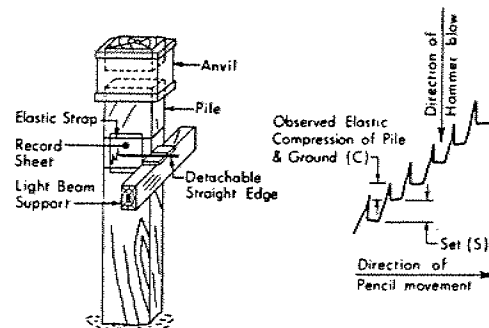
PLAN
1:100



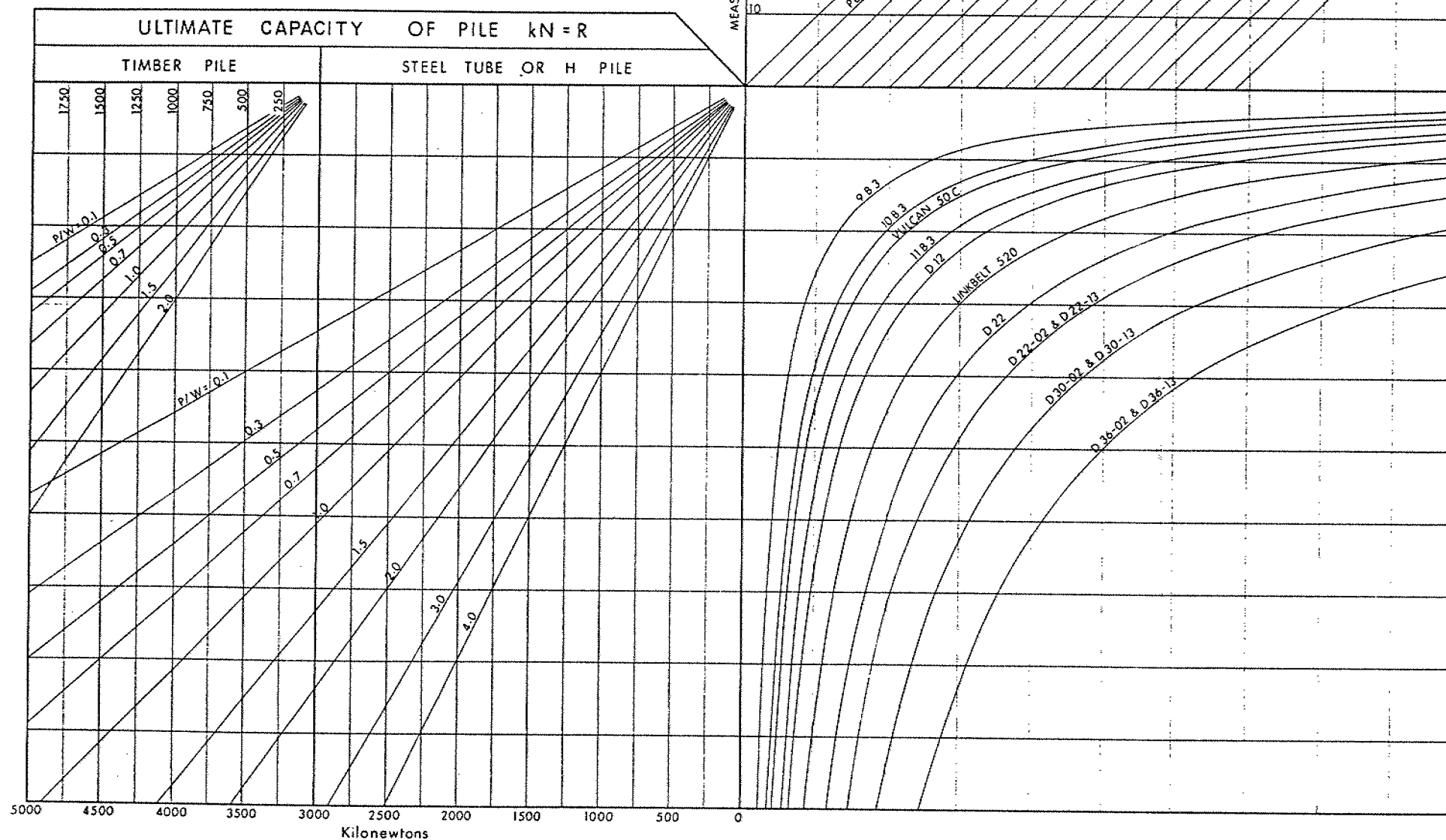
FIELD WELD 6 THICK x 300 DEEP
PLATE TO OUTSIDE EDGE OF
EXISTING SHEET PILE. USE
PLATE AS GUIDE FOR NEW WELD
PLATE TO NEW PILE
AFTER DRIVING



HAMMERS		
TYPE	MASS OF RAM W Kilograms	MAXIMUM ENERGY Joules/blow
9 B 3	726	12 419
10 B 3	1 361	16 948
50 C	2 268	20 337
11 B 3	2 268	26 005
D 12	1 250	30 506
B 225	1 360	39 300
L B 520	2 300	40 675
B 300	1 700	46 100
D 22	2 200	53 826
B 400	2 268	62 400
D 22-02	2 200	67 000
D 22-13	2 200	67 000
D 30-02	3 000	91 000
D 30-13	3 000	91 000
B 500	3 129	107 100
D 36-02	3 600	115 000
D 36-13	3 600	115 000



NOTE:
Ram may also be referred to as Piston



METHOD OF APPLYING THE HILEY FORMULA

$$R = \frac{nWgh}{S + \frac{C}{2}} \quad (\text{Hiley Formula}) \quad g = 9.80665 \text{ m/s}^2$$

Where R = Ultimate pile capacity in kilonewtons
 S = Measured penetration of pile per hammer blow in millimetres
 C = Measured rebound of pile per hammer blow in millimetres
 Wgh = Energy of hammer blow in joules
 n = Efficiency of blow = $\frac{W + Pe^2}{W + P}$

where $e = 0.32$ for steel (These values of e have been determined by experiment)
 $= 0.25$ for timber
 P = Mass of pile + anvil in kilograms
 W = Mass of ram (piston) in kilograms

The P/W curves form the required reduction of total energy of the hammer blow according to the value of P/W

$L = R/Q$ kilonewtons

Where L = Design capacity of pile

Q = Factor of safety

Use $Q = 3$ unless otherwise authorized by the Engineer

EXAMPLE 1:

Steel tube pile, O D = 323.90 mm linear density = 49.73 kg/m, 20 m long plus anvil of mass 600 kg, giving $P = 994.6 + 600 = 1594.6$ kg

Delmag D12 hammer $W = 1250$ kg $P/W = \frac{1594.6}{1250} = 1.28$

Observed measured rebound $C = 10$ mm

Observed measured penetration $S = 5$ mm

USING CHART: With $C = 10$ proceed horizontally to right to cut line $S = 5$ then vertically down to cut curve D12 then horizontally to left to cut $P/W = 1.28$ then vertically down to read ultimate capacity $R = 1512$ kN $L = \frac{1512}{3} = 504$ kN

EXAMPLE 2:

HP 310x110, 50 m long plus anvil of mass 600 kg giving $P = 5500 + 600 = 6100$ kg. The hammer is a Delmag D22-13

$W = 2200$ kg, $n = \frac{W + Pe^2}{W + P} = \frac{2200 + (6100 \times 0.32 \times 0.32)}{2200 + 6100} = \frac{2824}{8300} = 0.34$

Energy of hammer (Wgh) = 67 000 J/blow

Observed measured rebound $C = 10$ mm

Observed measured penetration $S = 5$ mm

USING HILEY FORMULA

Ultimate capacity $R = \frac{nWgh}{S + \frac{C}{2}} \text{ kN} = \frac{0.34 \times 67000}{5 + \frac{10}{2}} = 2278$ kN

Design capacity $L = \frac{2278}{3} = 759$ kN

NOTE 1:

These charts are designed to cover most cases which will be encountered on normal construction projects. Occasionally it will be found that R cannot be obtained from the charts, for instance when $C = 5$ mm and $S = 2$ mm using a Delmag D22 hammer. In such cases it will be necessary to calculate R using the original equation $R = \frac{nWgh}{S + \frac{C}{2}}$

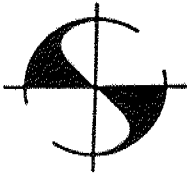
In cases where the energy of the hammer being used is slightly different from the hammer energy for which curves are drawn the curves may still be used but the result should be reduced or increased according to the energy ratios. Example use Linkbelt 520 curve (Energy 40 675 J) for Berminghammer 225 (Energy 39 300 J) but reduce result by multiplying by $\frac{39300}{40675}$

NOTE 2:

For projects designed to the OHBDC, the ultimate capacity (R) is shown on the contract drawings and L and Q are not required

STANDARD DRAWING
JULY 1981 SS 103-11

REVISIONS		DATE		BY	DESCRIPTION
DESIGN	K S	CHECK	M W	LOADING CLASS A	DATE 05/91
DRAWING	CP	CHECK	D J R	SITE No 19-305	DWG 9



STRATA ENGINEERING CORP.

RESEARCH . ENGINEERING . SCIENCE

Tel.: (416) 441-2560
Fax: (416) 441-4161

Suite 410, 170 The Donway West,
Don Mills, Ontario, Canada M3C 2G3

FOUNDATION INVESTIGATION REPORT

100-90-01 *CONT 92-06*

W.P. ~~479-89-06/07~~ Bridge Site No: 19-305

Proposed Culvert Extension or New Structure

Hwy. 401 and Reynolds Creek

District 2, London, Southwestern region

Ministry of Transportation, Ontario

Report Issue Date: 1990 11 22

Strata File: W-90-004

GEOCREP # 40I15-27

Distribution:

MTO Foundation Design Section - 13 copies
Strata Files - 1 copy

w.p. 479-89-06/07

TABLE OF CONTENTS

1.0	INTRODUCTION	1
2.0	SITE AND GEOLOGY	1
3.0	FIELD AND LABORATORY WORK	2
4.0	SUBSURFACE CONDITIONS	4
4.1	General	4
4.2	Organics and Fill Materials	4
4.3	Clayey Silt	4
4.4	Silty Sand (Glacial Till)	6
4.5	Sandy Gravel	6
5.0	GROUNDWATER CONDITIONS	6
6.0	DISCUSSION AND RECOMMENDATIONS	7
6.1	General	7
6.2	Structure Foundations	7
6.3	Earth Pressures	8
6.4	Approach and Ramp Fills	9
6.5	Constructuion Considerations	9
7.0	CLOSURE	10

APPENDIX

FOUNDATION INVESTIGATION REPORT

W.P. 479-89-06/07, Bridge Site No: 19-305

Proposed Culvert Extension or New Structure

Hwy. 401 and Reynolds Creek

District 2, London

Ministry of Transportation, Ontario

1.0 INTRODUCTION

Strata Engineering Corp. has been retained by the Foundation Design Section of the Ministry of Transportation, Ontario, under Consultant Agreement No: 4240-9190-090, to conduct a foundation investigation for a proposed extension to the reinforced concrete arch slab culvert across Reynolds Creek. The terms of reference were to investigate the site by means of sampled boreholes and dynamic cone penetration tests, and to provide a full geotechnical report in advance of the issuance of E-Plans for the site.

This report is submitted in compliance with these terms of reference and contains recommendations for the design and construction of the culvert extension or its replacement with a new bridge structure, new interchange ramps, and widening of the existing approach fills.

2.0 SITE AND GEOLOGY

The site is located on Highway 401 at Interchange No. 208, in North Oxford Township, County of Middlesex, about 21km east of London.

The terrain in this area is flat to gently undulating. The banks and shoreline areas beyond the creek channel itself have developed marshes and swampy conditions. The boundaries around some of the interchange ramp loops are heavily wooded. Both of these site specific features made access to proposed drilling locations extremely difficult, and in a few instances, virtually impossible. Access to specific site locations near the proposed culvert extension limits is possible only in winter when the ground has frozen sufficiently to support drilling machinery. Also, some major trees would need to be clear-cut to enable access into the open areas near the existing culvert.

This site lies in an area where two physiographic regions of southern Ontario intersect, namely the Mount Elgin Ridges and the Oxford Till Plain.

The dominant geomorphological feature of the site is a north-south tending spillway breached into the east-west tending Ingersoll Moraine. Outwash flow occurred from south to north through the breached channel. The major soil types in this area are therefore ice-contact stratified drift related to the Ingersoll and Westminster Moraines, and the outwash materials through the spillway.

The spillway formed a broad valley which became infilled with fluvio-lacustrine cohesive sediments. The infilled spillway valley now forms the drainage channel for Reynolds Creek, which flows northerly to join the Thames River near Putnam. It follows a circuitous route through the St. Thomas Moraine, and is believed to have performed very little recent dissection (Chapman and Putnam, 1984)¹.

Drift thickness and bedrock topography maps indicate a depth to bedrock in this area of some 30m below ground surface. The bedrock has been mapped as dolomites and limestones of the Detroit River Group of Middle Devonian Age.

3.0 FIELD AND LABORATORY WORK

At the time of assignment of the project, an ETR plan was supplied showing the proposed culvert extensions on the north and south sides of Highway 401, together with an option to replace the culvert with a bridge on new foundations. After clearing all underground utilities, boreholes were laid out to coincide with the ends of the proposed extensions, and/or new footings, wherever feasible.

Lack of access to many of the proposed structure footing locations (due to reasons given earlier) necessitated the drilling of boreholes some distance away from these intended locations, as shown on Drawing 4798906/07-A.

The field investigation was conducted from 1990 07 31 to 1990 08 03, using a bombardier mounted CME 55 hollow stem drilling machine. At certain depths in some boreholes, washboring techniques were employed, along with tri-cone drilling, to advance the boreholes through very dense or hard strata. On 1990 07 24, hand auger boreholes were attempted in areas not accessible to the drilling machine.

1. Physiography of Southern Ontario, 3rd ed. OGS Special Vol. 2, p. 93

A total of seven sampled boreholes were drilled (BH's: 2, 3, 4, 5, 6, 8, 9). Boreholes 1 and 7 were drilled by means of a hand auger, and sampled with a small diameter piston sampler. Near Boreholes 2 and 6, dynamic cone penetration resistance tests were performed. Within Borehole 8, a dynamic cone test was attempted when the borehole could not be advanced due to artesian pressure related problems.

Borehole 3 was drilled to determine the soil conditions for the proposed Reynolds Creek channel re-alignment. Boreholes 8 and 9 were drilled from the existing interchange ramp loop fills because access to the east side of the culvert, both north and south of Highway 401, was impossible given the heavy tree growth and soft terrain conditions at the time of this investigation. Boreholes 4 and 5 were drilled to determine the soil conditions below the proposed interchange ramp fills. The end result is that only Boreholes 2 and 6 are located close to the existing culvert, and only on its west side. However, the soil conditions across the valley are uniform; therefore, reliable interpolations of the soil conditions on the east side of the culvert may be made from representative cross-sections across the creek channel.

Samples of the overburden were obtained in the split-barrel sampler, the N values being noted for the Standard Penetration Test in blows/0.3m. Where feasible, thin walled tube samples were obtained in cohesive portions of the overburden. An MTO specification field vane was used with fish scales to apply a coupled torque for the measurement of undrained in situ shear strength in cohesive strata.

Bedrock was not reached in any of the boreholes.

In the laboratory, all soil samples were examined visually. Index property tests, such as moisture contents, Atterberg limits and grain size distributions were conducted on selected specimens. Some thin walled samples were extruded. Tests were conducted on some of the extruded specimens for consolidation and undrained shear strength characterization of the cohesive stratum.

The laboratory test results are shown in Figures 1 to 5 and on the Borehole Log Sheets in the Appendix.

Groundwater levels were monitored on a daily basis and a week after completion of drilling. The last recorded levels are shown on the Borehole Log Sheets.

In Borehole 2, a sealed perforated standpipe was installed to measure an artesian head condition.

4.0 SUBSURFACE CONDITIONS

4.1 General

Below fill or surficial organics, the predominant soil of concern is a laminated clayey silt stratum which is underlain by a silty sand glacial till overlying a sandy gravel deposit. Artesian groundwater conditions were encountered within the silty sand and underlying strata. Details follow.

4.2 Organics and Fill Materials

Organic soils were encountered in Boreholes 1, 4, 5, 6, and 7 at the surface. They range from peat (at Borehole 7) to topsoil and surficial sandy, flood plain type of deposits, mixed with vegetative organics. The thickness of these surficial organic materials ranged from 2.9m at Borehole 7 to 1.0m at Borehole 6.

Moisture content determinations show a range in values, depending on organic matter content. The values range from 119 per cent for the peat to 15 per cent for the organically contaminated sandy soils.

N values ranged between 5 and 14 blows/0.3m, indicating a loose to compact relative density for the organic sandy soils. The peaty soils are of generally soft consistency.

In Boreholes 8 and 9 which were drilled through the existing interchange ramp fills, the fill material consists of a medium to fine sand (Figure 1), with N values ranging from 4 to over 65 blows/0.3m. In Borehole 8, the fill was found to be underlain, at a depth of 9.4m, by a compressed peat deposit of 700mm thickness, with a moisture content of 26 per cent.

A fill type of material was also encountered in Borehole 2, close to the west side of the north portion of the existing culvert. This material may have originated as a result of construction of the existing culvert. Its thickness was 2.9m, with N values ranging between 5 and 12 blows/0.3m, and moisture contents approaching 30 per cent.

4.3 Clayey Silt

The major soil deposit at this site, from a design viewpoint, is a clayey silt stratum. The stratum was encountered in all machine drilled boreholes at elevations ranging between 259.7m and 260.9m. This uniformity in upper surface elevation indicates the deposit is widespread and of likely lacustrine origin. Therefore, its existence is suspected also on the east side of the culvert, at about elevation ± 260 m.

This cohesive deposit consists of a clayey silt. The soil has a distinct laminar feature, consisting of fine sand or silt seams of 1mm to 2mm thickness, spaced regularly to irregularly at 25mm to 40mm spacings. In some samples, the laminates appear to have been replaced with pockets of fine sand. This shows that the depositional conditions were not constant, and that turbidity was a major factor during genesis of the stratum.

The total thickness of the deposit ranged between 3.0m at Borehole 2 and 6.6m at Borehole 8, averaging about 5.5m in all boreholes through which the deposit was fully penetrated.

The moisture content of the soil was found to range between 16 and 27 per cent. The moisture content shows a tendency to increase with depth in Boreholes 3, 5, and 8 and a slight tendency to decrease with depth in Borehole 6. The observed moisture contents are all above the plastic limit of the soil, and in some cases are equal to the liquid limit, indicating a liquidity index of unity. The plasticity characteristics of the soil are shown in Figures 2A and 2B. The soil is classified as a clayey silt to silt of low plasticity (CL-ML soil).

