



**TABLE A**  
**ROCK CORE DESCRIPTION**

CORE RECOVERY					CORE DESCRIPTION	
BOREHOLE NO.	CORE NO.	DEPTH (m)	RECOVERY (%)	RQD (%)	DEPTH (m)	DESCRIPTION
1	15	29.4 – 30.8	96	0	29.4 – 32.4	DOLOSTONE: : Buff to grey, fine grained, low to medium strength; unweathered; with numerous black shale partings and occ. seams /partings of gypsum and calcite, occ. sphalerite inclusions; very close to close spaced flat bedding layers, smooth to rough planar, tight; very poor quality. (Salina Formation)
	16	30.8 – 32.4	93	0		

RQD: Rock Quality Designation

Originated: MR  
 Compiled: JFW  
 Checked: NB/CN



**TABLE 1**  
**LIST OF STANDARD SPECIFICATIONS REFERENCED IN REPORT**

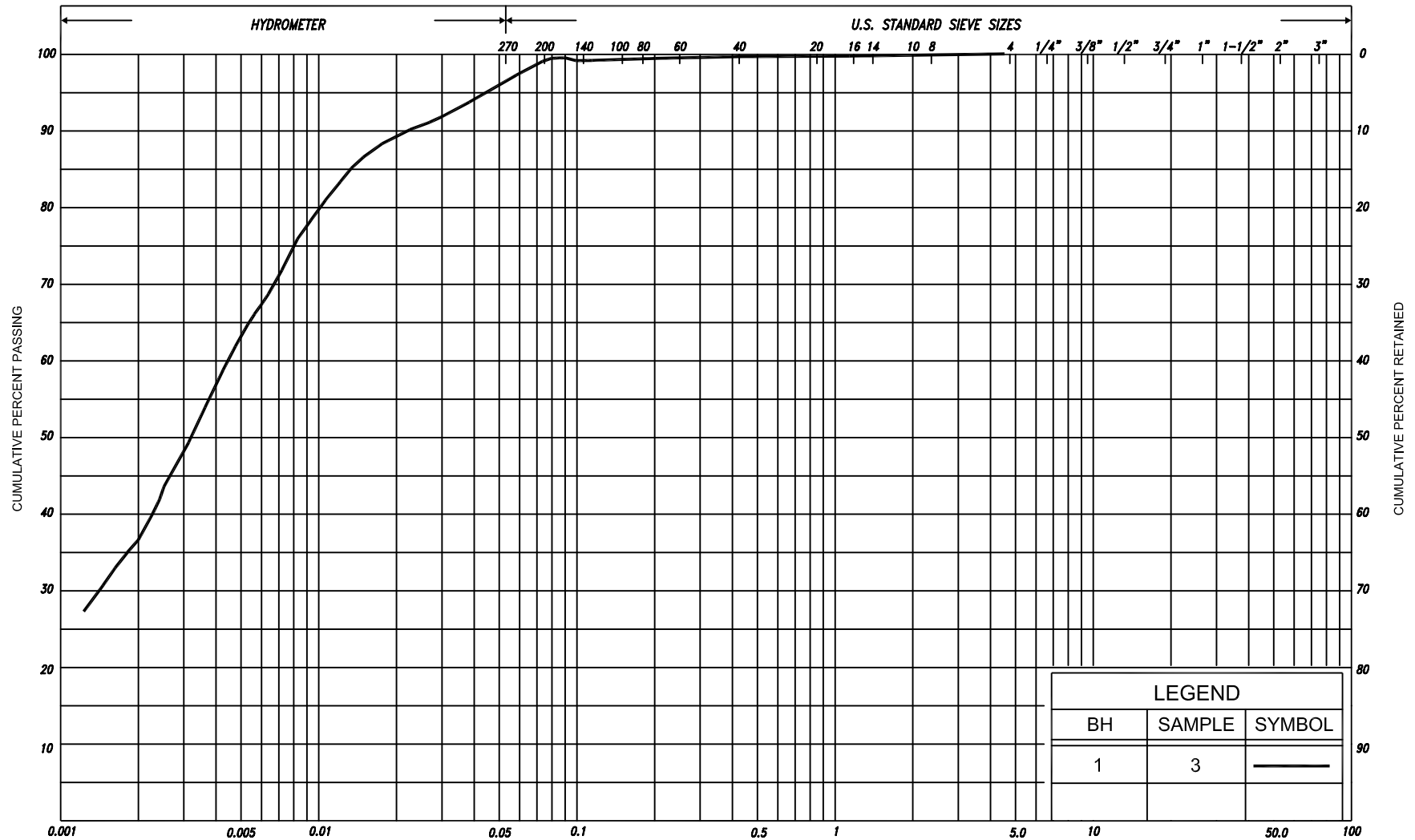
<b>DOCUMENT</b>	<b>TITLE</b>
OPSS 501	Construction Specification for Compacting
OPSS 571	Construction Specification for Sodding
SP 206S03	Construction Specification for Grading
SP 405F03	Construction Specification for Pipe Subdrains
SP 599S22	Requirements for The Design, Supply and Construction of Retaining Soil Systems (RSS)
SP 903S01	Construction Specification for Piling
OPSD-200.010	Earth/Shale Grading – Undivided Rural
OPSD-201.010	Rock Grading-Undivided Rural
OPSD-202.010	Slope Flattening Using Excess Material on Earth or Rock Embankment
OPSD-3000.100	Foundation Piles – Steel H-Pile Driving Shoe
OPSD-3101.200	Rock Backfill - Walls Abutment
OPSD-3190.100	Retaining Wall and Abutment Wall Drain Detail



**TABLE 2**  
**GRADATION SPECIFICATION FOR SAND FILL IN**  
**PRE-AUGERED HOLES AT INTEGRAL ABUTMENTS**

<b>MTO Sieve Designation</b>	<b>Percentage Passing by Mass</b>
2 mm (#10)	100
600 µm (#30)	80 – 100
425 µm (#40)	40 – 80
250 µm (#60)	5 – 25
150 µm (#100)	0 – 6

Note: From MTO Report S0-96-01, Revision 1 – July, 1996.



SILT & CLAY				FINE SAND			MEDIUM SAND		COARSE SAND		GRAVEL		COBBLES	UNIFIED
													COBBLES	M.I.T.
														U.S. BUREAU

