

DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. SOM12-183

DIST. 6 REGION

W.P. No. 54-82-02

CONT. No.

W. O. No.

STR. SITE No. 24-132

HWY. No. 401

LOCATION HWY 10 UNDERPASS

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

ENGINEERING MATERIALS OFFICE
PAVEMENT & FOUNDATION DESIGN SECTION

WP 54-82-02

DIST 6

HWY 401

STR SITE 24-132

Highway 10 Underpass

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FOUNDATION INVESTIGATION REPORT

For

Hwy. 10 Underpass

W.P. 54-82-02, Site 24-132

Highway 401, District 6, Toronto

INTRODUCTION:

This report summarizes the factual information obtained from a foundation investigation carried out between 83 08 24 and 83 08 29 at the above mentioned structure site. The field work consisted of 8 sampled boreholes advanced by means of solid stem augers to depths of up to 15.3 m below ground surface.

SITE DESCRIPTION AND GEOLOGY

The site is located immediately west of the existing Hwy. 401, Hwy. 10 structure in the Regional Municipality of Peel.

Land use in the surrounding area is predominantly agricultural.

The site is located in the physiographic region known as the "Peel Plain". This region is characterized by a level to undulating "till or boulder clay" plain underlain by shale or limestone bedrock.

SUBSURFACE CONDITIONS

General

The predominant soil deposit in this area is a hard glacial till composed of a heterogeneous mixture of silty clay, some sand and gravel. This generally cohesive deposit, varies in the thickness from 1.1 to 3.1 m. Underlying the glacial till is shale bedrock which is very weathered for a thickness of up to 5.5 m.

The upper portion of the existing roadway fill in some areas is composed of a fine to medium sand with some silt. In general, however, the embankment fill consists of a silty clay with sand and some gravel.

The boundaries between the various subsoil types are shown on the Record of Borehole Sheets. The locations and elevations of the borings together with four stratigraphical sections inferred from the borehole data are shown on Drawing No. 548202-A. The various subsoil types are described as follows.

Fill: Fine to Medium Sand some Silt

This fill was encountered during the investigation at various locations extending from the top of the Hwy. 10 or Hwy. 401 road base down to a depth of 1.7 to 4.0 m.

The result of grain size distribution testing conducted on selected representative samples from this deposit are plotted in envelope form on Fig. 1. The testing indicated that this fill is composed of generally a uniform fine to medium sand with some silt.

Based on Standard Penetration Test 'N' values ranging from 5 to 31 this non-cohesive fill is assessed as being in a loose to dense state of relative density and is inferred to have undergone a moderate to high degree of compactive effort.

Fill: Silty Clay, with Sand, some Gravel

This was the predominant embankment fill material encountered in borings put down through the existing Hwy. 10 fill. This fill is estimated to be up to 6.3 m thick.

The results of grain size distribution tests carried out on selected representative samples from this deposit are shown in Fig. 2 in an envelope form. Atterberg limit tests conducted on selected samples of this fill material are plotted on the Record of Borehole Sheets and on the Plasticity Chart, Fig. 3. The limit testing indicated that the matrix of the fill consists of a silty clay to silt of low plasticity (CL-ML zone) varying to a silty clay of intermediate plasticity (CI zone). In accordance with the laboratory test results the fill can be described as generally a silty clay some sand trace gravel.

This cohesive fill material was also found to contain zones of non-cohesive silt to silty sand fill as well as at least one pocket of asphaltic concrete debris up to 0.6 m thick. The fill material in general contains traces of organic matter.

The consistency of this deposit varies from firm to very stiff based on Standard Penetration Test 'N' values ranging from 5 to 25. Accordingly, the fill material has undergone a moderate degree of compactive effort.

Glacial Till: Heterogenous Mixture of Silty Clay, some Sand and Gravel

This is the predominant deposit in this area and where present was found to vary from 1.1 to 3.1 m thick.

At the upper boundary of this deposit layers up to 75 mm thick of black silty clay with organic material was encountered. It is probable that this layer is the original topsoil in this area.

A grain size distribution envelope for this material is given on Fig. 4 which is based on laboratory testing. The results of Atterberg Limits testing carried out on selected samples from this generally cohesive deposit are plotted on Fig. 5 indicating that the matrix of this glacial till is a silty clay of low plasticity (CL zone), with occasional seams of slightly plastic silt (ML zone). Based on the aforementioned laboratory test results this cohesive glacial till is described as a heterogeneous mixture of silty clay, some sand and gravel.

Standard Penetration Test 'N' values ranged from a low of 16 to in excess of 70 blows per 8 cm. Accordingly this deposit is assessed as being of hard consistency.

Bedrock

Bedrock was encountered in each of the boreholes immediately below either the fill material, or the glacial till deposit. The depth at which bedrock was encountered varies from 2.5 to 10.9 m below ground surface. The elevation of the bedrock surface varies from 188.3 to 190.3.

The boreholes were advanced into the bedrock 1.1 to 5.5 m utilizing solid stem augers. In addition, the Standard Penetration Test 'N' values ranging from 72 to 100 blows per 50 mm indicate that the upper surface of the bedrock is in a very weathered state.

The bedrock is described as a red shale of the Queenston Formation with occasional layers of grey shale 30 to 50 mm thick.

Groundwater Conditions

The groundwater level was established by measuring in the open boreholes. The measurements indicated that the groundwater level varies from elevation 187.2 to 190.6 m and was in general at elevation 190.3 during the period of the field investigation.

DISCUSSION AND RECOMMENDATIONS

General

Hwy. 401, in the area of the existing Hwy. 10 interchange, will be up-graded to a core collector system. A new three span structure (30 m, 24 m, 41 m) is proposed to carry Hwy. 10 over the expanded MacDonald Cartier Freeway. Present proposals call for locating the new structure immediately west of the existing crossing. No significant grade revisions are contemplated.

The predominant subsurface conditions consist of generally shallow deposits of hard glacial till overlying shale bedrock. The existing Hwy. 10 embankment is composed generally of firm to stiff silty clay some sand and a trace of gravel.

In the following paragraphs are given our recommendations for the design and construction of the structure and related earth works.

Structure

If perched abutments are contemplated they can be founded on steel 'H' piles driven into the shale bedrock. For design and estimating purposes the pile tip elevations and bearing capacities for steel H.P. 310x110 piles given below can be used.

Abutment	Reference Borehole(s)	Estimated Pile Tip Elevation metres	Factored Axial Bearing Capacity @ U.L.S.	Axial Bearing Capacity @ S.L.S. Type II
South	1&6	190.0	1600 kN	1150 kN
North	3 4	188.5 190.0	1600 kN	1150 kN

The pile tips should be equipped with standard tip reinforcement. In addition abutments founded as described above should be provided with a minimum of 1.2 m of earth cover for frost protection purposes.

Alternatively, the abutments can be founded on spread footings located within the competent glacial till, or shale bedrock deposits. In addition, it is recommended that the piers be founded in a similar fashion since for deep foundations the shallow embedment of piles will not provide sufficient lateral restraint. Founding elevations with corresponding bearing capacities are given below.

Structure Element	Reference Borehole(s)	Founding Elevation (m)	Factored Bearing Capacity @ U.L.S.	Bearing Capacity @ S.L.S. Type II
South Abutment	1&6	190.0	1000 kPa	500 kPa
South Pier	2&5	191.0	1000 kPa	500 kPa
North Pier	7&8	191.0	800 kPa	400 kPa
		189.0	1500 kPa	800 kPa
North Abutment	3&4	190.5	1000 kPa	500 kPa

Miscellaneous Considerations

All structure elements should be provided with a minimum of 1.2 m of earth cover for frost protection purposes.

If free draining granular backfill is specified the earth pressures can be calculated by assuming the equivalent fluid pressures given in Clause 6.6.1.2.2 of O.H.B.D.C. Earth pressures due to highway loading should be calculated in accordance with clause 6.6.1.2.4. If the abutment is designed to yield laterally at the top more than 1/2 percent of the wall height, then the active earth pressure shall be used. Otherwise earth pressures can be calculated assuming an "at rest" case.

For sliding resistance of the structure founded on spreading footings a reduction of the factored bearing capacity at Ultimate Limit States should be applied in accordance with Clause 6.7.3.3 and assuming the "cohesive soil" reduction factor.

For construction of the proposed structure, temporary excavations through the existing embankment will be stable at an angle of 45°. Some surficial erosion due to surface water is expected in the sand fill. This can be minimized during construction by covering with tarps during periods of rains. In some areas, roadway protection of both the Hwy. 401 and Hwy. 10 embankment will be required. This can be accomplished by the use of soldier piles, timber lagging and raker supports.

Earthworks

As mentioned earlier, no significant grade changes are contemplated. Subsurface conditions are sufficiently competent to ensure the stability of the proposed earthworks. However, relocation of the structure immediately to the west of the existing crossing will require a widening of the existing embankment to the west. This widening must be carried out by stripping topsoil from the existing embankment and keying the additional fill into the existing slopes in accordance with MTC Standard DD-414.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of Mr. R. Matthys, Student Specialist Engineer, utilizing equipment owned and operated by Atcost Soil Investigation, Toronto. This report was written by Mr. R. Matthys and reviewed by Mr. M. MacLean, Foundations Engineer, and Mr. M. Devata, Senior Foundations Engineer.



Mr. R. Matthys
Student Specialist Engineer



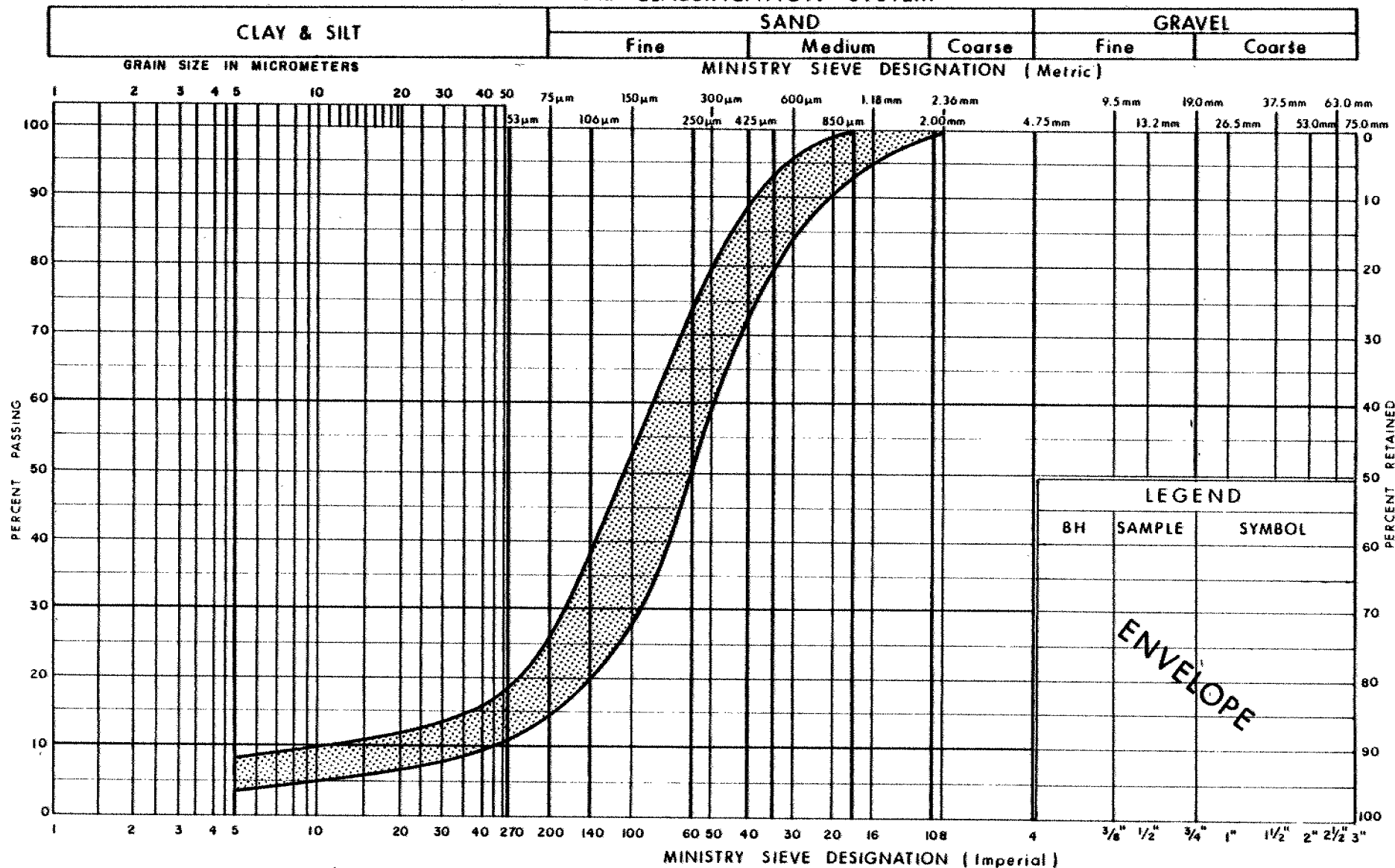
M. MacLean, P. Eng.
Foundations Engineer