Standard Penetration Resistance N values generally decreased with depth, ranging between 7 and 20 blows/0.3m in boreholes positioned at prevailing ground surface level. In Boreholes 8 and 9, below the ramp fills, the N values ranged between 15 and 42 blows/0.3m, showing the effects of consolidation over time. Also, the average moisture content of the soil in Boreholes 8 and 9 was a few percentage points below the average moisture content in the other boreholes.

Undrained in situ vane shear testing was attempted in Boreholes 6 and 8. In Borehole 6, a field vane undrained shear strength value of just over 40kPa was measured near the middle of the stratum, some 4.5m below ground surface. At approximately the same elevation in Borehole 8, the field vane could not be turned. In Borehole 6, an unconfined compression test gave an undrained shear strength of 30kPa near mid-thickness. At the same elevation in Borehole 8, the unconfined undrained shear strength was over 70kPa. Near the base of the deposit in Boreholes 6 and 8, the field vane could not be turned. Unconfined compression tests yielded values of the undrained shear strength of between 80kPa and 190kPa.

The result of one oedometer test is shown in Figure 3. The test shows a possible pre-consolidation value of the soil of about between 100kPa and 120kPa. The compression index, C_c , is 0.122. The coefficient of consolidation, c_v , was found to be about 0.5 cm²/min. at stresses ranging between 100kPa and 200kPa.

Based on the above field observations and laboratory tests, the overall consistency of the deposit is estimated to range between firm and very stiff, being generally firm near the middle of the deposit, except below ramp fills, where it is very stiff to hard.

4.4 Silty Sand (Glacial Till)

The clayey silt stratum is underlain by a silty sand deposit (glacial till) occurring between elevations 256.8m at Borehole 2, and 252.5m at Borehole 6. This stratum was not found at Borehole 3 below the clayey silt deposit.

The soil consists of a silty sand, with gravel. Some typical grain size distribution curves are shown in Figure 4, and indicate a range in gravel content of between 3 and 30 per cent. The silt content is generally less than 15 per cent. However, silty zones are present within the deposit, and occur more or less at random.

The thickness of this stratum was found to be between 1.5m and 1.9m in locations where it was fully penetrated (Boreholes 9 and 2 respectively), and over 3.9m at Borehole 6, where the deposit was not fully penetrated.

The moisture content of the stratum ranged between 7 and 14 per cent, being over 25 per cent in a clayey silt contaminated transition zone in Borehole 9.

N values of 43 to over 100 blows/0.3m indicate the deposit is generally dense to very dense. Some low recorded N values are suspected to be the result of "boiling" during sampling due to unbalanced hydrostatic heads and artesian pressure.

4.5 Sandy Gravel

A deposit of sandy gravel was encountered below the silty sand glacial till deposit in Boreholes 2 and 9 at an elevation of about ± 255 m. Typical grain size curves for representative samples are shown in Figure 5. The moisture content of this soil varied between 6 and 12 per cent. N values were generally over 100 blows/0.3m, indicating the deposit to be very dense.

5.0 GROUNDWATER CONDITIONS

Groundwater level observations were made in open boreholes at time of drilling or in piezometers and open standpipes after completion of drilling. These observations show the general phreatic level to be at about elevation ± 260 m.

However, artesian heads, reaching up to 2.5m above prevailing ground level were measured at Borehole 2, and are suspected to be the cause of an elevation observation of over 262m at Borehole 8.

6.0 DISCUSSION AND RECOMMENDATIONS

6.1 General

It is proposed to widen Highway 401 to 6 lanes between London and Woodstock. This will involve a reconstruction of the existing interchange at Putnam Road. In connection with this reconstruction, the existing reinforced concrete arch slab culvert supporting Highway 401 above Reynolds Creek, just west of Putnam Road, will need to be either extended or replaced with a new bridge.

It is understood the existing culvert is supported on caisson foundations. If a new structure is provided in lieu of extending the culvert, it will likely be a monolithic single span type, with wing walls to retain fill material.

The realigned ramp heights will be about 8m above prevailing ground level.

The proposed reconstruction of the W-S/N Ramp will involve a southerly extension of the south end of the existing culvert, and the proposed reconstruction of the S/N-W Ramp will involve a northerly extension of the northern end of the existing culvert.

This site investigation shows the presence of shallow surficial organics and clayey silt fill materials overlying a compressible deposit of firm to very stiff clayey silt above a silty sand glacial till deposit overlying very dense sandy gravel at depth. The non-cohesive strata below the clayey silt deposit are the source of artesian to sub-artesian heads.

6.2 Structure Foundations

6.2.1 Spread Footings

The presence of the compressible clayey silt deposit across the site, and at both ends and sides of the existing culvert (from geological inference) prohibits the use of spread footings for the proposed extensions and for the foundations for the alternative new structure. Therefore, the culvert extensions and abutments of the new structure will need to be supported on a deep foundation.

6.2.2 Deep Foundations

Due to the presence of artesian conditions, steel H piles are the preferred deep foundation type for this site.

For purposes of the OHBDC, assuming embedment lengths as indicated by the toe elevations given below, the following values are recommended for steel H piles (HP 310x110):

Factored capacity at ULS	1250kN
Capacity at SLS Type II	900kN

Location of Footing	Likely Pile Toe Elev. @ Design Capacity
North Extension	
East Side	254.5 m
West Side	255.5 m
South Extension	
East Side	252.0 m
West Side	251.5 m

Pile driving should be monitored using the Hiley Formula. Pile caps should be provided with 1.2m of earth cover for protection against frost action.

6.3 Earth Pressures

Earth pressures should be computed as per subsection 6-6.1.2.2 of OHBD Code. A yielding foundation condition may be assumed. The Granular "A" or "B" backfill should be backfill should be in accordance with Special Provision No. 109F03 (latest revision). The following parameters are recommended for the granular backfill:

	Gran. "A"	Gran. "B"
Angle of internal friction, ϕ'	35.0°	30.0°
Unit Weight (kN/m ³), γ	22.8	21.2

Surcharge effects, if any, should be computed as per Clause 6-6.1.2.4 of the OHBD Code.

6.4 Approach and Ramp Fills

6.4.1 Stability considerations

A review of the existing approach and ramp fills shows no signs of instability. However, the presence of the compressible clayey silt deposit at this site raises some concerns with respect to stability of the proposed revised ramp fills. Therefore, stability calculations were carried out. The result is shown in Figure 6. Bishop's simplified method of circular arc total stress analysis was used, and the minimum factor of safety was computed to be 1.31.

It is assumed in the stability analysis that all surficial organics have been stripped down to native mineral soil, and that all fills are built with standard 2:1 slopes.

6.4.2 Settlement Considerations

Settlement analyses show maximum settlements of 8m high fills to be in the order of 150mm, with about 90 per cent of this settlement occurring within one year of imposition of full loading.

6.5 Construction Considerations

Excavations taken below prevailing phreatic groundwater levels will require dewatering. Dewatering may be accomplished by the use of interlocking steel sheet piling driven at least 1.0m into the clayey silt stratum to form a watertight enclosure.

The native soil lining the channel side slopes and invert is considered to be moderately erodible. Therefore, the creek realignment channel should have cut side slopes no steeper than 2H:1V to preserve long term stability and to minimize erosion.

Consideration should be given to providing erosion protection lining to high water level within the channel by means of geotextile covered rip-rap or other suitable alternative, based on hydrological considerations of stream flows and velocities.

Fills crossing the abandoned creek channel should be placed with due consideration of the possibility of soft compressible materials being present within the channel, at least within 1m or so of the creek bed. Subexcavation backfill should be non-cohesive materials.

Environmental protection, in the form of silt barriers, may be required to protect against sediment movement into the creek.

7.0 CLOSURE


The field work for this investigation was carried out by Ms. Andrea C. Abel, assisted by Mr. Justin Klodner.

The drilling equipment and crew were rented from Atcost Soil Drilling Limited of Concord, Ontario.

Respectfully submitted:
STRATA ENGINEERING CORP.



A. C. Abel, M. Sc
Project Engineer



C. Mirza, P. Eng.
Senior Principal

Report Distribution:

MTO Foundation Design Section	13 copies
Strata File W-90-004	1 copy

Date of Submission: 1990 11 06

W.P. 479-89-06/07

APPENDIX

Explanation of Terms used in Report

Office Record of Borehole Logs 1- 9

Figures 1-6

Drawing 4798906/07-A

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_a	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_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
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^2	SEEPAGE FORCE
γ'	KN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

RECORD OF BOREHOLE No1

METRIC

W P 479-89-06/07 LOCATION Co-ords. 4,760,448 N; 186,269 E ORIGINATED BY AA
 DIST 2 HWY 401 BOREHOLE TYPE Hand Auger COMPILED BY AK
 DATUM Geodetic DATE 1990 07 24 CHECKED BY CM

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					
262.1	Ground surface																GR SA SI CL
0.0	Organic Clayey Silt Brown some sand, Tr. Grav. Soft		1	TP	PM		262										
			2	TP	PM		261										
260.7			3	TP	PM		260										
1.4	Clayey Silt with sand and Occ. gravel - Grey Soft																
259.5																	
2.6	End of Borehole No further penetration possible with hand auger. * Borehole dry upon completion																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No2

METRIC

W P 479-89-06/07 LOCATION Co-ords. 4,760,373 N; 186,252 E ORIGINATED BY AA
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Test & washboring COMPILED BY AK
 DATUM Geodetic DATE 1990 08 01 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa					
262.7	Ground surface													
0.0	Organic Clayey Silt and Topsoil incl. Firm (Fill)		1	SS	5									Water Levels on 1990 08 10
	with Gravel		2	SS	12									43 41 (16)
	Stiff		3	SS	11									
259.8	Clayey Silt (Laminated)		4	SS	8									
2.9	Stiff to Firm		5	SS	7									
	Grey		6	SS	7									
256.8	Silty Sand to Silt		7	SS	100									
5.9	Occ. gravel Tr. clay (Glacial Till) Very Dense Grey		8	SS	110/0.2m									Wash casing installed and sampling conducted by triconing to desired depth.
254.9	Sandy Gravel		9	SS	101/0.1m									
7.8	Very Dense Grey													
253.3	End of Borehole													
9.4	Artesian pressure controlled by sealing with "Benseal".													

RECORD OF BOREHOLE No3

METRIC

W P 479-89-06/07 LOCATION Co-ords. 4,760,437 N; 186,264 E ORIGINATED BY AA
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AK
 DATUM Geodetic DATE 1990 08 01 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W _p	W	W _L	WATER CONTENT (%)		
262.6	Ground surface													GR SA SI CL
0.0	Sandy Silt with gravel						262							
261.4	Compact Rusty Brown		1	SS	13									
1.2	Clayey Silt (Laminated)		2	SS	18		261							
	Stiff to Very Stiff		3	SS	16		260							
			4	SS	15		259							
			5	SS	12		258							
			6	SS	12		257							
	Grey		7	SS	8									
256.0			8	SS	11		256							
6.6	Sandy Gravel with silt (Glacial Till)													WL on 1990 08 01
255.3	Very Dense - Grey		9	SS	71									52 37 (11)
7.3	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 4

METRIC

W P 479-89-06/07 LOCATION Co-ords. 4,760,348 N; 186,212 E ORIGINATED BY JK
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AK
 DATUM Geodetic DATE 1990 08 01 CHECKED BY CM

SOIL PROFILE		STRAT PLOT	SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION		NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
262.2	Ground surface																GR SA SI CL
0.0	Topsoil & Clayey Silt with organics Soft - Firm						262										
261.1			1	SS	14												
1.1	Clayey Silt (Laminated)		2	SS	20		261										
			3	SS	14		260										
	V. Stiff - Stiff		4	SS	17		259										
	Grey		5	SS	15		258										
			6	SS	12		257										
	with Fine Sand partings		7	SS	11		256										
255.9			8	SS	105		255										
6.3	Silty Sand Occ. gravel (Glacial Till) Very Dense Grey																
254.3			9	SS	160/	23cm											
7.9	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

*3, *5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 5

METRIC

W P 479-89-06/07 LOCATION Co-ords. 4,760,292 N; 186,223 E ORIGINATED BY JK
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AK
 DATUM Geodetic DATE 1990 07 31 CHECKED BY CM

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					
261.8	Ground surface																GR SA SI CL
0.0	Silty Sand with organics Compact to Loose Brown		1	SS	11		261										WL on 1990 07 31
			2	SS	9		260										
259.7			3	SS	12		259										
2.1	Clayey Silt (Laminated)		4	SS	12		258										
	Fine Sand Partings at random		5	SS	10		257										
	Stiff - Firm		6	SS	9		256										
	Grey		7	SS	9		255										
			8	SS	9		254										
255.0			9	SS	80/	30cm	253.9										
6.8	Silty Sand Occ. gravel (Glacial Till)																
253.9	Very Dense - Grey																
7.9	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No6

METRIC

W P 479-89-06/07 LOCATION Co-ords. 4,760,282 N; 186,268 E ORIGINATED BY JK
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger and Dynamic Cone Test, Washboring COMPILED BY AK
 DATUM Geodetic DATE 1990 07 31 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)				
								20 40 60 80 100							10 20 30				
260.9	Ground surface							○ UNCONFINED	+ FIELD VANE					GR SA SI CL					
0.0	Sandy Silt with organics Topsoil							○ QUICK TRIAXIAL	× LAB VANE										
259.9			1	SS	13		260							WL on 1990 07 31					
1.0	Clayey Silt (Laminated)		2	SS	8		259												
	Firm		3	SS	8		258												
			4	SS	8		257												
	Grey		5	TW	PH		256						20.5	Consol. Test (Fig. 3)					
			6	SS	7		255												
	becoming stiff to very stiff with depth		7	SS	8		254												
			8	TW	PH		253						20.7						
253.5	Clayey Silt with sand and gravel (Glacial Till)		9	SS	55		252												
7.4	Hard - Grey [Transition Zone]						251												
252.5	Silty Sand with gravel (Glacial Till)		10	SS	62		250							20 65 (15)					
8.4	Very Dense						249												
	Grey		11	SS	181/30cm									Wash casing installed Borehole advanced by triconing.					
248.6			12	SS	140/15cm														
12.3	End of Borehole																		

+³, x⁵: Numbers refer to
Sensitivity

20
15
10
5
0
5
10
15
20
(%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No7

METRIC

W P 479- 89-06/07 LOCATION Co-ords. 4,760,205 N; 186,327 E ORIGINATED BY JK
 DIST 2 HWY 401 BOREHOLE TYPE Hand Auger COMPILED BY AK
 DATUM Geodetic DATE 1990 08 01 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						WATER CONTENT (%)
								SHEAR STRENGTH kPa						10 20 30
260.8	Ground surface													
0.0	Peat													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 8

METRIC

W P 479-89-06/07 LOCATION Co-ords. 4,760,385 N; 186,321 E ORIGINATED BY AA
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY AK
 DATUM Geodetic DATE 1990 08 02 CHECKED BY CM

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					
271.0	Ground surface															
0.0																
	Medium Sand (Fill)		1	SS	33											
			2	SS	44											
	Dense to Very Dense															
	Brown		3	SS	33											
			4	SS	101											
			5	SS	37											
	Silty Sand		6	SS	44											
	Occ. gravel															
	Compact to Very Dense		7	SS	68											
	Grey															
			8	SS	23											
261.6			9	SS	34											
9.4	Peat Stiff Black															
260.9			10	SS	42											
10.1	Clayey Silt															
	Occ. Fine Sand Partings		11	SS	28											
	Hard to Very Stiff		12	SS	24											
	Grey		13	SS	27											
			14	SS	15											
			15	TW	PH											
			16	SS	15											
256.0																

15.0 Borehole continued...

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

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No8 cont'd

METRIC

W P 479-89-06/07 LOCATION Co-ords. 4,760,385 N; 186,321 E ORIGINATED BY AA
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY AK
 DATUM Geodetic DATE 1990 08 02 CHECKED BY CM

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					
256.0	cont. from page 1																
15.0	Clayey Silt occ. Fine Sand Partings Stiff - V. Stiff		17	TW	PH		255									21.0	
254.5																	
16.5	Silty Sand, Occ. gravel (Glacial Till)					Artesian Pressure encountered	254										
253.7	Compact - Grey		18	SS	25												3 83 (14)
17.3	End of Borehole and Cone Test Cone Test conducted since augers were sinking and sand was coming up in them.																