## GRAIN SIZE DISTRIBUTION

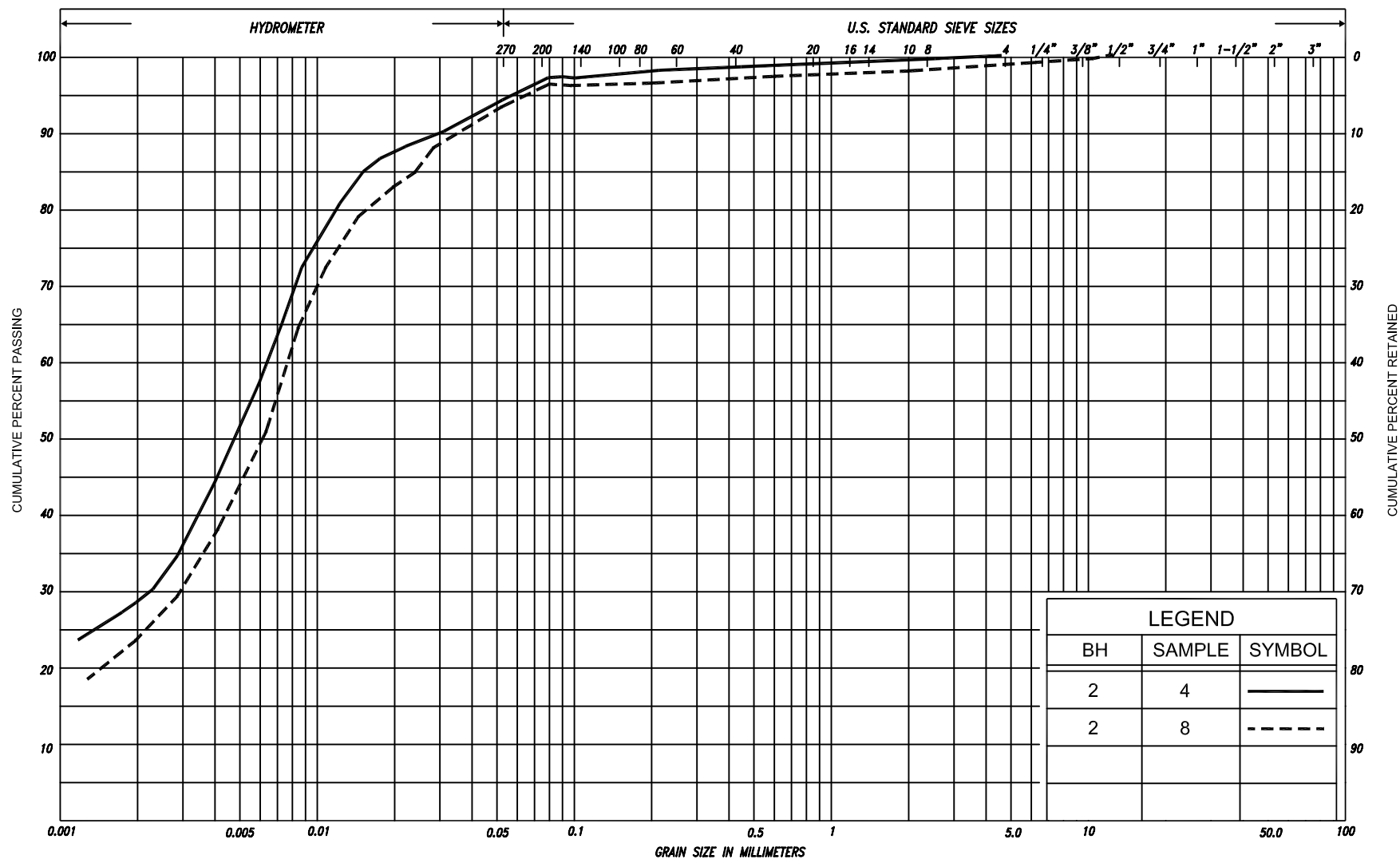
CLAYEY SILT, trace sand

FIG No. GS-TR-1

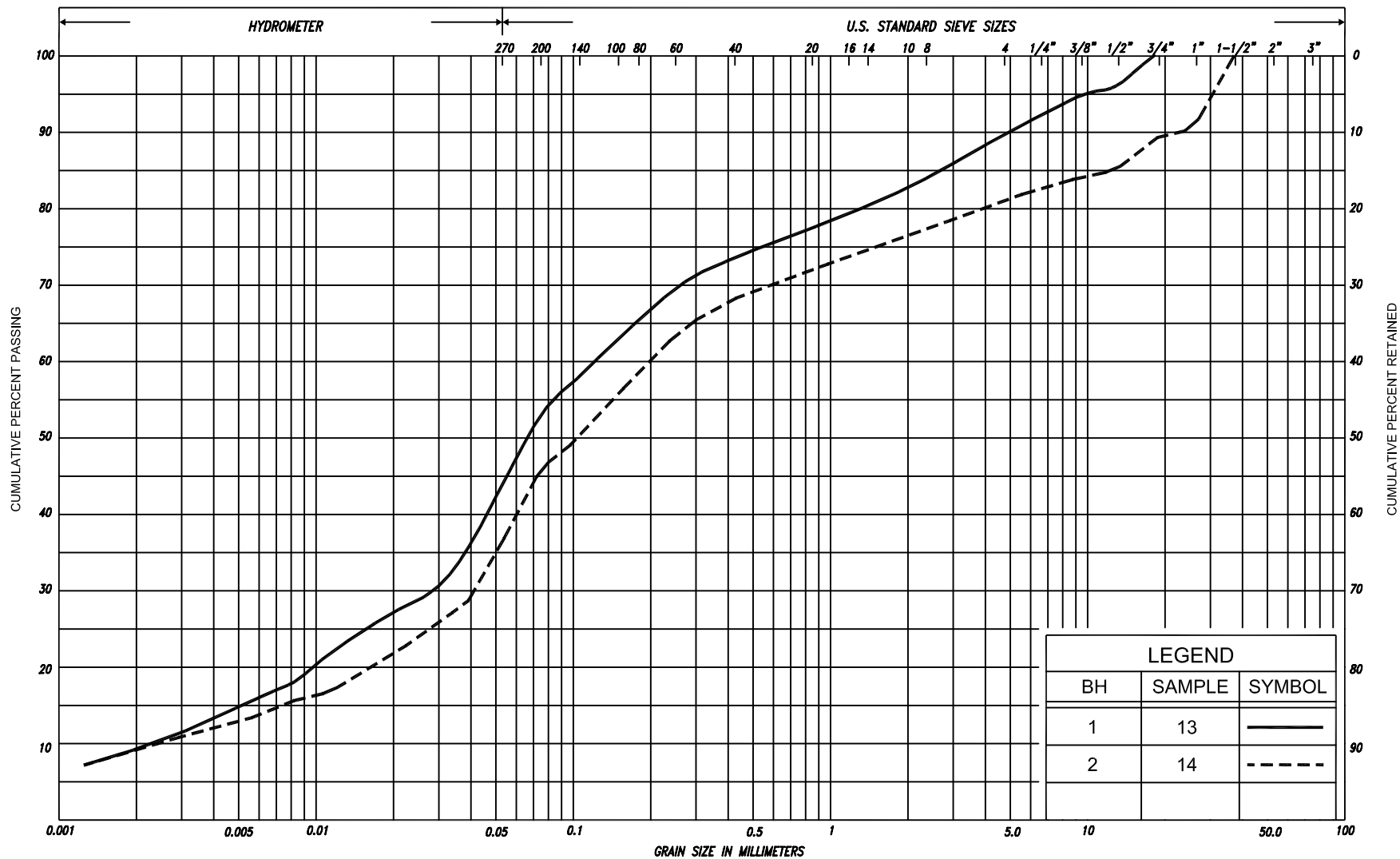
HWY: 406

G.W.P. No. 280-99-00

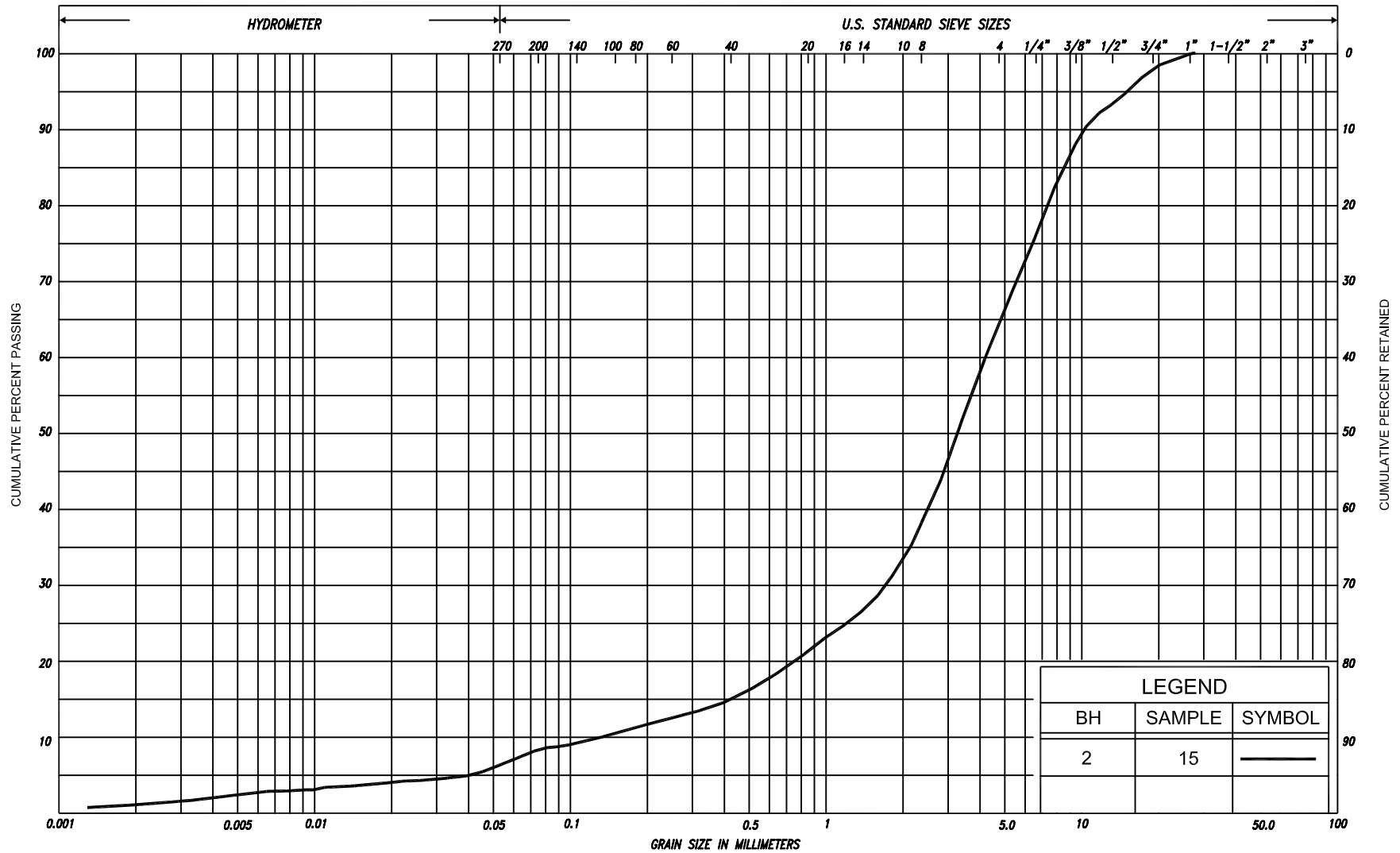




SILT & CLAY					FINE		MEDIUM		COARSE		GRAVEL				COBBLES	UNIFIED			
					SAND														
CLAY	FINE		MEDIUM		COARSE		FINE		MEDIUM		COARSE		GRAVEL				COBBLES	M.I.T.	
	SILT																		
CLAY			SILT			V. FINE	FINE	MED.	COARSE		GRAVEL							U.S. BUREAU	
					SAND														



SILT & CLAY					FINE		MEDIUM		COARSE		GRAVEL			COB BLES	UNIFIED		
					SAND												
CLAY	FINE		MEDIUM		COARSE		FINE		MEDIUM		COARSE		GRAVEL			COBBLES	M.I.T.
	SILT																
CLAY		SILT			V. FINE	FINE	MED.	COARSE		GRAVEL							U.S. BUREAU
					SAND												



SILT & CLAY					FINE		MEDIUM		COARSE		GRAVEL			COB BLES	UNIFIED	
CLAY	FINE		MEDIUM		COARSE		SAND					GRAVEL			COBBLES	M.I.T.
	SILT					FINE		MEDIUM		COARSE						
CLAY		SILT			V. FINE	FINE	MED.	COARSE		GRAVEL					U.S. BUREAU	