M. Devata, P. Eng.
Senior Foundations Engineer

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM



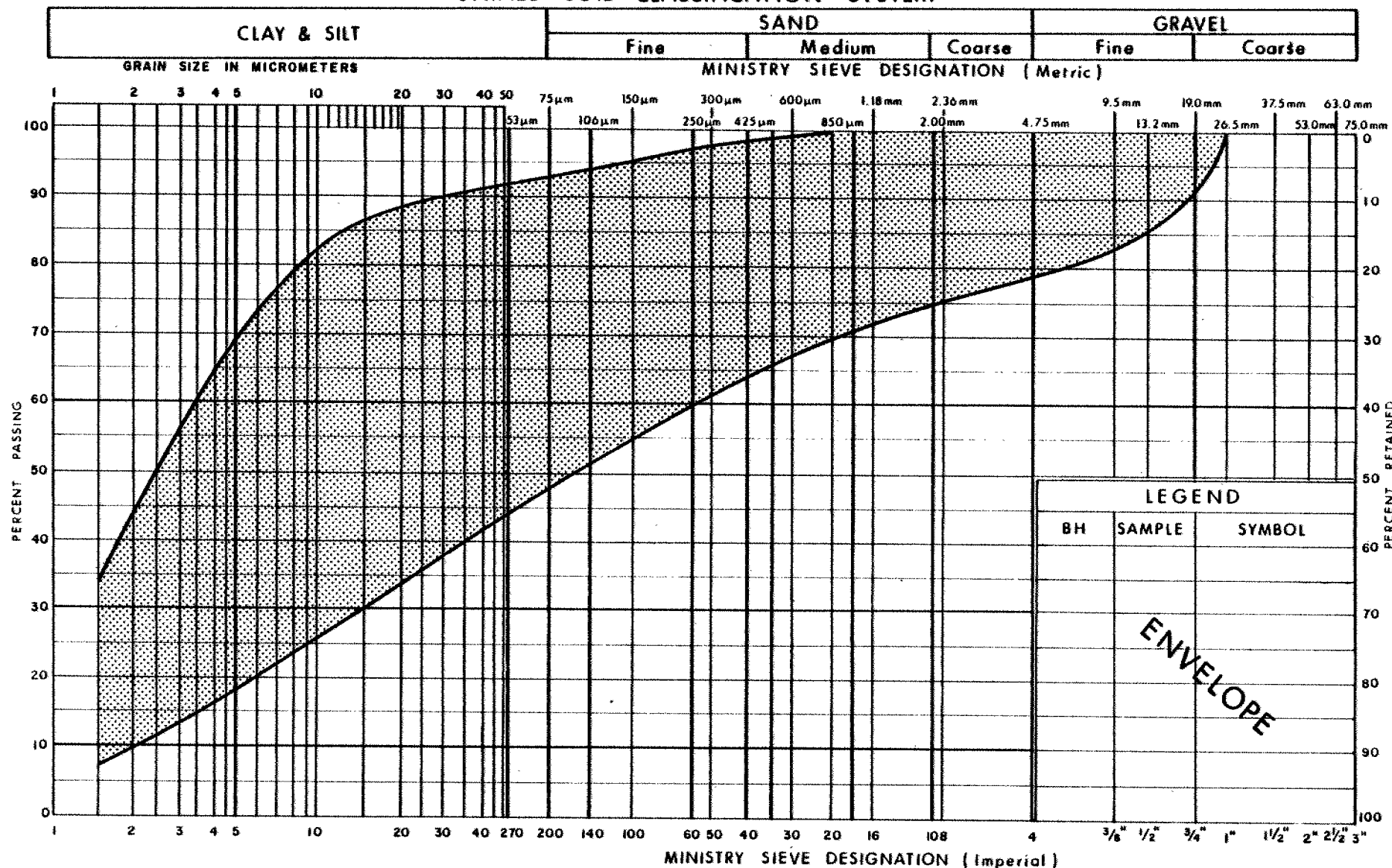
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Communications

GRAIN SIZE DISTRIBUTION
SAND, SOME SILT (FILL)

FIG No 1

W P 54-82-02

UNIFIED SOIL CLASSIFICATION SYSTEM

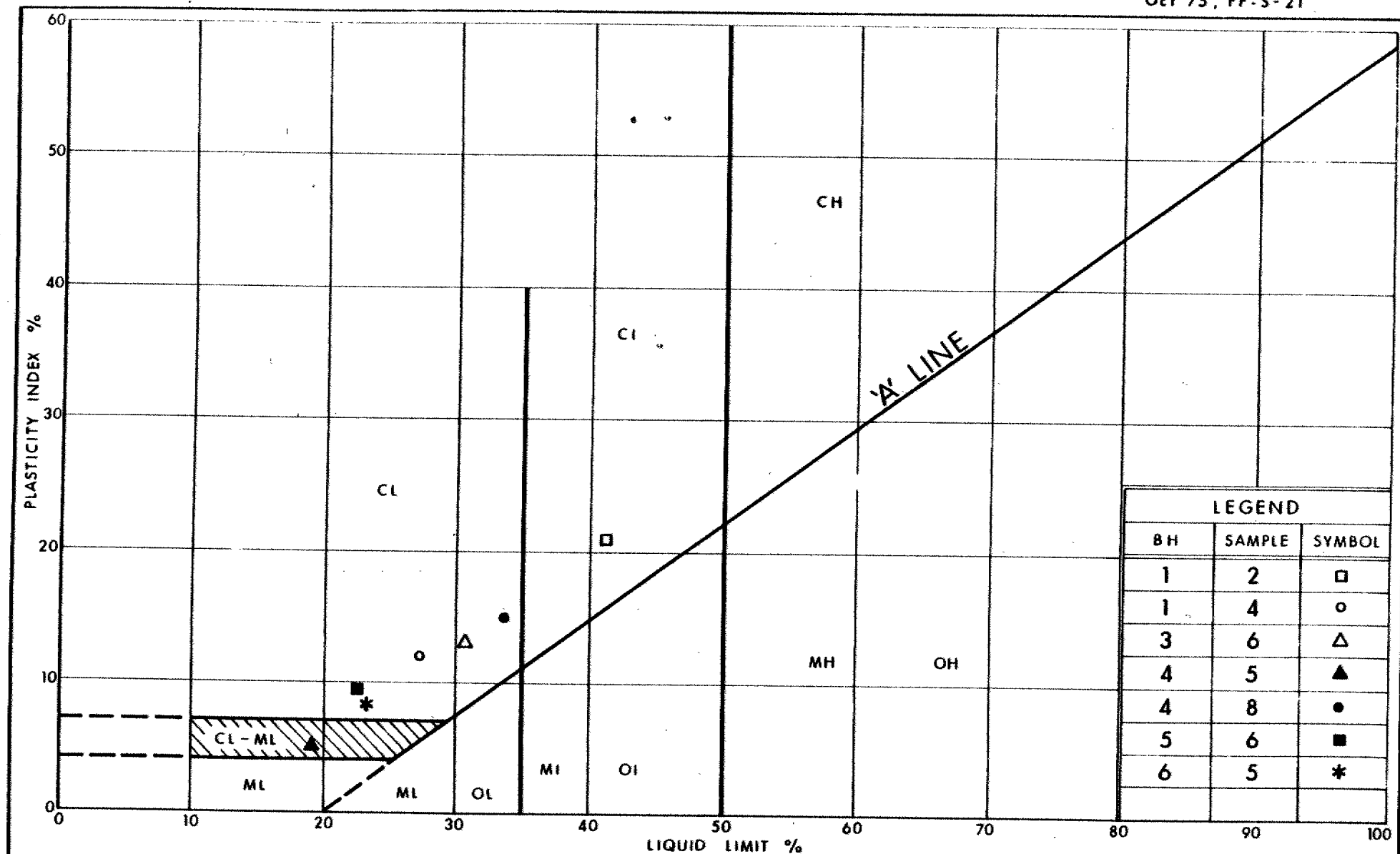


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Communications

GRAIN SIZE DISTRIBUTION
SILTY CLAY WITH SAND, SOME GRAVEL (FILL)

FIG No 2

W P 54-82-02



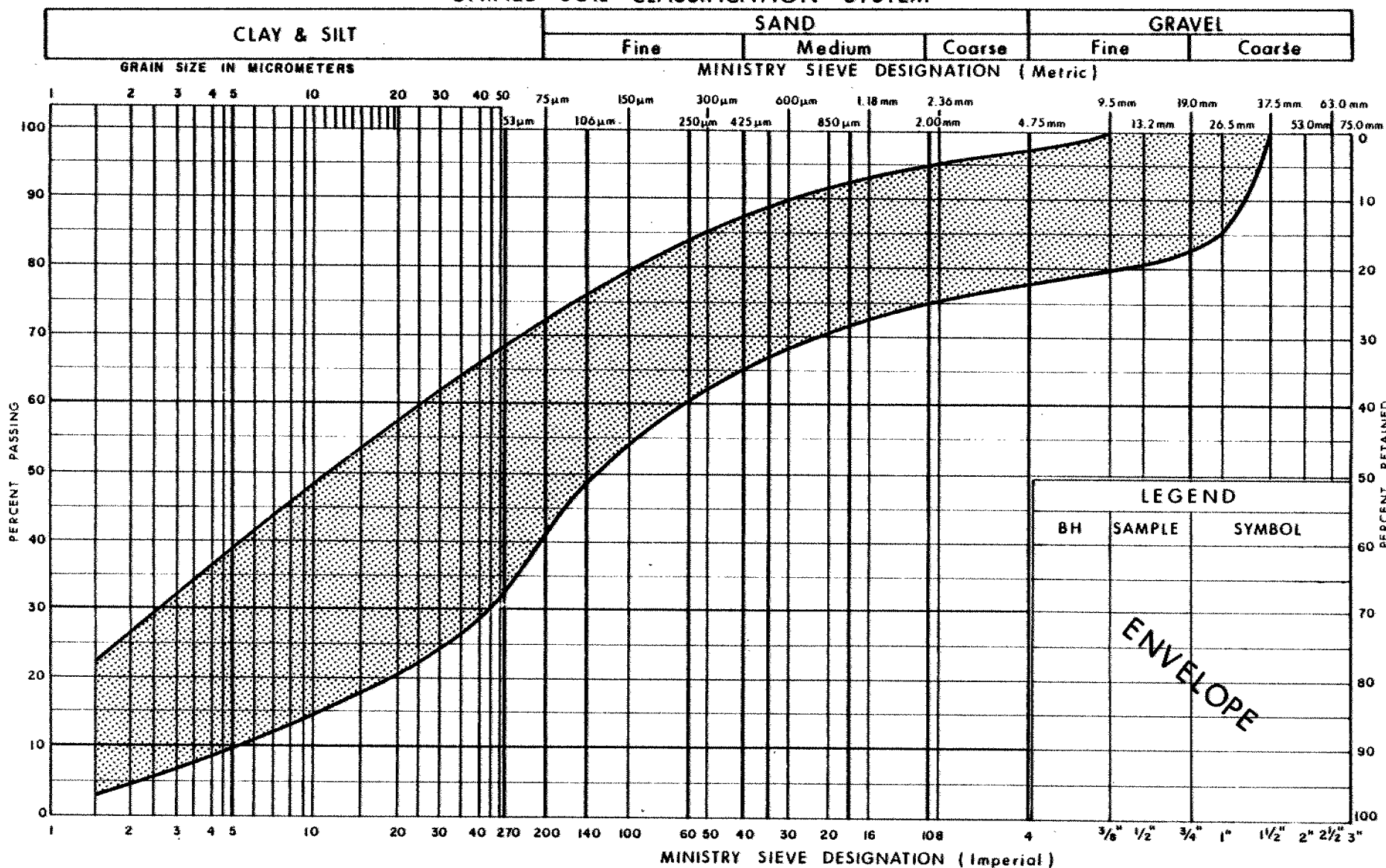
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PLASTICITY CHART SILTY CLAY, WITH SAND SOME GRAVEL (FILL)