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No9

METRIC

W P 479-89-06/07 LOCATION Co-ords. 4,760,261 N; 186,347 E ORIGINATED BY JK
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AK
 DATUM Geodetic DATE 1990 08 03 CHECKED BY CM

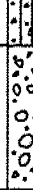
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100								SHEAR STRENGTH kPo			WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE								● QUICK TRIAXIAL x LAB VANE			10 20 30		
270.8	Ground surface														GR SA SI CL						
0.0	Medium Sand (Fill)						270														
	Compact to Very Dense		1	SS	42		269					○			4 84 (12)						
							268						○								
	Brown		2	SS	11		267														
			3	SS	65		266					○									
							265														
			4	SS	59		264						○		5 81 (14)						
							263														
262.7	Tr. Organics		5	SS	4		262					○									
8.1	Clayey Silt (Laminated)		6	SS	23		261						○								
	V. Stiff		7	SS	21		260						○								
	Occ. fine sand partings		8	SS	25		259							○	WL on 1990 08 03						
	Grey		9	SS	19		258						○								
			10	SS	14		257							○							
	Stiff		11	SS	12		256							○							
258.2			12	SS	8																
12.6	Silty Sand Occ. silty clay zones (Glacial Till) Loose to Compact		13	SS	11										0 83 (17)						
	Grey		14	SS	19																
255.8	with some gravel																				

15.0 Borehole continued...

+3, x5: Numbers refer to
Sensitivity

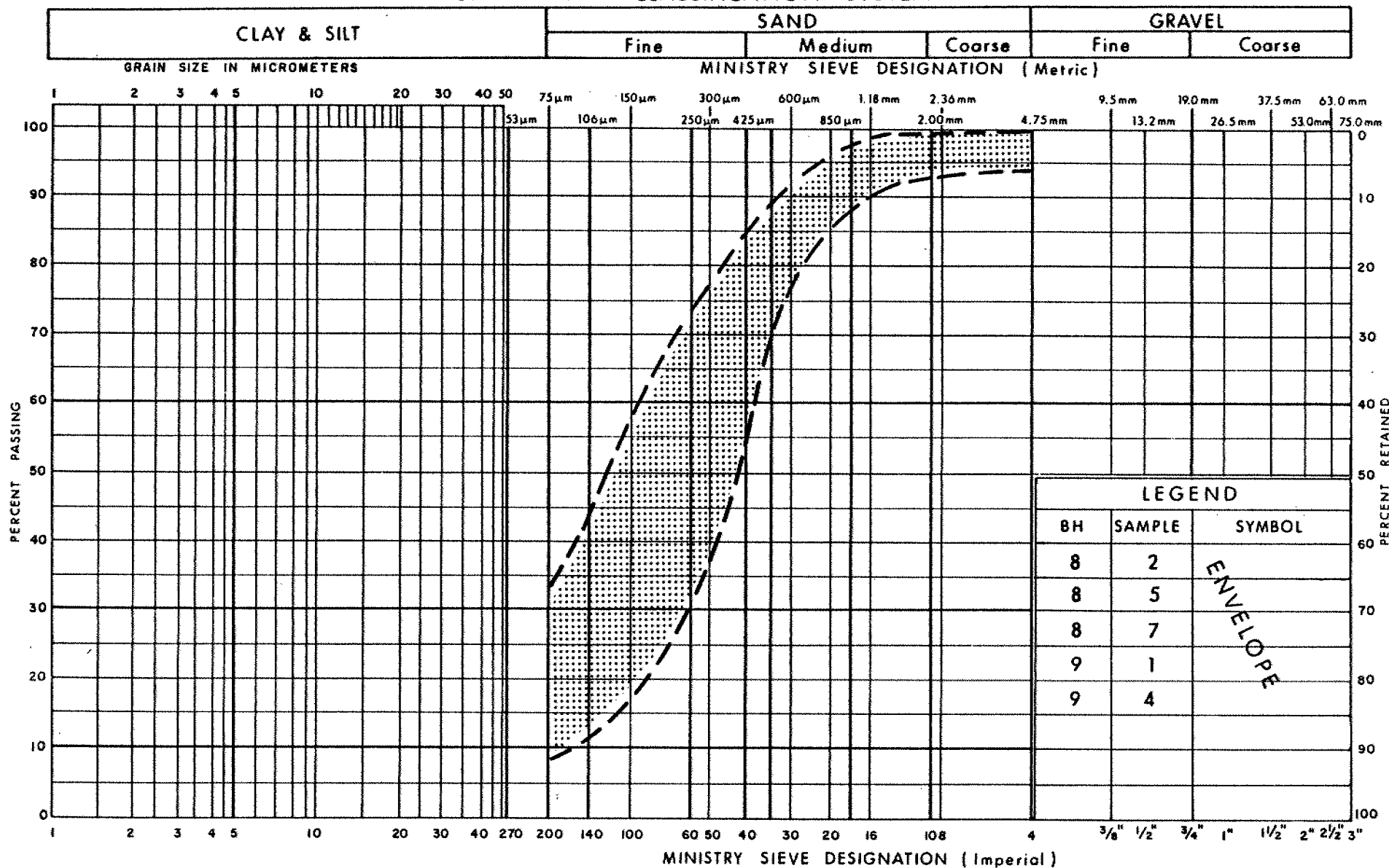
20
15 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 9 cont'd										METRIC						
W P 479-89-06/07		LOCATION Co-ords. 4,760,261 N; 186,347 E				ORIGINATED BY JK										
DIST 2 HWY 401		BOREHOLE TYPE Hollow Stem Auger				COMPILED BY AK										
DATUM Geodetic		DATE 1990 08 03				CHECKED BY CM										
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80	100	W _p	W		
255.8	cont. from page 1															
15.0	Silty Sand		15	SS	43											26 67 (7)
255.3	Dense (Glacial Till)															
15.5	Sandy Gravel															
	Very Dense		16	SS	78											
	Grey															
253.8			17	SS	130	25cm	254									60 35 (5)
17.0	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

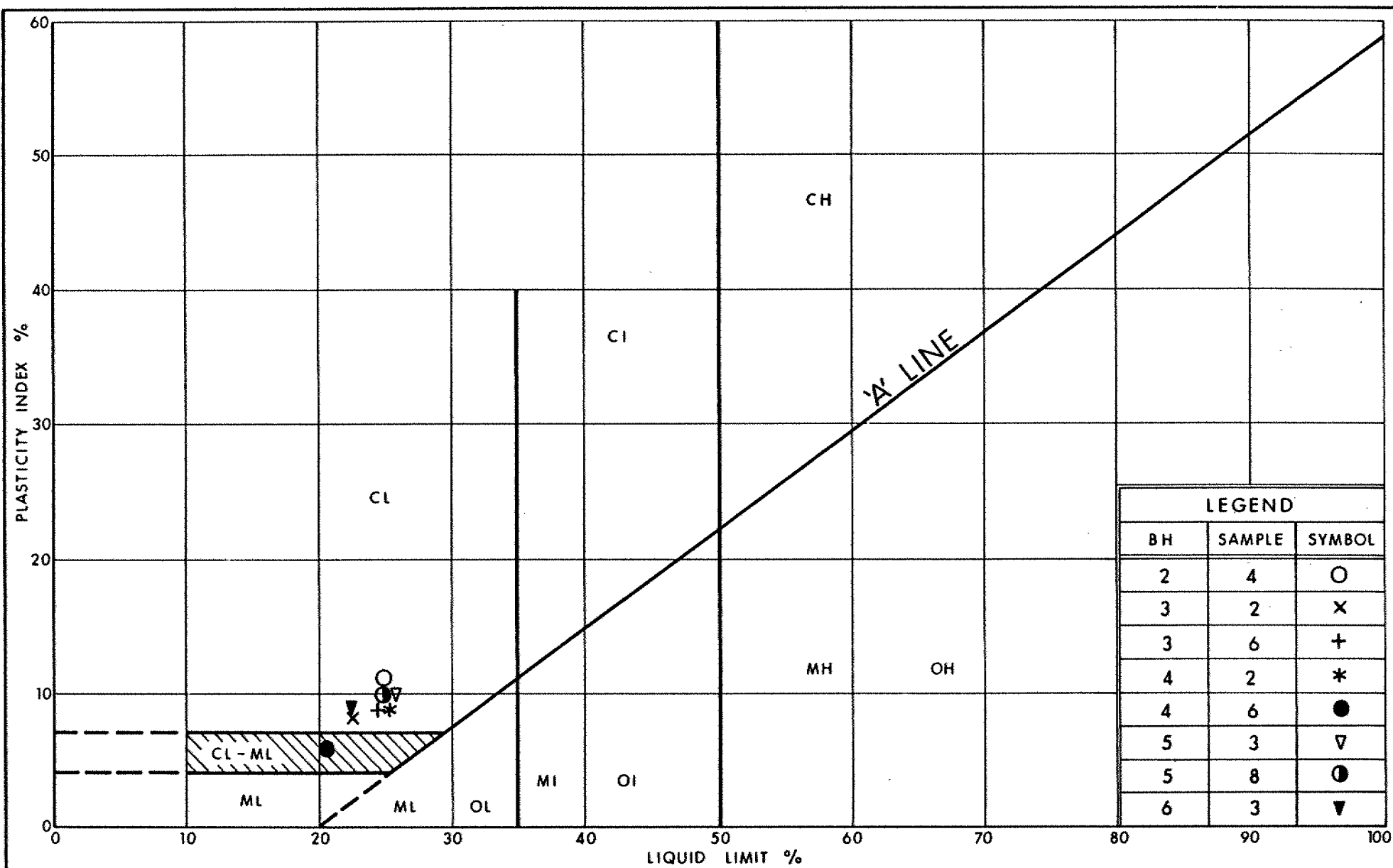
GRAIN SIZE DISTRIBUTION

Sand to Silty Sand (Ramp Fill)

FIG No 1

W P 479-89-06/07

Site No. 19-305



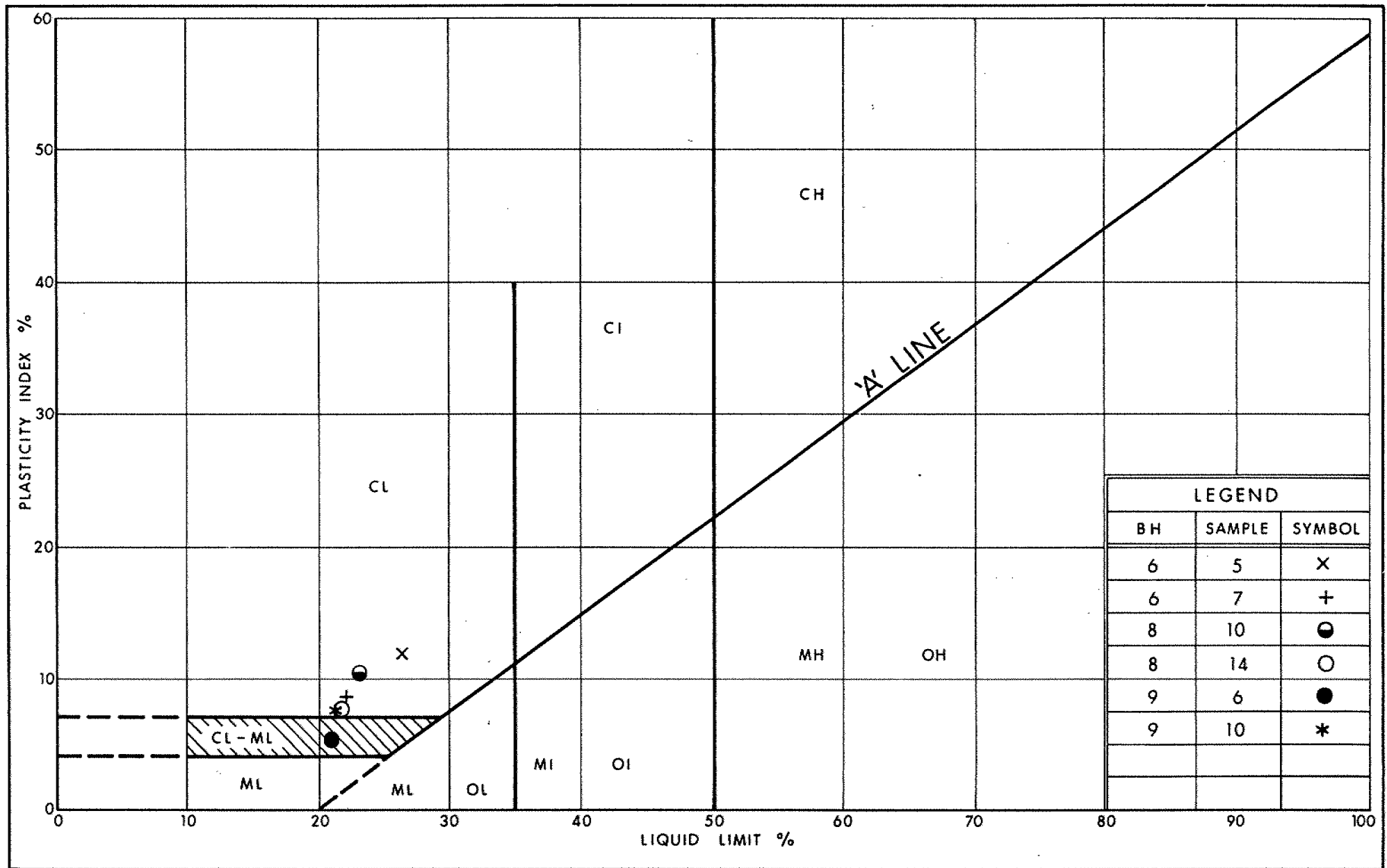
Ministry of
Transportation

PLASTICITY CHART Clayey Silt

FIG No 2A

W P 479-89-06/07

Site No. 19-305



Ministry of
Transportation

PLASTICITY CHART

Clayey Silt

FIG No 2B

W P 479-89-06/07

Site No. 19-305

VOID RATIO - PRESSURE CURVES

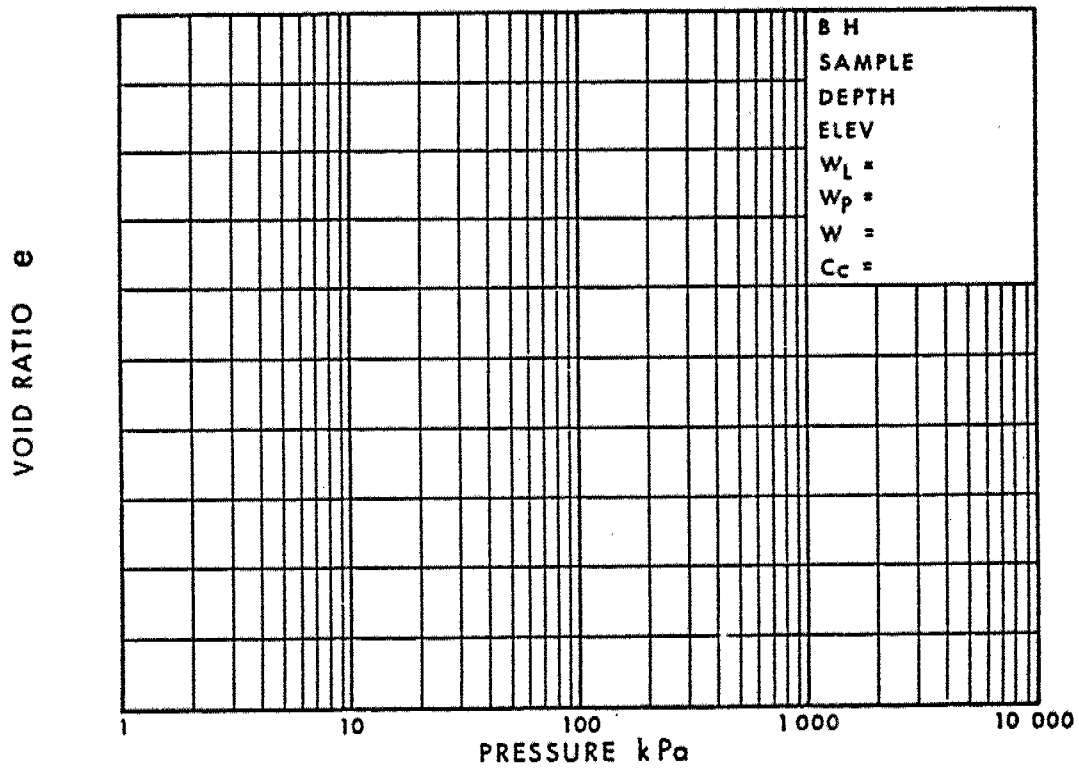
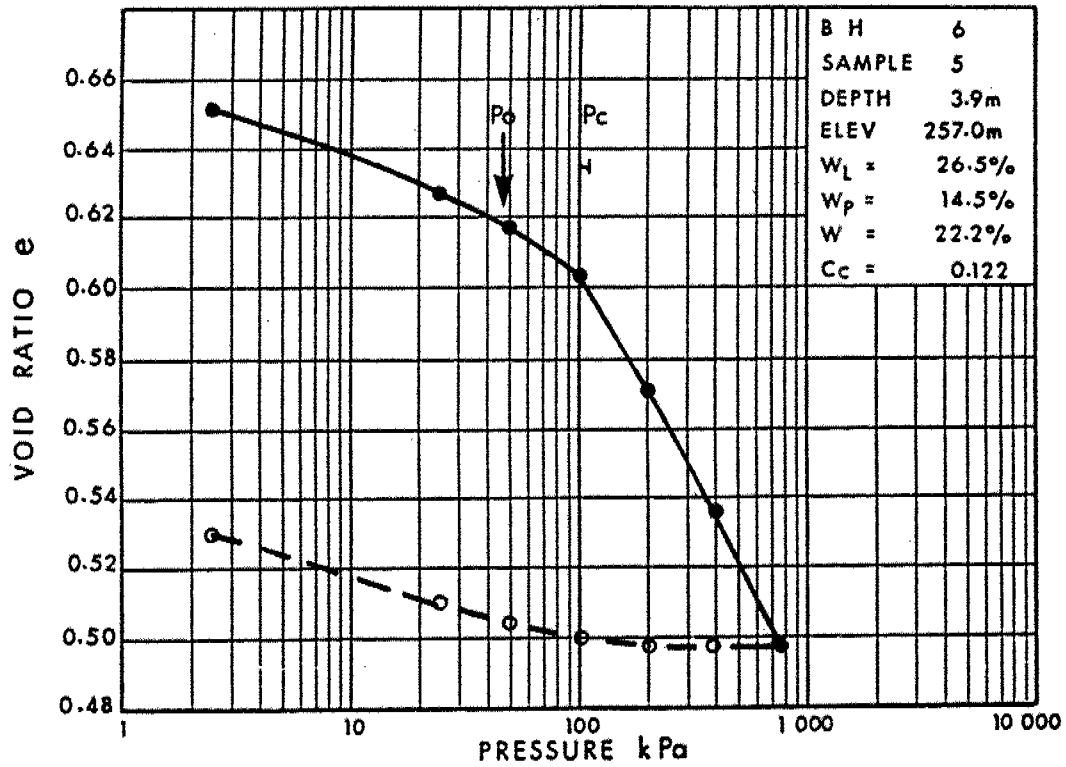
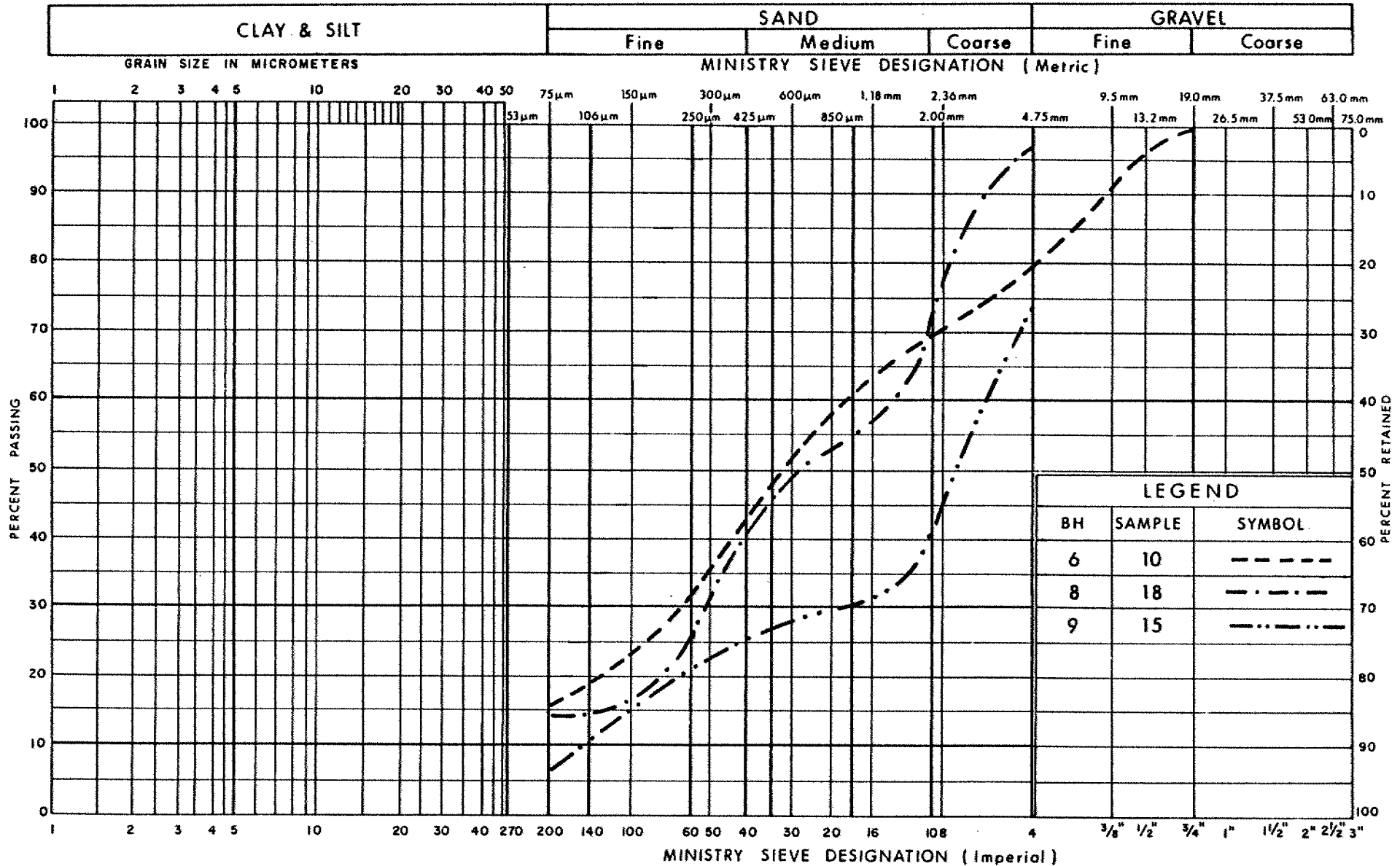