Ministry of  
Transportation  
Ontario

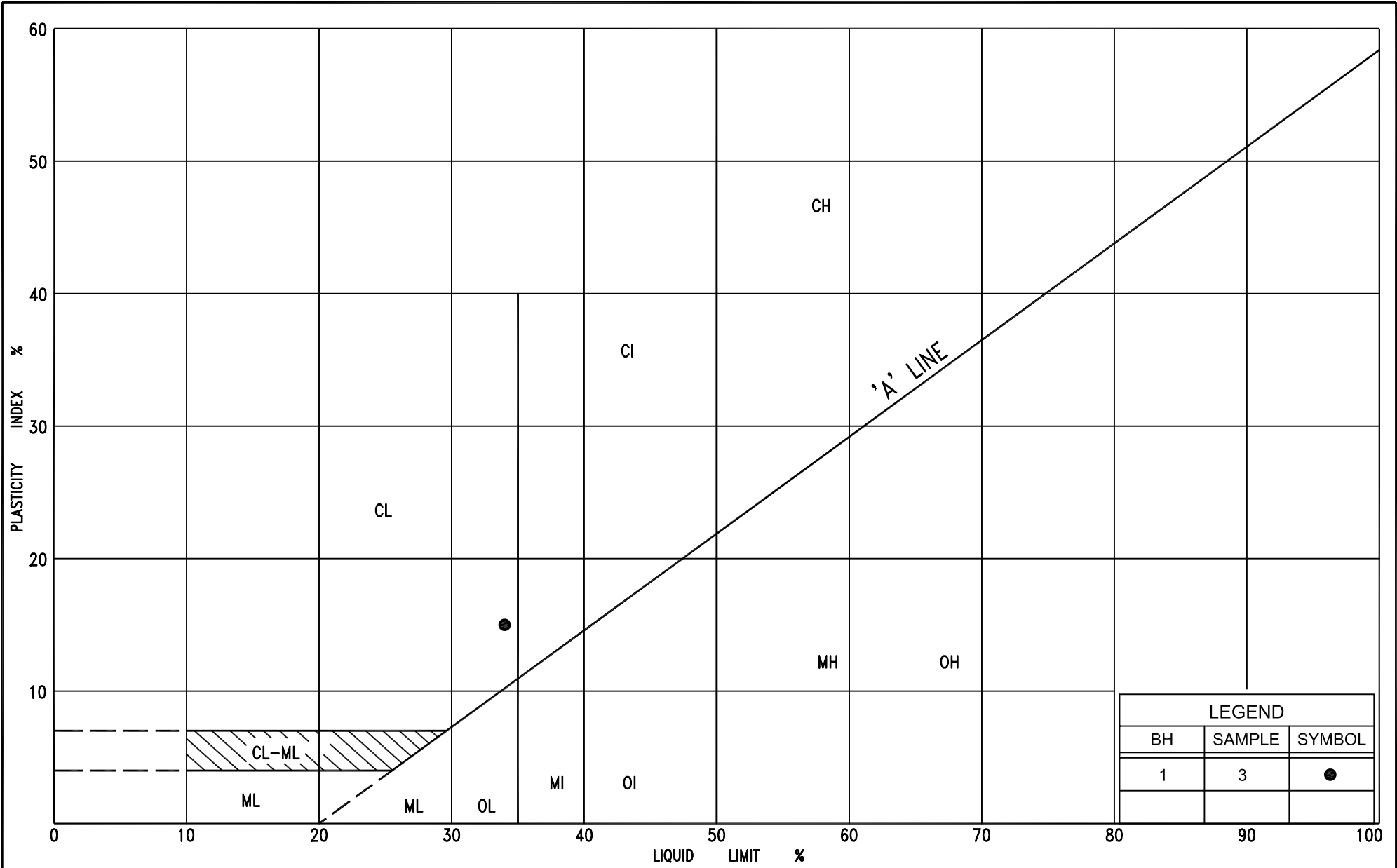
## GRAIN SIZE DISTRIBUTION

GRAVELLY SAND (SHALE and DOLOSTONE fragments), trace silt, trace clay

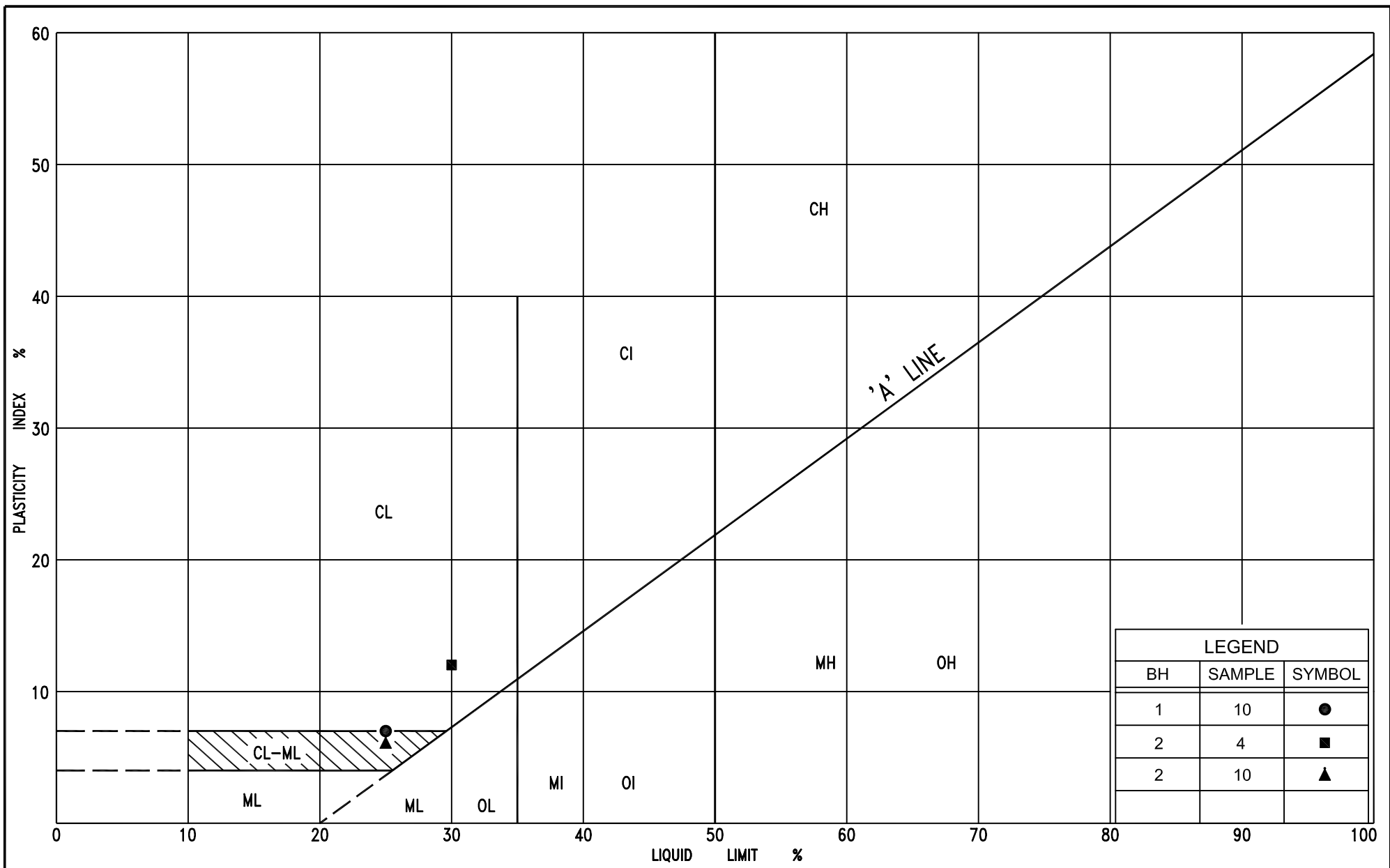
FIG No. GS-TR-4

HWY: 406

G.W.P. No. 280-99-00



LEGEND		
BH	SAMPLE	SYMBOL
1	3	●



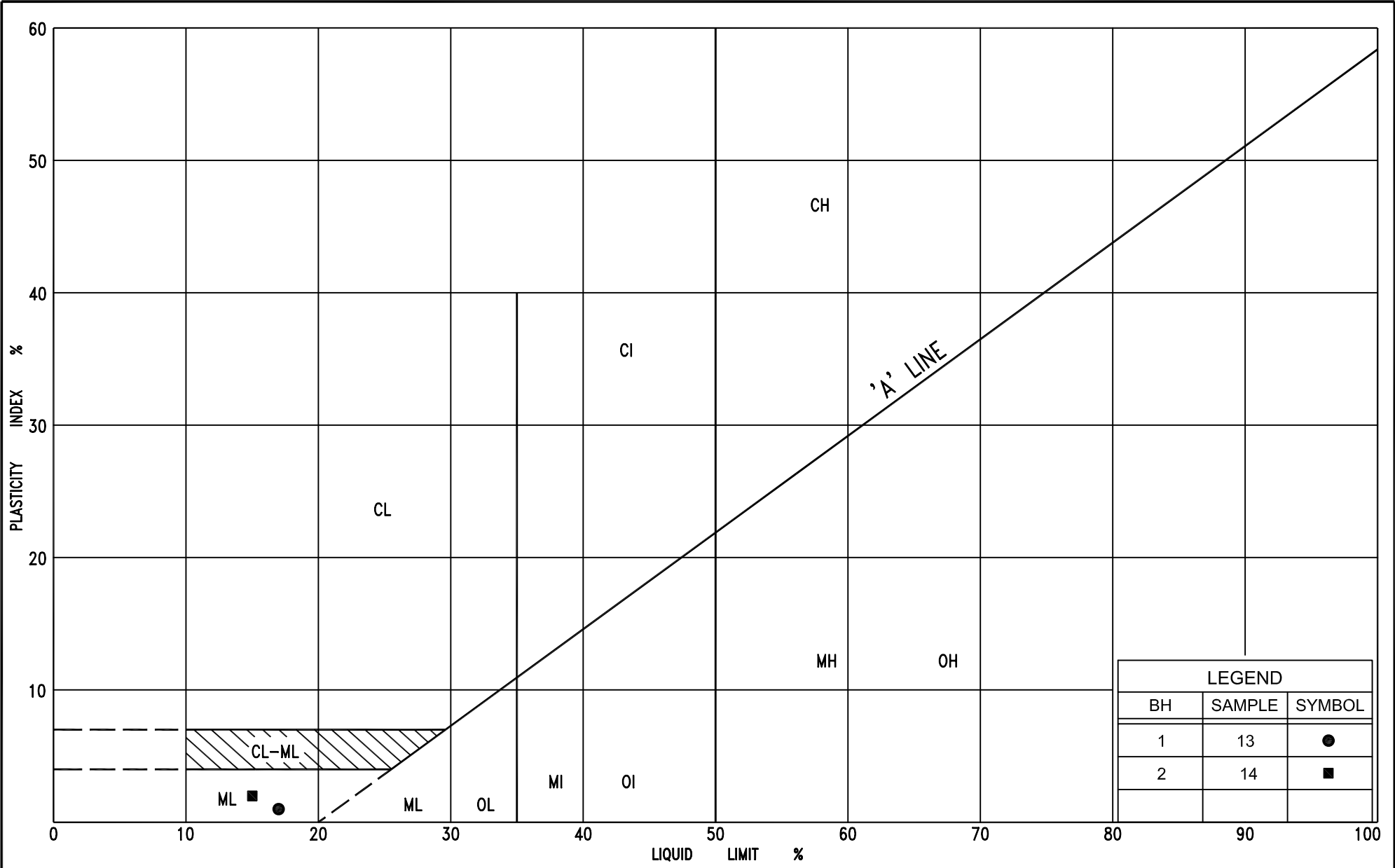
Ministry of  
Transportation  
Ontario

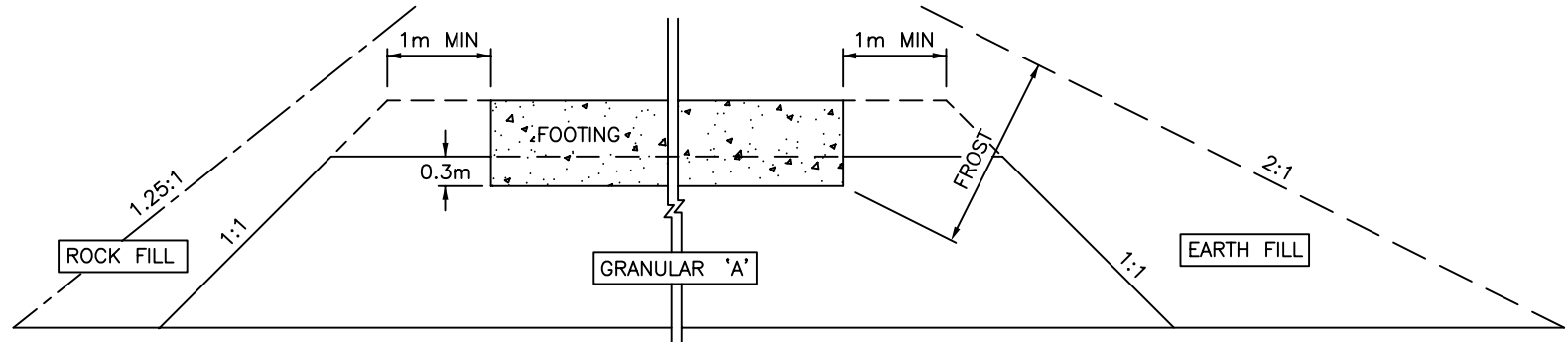
PLASTICITY CHART  
CLAYEY SILT, trace sand, trace gravel  
(TILL)

FIG No. PC-TR-2

HWY: 406

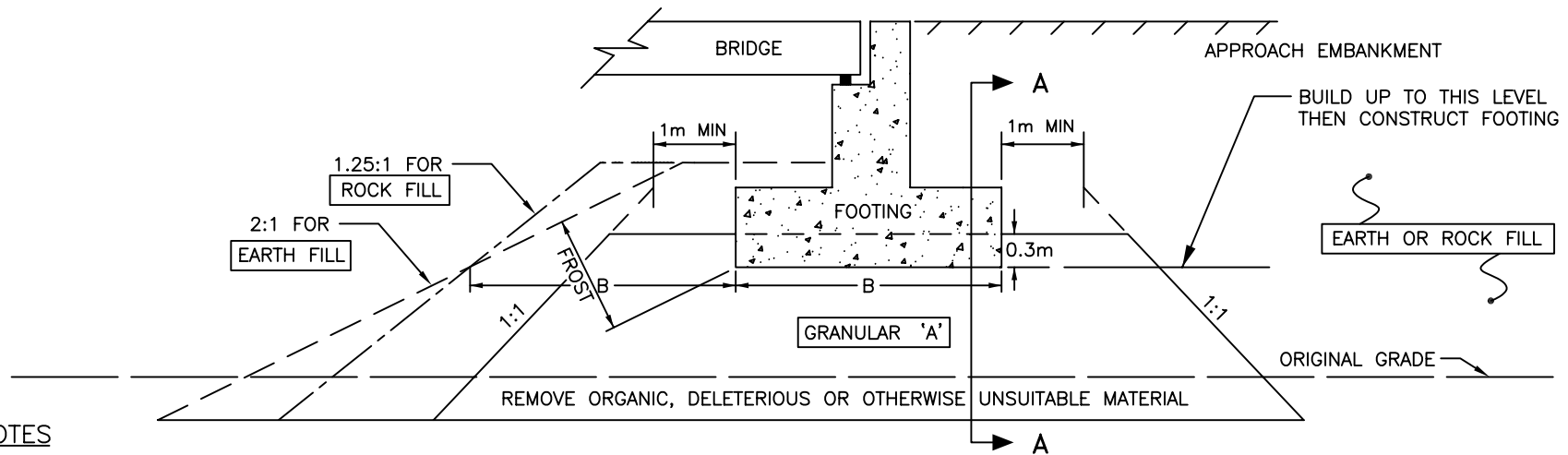
G.W.P. No. 280-99-00





**CROSS SECTION A-A**

NOT TO SCALE



**LONGITUDINAL SECTION**

NOT TO SCALE

**NOTES**

1. CONCEPT SHOWN DOES NOT INCLUDE A MIDHEIGHT BERM.
2. LIMITS OF GRANULAR 'A' CORE TO BE DEFINED BY A SITE SPECIFIC SURVEY.
3. REMOVE ORGANIC, DELETERIOUS OR OTHERWISE UNSUITABLE MATERIAL UNDER AREA OF COMPACTED GRANULAR 'A' AND EARTH OR ROCK FILL AS NOTED IN TEXT OF REPORT.
4. PLACE GRANULAR 'A' AND EARTH OR ROCK FILL ON APPROVED SUBGRADE TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO CURRENT M.T.O. STANDARDS.
5. CONSTRUCT CONCRETE FOOTING.
6. PLACE REMAINDER OF GRANULAR 'A' AND EARTH OR ROCK FILL INCLUDING MIDHEIGHT BENCHES, AS REQUIRED.
7. REFER TO TEXT OF REPORT FOR FROST DEPTH.

**FIGURE 1: ABUTMENT ON COMPACTED FILL SHOWING GRANULAR 'A' CORE**

## EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

**JOINTING AND BEDDING:**

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

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

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

### STRESS AND STRAIN

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

### MECHANICAL PROPERTIES OF SOIL

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

### PHYSICAL PROPERTIES OF SOIL

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



**RECORD OF BOREHOLE No 1**

1 of 3

**METRIC**

G.W.P. 280-99-00 LOCATION Co-ords. 4 763 935 N; 327 487 E ORIGINATED BY M.R.  
DIST CR HWY 406 BOREHOLE TYPE C.F.S.S.A. + Rotary Diamond Drilling COMPILED BY P.C.  
DATUM Geodetic DATE November 08, 2001 CHECKED BY D.W.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)		