FIG No 3

W P 54-82-02

UNIFIED SOIL CLASSIFICATION SYSTEM



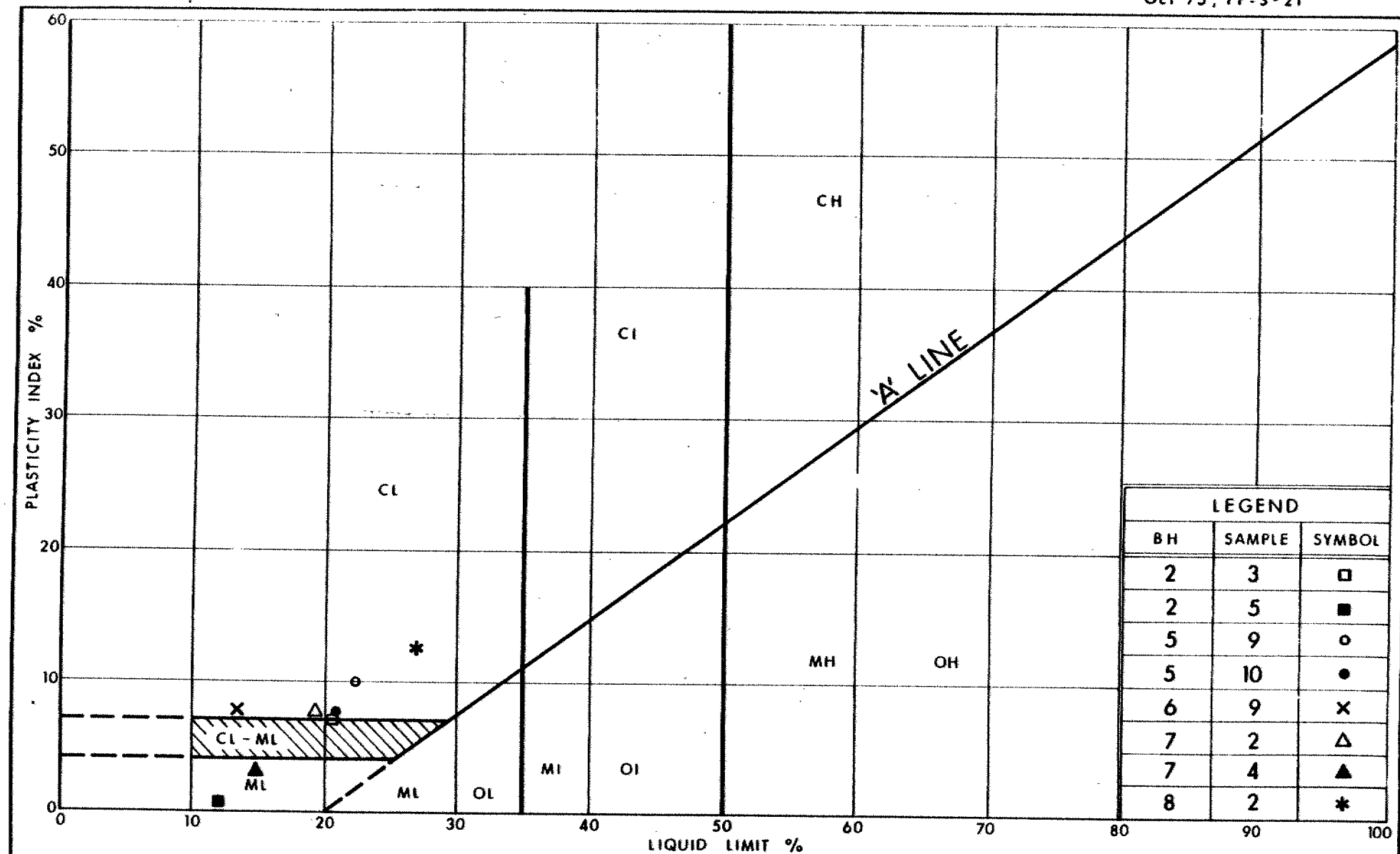
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GRAIN SIZE DISTRIBUTION
HET MIXTURE OF
SILTY CLAY, SOME SAND AND GRAVEL (Glacial Till)

FIG No 4

W P 54-82-02



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PLASTICITY CHART HET MIXTURE OF SILTY CLAY, SOME SAND AND GRAVEL (Glacial Till)

FIG No 5

W P 54-82-02

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

MECHANICAL PROPERTIES OF SOIL

m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{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 = $\frac{c_u}{\tau_r}$

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 No 1

METRIC

W P 54-82-02 LOCATION Co-ords. N 4 831 951.5; E 289 917.2 ORIGINATED BY RM
 DIST 6 HWY 10 & 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY RM
 DATUM Geodetic DATE 1983 08 24 CHECKED BY ef

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	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								
194.7	Ground Surface											
0.0	Fill Silty Clay, some sand, trace gravel trace organics Stiff to Very Stiff		1	SS	37	194						1 6 53 40
			2	SS	14							
			3	SS	21	192						
			4	SS	18							
190.3			5	SS	25							
4.4	Shale Bedrock Very Weathered Red		6	SS	80/12 cm	190						
			7	SS	115/15 cm							
187.8			8	SS	100/10 cm	188						
6.9	End of Borehole											

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
5-5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 2

METRIC

W P 54-82-02 LOCATION Co-ords. N 4 831 975.5; E 289 898.5 ORIGINATED BY RM
DIST 6 HWY 10 & 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY RM
DATUM Geodetic DATE 1983 08 24 CHECKED BY [Signature]

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						
192.7	Ground Surface													
0.0	Fill		1	SS	17		192							
191.3	Silty Clay, some sand, trace gravel Very Stiff		2	SS	45									
1.4	Heterogenous Mixture Silty Clay some sand and gravel (Glacial Till) Hard		3	SS	90/	10 cm	190							22 20 45 13
			4	SS	70/	8 cm								
188.3			5	SS	112									17 39 39 5
4.4	Shale Bedrock Very Weathered Red		6	SS	71/	12 cm	188							
186.2			7	SS	70/	8 cm								
6.5	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION



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RECORD OF BOREHOLE No 3

METRIC

W P 54-82-02 LOCATION Co-ords. N 4 832 022.5; E 289 852.5 ORIGINATED BY RM
DIST 6 HWY 10 & 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY RM
DATUM Geodetic DATE 1983 08 24 CHECKED BY OP

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					
195.7	Ground Surface																
0.0	Fill		1	SS	12		194										
	Silty Clay with sand		2	SS	19												
	some gravel		3	SS	35												
	Stiff to Very Stiff		4	SS	17		192										
	Asphaltic		5	SS	24												
	Concrete		6	SS	30												
191.0	Organic Matter		7	SS	100/10 cm		190									Om 2%	2 28 54 16
4.7	Heterogenous Mixture																
	Silty Clay																
	some sand and gravel																
	Hard																
188.7	Shale Bedrock		8	SS	100/8 cm		188										
7.0	Very Weathered																
	Red																
186.3	End of Borehole		9	SS	80/8 cm												
9.4																	

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 4

METRIC

W P 54-82-02 LOCATION Co-ords. N 4 832 029.2; E 289 870.5 ORIGINATED BY RM
 DIST 6 HWY 10 & 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY RM
 DATUM Geodetic DATE 1983 08 25 CHECKED BY CP

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								WATER CONTENT (%)	GR SA SI CL		
								SHEAR STRENGTH											
199.9	Ground Surface																		
0.0	Fill		1	SS	25														
	Fine to Medium Sand, some silt		2	SS	15														
	--- Compact		3	SS	5														
	Silty Clay with sand		4	SS	5														
	some gravel		5	SS	8														
	traces of organic matter		6	SS	9														
	Firm to Very Stiff																		
	Silty Sand		7	SS	17														
192.2	Organic Matter		8	SS	31														
7.7	Heterogenous Mixture																		
	Silty Clay, some sand and gravel		9	SS	87														
190.1	(Glacial Till) Hard																		
9.8			10	SS	100/	5 cm													
	Shale Bedrock																		
	Very Weathered		11	SS	123														
	Red		12	SS	100/	8 cm													
184.6			13	SS	100/	5 cm													
15.3	End of Borehole																		

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE



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RECORD OF BOREHOLE No 5

METRIC

W P 54-82-02 LOCATION Co-ords. N 4 831 977.2; E 289 922.2 ORIGINATED BY RM
DIST 6 HWY 10 & 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY RM
DATUM Geodetic DATE 1983 08 25 & 26 CHECKED BY EP

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					
200.0	Ground Surface																
0.0	Fill		1	SS	22		198										0 82 14 4
	Fine to Medium Sand Some Silt		2	SS	31												
			3	SS	14												
			4	SS	5												
	Loose to Dense Stiff to V. Stiff		5	SS	5		196										5 32 48 15
	Silty Sand		6	SS	16												
	Silty Clay with sand some gravel traces of organic matter		7	SS	13		194										
192.1			8	SS	30		192										
7.9	Heterogenous Mixture of Silty Clay some sand and gravel (Glacial Till) Hard		9	SS	63		190										3 30 47 20
189.3			10	SS	100	12 cm											
10.7	Shale Bedrock Very Weathered Red		11	SS	100	43 cm	188										
187.6																	
12.4	End of Borehole																

+3, x5: Numbers refer to
Sensitivity

20
5-5 (%) STRAIN AT FAILURE
10



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RECORD OF BOREHOLE No 6

METRIC

W P 54-82-02

LOCATION Co-ords. N 4 831 960.0; E 289 939.2

ORIGINATED BY RM

DIST 6 HWY 10 & 401

BOREHOLE TYPE Solid Sem Augers

COMPILED BY RM

DATUM Geodetic

DATE 1983 08 26

CHECKED BY EP

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				
199.8	Ground Surface															
0.0	Fill															
	Fine to Medium Sand		1	SS	15											
	some silt		2	SS	22		198									
	silt		3	SS	6											
	Compact		4	SS	13											
	Stiff		5	SS	13		196									
	Silty Sand		6	SS	9											
	Silty Clay with sand some gravel		7	SS	12		194									
192.0																
7.8	Heterogenous Mixture of Silty Clay, some sand and gravel (Glacial Till)		8	SS	26		192									
	Hard		9	SS	117											
188.9							190									
10.9	Shale Bedrock Very Weathered		10	SS	1007	3cm										
187.8	Bed		11	SS	125	13 cm	188									
12.0	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

3, x 5, Numbers refer to
Sensitivity

20
5-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 7

METRIC

W P 54-82-02

LOCATION

Co-ords. N 4 831 998.4; E 289 899.5

ORIGINATED BY RM

DIST 6 HWY 10 & 401

BOREHOLE TYPE

Solid Stem Auger

COMPILED BY RM

DATUM Geodetic

DATE

1983 08 29

CHECKED BY

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					
192.5	Ground Surface																
0.0	Fill - Silty Clay with sand some gravel		1	SS	16		192										
191.1			2	SS	31												2 32 49 17
1.4	Het. Mixture of Silty Clay, some sand and gravel (Glacial Till)		3	SS	58		190										
189.0	Hard		4	SS	70	5 cm											13 38 40 9
3.5			5	SS	72												
	Shale Bedrock Very Weathered Red		6	SS	50	8 cm	188										
			7	SS	100	13 cm											
185.9			8	SS	100	8 cm	186										
6.6	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

+3, x⁵: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



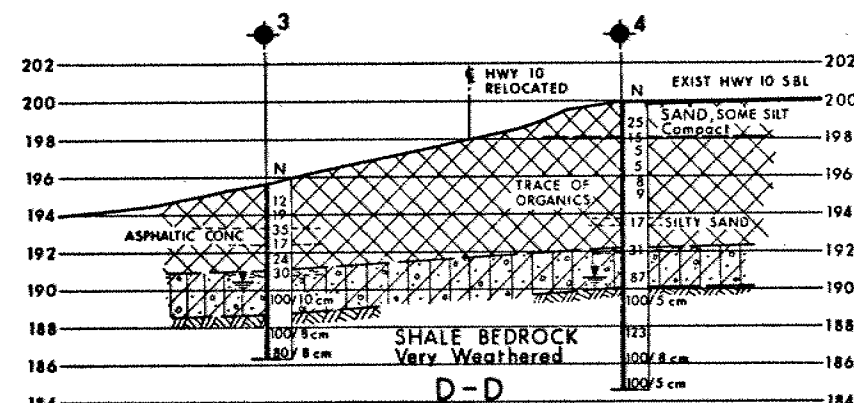
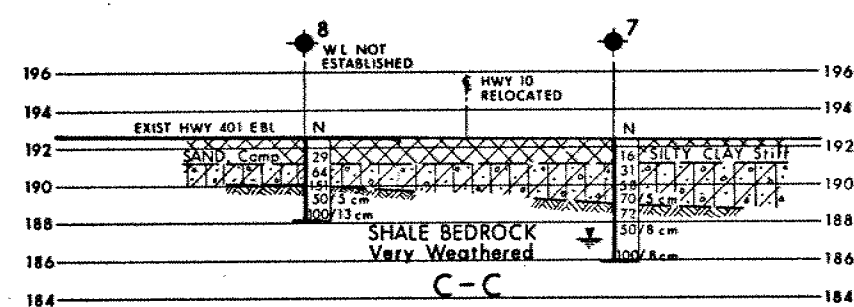
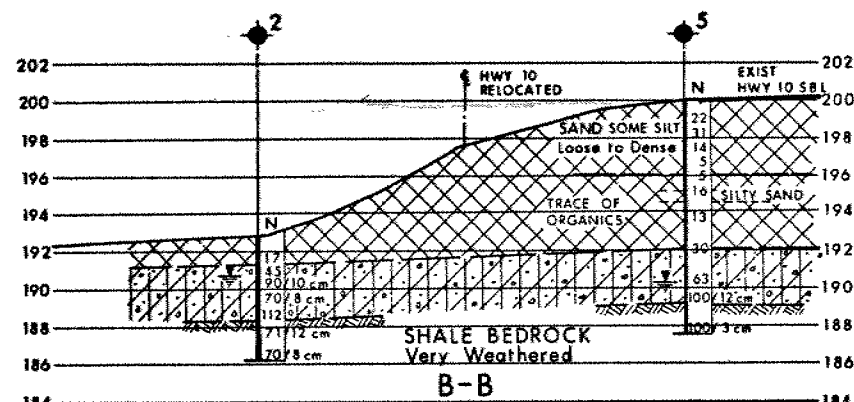
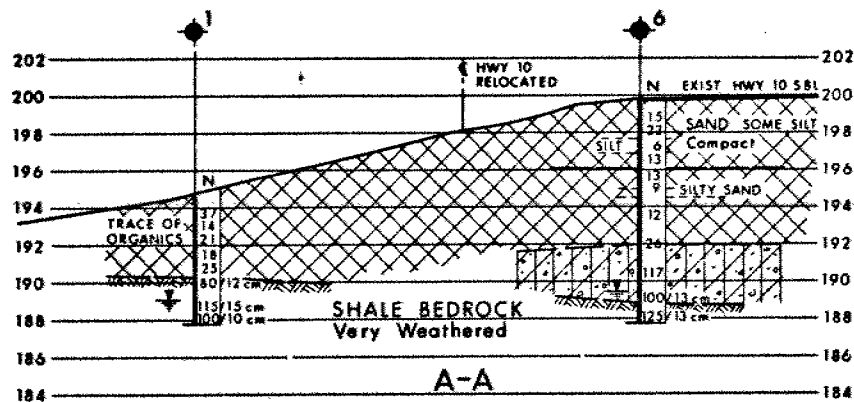
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RECORD OF BOREHOLE No 8