Fig 3

W P 479-89-06/07

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION

Silty Sand with Gravel
(Glacial till)



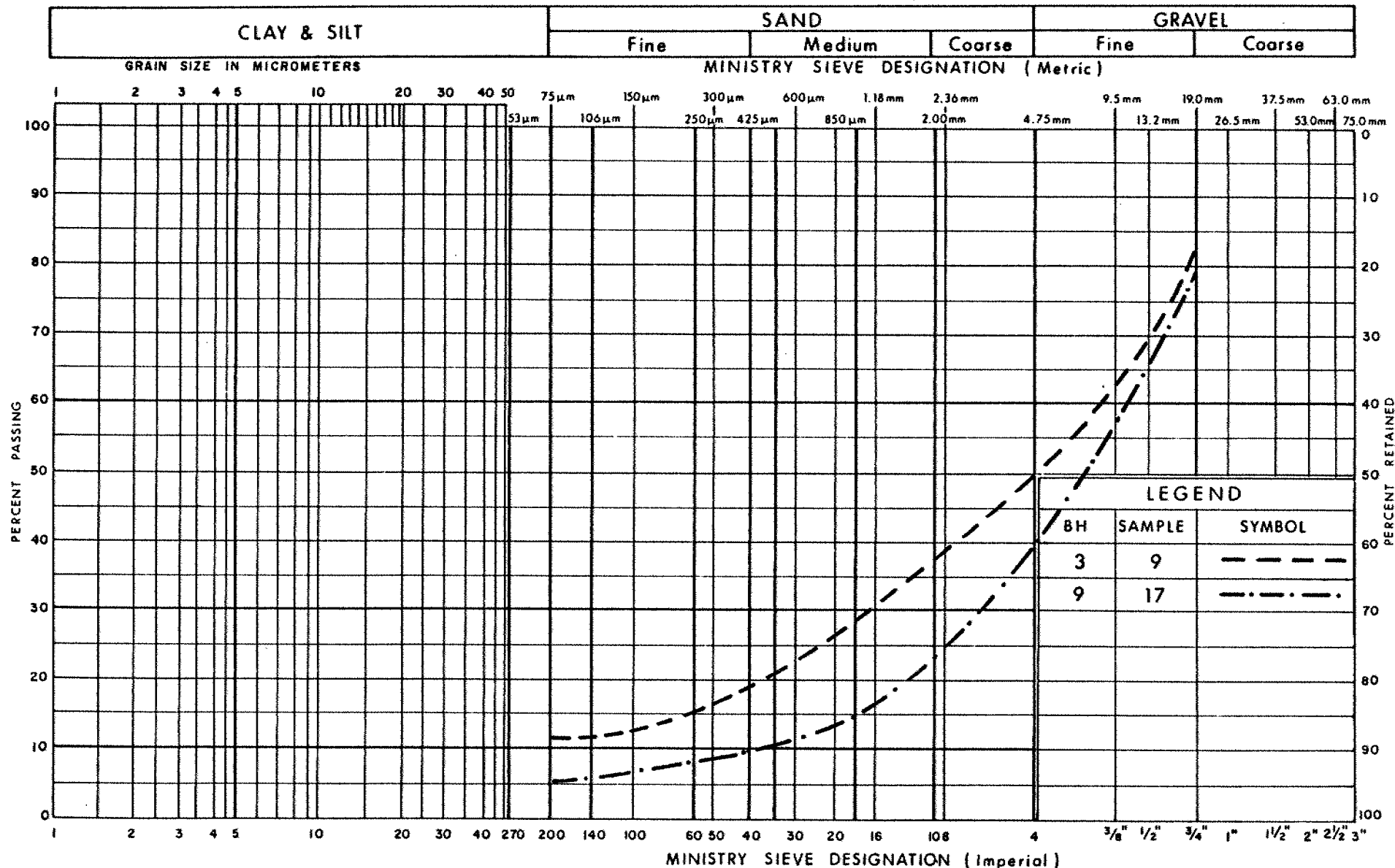
Ministry of
Transportation

FIG No 4

W P 479-89-06/07

Site No. 19-305

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION

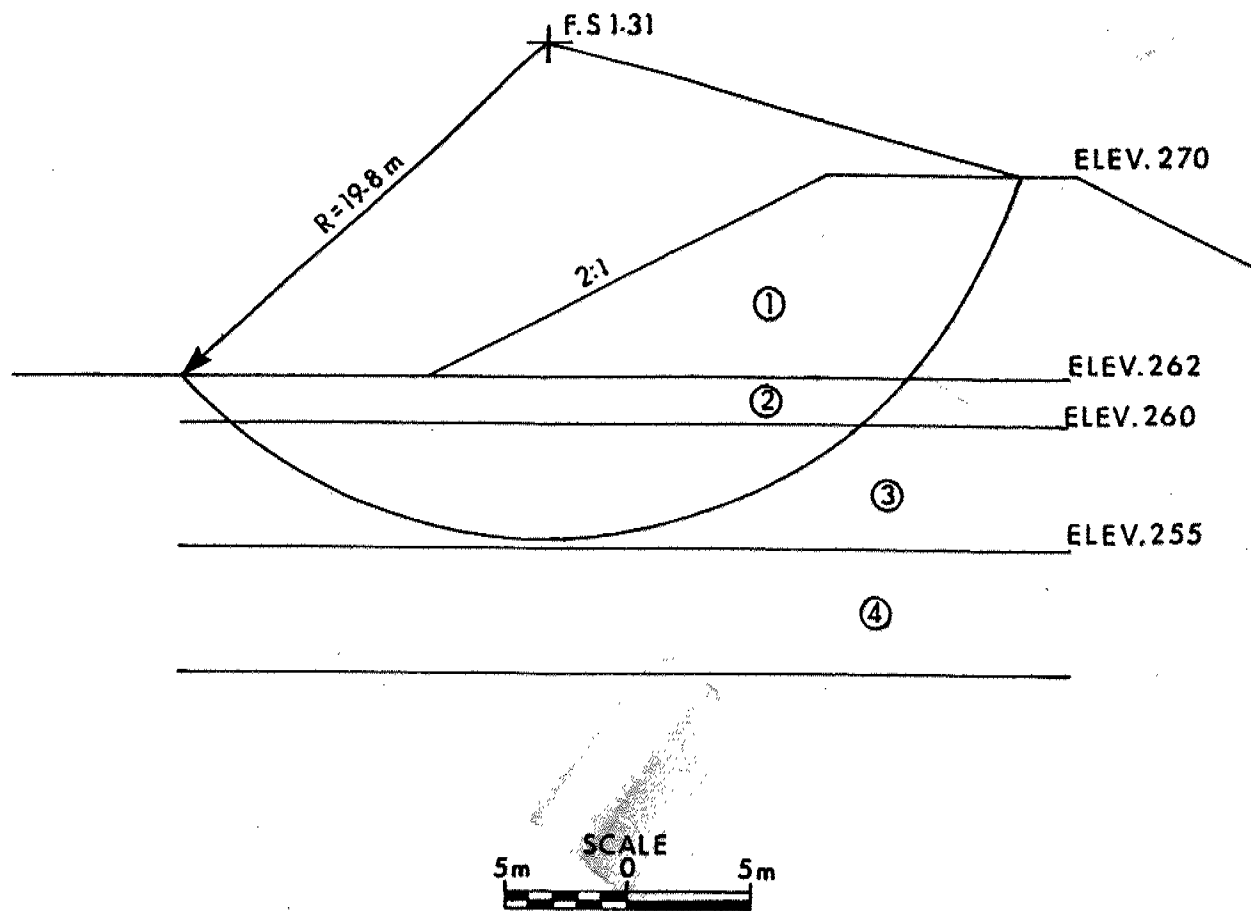
Sandy Gravel

FIG No 5

W P 479-89-06/07

Site No. 19-305

MATERIAL PROPERTIES				
LAYER	TYPE	ϕ' DEG.	C' KPa	γ KN/m ³
1	FILL	30	0	18
2	TOP SOIL	0	20	16
3	CL. SILT	0	32	20
4	SI. SAND	25	5	18

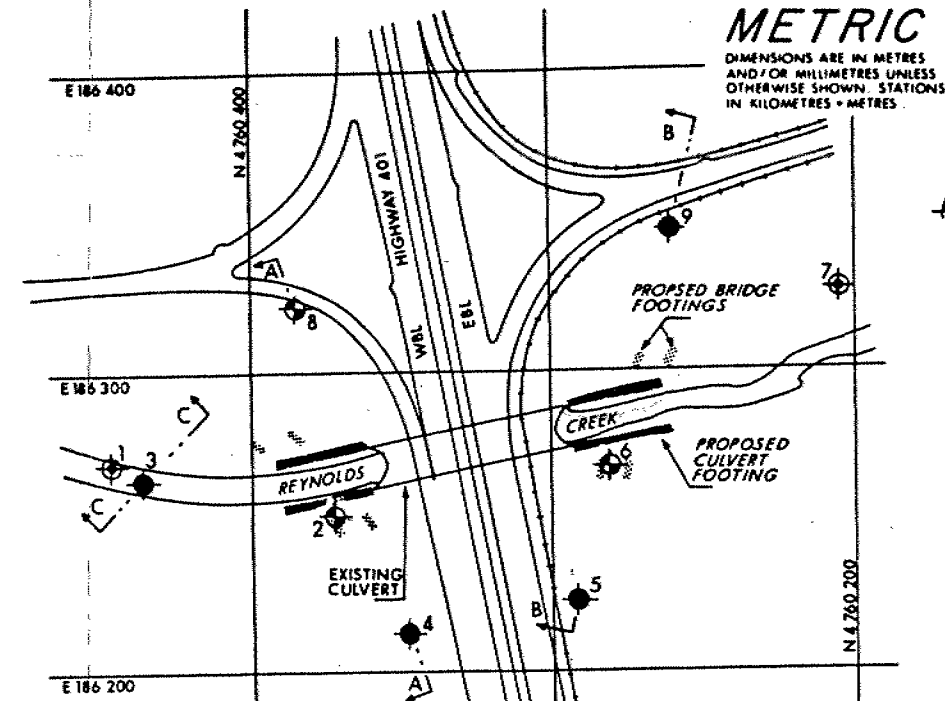
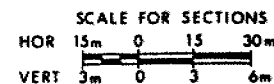
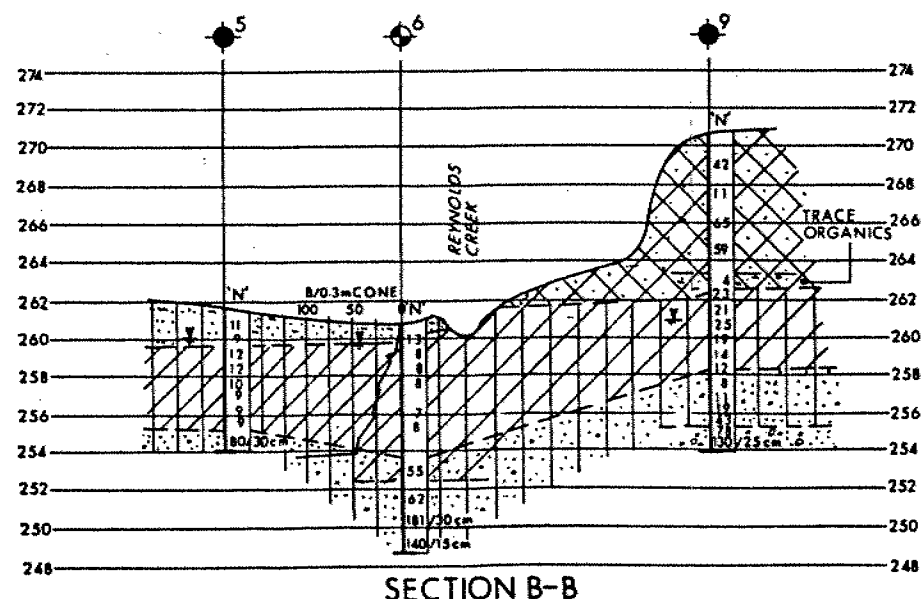
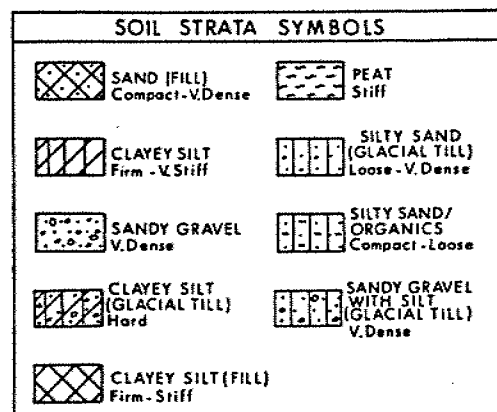
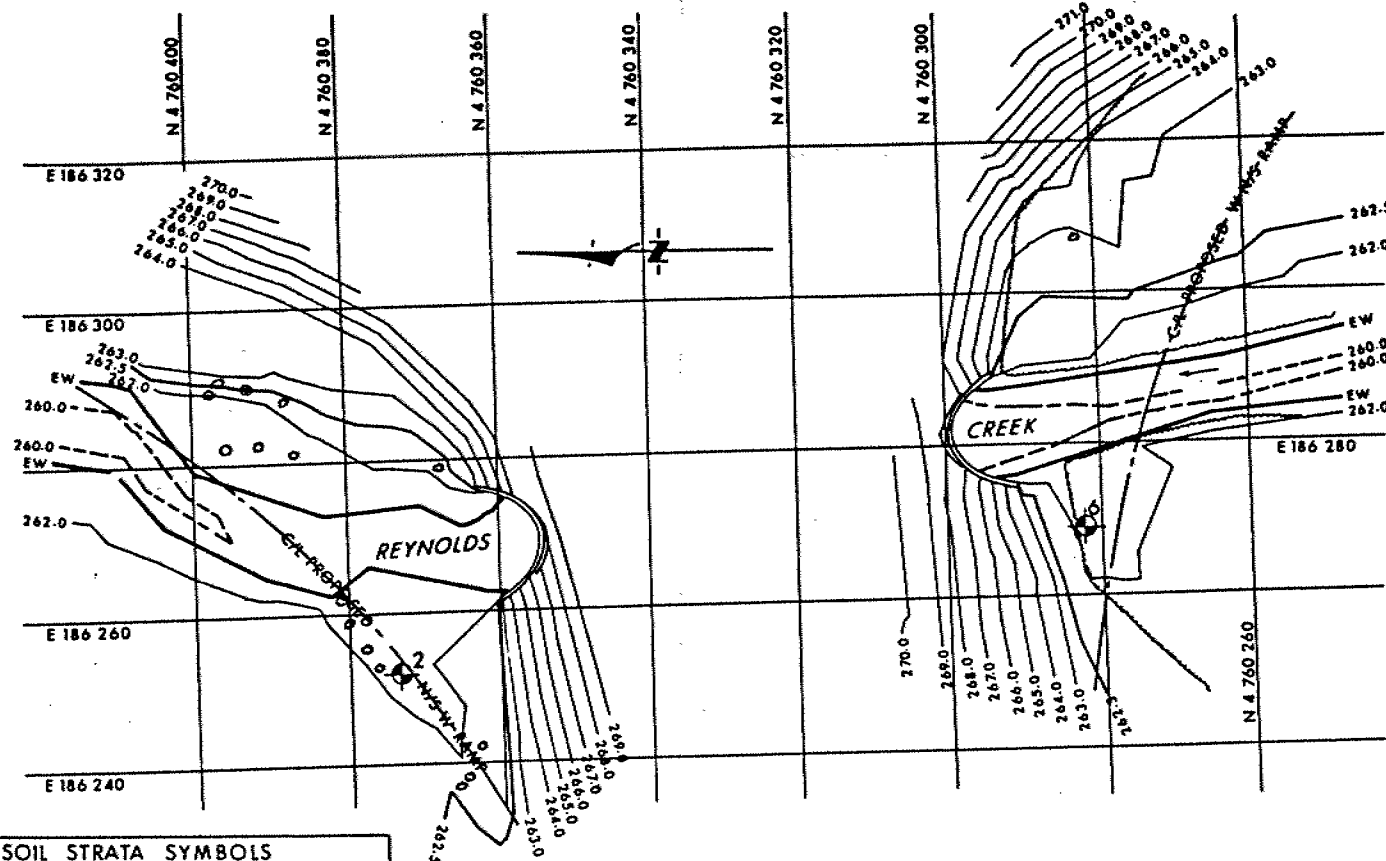