								○ UNCONFINED		+ FIELD VANE									
								● QUICK TRIAXIAL		× LAB VANE									
183.4	Ground Surface						20	40	60	80	100	20	40	60		GR SA SI CL			
0.0	Clayey silt, trace sand faintly layered thin partings of silt  Very stiff Brown Moist																		
			1	SS	16														
			2	SS	30														
			3	SS	23														
			4	SS	23														
179.3	Clayey silt trace sand, trace gravel  Stiff to Reddish Moist very stiff brown (Till)		5	SS	13														
4.1			6	SS	12														
			7	SS	20														
	Layer of silt		8	SS	11														
	Stiff to firm		9	SS	9														
			10	SS	7														

**RECORD OF BOREHOLE No 1**

2 of 3

**METRIC**

G.W.P. 280-99-00 LOCATION Co-ords. 4 763 935 N; 327 487 E ORIGINATED BY M.R.  
DIST CR HWY 406 BOREHOLE TYPE C.F.S.S.A. + Rotary Diamond Drilling COMPILED BY P.C.  
DATUM Geodetic DATE November 08, 2001 CHECKED BY D.W.K.

SOIL PROFILE			SAMPLES			* GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)			GR	SA	SI	CL
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE															
168.4 15.0	Hard		11	SS	18																		
					12	SS	32																
	Sand and Silt some gravel, trace clay  Very dense Reddish Moist to dense brown  (Till)																						
			13	SS	66																		

**RECORD OF BOREHOLE No 1**

3 of 3

**METRIC**

G.W.P. 280-99-00 LOCATION Co-ords. 4 763 935 N; 327 487 E ORIGINATED BY M.R.  
 DIST CR HWY 406 BOREHOLE TYPE C.F.S.S.A. + Rotary Diamond Drilling COMPILED BY P.C.  
 DATUM Geodetic DATE November 08, 2001 CHECKED BY D.W.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)				GR	SA	SI	CL
								○ UNCONFINED	+	FIELD VANE	● QUICK TRIAXIAL	×					LAB VANE							
153.4 30.0	Bedrock Dolostone Buff to grey Low to medium strength Unweathered Very poor quality		15	RC NQ	REC 96%		153											RQD 0%						
			16	RC NQ	REC 93%		152												RQD 0%					
151.0 32.4	End of borehole						151																	
	<div>* Borehole charged with drilling water</div> <div>■ Penetrometer test</div> <div>C.F.S.S.A. denotes Continuous Flight Solid Stem Augers</div>																							