METRIC

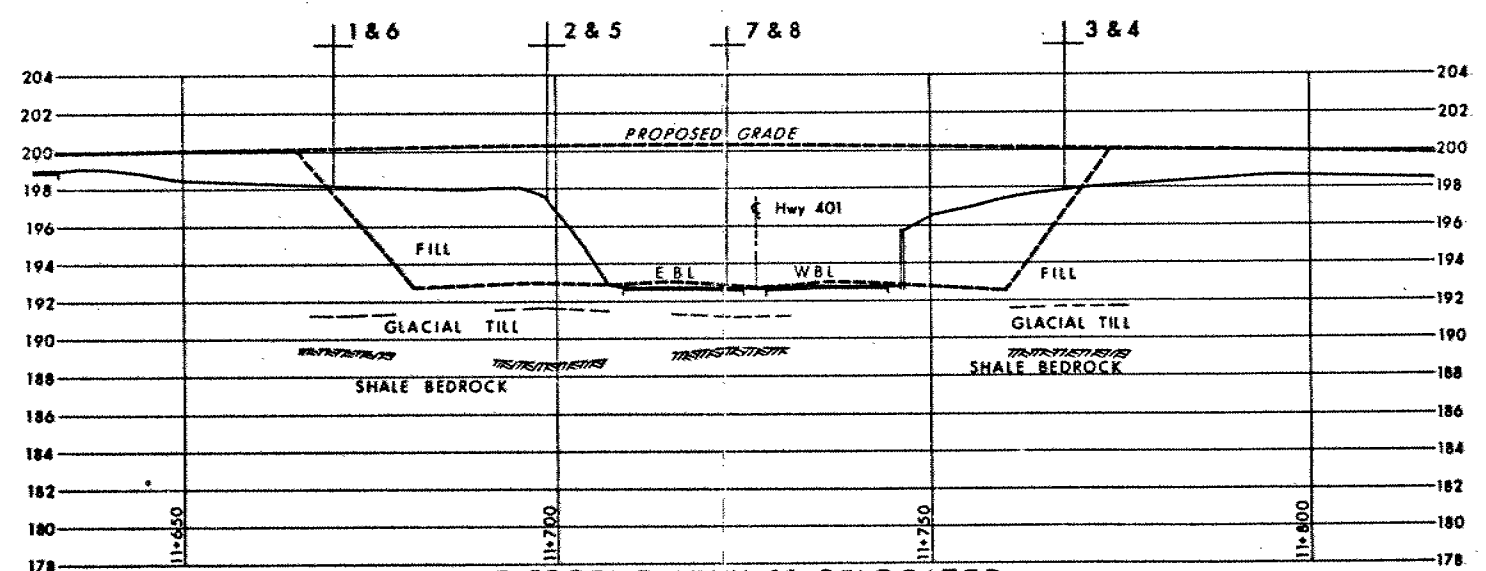
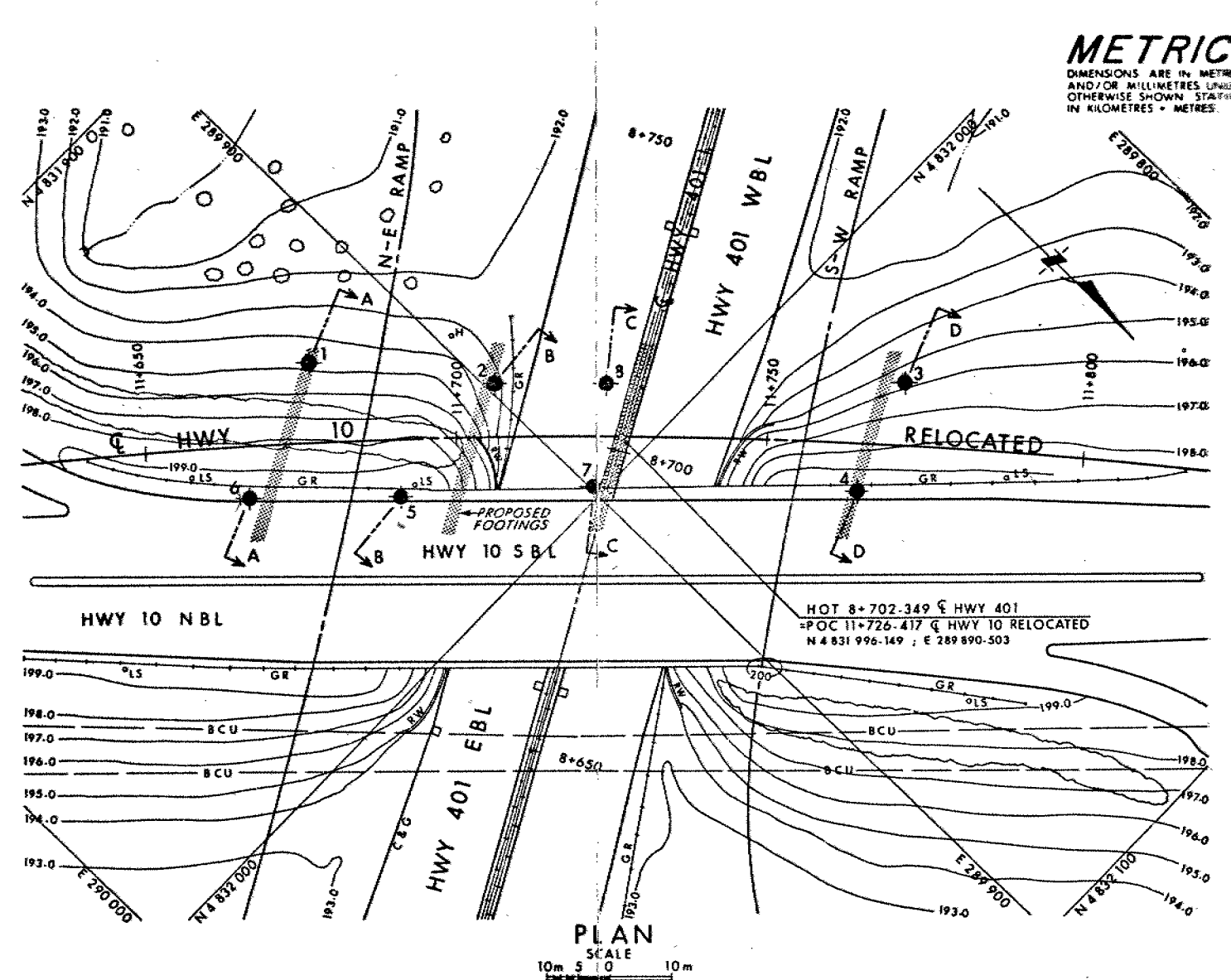
W P 54-82-02 LOCATION Co-ords. N 4 831 988.3; E 289 886.2 ORIGINATED BY RM
DIST 6 HWY 10 & 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY RM
DATUM Geodetic DATE 1983 08 29 CHECKED BY CP

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						
192.6	Ground Surface													
0.0	Fill													
191.2	Fine to Medium Sand trace clay Compact		1	SS	29		192							
1.4	Silty Clay, some sand and gravel		2	SS	64									
190.1	(Glacial Till) Hard		3	SS	151									
2.5	Shale Bedrock Very Weathered Red		4	SS	50/5	5 cm	190							8 21 51 20
188.2			5	SS	100/13	13 cm								
4.4	End of Borehole													
Note: Groundwater Level not Established														



SOIL STRATIGRAPHY LEGEND

- SILTY CLAY (FILL) WITH SAND SOME GRAVEL Firm to Very Stiff
- HET MIXTURE OF SILTY CLAY, SOME SAND AND GRAVEL (Glacial Till) Hard



PROFILE HWY 10 RELOCATED

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

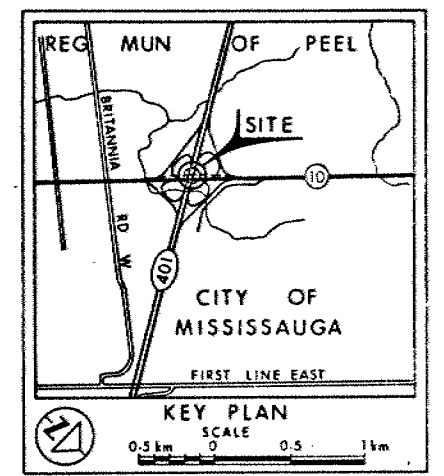
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.

CONT No
WP No 54-82-02

HWY 10 UNDERPASS

BORE HOLE LOCATIONS & SOIL STRATA

SHEET



- ### 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 1983 08
 - W/L Not Established in BH 8

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	194.7	4 831 951.5	289 917.2
2	192.7	4 831 975.5	289 898.5
3	195.7	4 832 022.5	289 852.5
4	199.9	4 832 029.2	289 870.5
5	200.0	4 831 977.2	289 922.2
6	199.8	4 831 960.0	289 939.2
7	192.5	4 831 998.4	289 899.5
8	192.6	4 831 988.3	289 886.2

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
1			

Geocres No 30M12-183

HWY No 401	SUBNO M.M.	CHECKED	DATE 1983 11 15	SITE 24-132
DRAWN	BY	CHECKED	DATE	DWG 548202-A

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FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

**ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION**

WP 54-82-02 DIST 6
HWY 401 STR SITE 24-132

Highway 10 Underpass

DISTRIBUTION

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FOUNDATION INVESTIGATION REPORT

For

Highway 10 Underpass

W.P. 54-82-02, Site 24-132

Highway 401, District 6, Toronto

INTRODUCTION

This report summarizes the factual information obtained from a foundation investigation carried out between 83 08 24 and 83 08 29 at the above mentioned structure site. The field work consisted of 8 sampled boreholes advanced by means of solid stem augers to depths of up to 15.3 m below ground surface.

SITE DESCRIPTION AND GEOLOGY

The site is located immediately west of the existing Highway 401, Highway 10 structure in the Regional Municipality of Peel.

Land use in the surrounding area is predominantly agricultural.

The site is located in the physiographic region known as the "Peel Plain". This region is characterized by a level to undulating "till or boulder clay" plain underlain by shale or limestone bedrock.

SUBSURFACE CONDITIONS

General

The predominant soil deposit in this area is a hard glacial till composed of a heterogenous mixture of silty clay, some sand and gravel. This generally cohesive deposit, varies in thickness from 1.1 to 3.1 m. Underlying the glacial till is shale bedrock which is highly weathered for a thickness of up to 5.5 m.

The upper portion of the existing roadway fill in some areas is composed of a fine to medium sand with some silt. In general, however, the embankment fill consists of a silty clay with sand and some gravel.

The boundaries between the various subsoil types are shown on the Record of Borehole Sheets. The locations and elevations of the borings together with four stratigraphical sections inferred from the borehole data are shown on Drawing No. 548202-A. The various subsoil types are described as follows.

Fill: Fine to Medium Sand, Some Silt

This fill was encountered during the investigation at various locations extending from the top of the Highway 10 or Highway 401 road base down to a depth of 1.7 to 4.0 m.