SLOPE STABILITY ANALYSIS
RAMP FILL, REYNOLDS CREEK
W.P 479-89-06/07
SITE NO. 19-305
HWY. 401

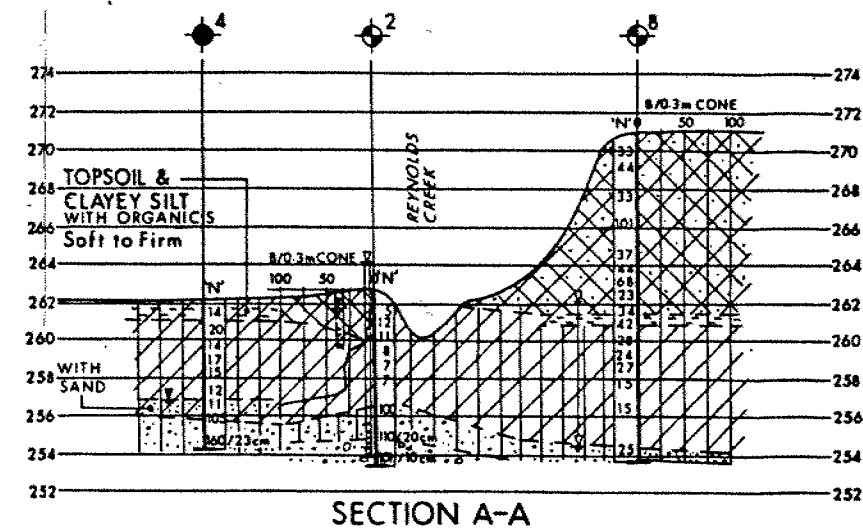
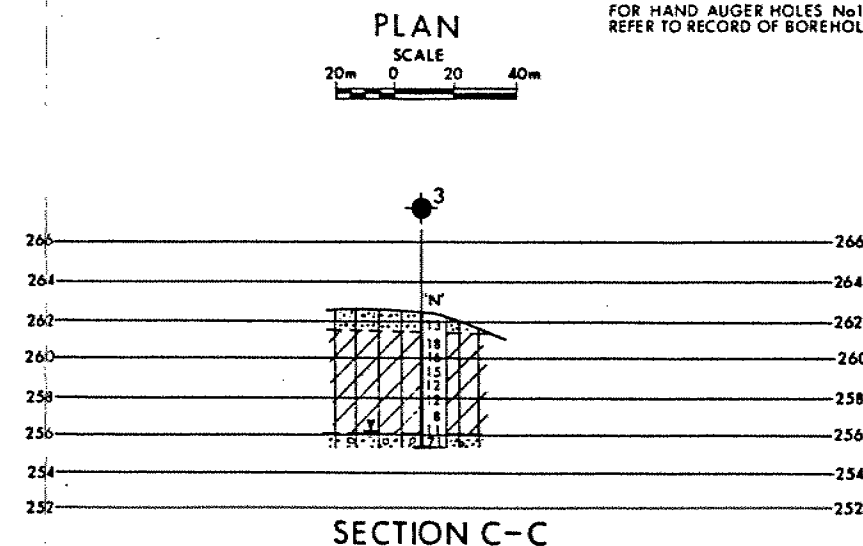


STRATA ENGINEERING CORP.

FIGURE 6



NOTE
FOR HAND AUGER HOLES No1 & 7
REFER TO RECORD OF BOREHOLE SHEETS



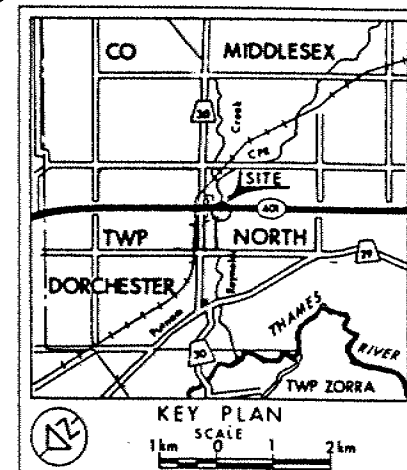
CONT No
WP No 479-89-06/07









REYNOLDS CREEK

SHEET

BORE HOLE LOCATIONS & SOIL STRATA

STRATA ENGINEERING CORP.



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 0708 1990		
	Hand Auger Hole		Stand Pipe
	Head		
	ARTESIAN WATER Encountered		
No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	262.1	4 760 448	186 269
2	262.7	4 760 373	186 252
3	262.6	4 760 437	186 264
4	262.2	4 760 348	186 212
5	261.8	4 760 292	186 223
6	260.9	4 760 282	186 268
7	260.8	4 760 205	186 327
8	271.0	4 760 385	186 321
9	270.8	4 760 261	186 347

-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.

REV.				
DATE	BY	DESCRIPTION		
Graceros No 40115-27				
HWY No 401				DIST 2
SUBWD A A	CHECKED A A	DATE NOV 06 1990	SITE 19-305	
DRAWN A K	CHECKED A A	APPROVED A	LDWG 4798906-02A	

REF NO E-92-401-1-2 &
PLATE NO 92-401/45-0

DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. 40I15-27

DIST. 2 REGION

W.P. No. 479-89-06/07

CONT. No.

W. O. No.

STR. SITE No. 19-305

HWY. No. 401

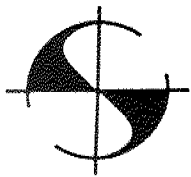
LOCATION Hwy 401 & REYNOLDS
CREEK

No. of PAGES -

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:



STRATA ENGINEERING CORP.

RESEARCH . ENGINEERING . SCIENCE

GEORECS No
40I15-27

Tel.: (416) 441-2560
Fax: (416) 441-4161

Suite 410, 170 The Donway West,
Don Mills, Ontario, Canada M3C 2G3

FOUNDATION INVESTIGATION REPORT

W.P. 479-89-06/07 Bridge Site No: 19-305

Proposed Culvert Extension or New Structure

Hwy. 401 and Reynolds Creek

District 2, London, Southwestern region

Ministry of Transportation, Ontario

Report Issue Date: 1990 11 22

Strata File: W-90-004

Distribution:

MTO Foundation Design Section	- 13 copies
Strata Files	- 1 copy

TABLE OF CONTENTS

1.0	INTRODUCTION	1
2.0	SITE AND GEOLOGY	1
3.0	FIELD AND LABORATORY WORK	2
4.0	SUBSURFACE CONDITIONS	4
4.1	General	4
4.2	Organics and Fill Materials	4
4.3	Clayey Silt	4
4.4	Silty Sand (Glacial Till)	6
4.5	Sandy Gravel	6
5.0	GROUNDWATER CONDITIONS	6
6.0	DISCUSSION AND RECOMMENDATIONS	7
6.1	General	7
6.2	Structure Foundations	7
6.3	Earth Pressures	8
6.4	Approach and Ramp Fills	9
6.5	Constructuion Considerations	9
7.0	CLOSURE	10

APPENDIX

FOUNDATION INVESTIGATION REPORT

W.P. 479-89-06/07, Bridge Site No: 19-305

Proposed Culvert Extension or New Structure

Hwy. 401 and Reynolds Creek

District 2, London

Ministry of Transportation, Ontario

1.0 INTRODUCTION

Strata Engineering Corp. has been retained by the Foundation Design Section of the Ministry of Transportation, Ontario, under Consultant Agreement No: 4240-9190-090, to conduct a foundation investigation for a proposed extension to the reinforced concrete arch slab culvert across Reynolds Creek. The terms of reference were to investigate the site by means of sampled boreholes and dynamic cone penetration tests, and to provide a full geotechnical report in advance of the issuance of E-Plans for the site.

This report is submitted in compliance with these terms of reference and contains recommendations for the design and construction of the culvert extension or its replacement with a new bridge structure, new interchange ramps, and widening of the existing approach fills.

2.0 SITE AND GEOLOGY

The site is located on Highway 401 at Interchange No. 208, in North Oxford Township, County of Middlesex, about 21km east of London.

The terrain in this area is flat to gently undulating. The banks and shoreline areas beyond the creek channel itself have developed marshes and swampy conditions. The boundaries around some of the interchange ramp loops are heavily wooded. Both of these site specific features made access to proposed drilling locations extremely difficult, and in a few instances, virtually impossible. Access to specific site locations near the proposed culvert extension limits is possible only in winter when the ground has frozen sufficiently to support drilling machinery. Also, some major trees would need to be clear-cut to enable access into the open areas near the existing culvert.

This site lies in an area where two physiographic regions of southern Ontario intersect, namely the Mount Elgin Ridges and the Oxford Till Plain.

The dominant geomorphological feature of the site is a north-south tending spillway breached into the east-west tending Ingersoll Moraine. Outwash flow occurred from south to north through the breached channel. The major soil types in this area are therefore ice-contact stratified drift related to the Ingersoll and Westminster Moraines, and the outwash materials through the spillway.

The spillway formed a broad valley which became infilled with fluvio-lacustrine cohesive sediments. The infilled spillway valley now forms the drainage channel for Reynolds Creek, which flows northerly to join the Thames River near Putnam. It follows a circuitous route through the St. Thomas Moraine, and is believed to have performed very little recent dissection (Chapman and Putnam, 1984)¹.

Drift thickness and bedrock topography maps indicate a depth to bedrock in this area of some 30m below ground surface. The bedrock has been mapped as dolomites and limestones of the Detroit River Group of Middle Devonian Age.

3.0 FIELD AND LABORATORY WORK

At the time of assignment of the project, an ETR plan was supplied showing the proposed culvert extensions on the north and south sides of Highway 401, together with an option to replace the culvert with a bridge on new foundations. After clearing all underground utilities, boreholes were laid out to coincide with the ends of the proposed extensions, and/or new footings, wherever feasible.

Lack of access to many of the proposed structure footing locations (due to reasons given earlier) necessitated the drilling of boreholes some distance away from these intended locations, as shown on Drawing 4798906/07-A.

The field investigation was conducted from 1990 07 31 to 1990 08 03, using a bombardier mounted CME 55 hollow stem drilling machine. At certain depths in some boreholes, washboring techniques were employed, along with tri-cone drilling, to advance the boreholes through very dense or hard strata. On 1990 07 24, hand auger boreholes were attempted in areas not accessible to the drilling machine.

1. Physiography of Southern Ontario, 3rd ed. OGS Special Vol. 2, p. 93

A total of seven sampled boreholes were drilled (BH's: 2, 3, 4, 5, 6, 8, 9). Boreholes 1 and 7 were drilled by means of a hand auger, and sampled with a small diameter piston sampler. Near Boreholes 2 and 6, dynamic cone penetration resistance tests were performed. Within Borehole 8, a dynamic cone test was attempted when the borehole could not be advanced due to artesian pressure related problems.

Borehole 3 was drilled to determine the soil conditions for the proposed Reynolds Creek channel re-alignment. Boreholes 8 and 9 were drilled from the existing interchange ramp loop fills because access to the east side of the culvert, both north and south of Highway 401, was impossible given the heavy tree growth and soft terrain conditions at the time of this investigation. Boreholes 4 and 5 were drilled to determine the soil conditions below the proposed interchange ramp fills. The end result is that only Boreholes 2 and 6 are located close to the existing culvert, and only on its west side. However, the soil conditions across the valley are uniform; therefore, reliable interpolations of the soil conditions on the east side of the culvert may be made from representative cross-sections across the creek channel.

Samples of the overburden were obtained in the split-barrel sampler, the N values being noted for the Standard Penetration Test in blows/0.3m. Where feasible, thin walled tube samples were obtained in cohesive portions of the overburden. An MTO specification field vane was used with fish scales to apply a coupled torque for the measurement of undrained in situ shear strength in cohesive strata.

Bedrock was not reached in any of the boreholes.

In the laboratory, all soil samples were examined visually. Index property tests, such as moisture contents, Atterberg limits and grain size distributions were conducted on selected specimens. Some thin walled samples were extruded. Tests were conducted on some of the extruded specimens for consolidation and undrained shear strength characterization of the cohesive stratum.

The laboratory test results are shown in Figures 1 to 5 and on the Borehole Log Sheets in the Appendix.

Groundwater levels were monitored on a daily basis and a week after completion of drilling. The last recorded levels are shown on the Borehole Log Sheets.

In Borehole 2, a sealed perforated standpipe was installed to measure an artesian head condition.

4.0 SUBSURFACE CONDITIONS

4.1 General

Below fill or surficial organics, the predominant soil of concern is a laminated clayey silt stratum which is underlain by a silty sand glacial till overlying a sandy gravel deposit. Artesian groundwater conditions were encountered within the silty sand and underlying strata. Details follow.

4.2 Organics and Fill Materials

Organic soils were encountered in Boreholes 1, 4, 5, 6, and 7 at the surface. They range from peat (at Borehole 7) to topsoil and surficial sandy, flood plain type of deposits, mixed with vegetative organics. The thickness of these surficial organic materials ranged from 2.9m at Borehole 7 to 1.0m at Borehole 6.

Moisture content determinations show a range in values, depending on organic matter content. The values range from 119 per cent for the peat to 15 per cent for the organically contaminated sandy soils.

N values ranged between 5 and 14 blows/0.3m, indicating a loose to compact relative density for the organic sandy soils. The peaty soils are of generally soft consistency.

In Boreholes 8 and 9 which were drilled through the existing interchange ramp fills, the fill material consists of a medium to fine sand (Figure 1), with N values ranging from 4 to over 65 blows/0.3m. In Borehole 8, the fill was found to be underlain, at a depth of 9.4m, by a compressed peat deposit of 700mm thickness, with a moisture content of 26 per cent.

A fill type of material was also encountered in Borehole 2, close to the west side of the north portion of the existing culvert. This material may have originated as a result of construction of the existing culvert. Its thickness was 2.9m, with N values ranging between 5 and 12 blows/0.3m, and moisture contents approaching 30 per cent.

4.3 Clayey Silt

The major soil deposit at this site, from a design viewpoint, is a clayey silt stratum. The stratum was encountered in all machine drilled boreholes at elevations ranging between 259.7m and 260.9m. This uniformity in upper surface elevation indicates the deposit is widespread and of likely lacustrine origin. Therefore, its existence is suspected also on the east side of the culvert, at about elevation $\pm 260\text{m}$.

This cohesive deposit consists of a clayey silt. The soil has a distinct laminar feature, consisting of fine sand or silt seams of 1mm to 2mm thickness, spaced regularly to irregularly at 25mm to 40mm spacings. In some samples, the laminates appear to have been replaced with pockets of fine sand. This shows that the depositional conditions were not constant, and that turbidity was a major factor during genesis of the stratum.

The total thickness of the deposit ranged between 3.0m at Borehole 2 and 6.6m at Borehole 8, averaging about 5.5m in all boreholes through which the deposit was fully penetrated.

The moisture content of the soil was found to range between 16 and 27 per cent. The moisture content shows a tendency to increase with depth in Boreholes 3, 5, and 8 and a slight tendency to decrease with depth in Borehole 6. The observed moisture contents are all above the plastic limit of the soil, and in some cases are equal to the liquid limit, indicating a liquidity index of unity. The plasticity characteristics of the soil are shown in Figures 2A and 2B. The soil is classified as a clayey silt to silt of low plasticity (CL-ML soil).

Standard Penetration Resistance N values generally decreased with depth, ranging between 7 and 20 blows/0.3m in boreholes positioned at prevailing ground surface level. In Boreholes 8 and 9, below the ramp fills, the N values ranged between 15 and 42 blows/0.3m, showing the effects of consolidation over time. Also, the average moisture content of the soil in Boreholes 8 and 9 was a few percentage points below the average moisture content in the other boreholes.

Undrained in situ vane shear testing was attempted in Boreholes 6 and 8. In Borehole 6, a field vane undrained shear strength value of just over 40kPa was measured near the middle of the stratum, some 4.5m below ground surface. At approximately the same elevation in Borehole 8, the field vane could not be turned. In Borehole 6, an unconfined compression test gave an undrained shear strength of 30kPa near mid-thickness. At the same elevation in Borehole 8, the unconfined undrained shear strength was over 70kPa. Near the base of the deposit in Boreholes 6 and 8, the field vane could not be turned. Unconfined compression tests yielded values of the undrained shear strength of between 80kPa and 190kPa.

The result of one oedometer test is shown in Figure 3. The test shows a possible pre-consolidation value of the soil of about between 100kPa and 120kPa. The compression index, C_c , is 0.122. The coefficient of consolidation, c_v , was found to be about 0.5 cm^2/min . at stresses ranging between 100kPa and 200kPa.

Based on the above field observations and laboratory tests, the overall consistency of the deposit is estimated to range between firm and very stiff, being generally firm near the middle of the deposit, except below ramp fills, where it is very stiff to hard.

4.4 Silty Sand (Glacial Till)

The clayey silt stratum is underlain by a silty sand deposit (glacial till) occurring between elevations 256.8m at Borehole 2, and 252.5m at Borehole 6. This stratum was not found at Borehole 3 below the clayey silt deposit.

The soil consists of a silty sand, with gravel. Some typical grain size distribution curves are shown in Figure 4, and indicate a range in gravel content of between 3 and 30 per cent. The silt content is generally less than 15 per cent. However, silty zones are present within the deposit, and occur more or less at random.

The thickness of this stratum was found to be between 1.5m and 1.9m in locations where it was fully penetrated (Boreholes 9 and 2 respectively), and over 3.9m at Borehole 6, where the deposit was not fully penetrated.

The moisture content of the stratum ranged between 7 and 14 per cent, being over 25 per cent in a clayey silt contaminated transition zone in Borehole 9.

N values of 43 to over 100 blows/0.3m indicate the deposit is generally dense to very dense. Some low recorded N values are suspected to be the result of "boiling" during sampling due to unbalanced hydrostatic heads and artesian pressure.

4.5 Sandy Gravel

A deposit of sandy gravel was encountered below the silty sand glacial till deposit in Boreholes 2 and 9 at an elevation of about ± 255 m. Typical grain size curves for representative samples are shown in Figure 5. The moisture content of this soil varied between 6 and 12 per cent. N values were generally over 100 blows/0.3m, indicating the deposit to be very dense.

5.0 GROUNDWATER CONDITIONS

Groundwater level observations were made in open boreholes at time of drilling or in piezometers and open standpipes after completion of drilling. These observations show the general phreatic level to be at about elevation ± 260 m.

However, artesian heads, reaching up to 2.5m above prevailing ground level were measured at Borehole 2, and are suspected to be the cause of an elevation observation of over 262m at Borehole 8.

6.0 DISCUSSION AND RECOMMENDATIONS

6.1 General

It is proposed to widen Highway 401 to 6 lanes between London and Woodstock. This will involve a reconstruction of the existing interchange at Putnam Road. In connection with this reconstruction, the existing reinforced concrete arch slab culvert supporting Highway 401 above Reynolds Creek, just west of Putnam Road, will need to be either extended or replaced with a new bridge.

It is understood the existing culvert is supported on caisson foundations. If a new structure is provided in lieu of extending the culvert, it will likely be a monolithic single span type, with wing walls to retain fill material.