**RECORD OF BOREHOLE No 2**

1 of 2

**METRIC**

G.W.P. 280-99-00 LOCATION Co-ords. 4 763 895 N; 327 442 E ORIGINATED BY M.R.  
DIST CR HWY 406 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY P.C.  
DATUM Geodetic DATE November 22, 2001 CHECKED BY D.W.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED      + FIELD VANE									
								● QUICK TRIAXIAL    × LAB VANE									
							20   40   60   80   100					20   40   60					
												WATER CONTENT (%)					
182.6	Ground Surface																
182.0	Topsoil																
0.2	Clayey silt, trace sand fissured						182										
	Stiff to Mottled Moist very stiff Brown		1	SS	13							○					
	_____																
	distorted lenses of silt						181										
			2	SS	19							○					
			3	SS	16		180								○		
179.8	Clayey silt, trace sand																
2.8	Very stiff Brown Moist (Till)		4	SS	23										○		
							179										
	layers of brown silt																
			5	SS	16		178								○		
	trace gravel						177										
	Stiff																
			6	SS	12		176								○		
							175								○		
			7	SS	8												
							174										
			8	SS	10		173								○		
							172								○		
			9	SS	8												
							171										
			10	SS	10		170								○		
							169										
167.6						168											

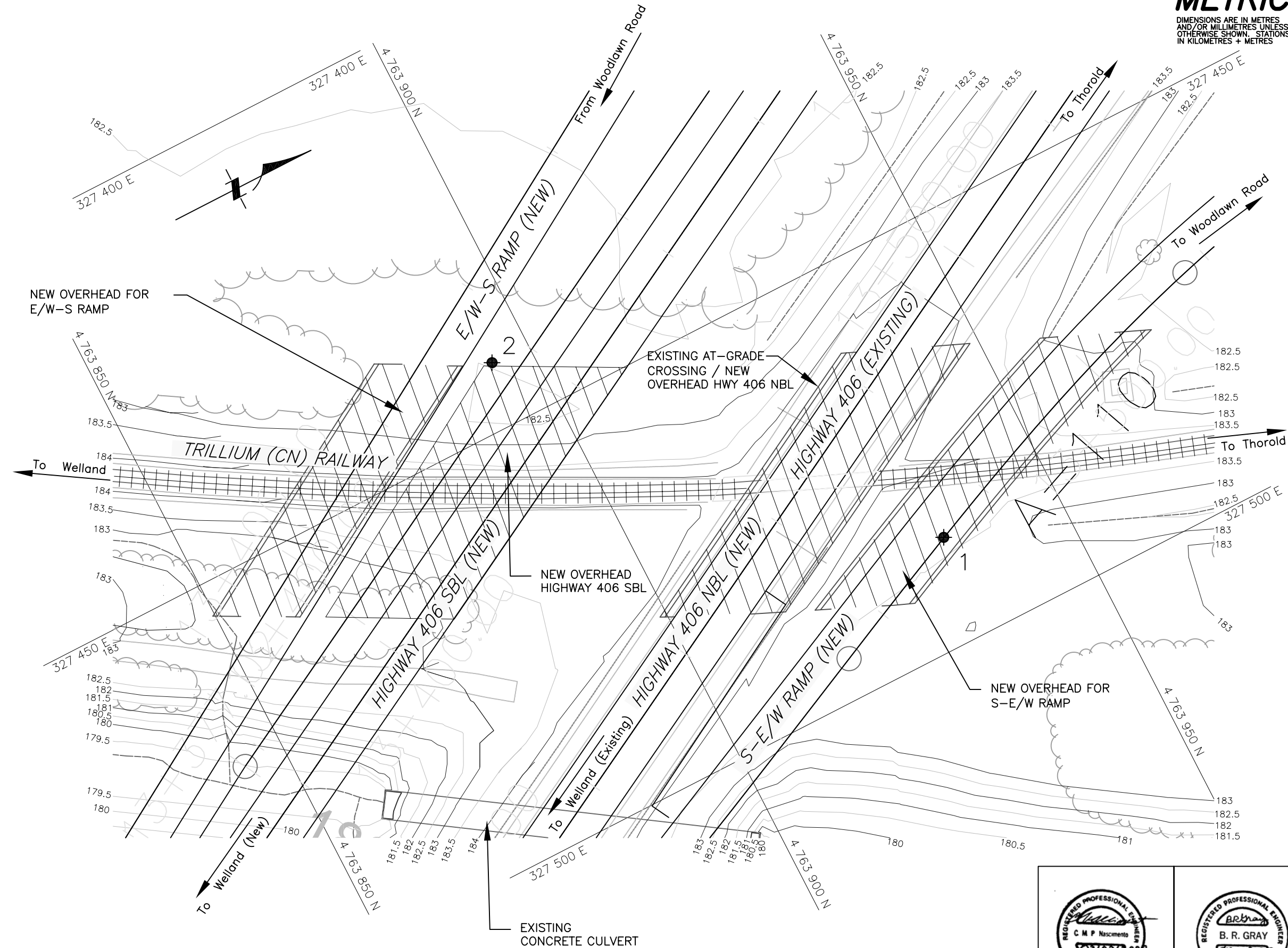
**RECORD OF BOREHOLE No 2**

2 of 2

**METRIC**

G.W.P. 280-99-00 LOCATION Co-ords. 4 763 895 N; 327 442 E ORIGINATED BY M.R.  
DIST CR HWY 406 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY P.C.  
DATUM Geodetic DATE November 22, 2001 CHECKED BY D.W.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT $w_p$	NATURAL MOISTURE CONTENT $w$	LIQUID LIMIT $w_L$	UNIT WEIGHT $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								$\circ$ UNCONFINED	$\bullet$ QUICK TRIAXIAL	$+$ FIELD VANE	$\times$ LAB VANE									
								20	40	60	80	100						20	40	60
167.6 15.0	Hard		11	SS	12															
					12	SS	38													
162.8 19.8	Sand and Silt some gravel, trace clay  Very dense Reddish Moist to dense brown (Till)																			
					13	SS	57													
			14	SS	30															
156.7 25.9	Gravelly sand trace silt, trace clay (shale and Dolostone fragments)  Very dense Grey Wet																			
155.1 27.5	End of borehole Refusal on probable bedrock		15	SS	60/3cm															
	* 2001 11 22  Water level observed during drilling Water level measured upon completion Penetrometer test																			

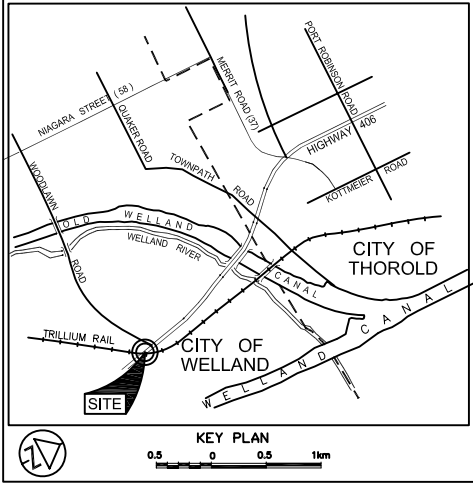


NOTE:  
1. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.

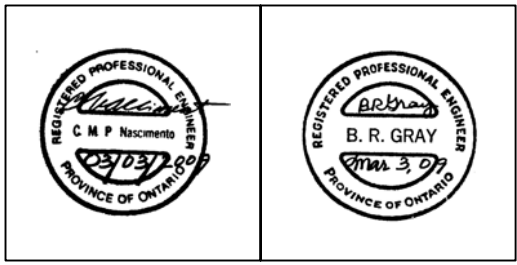


**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES UNLESS  
OTHERWISE SHOWN. STATIONS  
IN KILOMETRES + METRES

CONT No	17
GWP No 280-99-00	
TRILLIUM RAILWAY OVERHEADS HIGHWAY 406 BOREHOLE LOCATIONS	
SHEET	



LEGEND			
	Borehole		
	Dynamic Cone Penetration Test (Cone)		
	Borehole & 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 November 2001		
	Head		
	ARTESIAN WATER		
	Encountered		
	PIEZOMETER		
CO-ORDINATES			
BH No	ELEVATION	NORTHINGS	EASTINGS
1	183.4	4 763 935	327 487
2	182.6	4 763 895	327 442



— NOTE —  
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REVISIONS			
DATE	BY	DESCRIPTION	
Geocres No. 30M03-239			
HWY No	406	DIST	7
SUBM'D	NSB	CHECKED	CN
DRAWN	NA	CHECKED	CN
APPROVED	BRG	DWG	TR-1

REF No. MRC DRAWINGS: PREFERRED-option-22.5m.dwg;  
old-base map-ONE COLOUR.dwg; RECEIVED ON  
SEPTEMBER 25, 2008



## **APPENDIX A**

Previous Data from GEOCRE 30M3-181

DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. 30M3-181

DIST. 4 REGION

W.P. No. 11-68-10

CONT. No.

W. O. No.

STR. SITE No. 34-307S

HWY. No. 406

LOCATION Hwy 406 & CNR

OVERHEAD

No. of PAGES -

=====  
OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:



**ENGINEERING MATERIALS OFFICE  
FOUNDATION DESIGN SECTION**

**WP 11-68-10**

**DIST #4**

**HWY 406**

**STR SITE 34-132-3075**

**C.N.R. OVERHEAD STRUCTURE**

**DISTRIBUTION**

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FOUNDATION INVESTIGATION REPORT  
For

C.N.R. OVERHEAD STRUCTURE

Hwy. 406, Southbound

W. P. 11-68-10; Site: 34-132-307S

District #4 (Burlington)

INTRODUCTION

A Foundation Investigation was carried out at the aforementioned site between 85 10 24 and 85 11 06. The fieldwork consisted of four sampled boreholes and three dynamic cone penetration tests adjacent to each boring. The boreholes were advanced by a continuous flight auger machine equipped with hollow stem augers and BX size casings.

SITE DESCRIPTION

The structure site is located at the crossing of the C.N.R. tracks and the proposed Hwy. 406, near Cambridge Road and Brown Road corner in the City of Welland. The adjacent land with the exception of the man-made railway embankment and a drainage ditch is relatively flat and in part bush covered.

Physiographically, the site is located in the region referred to as the Haldimand Clay Plain.

SUBSURFACE CONDITIONS

General

In general, the overburden was found to consist of silty clay and silty sand deposits followed by shaley dolostone and shale type bedrock. The boundaries of the different strata, together with the obtained field and laboratory test results are shown on the Record of Borehole Sheets contained in the Appendix of this report. A stratigraphical profile is shown on Drawing No. 116810-A. A description of the different strata encountered is given below.