The result of grain size distribution testing conducted on selected representative samples from this deposit are plotted in envelope form on Fig. 1. The testing indicated that this fill is composed of generally a uniform fine to medium sand with some silt.

Based on Standard Penetration Test "N" values, ranging from 5 to 31, this non-cohesive fill is assessed as being in a loose to dense state of relative density and is inferred to have undergone a moderate to high degree of compactive effort.

Fill: Silty Clay, With Sand, Some Gravel

This was the predominant embankment fill material encountered in borings put down through the existing Hwy 10 fill. This fill is estimated to be up to 6.3 m thick.

The results of grain size distribution tests carried out on selected representative samples from this deposit are shown in Fig. 2 in an envelope form. Atterberg limit tests conducted on selected samples of this fill material are plotted on the Record of Borehole Sheets and on the Plasticity Chart, Fig. 3. The limit testing indicated that the matrix of the fill consists of a silty clay to silt of low plasticity (CL-

ML zone) varying to a silty clay of intermediate plasticity (CI zone). In accordance with the laboratory test results, the fill can be described as generally a silty clay, some sand, trace gravel.

This cohesive fill material was also found to contain zones of non-cohesive silt to silty sand fill as well as at least one pocket of asphaltic concrete debris up to 0.6 m thick. The fill material in general contains traces of organic matter.

The consistency of this deposit varies from firm to very stiff based on Standard Penetration Test "N" values ranging from 5 to 25. Accordingly, the fill material has undergone a moderate degree of compactive effort.

Glacial Till: Heterogenous Mixture of Silty Clay, Some Sand and Gravel

This is the predominant deposit in this area and where present was found to vary from 1.1 to 3.1 m thick.

At the upper boundary of this deposit layers, up to 75 mm thick, of black silty clay with organic material was encountered. It is probable that this layer is the original topsoil in this area.

A grain size distribution envelope for this material is given on Fig. 4 which is based on laboratory testing. The results of Atterberg Limits testing carried out on selected samples from this generally cohesive deposit are plotted on Fig. 5 indicating that the matrix of this glacial till is a silty clay of low plasticity (CL zone), with occasional seams of slightly plastic silt (ML zone). Based on the aforementioned laboratory test results, this cohesive glacial till is described as a heterogeneous mixture of silty clay, some sand and gravel.

Standard Penetration Test "N" values ranged from a low of 16 to in excess of 70 blows per 8 cm. Accordingly, this deposit is assessed as being of hard consistency.

Bedrock

Bedrock was encountered in each of the boreholes immediately below either the fill material, or the glacial till deposit. The depth at which bedrock was encountered varies from 2.5 to 10.9 m below ground surface. The elevation of the bedrock surface varies from 188.3 to 190.3.

The boreholes were advanced into the bedrock 1.1 to 5.5 m utilizing solid stem augers. In addition, the Standard Penetration Test "N" values ranging from 72 to 100 blows per 50 mm indicate that the upper surface of the bedrock is in a highly weathered state.

The bedrock is red shale of the Queenston Formation with occasional layers of grey shale 30 to 50 mm thick.

Groundwater Conditions

The groundwater level was established by measuring in the open boreholes. The measurements indicated that the groundwater level varies from elevation 187.2 to 190.6 m and was, in general, at elevation 190.3 during the period of the field investigation.

DISCUSSION AND RECOMMENDATIONS

General

It is proposed to replace the existing Highway 10 underpass in order to accommodate widening of both Highways 401 and Highway 10. The new underpass will be twin two span (59 m, 55 m) steel box girder structures with the centre pier located at the existing Highway 401 centre line. The widened structure will be aligned approximately 21 m± west of the existing Highway 10. No significant grade revisions are contemplated.

The proposed construction sequence will commence with the erection of the southbound structure followed by the demolition of the existing bridge and completion of the new northbound segment. Since all traffic is to be maintained during construction, the foundation recommendations provided are those that are most amenable to the proposed construction staging.

Structure Foundations

Abutments

Shallow foundations at the abutments would require considerable excavation and shoring of existing structures. Hence, it is recommended that the abutments be founded on either short piles to bedrock or caissons socketed in the shale bedrock. False or integral abutments could be considered at these structures.

Pile Foundations

Piles should be driven to the shale bedrock using the following axial resistances as per the OHBDC, 3rd Edition:

Steel HP 310 x 110 Piles

	<u>North Abutment</u>	<u>South Abutment</u>
Reference Boreholes	3 & 4	1 & 6
Estimated Pile Tip Elevation		
NB Structure	190.0	189.0

	<u>North Abutment</u>	<u>South Abutment</u>
SB Structure	188.7	190.0
Factored Resistance @ U.L.S.	1 600 kN/pile	1 600 kN/pile
Axial Resistance @ S.L.S.	will not govern	will not govern

The pile tips should be equipped with rock points.

It is assumed that the proposed embankment fill required for the southbound structure will be placed prior to pile driving. If possible, the embankment should be placed 3 months prior to driving to encourage settlements within both the new and existing embankment.

The use of piles at the abutments would permit construction of integral abutments. If this alternative is selected, the Foundation Design Section should be contacted to provide treatment at the flexible zones.

Caissons

Caissons foundations could also be considered at the abutments. This alternative eliminates the possibility of constructing integral abutments due to the lack of flexibility. The following recommendations apply for caissons socketed into the weathered shale:

	<u>North Abutment</u>	<u>South Abutment</u>
Reference Boreholes	3 & 4	1 & 6
Est. Base of Caisson Elev.		
NB Structure	189.1	187.9
SB Structure	187.7	189.3
Factored Resistance @ U.L.S.	2 200 kPa	2 200 kPa
Axial Resistance @ S.L.S.	will not govern	will not govern

The depth of socketing should be equal to twice the caisson diameter.

It is expected that the caissons can be installed without liners and that any water encountered can be

removed from the excavated caisson by pumping prior to the placement of concrete.

Centre Pier

The centre pier of the NB and SB Highway 10 structures may be founded on either spread footings on bedrock or caissons socketed into the shale bedrock.

Shallow Foundations

Given that the Highway 401 traffic cannot be diverted from the median during construction of the Highway 10 SB structure, excavation for spread footings will require shoring for roadway protection.

Spread footings for the centre pier may be founded on the weathered shale at or below El. 189.0 with the following design values:

Factored Bearing Resistance at U.L.S. 1000 kPa

Bearing Resistance at S.L.S. will not govern design

General Recommendations for Spread Footings

No dewatering concerns are anticipated for the footing excavations. It is expected that any seepage into the excavation can be relieved by sump pumping techniques.

Due to the rapid disintegration of shale bedrock when exposed, it is recommended that a 150 mm thick working slab of concrete be poured within 8 hours of the completion of footing excavation. In addition, shale bedrock exposed on the sides of excavations should be protected with tarpaulins.

A minimum of 1.2 m of earth cover is required for frost protection.

The sliding resistance between the base of the footing and the weathered shale may be computed using an unfactored friction coefficient of $\tan 22^\circ$.

Centre Pier - Caisson Foundations

Caisson installation would minimize the need for roadway shoring.

	<u>NB Structure</u>	<u>SB Structure</u>
Reference Boreholes	7	8
Est. Caisson Base Elev.	188.0	189.0
Factored Resistance at U.L.S.	2 200 kPa	2 200 kPa
Axial Resistance at S.L.S.	will not govern	will not govern

As discussed earlier, the caisson sockets should penetrate a depth equal to twice the caisson diameter. Similar construction considerations apply as well.

Lateral Earth Pressure

Backfill to the abutments should consist of granular material in accordance with MTO Standard Special Provision 109F03. Computation of earth pressures should be carried out as per Section 6-7.4.2 of the OHBDC, 3rd Ed.. Design parameters of the acceptable granular backfill are as follows.

	<u>Granular "A"</u>	<u>Granular "B"</u>
Angle of Internal Friction (ϕ)	35°	30°
Unit Weight (kN/m ³)	22.8	21.2

The active earth pressure condition applies when the structure is yielding and movements within the soil mass are permitted. The at-rest condition applies for caisson foundations

Approaches

No stability problems are anticipated for fill heights of 8.0 m or less, provided that slopes of 2H:1V are maintained. Where fill heights exceed 8.0 m, a 2.0 m wide mid-height berm should be incorporated.

The relocation of the Highway 10 structure immediately to the west of the existing crossing will require a widening of the existing embankment. The widening should be carried out by stripping

topsoil from the existing embankment and keying additional fill into the slope in accordance with MTO practice.

Construction Considerations

A NSSP for caisson installation, developed by the Foundation Design Section, should be included in the contract documents.

Temporary excavations within the fill may be carried out at 1.5H:1V slopes or flatter to a maximum depth of 6.0 m before incorporating a 2.0m wide mid-height berm. Sides of excavations exposing shale bedrock should be protected with a tarpaulin to minimize disintegration of the shale.

Any excavations for the northbound structure in the vicinity of the newly erected southbound structure will require temporary shoring. As well, roadway protection will be required for shallow foundation construction at the pier. An active or at-rest condition may apply. The soil parameters for the calculation of earth pressures are as follows:

<u>Soil Type</u>	<u>Deposit Extent</u>	<u>ϕ'</u>	<u>γ (kN/m³)</u>
Silty Clay Fill	El. 200± to El. 190±	28°	20

Across the site, cohesive glacial till overlies shale bedrock. The Contractor should be made aware that cobbles/boulders may be encountered during excavation and during placement of foundations.

Miscellaneous

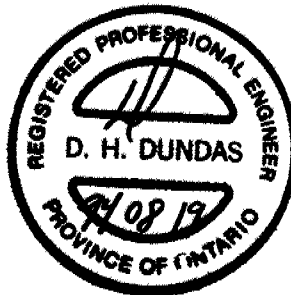
The fieldwork for this investigation was carried out in August 1983 under the supervision of R. Matthys, Engineering Student, utilizing drilling equipment owned and operated by Atcost Soil Drilling Inc.

The factual portion of the report was written by R. Matthys. The recommendations were prepared by B. Bennett, Sr. Foundation Engineer (Acting), and reviewed by D. Dundas, Chief Foundation Engineer (Acting).