The realigned ramp heights will be about 8m above prevailing ground level.

The proposed reconstruction of the W-S/N Ramp will involve a southerly extension of the south end of the existing culvert, and the proposed reconstruction of the S/N-W Ramp will involve a northerly extension of the northern end of the existing culvert.

This site investigation shows the presence of shallow surficial organics and clayey silt fill materials overlying a compressible deposit of firm to very stiff clayey silt above a silty sand glacial till deposit overlying very dense sandy gravel at depth. The non-cohesive strata below the clayey silt deposit are the source of artesian to sub-artesian heads.

6.2 Structure Foundations

6.2.1 Spread Footings

The presence of the compressible clayey silt deposit across the site, and at both ends and sides of the existing culvert (from geological inference) prohibits the use of spread footings for the proposed extensions and for the foundations for the alternative new structure. Therefore, the culvert extensions and abutments of the new structure will need to be supported on a deep foundation.

6.2.2 Deep Foundations

Due to the presence of artesian conditions, steel H piles are the preferred deep foundation type for this site.

For purposes of the OHBDC, assuming embedment lengths as indicated by the toe elevations given below, the following values are recommended for steel H piles (HP 310x110):

Factored capacity at ULS	1250kN
Capacity at SLS Type II	900kN

Location of Footing	Likely Pile Toe Elev. @ Design Capacity
North Extension	
East Side	254.5 m
West Side	255.5 m
South Extension	
East Side	252.0 m
West Side	251.5 m

Pile driving should be monitored using the Hiley Formula. Pile caps should be provided with 1.2m of earth cover for protection against frost action.

6.3 Earth Pressures

Earth pressures should be computed as per subsection 6-6.1.2.2 of OHBD Code. A yielding foundation condition may be assumed. The Granular "A" or "B" backfill should be backfill should be in accordance with Special Provision No. 109F03 (latest revision). The following parameters are recommended for the granular backfill:

	Gran. "A"	Gran. "B"
Angle of internal friction, ϕ'	35.0°	30.0°
Unit Weight (kN/m ³), γ	22.8	21.2

Surcharge effects, if any, should be computed as per Clause 6-6.1.2.4 of the OHBD Code.

6.4 Approach and Ramp Fills

6.4.1 Stability considerations

A review of the existing approach and ramp fills shows no signs of instability. However, the presence of the compressible clayey silt deposit at this site raises some concerns with respect to stability of the proposed revised ramp fills. Therefore, stability calculations were carried out. The result is shown in Figure 6. Bishop's simplified method of circular arc total stress analysis was used, and the minimum factor of safety was computed to be 1.31.

It is assumed in the stability analysis that all surficial organics have been stripped down to native mineral soil, and that all fills are built with standard 2:1 slopes.

6.4.2 Settlement Considerations

Settlement analyses show maximum settlements of 8m high fills to be in the order of 150mm, with about 90 per cent of this settlement occurring within one year of imposition of full loading.

6.5 Construction Considerations

Excavations taken below prevailing phreatic groundwater levels will require dewatering. Dewatering may be accomplished by the use of interlocking steel sheet piling driven at least 1.0m into the clayey silt stratum to form a watertight enclosure.

The native soil lining the channel side slopes and invert is considered to be moderately erodible. Therefore, the creek realignment channel should have cut side slopes no steeper than 2H:1V to preserve long term stability and to minimize erosion.

Consideration should be given to providing erosion protection lining to high water level within the channel by means of geotextile covered rip-rap or other suitable alternative, based on hydrological considerations of stream flows and velocities.

Fills crossing the abandoned creek channel should be placed with due consideration of the possibility of soft compressible materials being present within the channel, at least within 1m or so of the creek bed. Subexcavation backfill should be non-cohesive materials.

Environmental protection, in the form of silt barriers, may be required to protect against sediment movement into the creek.

7.0 CLOSURE

The field work for this investigation was carried out by Ms. Andrea C. Abel, assisted by Mr. Justin Klodner.

The drilling equipment and crew were rented from Atcost Soil Drilling Limited of Concord, Ontario.

Respectfully submitted:
STRATA ENGINEERING CORP.



A. C. Abel, M. Sc
Project Engineer



C. Mirza, P. Eng.
Senior Principal

Report Distribution:

MTO Foundation Design Section	13 copies
Strata File W-90-004	1 copy

Date of Submission: 1990 11 06

W.P. 479-89-06/07

APPENDIX

Explanation of Terms used in Report

Office Record of Borehole Logs 1- 9

Figures 1-6

Drawing 4798906/07-A

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						

RECORD OF BOREHOLE No1

METRIC

W P 479-89-06/07 LOCATION Co-ords. 4,760,448 N; 186,269 E ORIGINATED BY AA
 DIST 2 HWY 401 BOREHOLE TYPE Hand Auger COMPILED BY AK
 DATUM Geodetic DATE 1990 07 24 CHECKED BY CM

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100					
262.1	Ground surface															
0.0	Organic Clayey Silt Brown		1	TP	PM											
	some sand, Tr. Grav Soft		2	TP	PM											
260.7			3	TP	PM											
1.4	Clayey Silt with sand and															
259.5	Occ. gravel - Grey Soft															
2.6	End of Borehole															
	No further penetration possible with hand auger.															
	* Borehole dry upon completion															

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No2

METRIC

W P 479-89-06/07 LOCATION Co-ords. 4,760,373 N; 186,252 E ORIGINATED BY AA
DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Test & washboring COMPILED BY AK
DATUM Geodetic DATE 1990 08 01 CHECKED BY CM

Artesian head

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	W' VALUES			20	40	60	80	100				
262.7	Ground surface															GR SA SI CL
0.0	Organic Clayey Silt and Topsoil incl. Firm (Fill)		1	SS	5		262									Water Levels on 1990 08 10
	with Gravel		2	SS	12		261									43 41 (16)
	Stiff		3	SS	11		260									
259.8	Clayey Silt (Laminated)		4	SS	8	Seal	259									
2.9	Stiff to Firm		5	SS	7		258									
	Grey		6	SS	7		257									
256.8	Silty Sand to Silt Occ. gravel Tr. clay (Glacial Till) Very Dense Grey		7	SS	100	Seal	256									
5.9	Sandy Gravel		8	SS	110	0.2m	255									Wash casing installed and sampling conducted by triconing to desired depth.
254.9	Very Dense Grey		9	SS	101	0.1m	254									
7.8	End of Borehole															
253.3	Artesian pressure controlled by sealing with "Benseal".															
9.4																

+3, x⁵: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No3

METRIC

W P 479-89-06/07 LOCATION Co-ords. 4,760,437 N; 186,264 E ORIGINATED BY AA
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AK
 DATUM Geodetic DATE 1990 08 01 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	W _p	W	W _L		
262.6	Ground surface															GR SA SI CL
0.0	Sandy Silt with gravel					262										
261.4	Compact Rusty Brown		1	SS	13								o			
1.2	Clayey Silt (Laminated)		2	SS	18	261							o			
	Stiff to Very Stiff		3	SS	16	260							o			
			4	SS	15	259							o			
	Grey		5	SS	12	258							o			
			6	SS	12	257							o			
			7	SS	8	256							o			
256.0			8	SS	11								o			WL on 1990 08 01
6.6	Sandy Gravel with silt (Glacial Till)															
255.3	Very Dense - Grey		9	SS	71								o			52 37 (11)
7.3	End of Borehole															

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

RECORD OF BOREHOLE No 4

METRIC

W P 479-89-06/07 LOCATION Co-ords. 4,760,348 N; 186,212 E
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger
 DATUM Geodetic DATE 1990 08 01
 ORIGINATED BY JK
 COMPILED BY AK
 CHECKED BY CM

OFFICE REPORT ON SOIL EXPLORATION

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					
262.2	Ground surface																GR SA SI CL
0.0	Topsoil & Clayey Silt with organics Soft - Firm		1	SS	14		262										
261.1							261										
1.1	Clayey Silt (Laminated)		2	SS	20		260										
	V. Stiff - Stiff		3	SS	14		259										
			4	SS	17		258										
	Grey		5	SS	15		257										
			6	SS	12		256										
	with Fine Sand partings		7	SS	11		255										WL on 1990 08 01 (not stabili- zied)
255.9			8	SS	105		254										
6.3	Silty Sand Occ. gravel (Glacial Till) Very Dense Grey		9	SS	160		253										
254.3																	
7.9	End of Borehole																

RECORD OF BOREHOLE No 5

METRIC

W P 479-89-06/07 LOCATION Co-ords. 4,760,292 N; 186,223 E ORIGINATED BY JK
DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AK
DATUM Geodetic DATE 1990 07 31 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
261.8	Ground surface																
0.0	Silty Sand with organics Compact to Loose Brown		1	SS	11		261										
259.7			2	SS	9		260										
2.1	Clayey Silt (Laminated) Fine Sand Partings at random Stiff - Firm Grey		3	SS	12		259										
			4	SS	12		258										
			5	SS	10		257										
			6	SS	9		256										
			7	SS	9		255										
255.0			8	SS	9		254										
6.8	Silty Sand Occ. gravel (Glacial Till) Very Dense - Grey																
253.9			9	SS	80/	30cm	254										
7.9	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No6

METRIC

W P 479-89-06/07 LOCATION Co-ords. 4,760,282 N; 186,268 E ORIGINATED BY JK
DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger and Dynamic Cone Test, Washboring COMPILED BY AK
DATUM Geodetic DATE 1990 07 31 CHECKED BY CM

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					
260.9	Ground surface																GR SA SI CL
0.0	Sandy Silt with organics Topsoil																
259.9			1	SS	13		260										WL on 1990 07 31
1.0	Clayey Silt (Laminated)		2	SS	8		259										
			3	SS	8		258										
	Firm		4	SS	8		257										
	Grey		5	TW	PH		256										20.5 Consol. Test (Fig. 3)
			6	SS	7		255										
	becoming stiff to very stiff with depth		7	SS	8		254										
			8	TW	PH		253										
253.5							252										
7.4	Clayey Silt with sand and gravel (Glacial Till)		9	SS	55		251										
252.5	Hard - Grey [Transition Zone]						250										
8.4	Silty Sand with gravel (Glacial Till)		10	SS	62		249										
	Very Dense																20 65 (15)
	Grey		11	SS	181/30cm												Wash casing installed Borehole advanced by triconing.
248.6			12	SS	140/15cm												
12.3	End of Borehole																

+³, x⁵: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No7

METRIC

W P 479- 89-06/07 LOCATION Co-ords. 4,760,205 N; 186,327 E ORIGINATED BY JK
 DIST 2 HWY 401 BOREHOLE TYPE Hand Auger COMPILED BY AK
 DATUM Geodetic DATE 1990 08 01 CHECKED BY CM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100		
260.8	Ground surface													
0.0	Peat					*								
	Black		1	TP	PM		260						87.50	
	V. Soft - Soft		2	TP	PM		259						119.0	

	with gravel													
257.9	Firm		3	TP	PM		258						50.30	
2.9	End of Borehole													
*	Borehole dry upon completion													
	Further penetration not possible.													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 8

METRIC

W P 479-89-06/07 LOCATION Co-ords. 4,760,385 N; 186,321 E ORIGINATED BY AA
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY AK
 DATUM Geodetic DATE 1990 08 02 CHECKED BY CM

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					
271.0	Ground surface																
0.0																	
	Medium Sand (Fill)		1	SS	33		270										
			2	SS	44		269										1 90 (9)
	Dense to Very Dense						268										
	Brown		3	SS	33		267										
			4	SS	101		266										
			5	SS	37		265										0 88 (12)
	Silty Sand		6	SS	44		264										
	Occ. gravel		7	SS	68		263										3 63 (34)
	Compact to Very Dense		8	SS	23		262										
	Grey		9	SS	34		261										
261.6	Peat		10	SS	42		260										
9.4	Stiff		11	SS	28		259										
260.9	Black		12	SS	24		258										
10.1	Clayey Silt		13	SS	27		257										
	Occ. Fine Sand Partings		14	SS	15		256										
	Hard to Very Stiff		15	TW	PH												
	Grey		16	SS	15												
256.0																	

15.0 Borehole continued...

+³, x⁵: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No8 cont'd

METRIC

W P 479-89-06/07 LOCATION Co-ords. 4,760,385 N; 186,321 E ORIGINATED BY AA
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY AK
 DATUM Geodetic DATE 1990 08 02 CHECKED BY CM

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			SHEAR STRENGTH kPo					W_p	W	W_L		
256.0	cont. from page 1						20	40	60	80	100					
15.0	Clayey Silt occ. Fine Sand Partings Stiff - V. Stiff		17	TH	PH										21.0	
254.5						255										
16.5	Silty Sand, Occ. gravel (Glacial Till)					Artesian Pressure encountered										
253.7	Compact - Grey		18	SS	25	254										3 83 (14)
17.3	End of Borehole and Cone Test Cone Test conducted since augers were sinking and sand was coming up in them.															

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No9

METRIC

W P 479-89-06/07 LOCATION Co-ords. 4,760,261 N; 186,347 E ORIGINATED BY JK
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AK
 DATUM Geodetic DATE 1990 08 03 CHECKED BY CM

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	SHEAR STRENGTH kPo					
270.8	Ground surface							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						GR SA SI CL
0.0														
	Medium Sand (Fill)						270							
	Compact to Very Dense		1	SS	42		269			○				4 84 (12)
							268							
			2	SS	11		267			○				
	Brown						266			○				
			3	SS	65		265							
							264			○				5 81 (14)
			4	SS	59		263							
262.7	Tr. Organics		5	SS	4		262			○				
8.1	Clayey Silt (Laminated)		6	SS	23		261			○				
	V. Stiff		7	SS	21		260			○				
	Occ. fine sand partings		8	SS	25		259			○				WL on 1990 08 03
	Grey		9	SS	19		258			○				
	Stiff		10	SS	14		257			○				
258.2			11	SS	12		256			○				
12.6	Silty Sand													
	Occ. silty clay zones (Glacial Till)		12	SS	8					○				0 83 (17)
	Loose to Compact													
	Grey		13	SS	11					○				
255.8	with some gravel		14	SS	19					○				

15.0 Borehole continued...

+3, x⁵; Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 9 cont'd

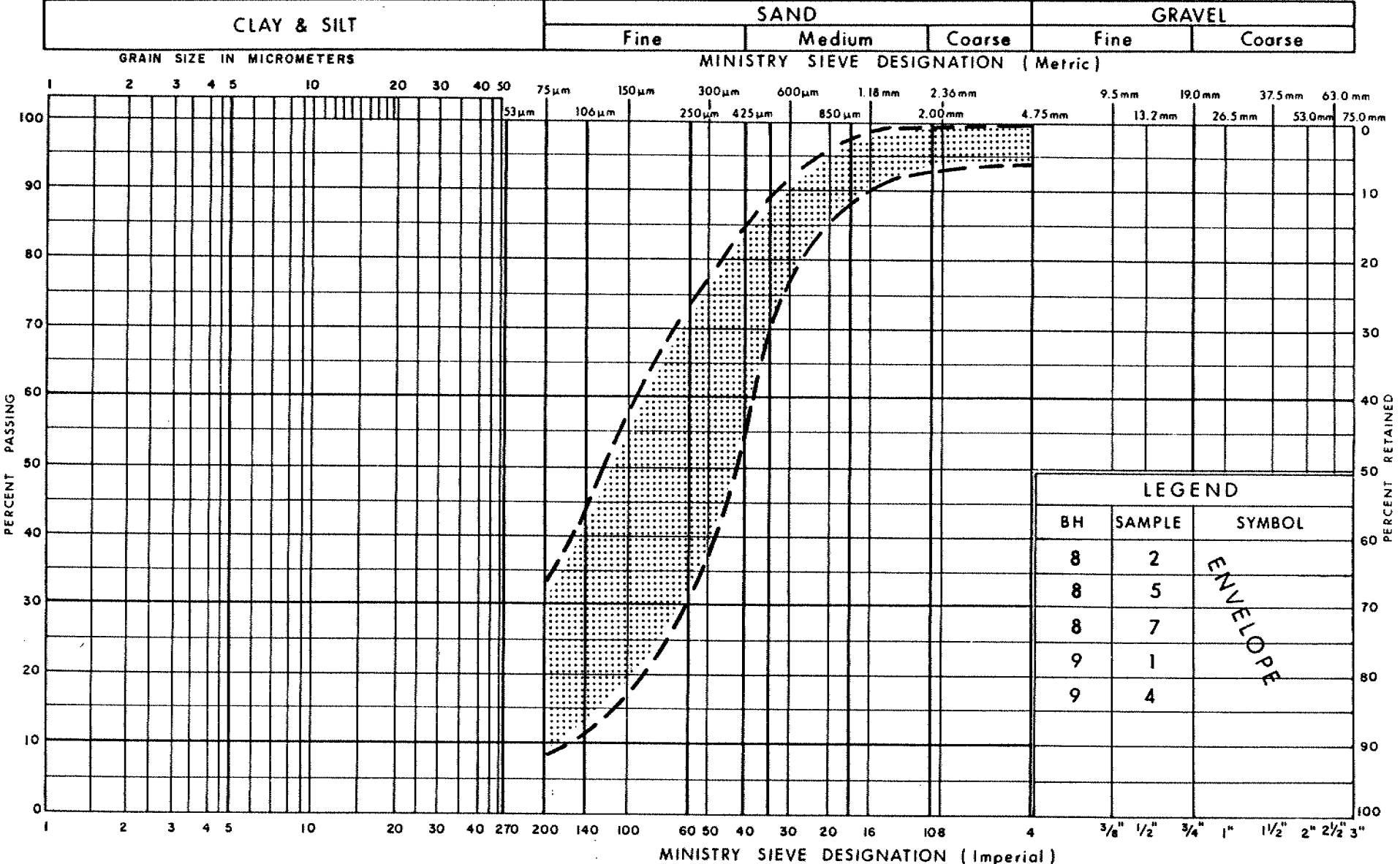
METRIC

W P 479-89-06/07 LOCATION Co-ords. 4,760,261 N; 186,347 E ORIGINATED BY JK
 DIST 2 HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AK
 DATUM Geodetic DATE 1990 08 03 CHECKED BY CM

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					
255.8	cont. from page 1																
15.0	Silty Sand																
255.3	Dense (Glacial Till)		15	SS	43												26 67 (7)
15.5	Sandy Gravel						255										
	Very Dense		16	SS	78												
	Grey																
253.8			17	SS	130	25cm	254										60 35 (5)
17.0	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