#### Silty Clay, Traces of Sand and Gravel

This deposit was encountered at every boring location from ground level to a maximum depth of about 21.3 m. The material in the stratum consists of silty clay, traces of sand and gravel. The plasticity in the upper zone is medium, while in the lower zone is only low (See Figure #1). Occasional silt layers were also observed within the main deposit. The physical properties as determined from field and laboratory tests are as follows:

	<u>Range</u>
Natural Moisture Content ( % )	12 - 29
Liquid Limit ( % )	21 - 41
Plastic Limit ( % )	13 - 22
Field Vane Test ( kPa )	55 -109
Sensitivity	2 - 3
Unconfined Shear Strength ( kPa )	87 -121
Unit Weight ( kN/m <sup>3</sup> )	20.4- 21.3

The results of the grain-size distribution tests are shown in an envelope form on Figure #2 of the Appendix.

The undrained shear strength of the overall deposit varies randomly. The consistency may be described as stiff to hard.

#### Silty Sand, Some Gravel and Trace of Clay

This stratum extends from the above described for a maximum depth of about 15.5 m on both sides of the track. The material consists mainly of sand and silt with varying proportions. In addition, gravel and clay sized particles and occasional boulders were also observed. The Natural Moisture Content ranges from 6 to 11%. The results of the grain-size distribution tests are shown in an envelope form on Figure #3 of the Appendix. The Standard Penetration Test 'N' values ranged from 12 to over 100 blows per 30 cm. Occasionally 'Boiling' of the material was observed. Some of the obtained lower 'N' values may be attributed to this fact. Based on the 'N' values, the state of the overall deposit varies from compact to very dense.

Bedrock - Shaley Dolostone to Shale

The bedrock was proved in two boreholes (#1, and #3) by obtaining AX size core samples. In these borings, the upper surface of the bedrock was found to be at El. 153.4 and El. 154.5 in #1 and #3 respectively.

The core samples were examined by Mr. E. R. Magni, MTC Geologist, and his description is appended to this report.

Groundwater Conditions

The following groundwater levels were observed during the field investigation:

BH. #1	El. 181.2
BH. #2	El. 181.2
BH. #3	El. 181.1
BH. #4	Not Observed

APPENDIX

## 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

### STRESS AND STRAIN

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

### MECHANICAL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	m <sup>2</sup> /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{v0}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_r$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_f$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL

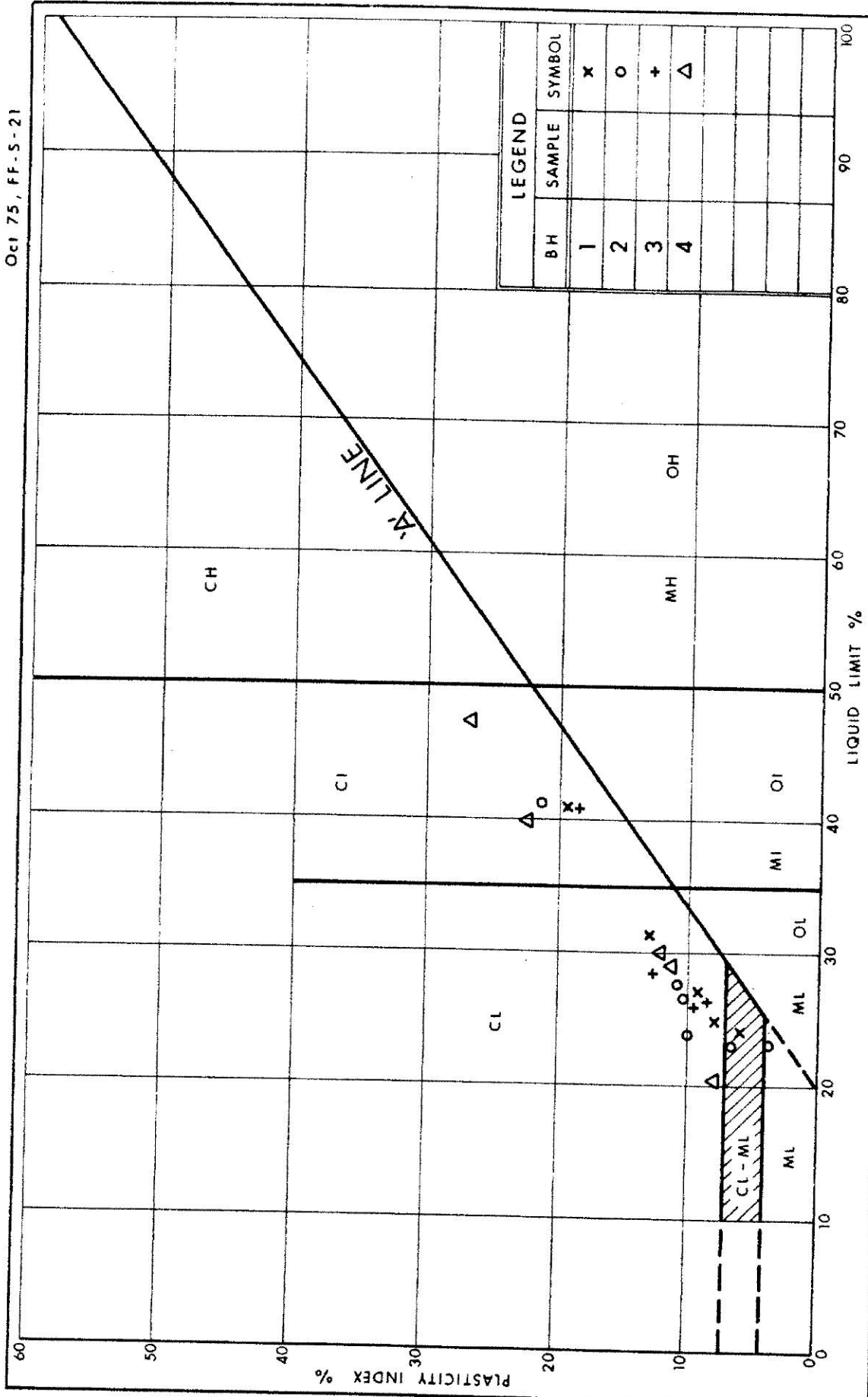
$\rho_s$	kg/m <sup>3</sup>	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	kn/m <sup>3</sup>	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\rho_w$	kg/m <sup>3</sup>	DENSITY OF WATER	w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

# DESCRIPTION OF ROCK CORE - W.P. 11-68-10

BOREHOLE NUMBER	CORE DESCRIPTION			
	DEPTH (m)	% CR *	% RQD *	DESCRIPTION
1	29.11-30.48	70	0	SHALEY DOLOSTONE, buff alternating with SHALE, dark green grey, with zones of gypsum (.23), slightly weathered with highly weathered and high core loss zones, very closely spaced joints.
	-31.27	71	0	
	-32.00	76	0	
3	28.55-30.07	43	0	SHALEY DOLOSTONE, buff alternating with SHALE, dark green grey, slightly weathered with highly weathered zones, high core loss zones apparently due to poor drilling.
	-31.60	70	0	