B. Bennett

B. Bennett, P. Eng.
Sr. Foundation Engineer (Acting)

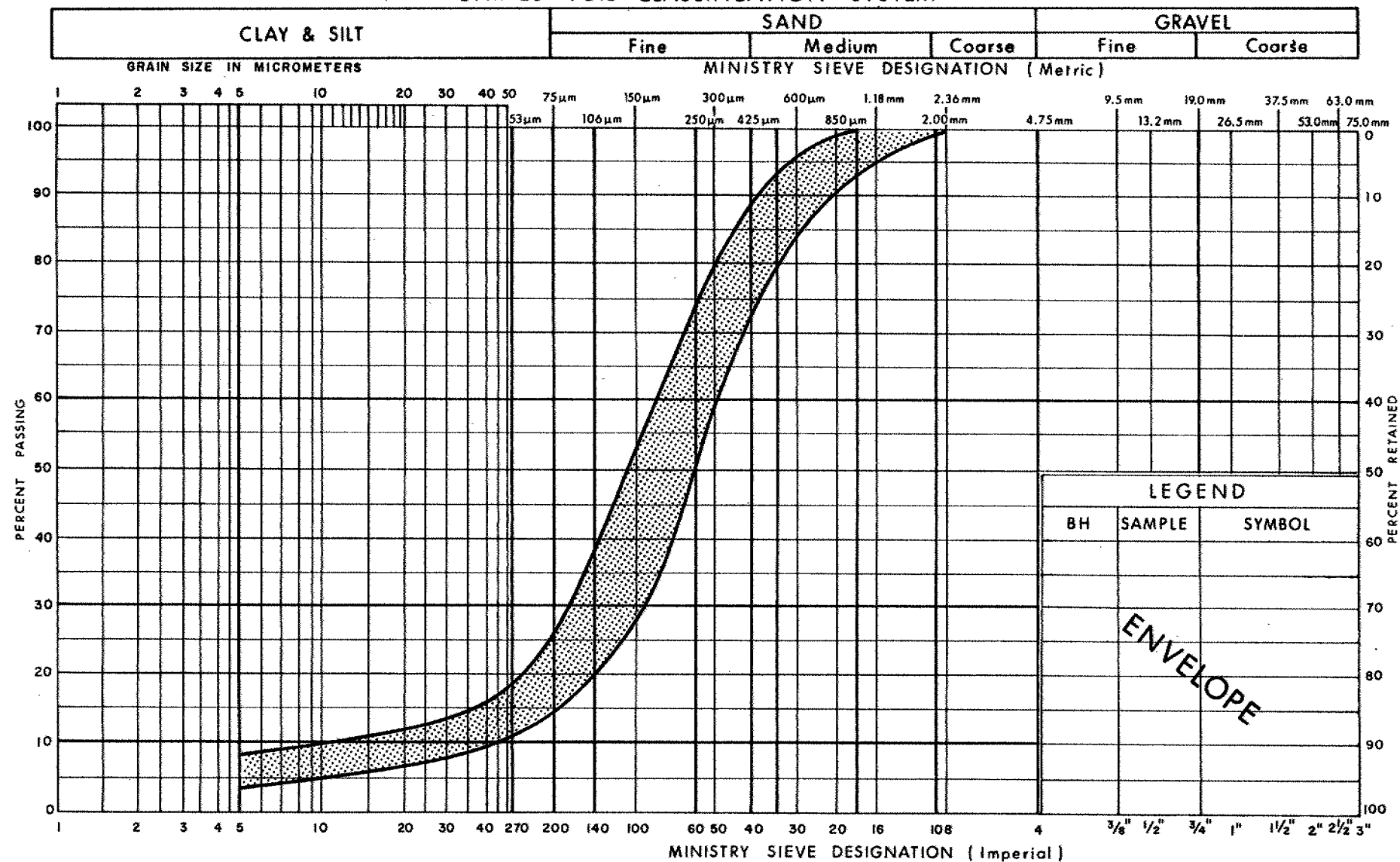


D. Dundas

D. Dundas, P. Eng.
Chief Foundation Engineer (Acting)

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM



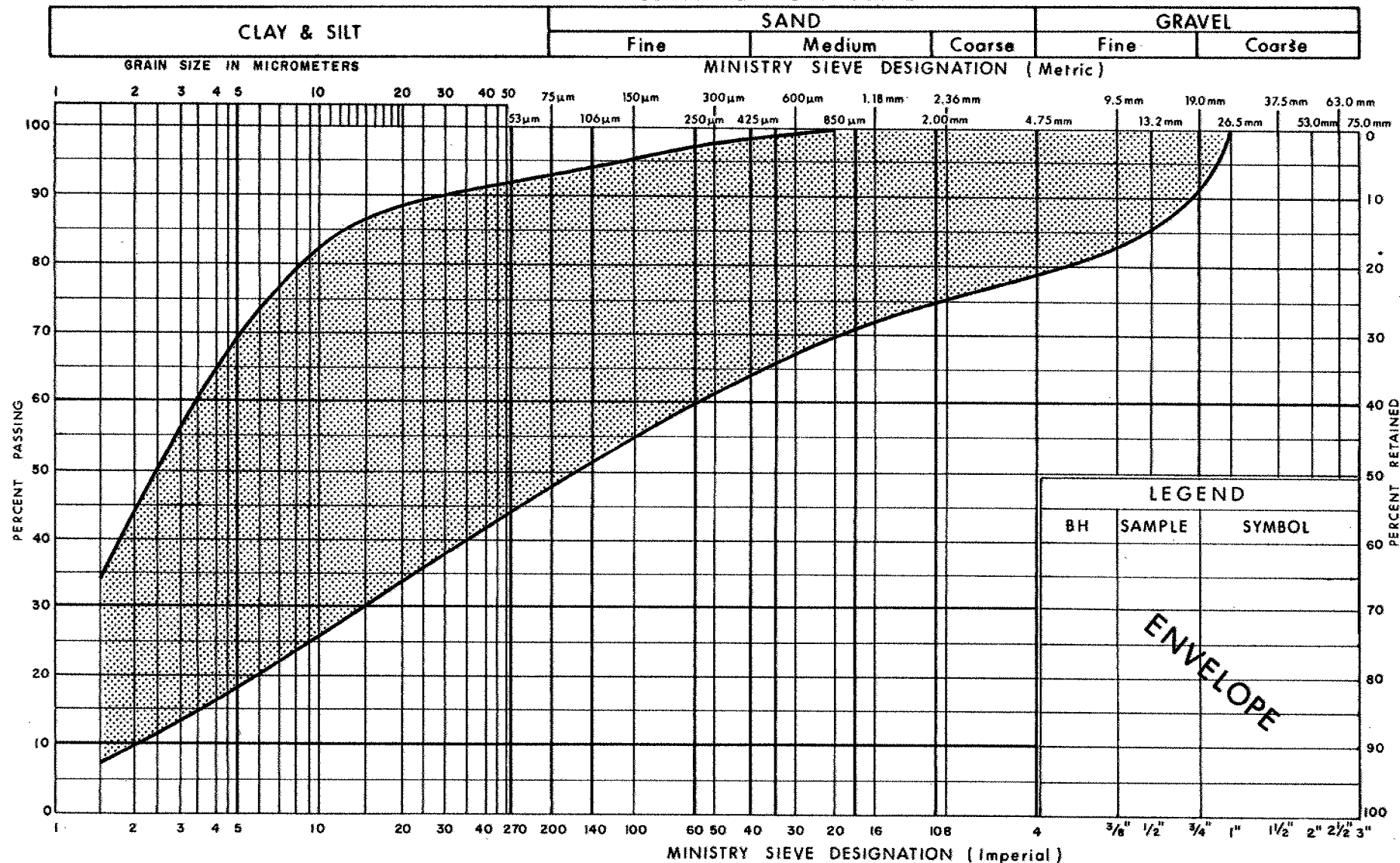
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GRAIN SIZE DISTRIBUTION
SAND, SOME SILT (FILL)

FIG No 1

W P 54-82-02

UNIFIED SOIL CLASSIFICATION SYSTEM

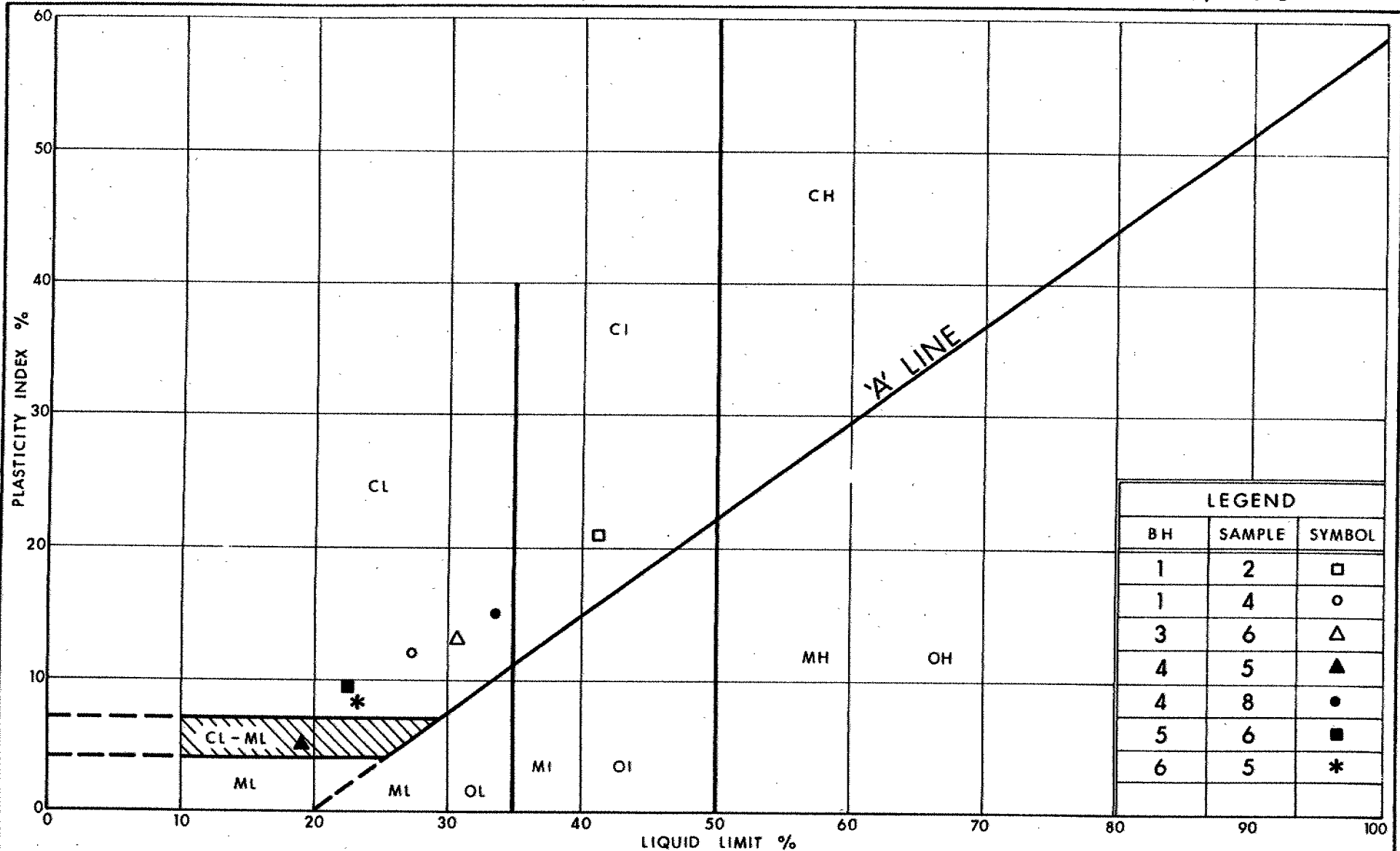


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GRAIN SIZE DISTRIBUTION
SILTY CLAY WITH SAND, SOME GRAVEL (FILL)

FIG No 2

W P 54-82-02



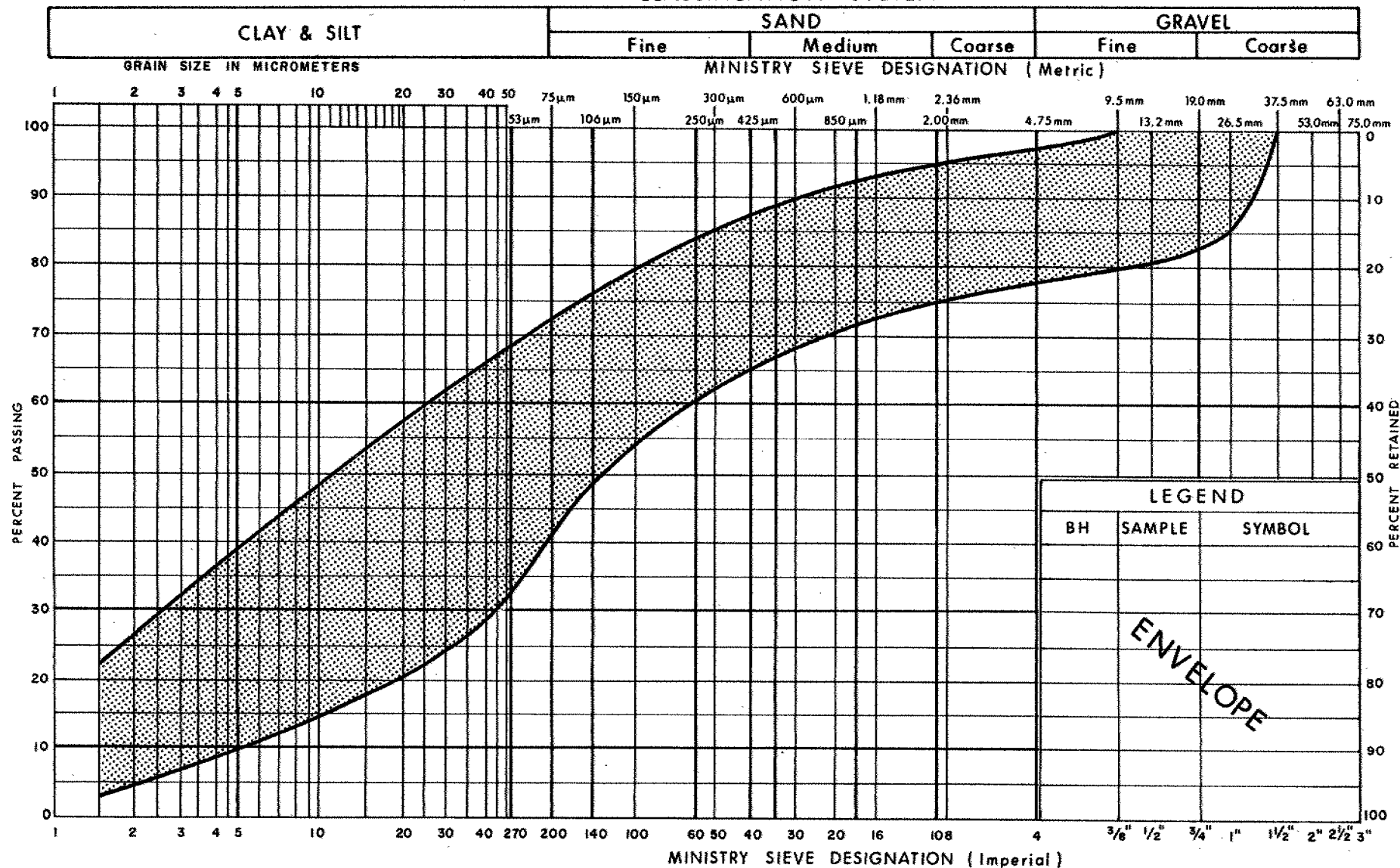
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PLASTICITY CHART SILTY CLAY, WITH SAND SOME GRAVEL (FILL)