UNIFIED SOIL CLASSIFICATION SYSTEM



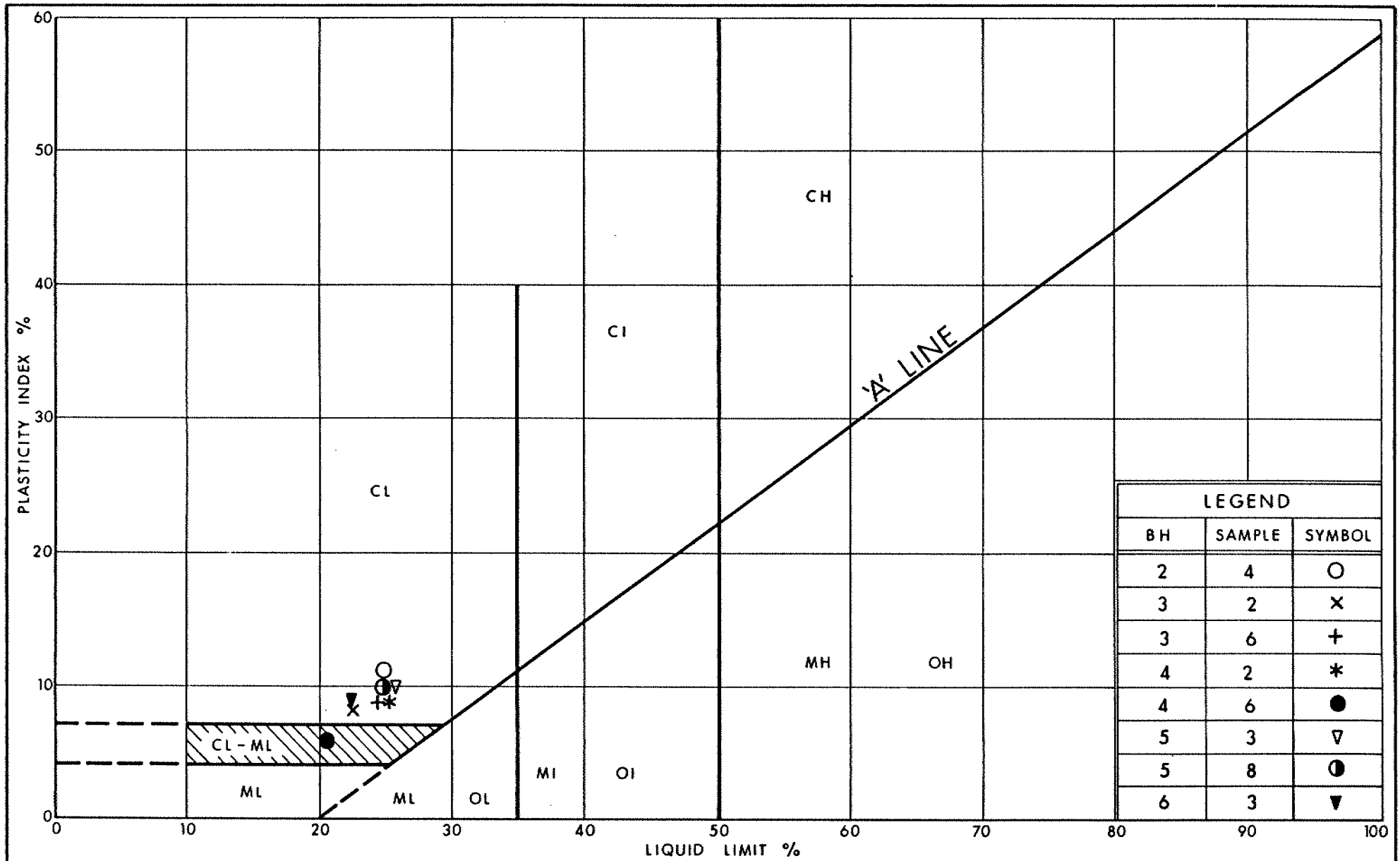
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION Sand to Silty Sand (Ramp Fill)

FIG No 1

W P 479-89-06/07

Site No. 19-305



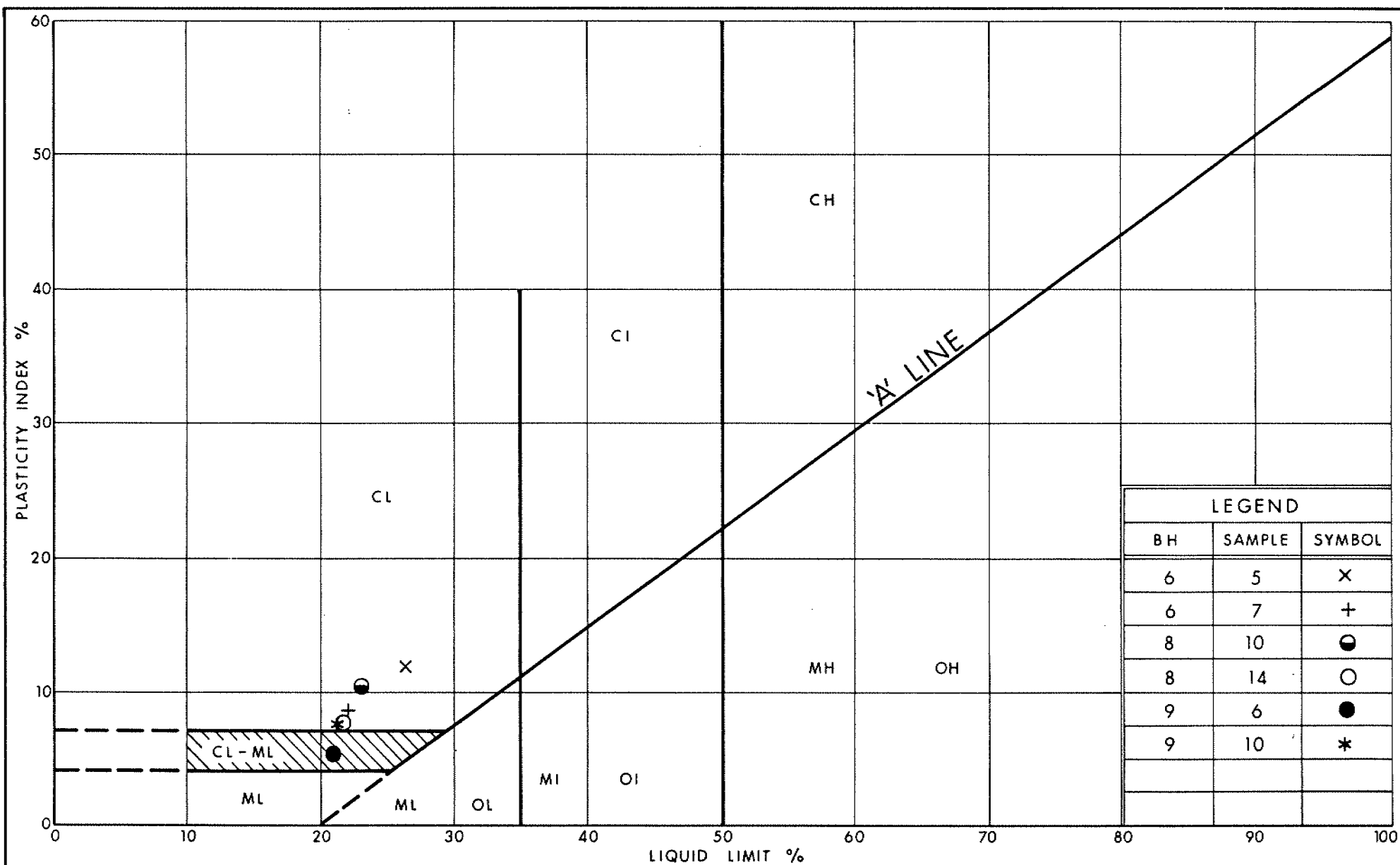
Ministry of
Transportation

PLASTICITY CHART Clayey Silt

FIG No 2A

W P 479-89-06/07

Site No. 19-305



Ministry of
Transportation

PLASTICITY CHART

Clayey Silt

FIG No 2B

W P 479-89-06/07

Site No. 19-305

VOID RATIO - PRESSURE CURVES

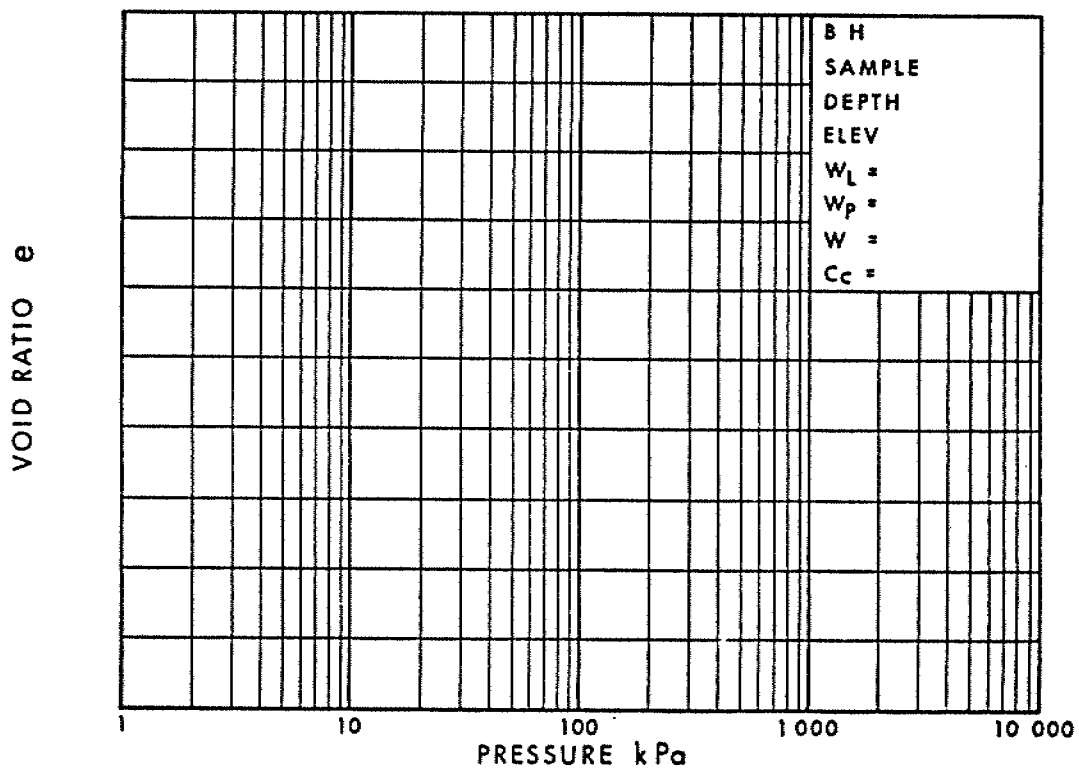
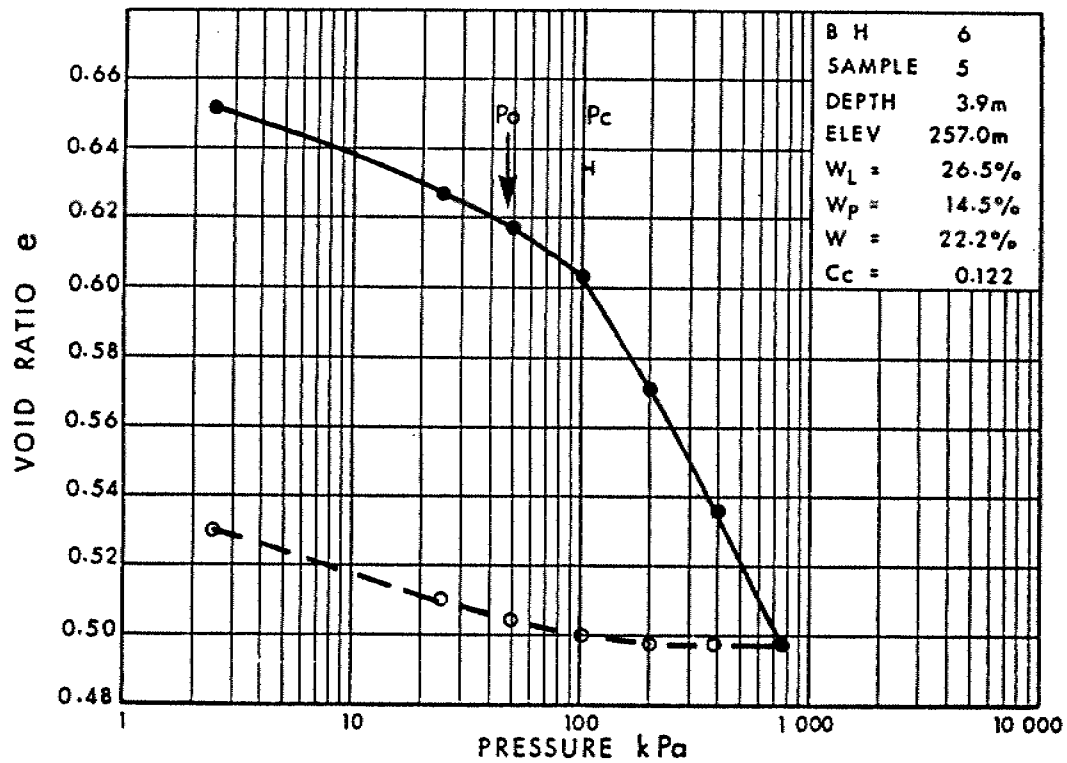
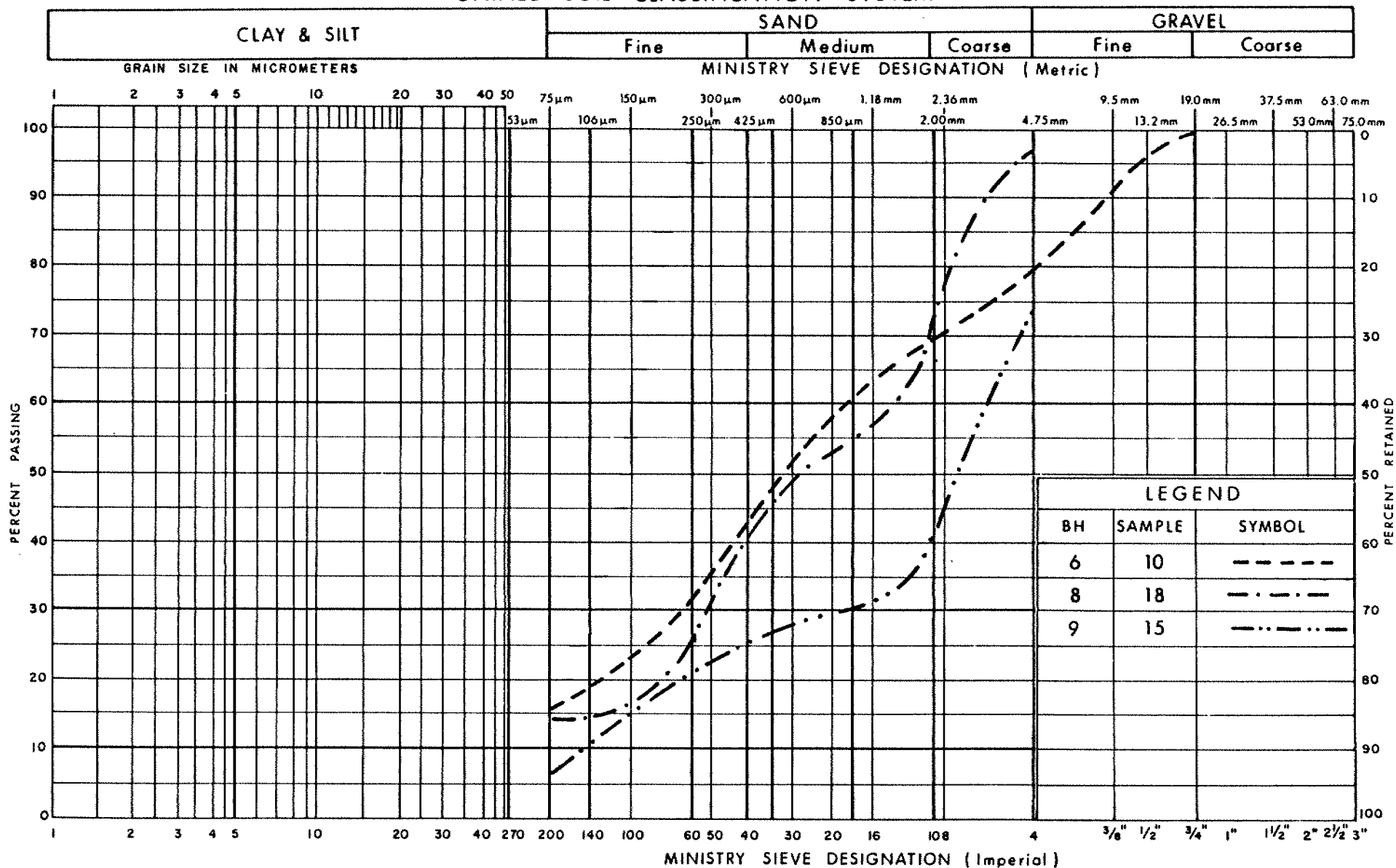


Fig 3

W P 479-89-06/07

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION

Silty Sand with Gravel
(Glacial Till)