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

Oct 75, FF-S-21



# PLASTICITY CHART SILTY CLAY

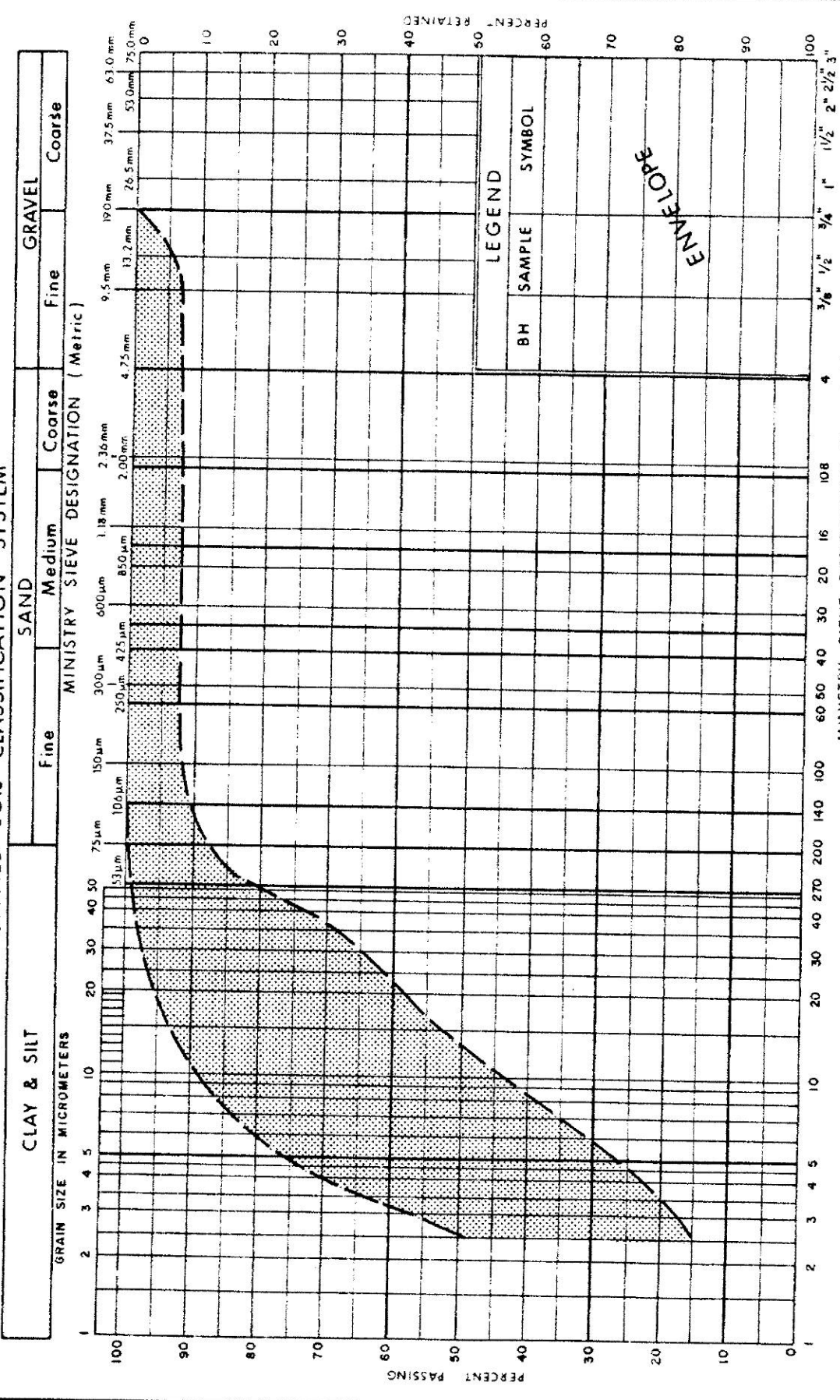
FIG No 1

W P 11-68-10



78 12 M

# UNIFIED SOIL CLASSIFICATION SYSTEM



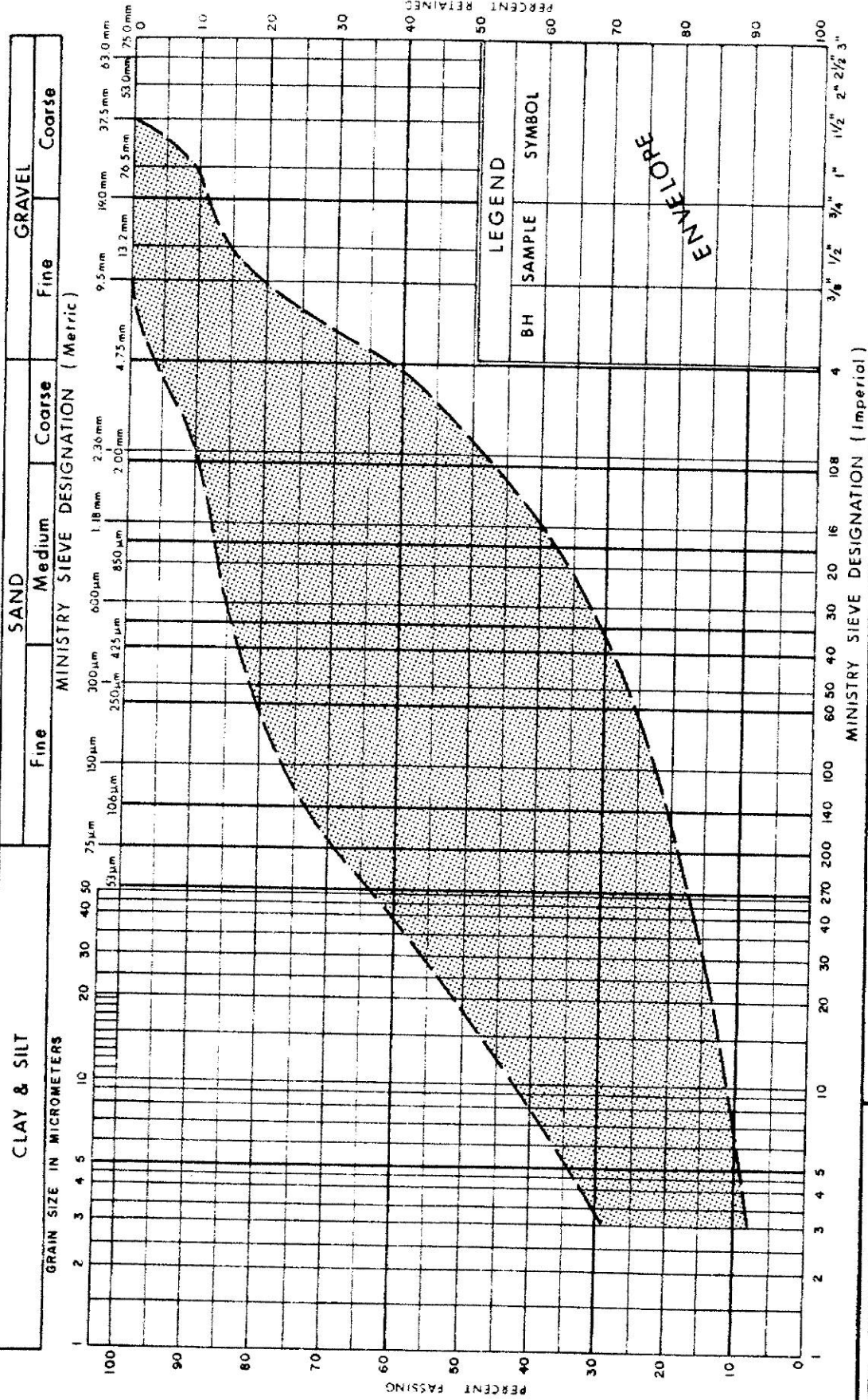
## GRAIN SIZE DISTRIBUTION

SILTY CLAY

FIG No 2

W P 11-68-10

# UNIFIED SOIL CLASSIFICATION SYSTEM

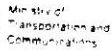
Ministry of  
Transportation and  
Communications

## GRAIN SIZE DISTRIBUTION

FIG No 3

SILTY SAND

WP 11-68-10



## METRIC

ORIGINATED BY S.C.

COMPILED BY P.P.

CHECKED BY                     

+3, x5: Numbers refer to Sensitivity

# RECORD OF BOREHOLE No 1 Cont

METRIC

W.P. 11-68-10 LOCATION CO-ORDS: N 4 763 751.9; E 327 425.7  
 DIST 4 HWY 406 BOREHOLE TYPE Cont. Flight Auger (H.S.) & BX Casing  
 DATUM Geodetic DATE 85 11 24 to 29  
 ORIGINATED BY S.C.  
 COMPILED BY P.P.  
 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
155.1	Cont'd.												
27.4													
153.4							154						
29.1	Shaley Dolostone and Shale Slightly to Highly Weathered		21	RC AX	Rec 70%		152						
150.5	Bedrock		22	RC AX	Rec 71%								
32.0	End of Borehole		23	RC AX	Rec 76%		150						

OFFICE REPORT ON SOIL EXPLORATION

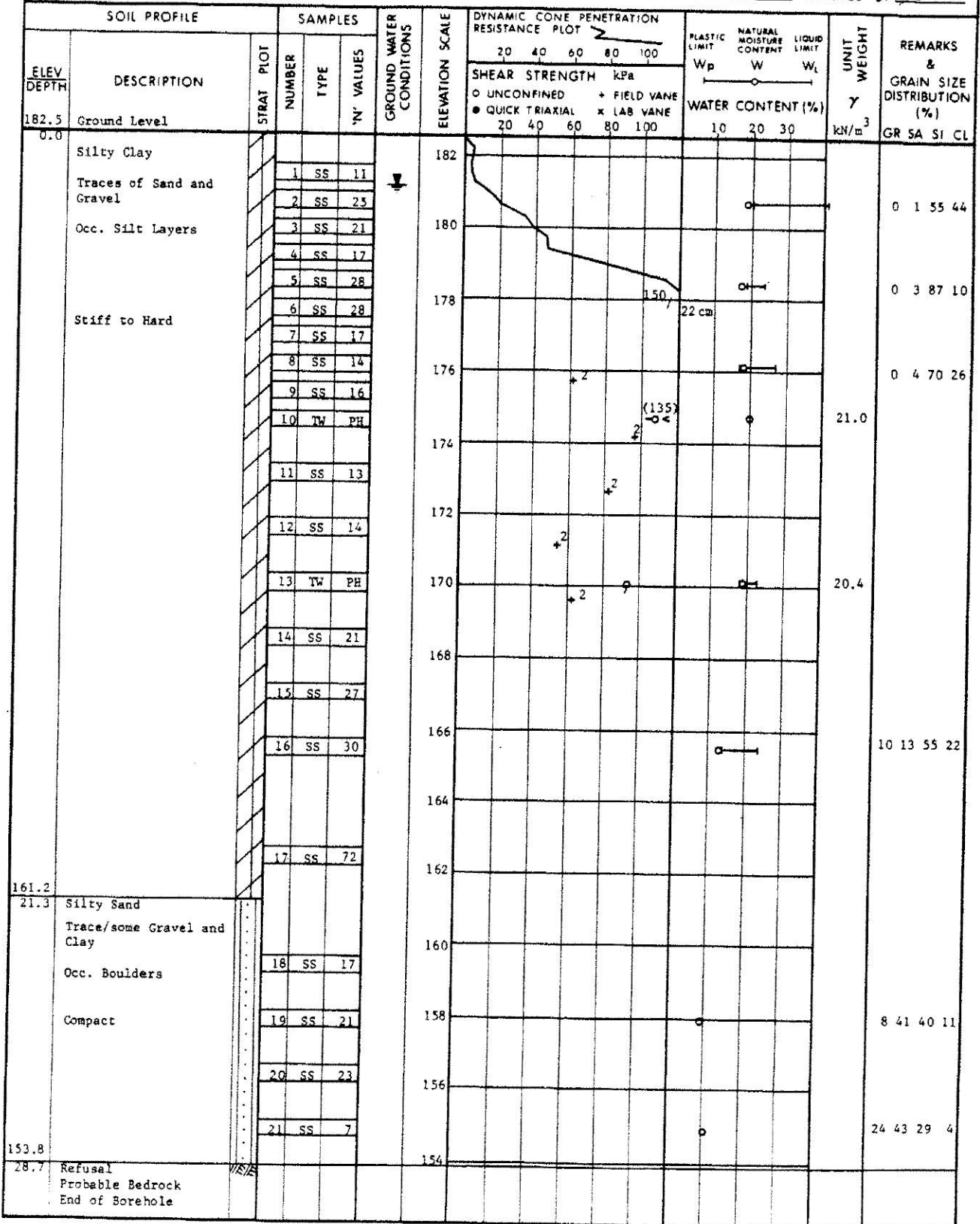
\*3, x5: Numbers refer to  
Sensitivity

20  
15  $\phi$  5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 2

METRIC

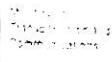
W P 11-68-10 LOCATION CO-ORDS: N 4 763 730.1; E 327 447.4  
 DIST 4 HWY 406 BOREHOLE TYPE Cont. Flight Auger (H.S.) & BX Casing  
 DATUM Geodetic DATE 85 10 30 and 31  
 ORIGINATED BY S.C.  
 COMPILED BY P.P.  
 CHECKED BY



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

OFFICE REPORT ON SOIL EXPLORATION





## METRIC

W P 11-68-10 LOCATION CO-ORDS: N 4 763 677.2; E 327 474.7 ORIGINATED BY S.C.  
DIST 4 HWY 406 BOREHOLE TYPE Cont. Flight Auger (H.S.) and BX Casing COMPILED BY P.P.  
DATUM Geodetic DATE 85 11 01, 04, 05 and 06 CHECKED BY [Signature]

[illegible]

+3, x5: Numbers refer to Sensitivity

OFFICE REPORT ON SOIL EXPLORATION



## RECORD OF BOREHOLE No 3 Cont

METRIC

W P 11-68-10

LOCATION

CO-ORDS: N 4 763 677.2; E 327 474.7

DIST 4

HWY 406

BOREHOLE TYPE

Cont. Flight Auger (H.S.) and BX Casing

ORIGINATED BY S.C.