FIG No 3

W P 54-82-02

UNIFIED SOIL CLASSIFICATION SYSTEM

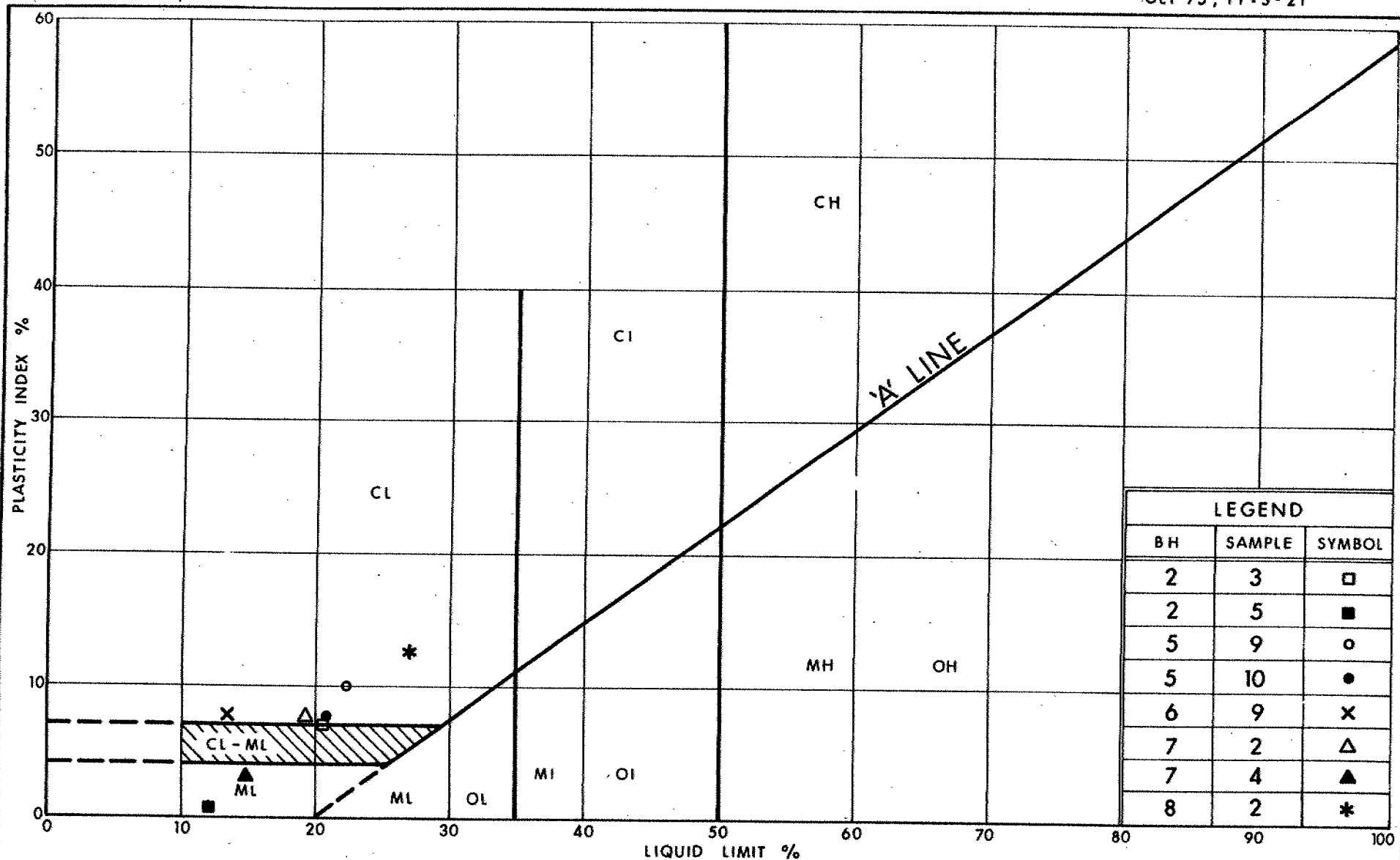


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GRAIN SIZE DISTRIBUTION
HET MIXTURE OF
SILTY CLAY, SOME SAND AND GRAVEL (Glacial Till)

FIG No 4

W P 54-82-02



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PLASTICITY CHART
HET MIXTURE OF
SILTY CLAY, SOME SAND AND GRAVEL (Glacial Till)

FIG No 5

W P 54-82-02

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'_{v0}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_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 No 1

METRIC

W P 54-82-02 LOCATION Co-ords. N 4 831 951.5; E 289 917.2 ORIGINATED BY RM
 DIST 6 HWY 10 & 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY RM
 DATUM Geodetic DATE 1983 08 24 CHECKED BY ef

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					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		
194.7 0.0	Ground Surface													
	Fill		1	SS	37		194							
	Silty Clay, some sand, trace gravel trace organics		2	SS	14									
	Stiff to Very Stiff		3	SS	21		192							
			4	SS	18									
190.3 4.4			5	SS	25									
	Shale Bedrock		6	SS	80/12 cm		190							
	Very Weathered		7	SS	115/15cm									
187.8 6.9			8	SS	100/10 cm		188							
	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 2

METRIC

W P 54-82-02 LOCATION Co-ords. N 4 831 975.5; E 289 898.5 ORIGINATED BY RM
 DIST 6 HWY 10 & 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY RM
 DATUM Geodetic DATE 1983 08 24 CHECKED BY [Signature]

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					
192.7	Ground Surface																
0.0	Fill						192										
191.3	Silty Clay, some sand, trace gravel Very Stiff		1	SS	17												
1.4	Heterogenous Mixture		2	SS	45												
	Silty Clay		3	SS	90/	10 cm	190										22 20 45 13
	some sand and gravel (Glacial Till)		4	SS	70/	8 cm											
	Hard		5	SS	112												17 39 39 5
188.3			6	SS	71/	12 cm	188										
4.4	Shale Bedrock Very Weathered Red		7	SS	70/	8 cm											
186.2																	
6.5	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 3

METRIC

W P 54-82-02 LOCATION Co-ords. N 4 832 022.5; E 289 852.5 ORIGINATED BY RM
 DIST 6 HWY 10 & 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY RM
 DATUM Geodetic DATE 1983 08 24 CHECKED BY CP

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					
195.7	Ground Surface																GR SA SI CL
0.0	Fill																
	Silty Clay with sand		1	SS	12												
	some gravel		2	SS	19												
	Stiff to Very Stiff		3	SS	35												
	Asphaltic		4	SS	17												
	Concrete		5	SS	24												
191.0	Organic Matter		6	SS	30											Om 2%	2 28 54 16
4.7	Heterogenous Mixture		7	SS	100/	10 cm											16 38 39 7
	Silty Clay																
	some sand and gravel																
	Hard																
188.7	Shale Bedrock		8	SS	100/	8 cm											
7.0	Very Weathered																
	Red																
186.3			9	SS	80/	8 cm											
9.4	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 4

METRIC

W P 54-82-02 LOCATION Co-ords. N 4 832 029.2; E 289 870.5 ORIGINATED BY RM
 DIST 6 HWY 10 & 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY RM
 DATUM Geodetic DATE 1983 08 25 CHECKED BY CP

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										WATER CONTENT (%)		
								SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE												
199.9 0.0	Ground Surface															GR 5A SI CL				
	Fill		1	SS	25															
	Fine to Medium Sand, some silt		2	SS	15															
	Compact		3	SS	5															
	Silty Clay with sand some gravel		4	SS	5											22 30 38 10				
	traces of organic matter		5	SS	8															
	Firm to Very Stiff		6	SS	9															
	Silty Sand		7	SS	17											8 32 44 16				
192.2 7.7	Organic Matter		8	SS	31										Om 2%	13 17 48 22				
	Heterogenous Mixture																			
	Silty Clay, some sand and gravel		9	SS	87															
190.1 9.8	(Glacial Till) Hard		10	SS	100/	5 cm														
	Shale Bedrock																			
	Very Weathered		11	SS	123															
	Red		12	SS	100/	8 cm														
184.6 15.3	End of Borehole		13	SS	100/	5 cm														

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 5

METRIC

W P 54-82-02 LOCATION Co-ords. N 4 831 977.2; E 289 922.2 ORIGINATED BY RM
 DIST 6 HWY 10 & 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY RM
 DATUM Geodetic DATE 1983 08 25 & 26 CHECKED BY EP

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					
200.0	Ground Surface																
0.0	Fill		1	SS	22												
	Fine to Medium Sand Some Silt		2	SS	31		198										0 82 14 4
			3	SS	14												
			4	SS	5												
	Loose to Dense Stiff to V.Stiff		5	SS	5		196										5 32 48 15
	Silty Sand		6	SS	16												
	Silty Clay with sand some gravel traces of organic matter		7	SS	13		194										
192.1			8	SS	30		192										
7.9	Heterogenous Mixture of Silty Clay some sand and gravel (Glacial Till) Hard		9	SS	63												3 30 47 20
189.3			10	SS	100	12 cm	190										
10.7	Shale Bedrock Very Weathered Red						188										
187.6			11	SS	100	3 cm											
12.4	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 6

METRIC

W P 54-82-02 LOCATION Co-ords. N 4 831 960.0; E 289 939.2 ORIGINATED BY RM
DIST 6 HWY 10 & 401 BOREHOLE TYPE Solid Sem Augers COMPILED BY RM
DATUM Geodetic DATE 1983 08 26 CHECKED BY EP

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							
199.8	Ground Surface														
0.0	Fill														
	Fine to Medium		1	SS	15										
	Sand		2	SS	22		198								
	some silt		3	SS	6										
	silt		4	SS	13		196								
	Compact		5	SS	13										
	Stiff		6	SS	9										
	Silty Sand		7	SS	12		194								
	Silty Clay														
	with sand														
	some gravel														
192.0			8	SS	26		192								
7.8	Heterogenous Mixture		9	SS	117		190								
	of Silty Clay,														
	some sand and gravel														
	(Glacial Till)														
	Hard		10	SS	100/13cm										
188.9	Shale Bedrock														
10.9	Very Weathered														
187.8	Red		11	SS	125/13 cm		188								
12.0	End of Borehole														

RECORD OF BOREHOLE No 7

METRIC

W P 54-82-02 LOCATION Co-ords. N 4 831 998.4; E 289 899.5 ORIGINATED BY RM
 DIST 6 HWY 10 & 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY RM
 DATUM Geodetic DATE 1983 08 29 CHECKED BY CP

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					
192.5	Ground Surface																
0.0	Fill - Silty Clay with sand some gravel		1	SS	16		192										
191.1	Stiff		2	SS	31												
1.4	Het. Mixture of Silty Clay, some sand and gravel (Glacial Till)		3	SS	58		190										2 32 49 17
189.0	Hard		4	SS	70	5 cm											13 38 40 9
3.5			5	SS	72												
	Shale Bedrock Very Weathered Red		6	SS	50	8 cm	188										
185.9			7	SS	100	13 cm											
6.6	End of Borehole		8	SS	100	8 cm	186										