FIG No 4

W P 479-89-06/07

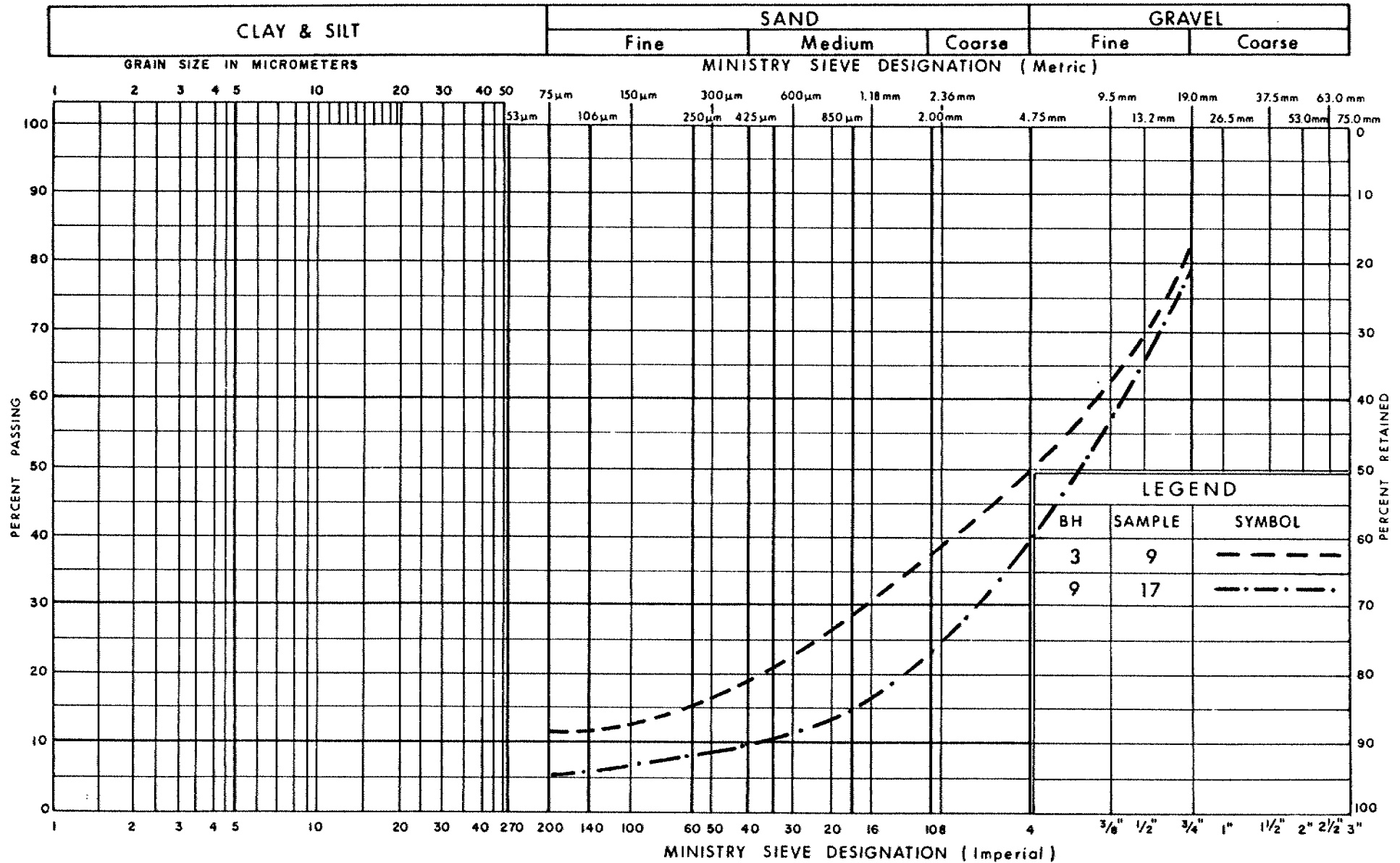
Site No. 19-305



Ontario

Ministry of
Transportation

UNIFIED SOIL CLASSIFICATION SYSTEM



GRAIN SIZE DISTRIBUTION

Sandy Gravel

FIG No 5

W P 479-89-06/07

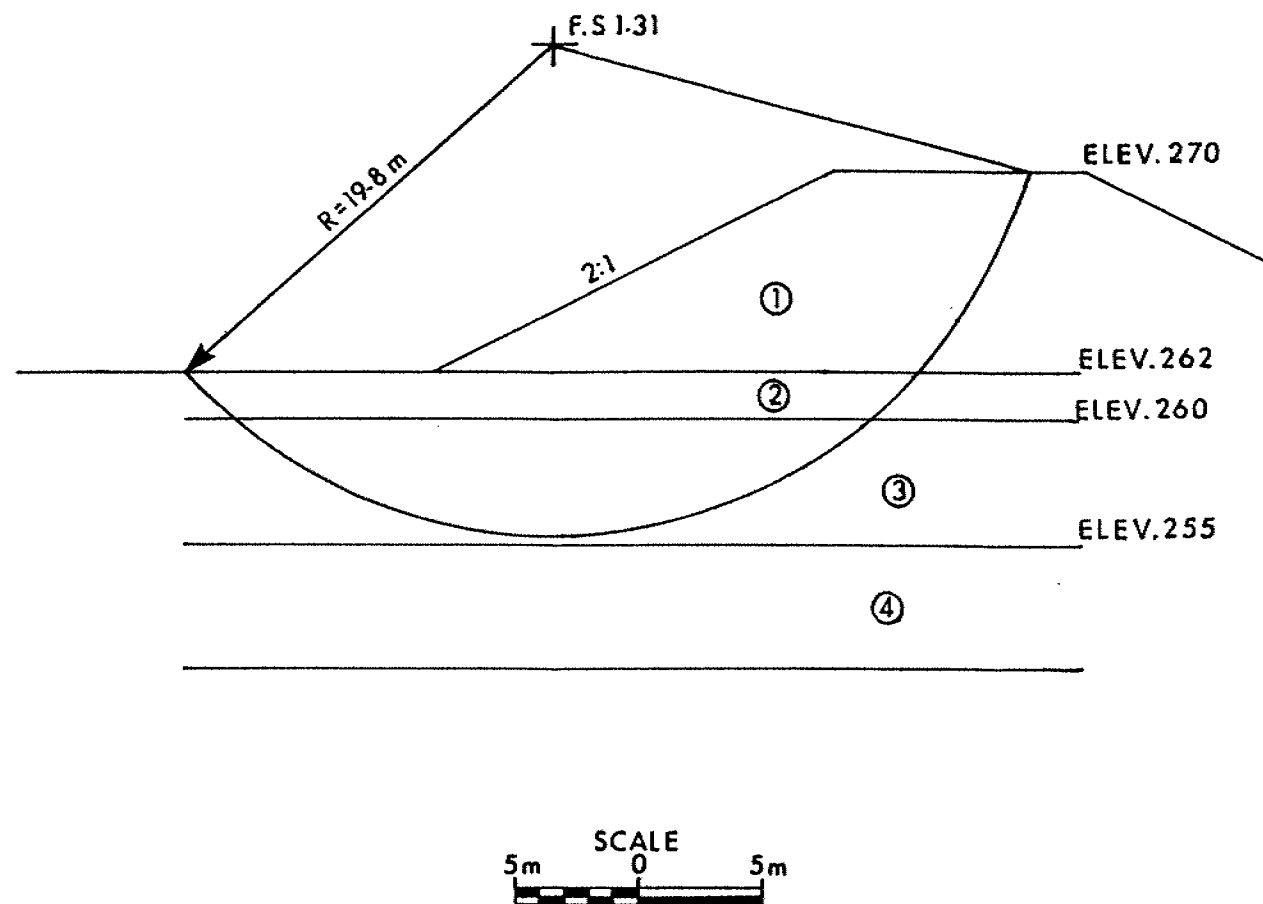
Site No. 19-305



Ministry of
Transportation

Ontario

MATERIAL PROPERTIES				
LAYER	TYPE	ϕ DEG.	C' KPa	γ KN/m ³
1	FILL	30	0	18
2	TOP SOIL	0	20	16
3	CL. SILT	0	32	20
4	SI. SAND	25	5	18

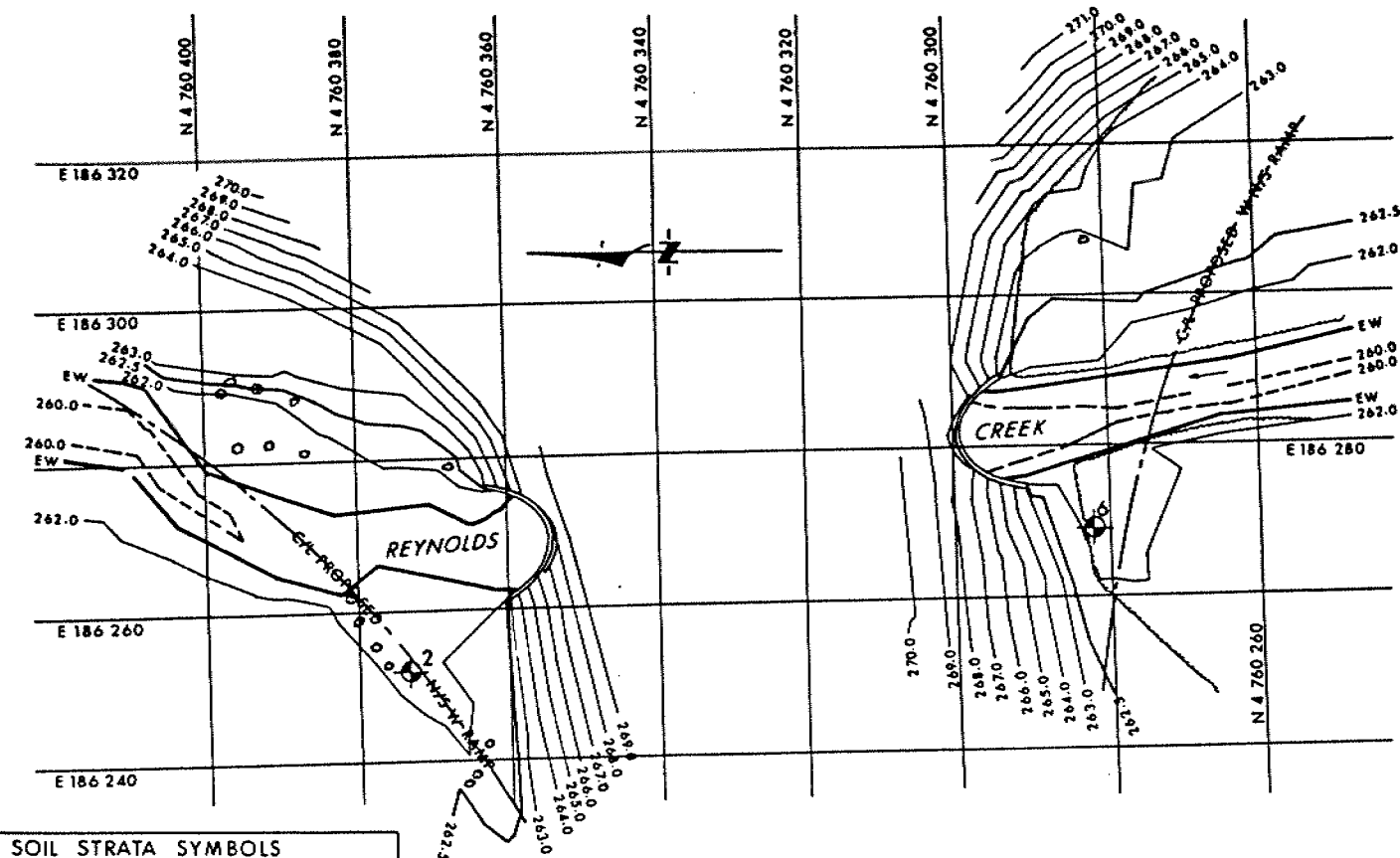


SLOPE STABILITY ANALYSIS
RAMP FILL, REYNOLDS CREEK
W.P 479-89-06/07
SITE NO. 19-305
HWY. 401



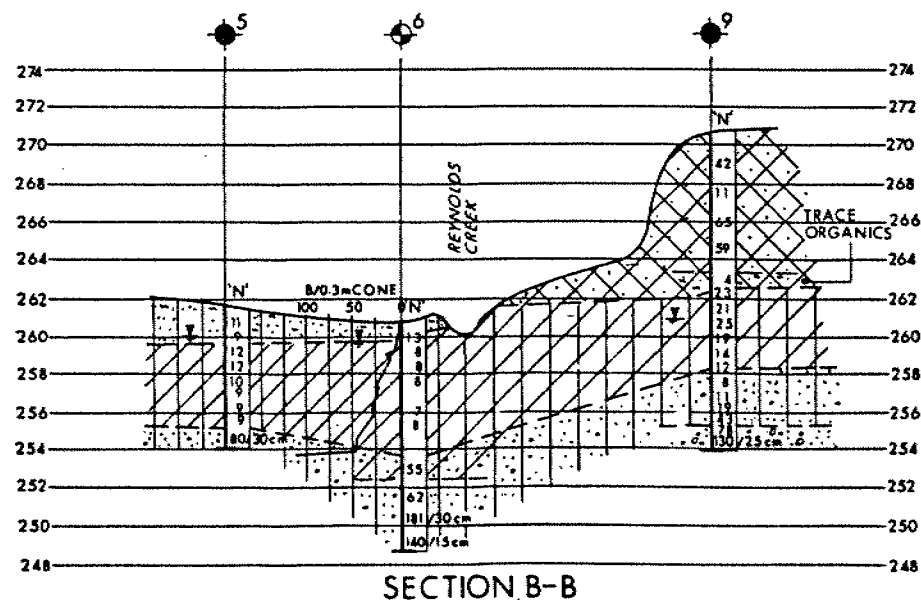
STRATA ENGINEERING CORP.

FIGURE 6



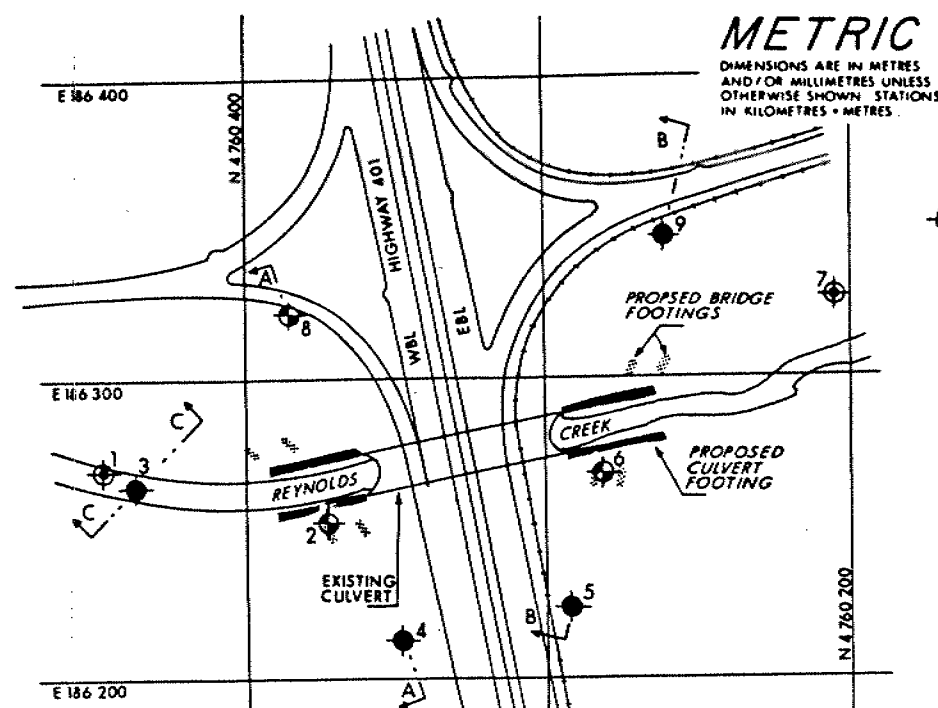
SOIL STRATA SYMBOLS	

PLAN
SCALE
10m 0 10m



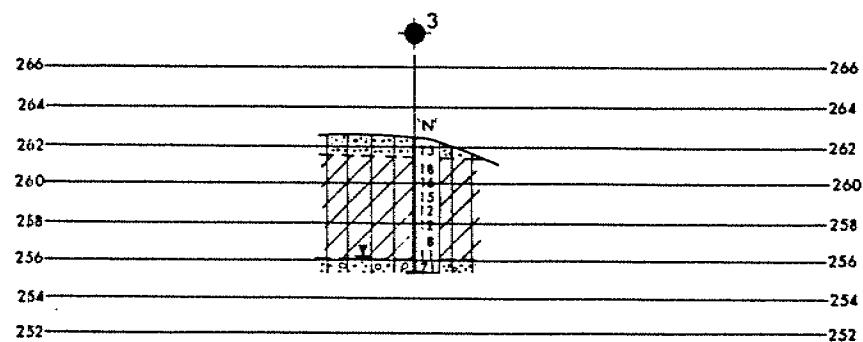
SECTION B-B

SCALE FOR SECTIONS
HOR 15m 0 15 30m
VERT 3m 0 3 6m

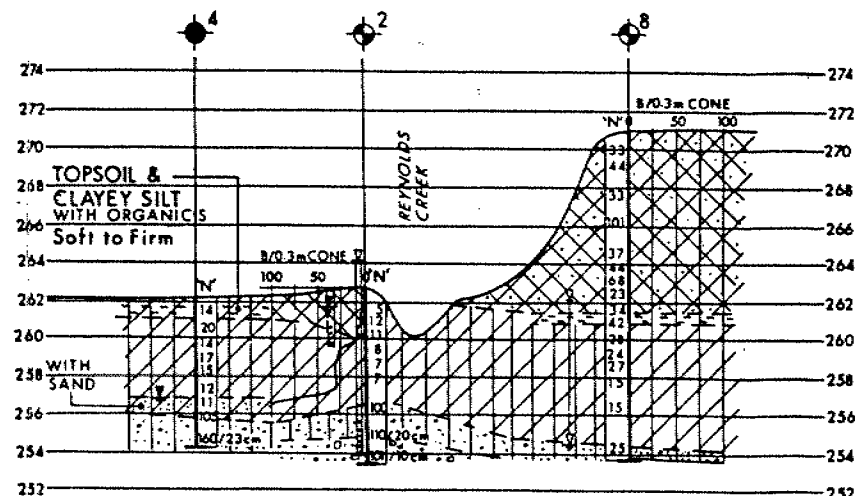


NOTE
FOR HAND AUGER HOLES No 1 & 7
REFER TO RECORD OF BOREHOLE SHEETS

PLAN
SCALE
20m 0 20 40m



SECTION C-C



SECTION A-A

CONT No
WP No 479-89-06/07

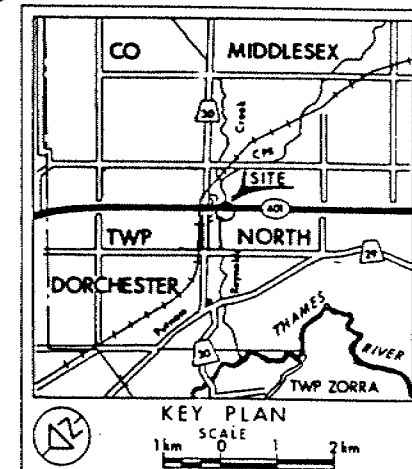
REYNOLDS CREEK

BORE HOLE LOCATIONS & SOIL STRATA

SHEET



STRATA ENGINEERING CORP.



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 07/08 1990
- Hand Auger Hole
- Head
- ARTESIAN WATER Encountered
- Stand Pipe

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	262.1	4 760 448	186 269
2	262.7	4 760 373	186 252
3	262.6	4 760 437	186 264
4	262.2	4 760 348	186 212
5	261.8	4 760 292	186 223
6	260.9	4 760 282	186 268
7	260.8	4 760 205	186 327
8	271.0	4 760 385	186 321
9	270.8	4 760 261	186 347

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 40115-27

HWY No 401
SUBMD A.A [CHECKED A.A] DATE NOV 06 1990 SITE 19-305
DRAWN A.K [CHECKED A.A] APPROVED A.K DWG 4798906/07A

REF NO E-92-401-1-2 &
PLATE NO 92-401/45-0