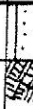
DATUM Geodetic

DATE

85 11 01, 04, 05 and 06

COMPILED BY P.P.

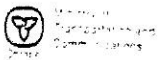
CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE							WATER CONTENT (%) 10 20 30
155.7	Cont'd.		22	SS	41		154								GR SA SI CL 14 42 40 4	
27.4																
154.5																
28.6	Shaley Dolostone and Shale Slightly to Highly Weathered		23	RC AX	Rec 43%											
151.5	Bedrock		24	RC AX	Rec 70%		152									
31.6	End of Borehole															
							150									

+3, x5: Numbers refer to Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLORATION



## RECORD OF BOREHOLE No 4

METRIC

W P 11-68-10 LOCATION CO-ORDS: N 4 763 634.7; E 327 488.5 ORIGINATED BY S.C.  
DIST 4 HWY 406 BOREHOLE TYPE Cont. Flight Auger (H.S.) COMPILED BY P.P.  
DATUM Geodetic DATE 85 11 01 CHECKED BY

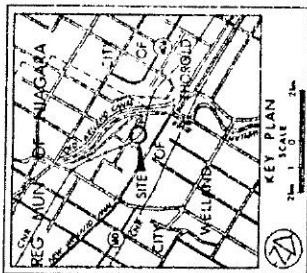
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	PLASTIC LIMIT Wp	NATURAL MOISTURE CONTENT W	LIQUID LIMIT Wl	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE								
183.7	Ground Level											
0.0	Silty Clay											
	Trace of Gravel		1	SS	17							0 8 49 43
	Trace/some Sand		2	SS	40							
			3	SS	41							
			4	SS	32							
			5	SS	19							
	Stiff to Hard		6	SS	19							0 0 52 48
			7	SS	22							
			8	SS	17							
			9	SS	19							0 2 77 21
			10	SS	16							
			11	TW	PH						20.6	2 4 60 34
			12	SS	19							
			13	SS	22							
			14	SS	24							
			15	SS	29							3 28 44 25
166.5			16	SS	73							
17.2	End of Borehole											
	* Groundwater Level not observed											

+3, x5: Numbers refer to Sensitivity

20  
15 → 5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLORATION





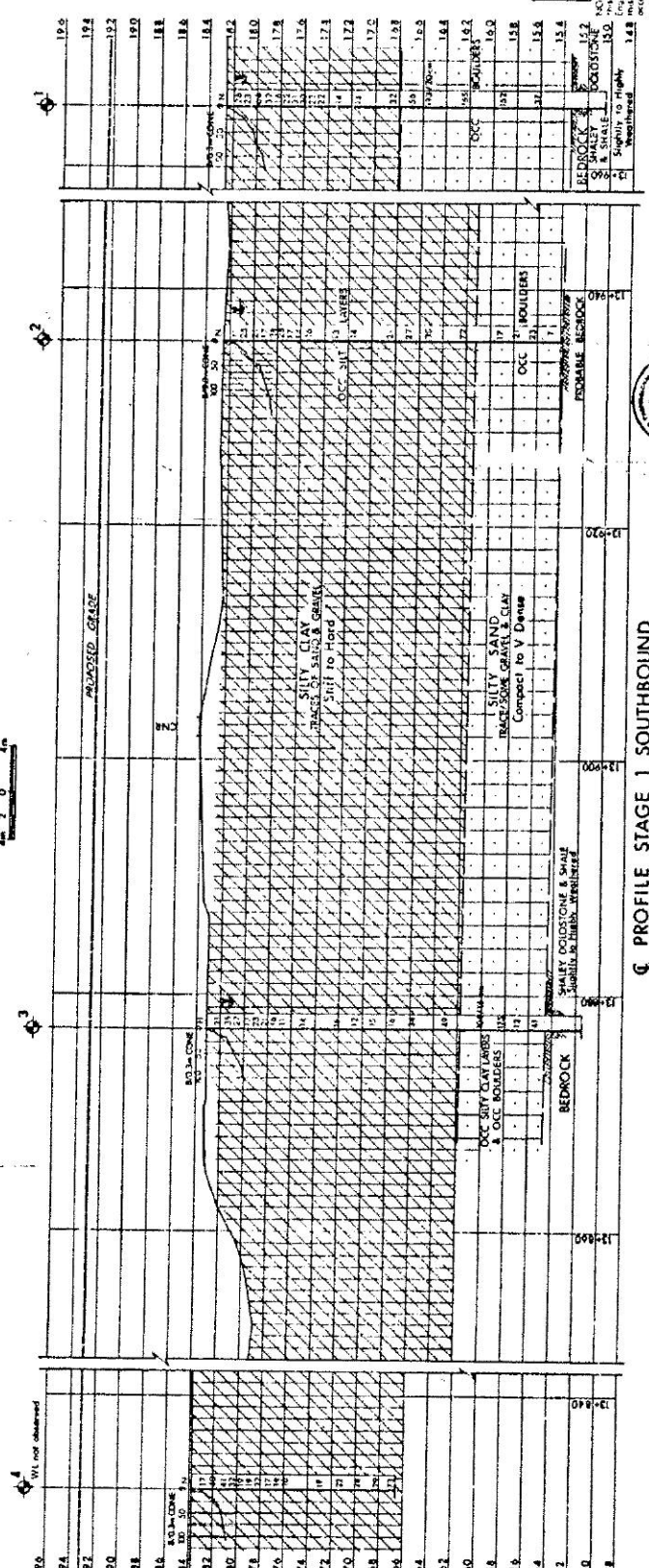
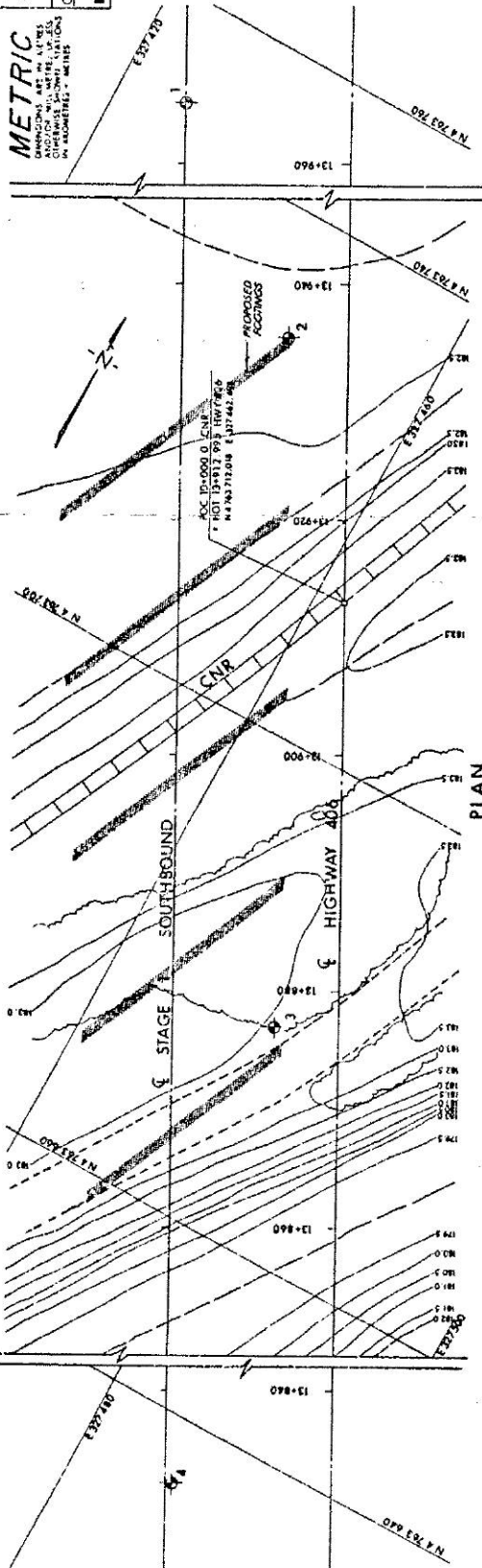
# LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N
- Blow/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation 1985.11

No	ELEVATION	CO ORIGINATES
1	182.5	4763751.9 327 425.7
2	182.5	4763750.1 327 447.4
3	183.1	4763672.3 327 474.7
4	183.7	4763634.7 327 488.5

NOTE:-  
The boundaries between soil strata have been established only at the bore hole locations. Between bore holes the boundaries are assumed from geological evidence.  
NOTE: The complete foundation investigation and design must be done by a qualified geotechnical engineer. The design must be done by a qualified geotechnical engineer. The design must be done by a qualified geotechnical engineer.

DATE	BY	DESCRIPTION
1985.11.18	181	Geotechnical
1985.11.18	181	Geotechnical
1985.11.18	181	Geotechnical



## PROFILE STAGE 1 SOUTHBOUND

SCALE  
4m 2 0 4m

REF NO E-6059-1 83 08