OFFICE REPORT ON SOIL EXPLORATION



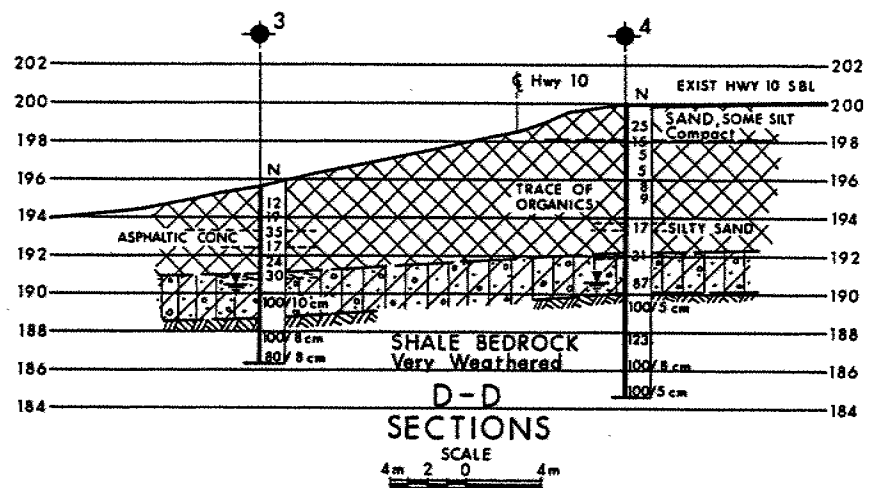
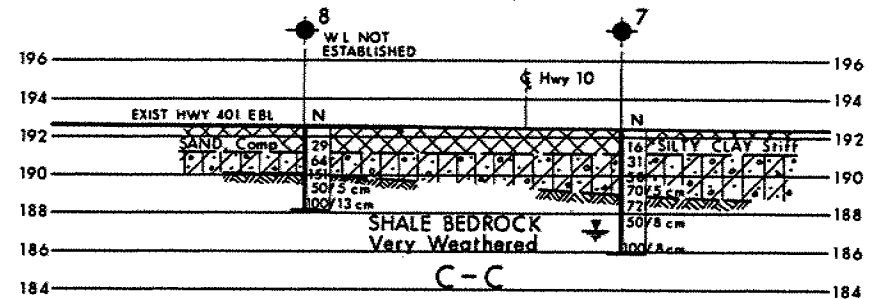
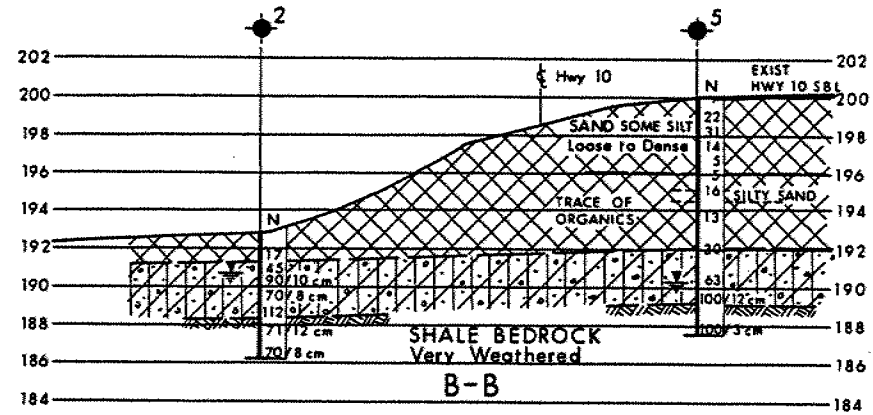
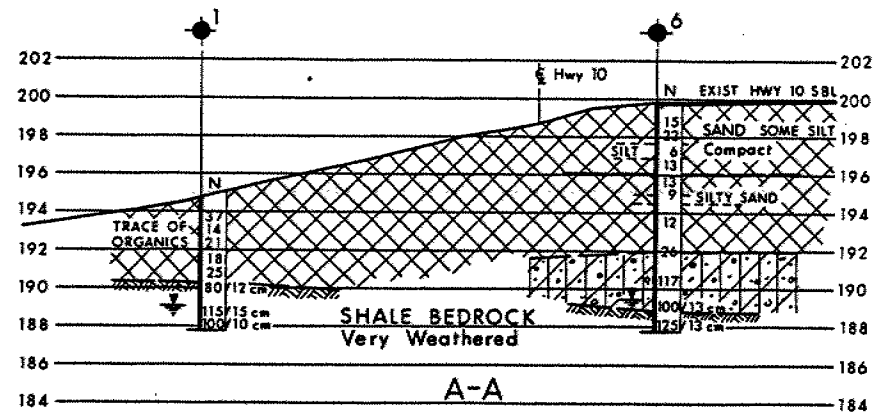
RECORD OF BOREHOLE No 8

METRIC

W P 54-82-02 LOCATION Co-ords. N 4 831 988.3; E 289 886.2 ORIGINATED BY RM
DIST 6 HWY 10 & 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY RM
DATUM Geodetic DATE 1983 08 29 CHECKED BY CP

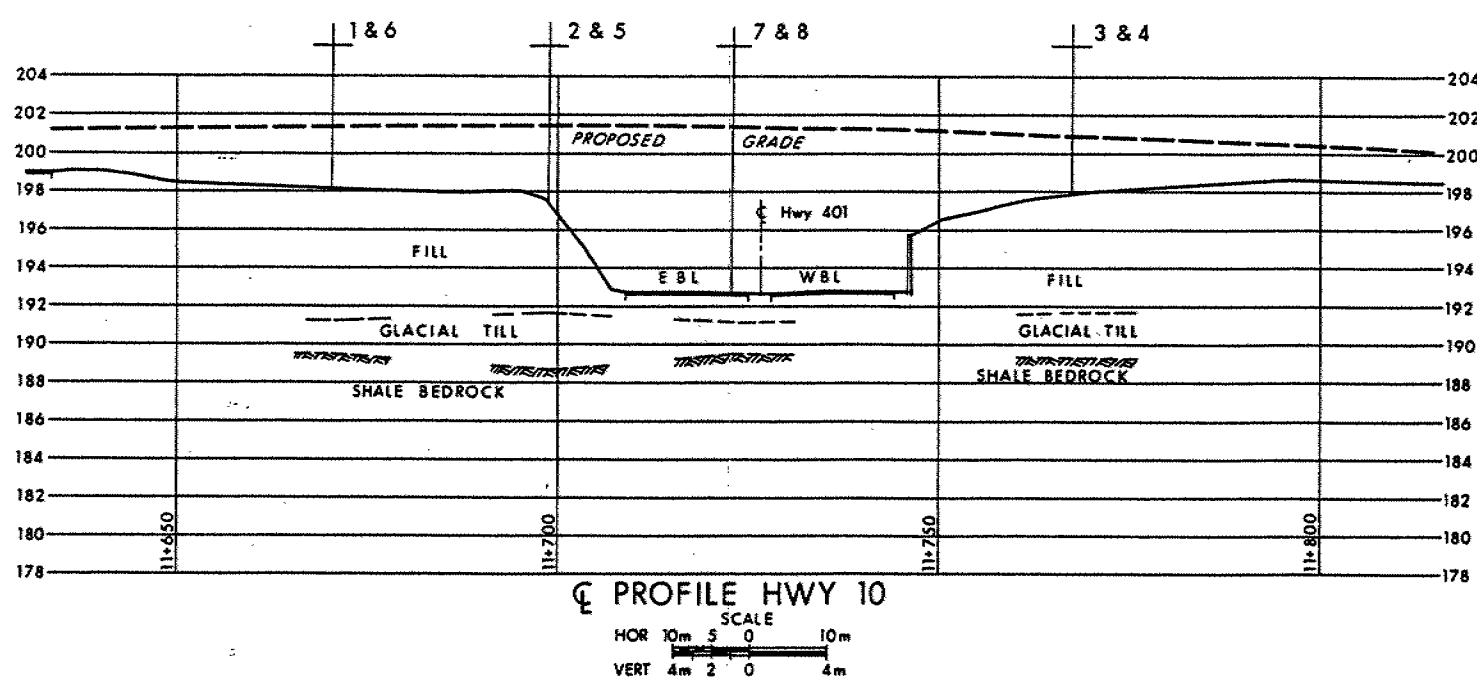
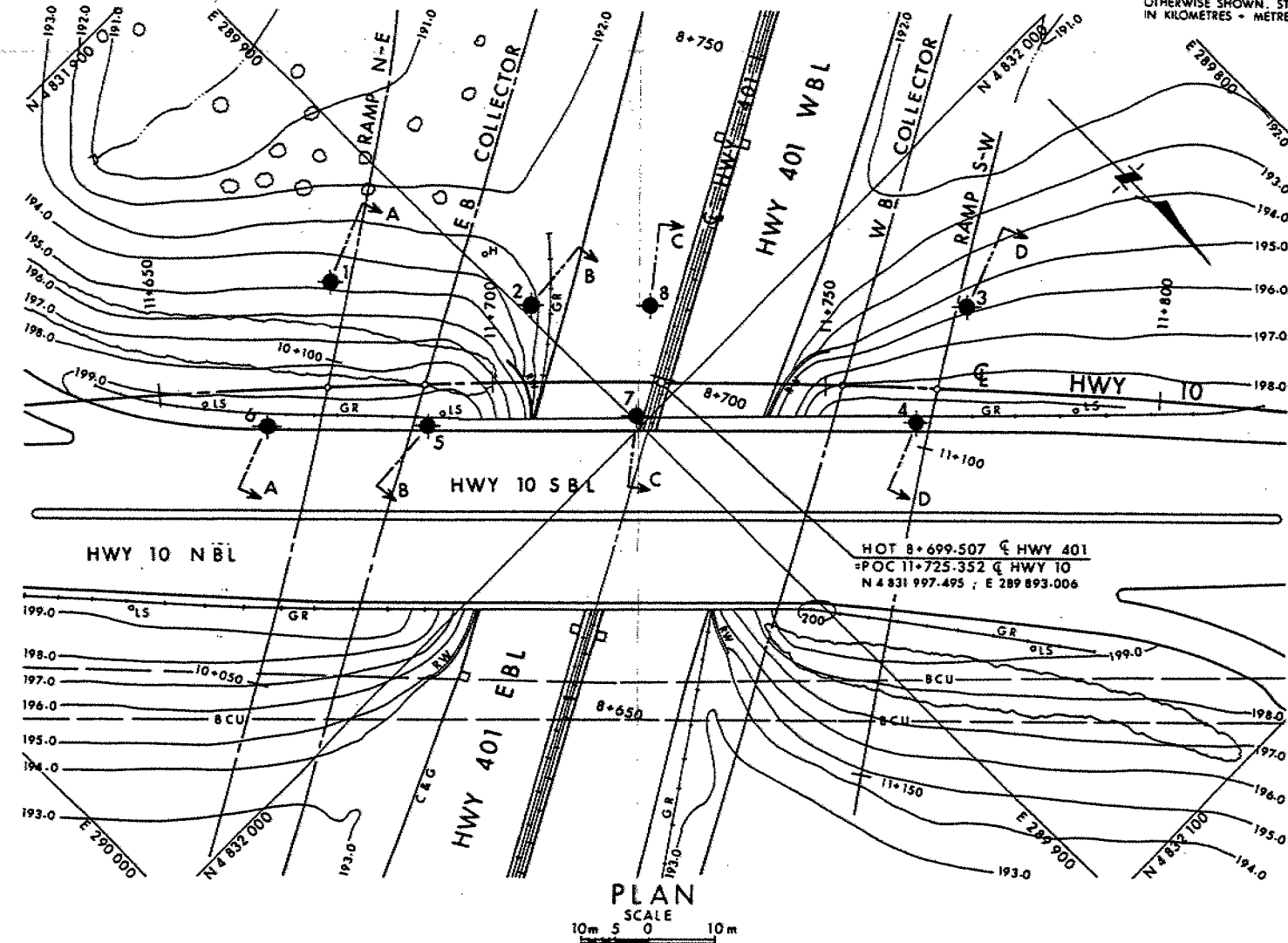
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
192.6	Ground Surface												
0.0	Fill												
	Fine to Medium Sand trace clay		1	SS	29								
191.2	Compact												
1.4	Silty Clay, some sand and gravel		2	SS	64								
190.1	(Glacial Till) Hard		3	SS	151								
2.5	Shale Bedrock		4	SS	50/	5 cm							
	Very Weathered												
188.2	Red		5	SS	100/	13 cm							
4.4	End of Borehole												
	Note: Groundwater Level not Established												

OFFICE REPORT ON SOIL EXPLORATION



SOIL STRATIGRAPHY LEGEND

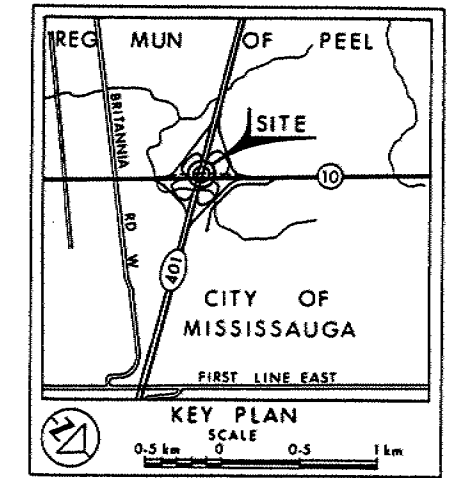
- SILTY CLAY (FILL) WITH SAND SOME GRAVEL Firm to Very Stiff
- MFT MIXTURE OF SILTY CLAY, SOME SAND AND GRAVEL (Glacial Till) Hard



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

CONT No
WP No 54-82-02

HWY 10 UNDERPASS
BORE HOLE LOCATIONS & SOIL STRATA



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 1983 08
- W.L. Not Established in BH 8

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	194.7	4 831 951.5	289 917.2
2	192.7	4 831 975.5	289 898.5
3	195.7	4 832 022.5	289 852.5
4	199.9	4 832 029.2	289 870.5
5	200.0	4 831 977.2	289 922.2
6	199.8	4 831 960.0	289 939.2
7	192.5	4 831 998.4	289 899.5
8	192.6	4 831 988.3	289 886.2

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 GC 2.01 of OPS Gen. Cond.

REV	DATE	BY	DESCRIPTION
94.08.18	GP		HWY 10 & PROPOSED GRADE CHANGED
Geacres No 30M12-183			
HWY No 401		DIST 6	
SUBMITTAL CHECKED		DATE 1983 11 15	
DRAWN		SITE 24-132	
		DWG 548202-A	