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DIST. 9 REGION

W.P. No. 43-79-01

CONT. No. 87-35

W. O. No.

STR. SITE No.

HWY. No. 417

LOCATION H.M.L. FOUNDATIONS

ALTA VISTA INTERCHANGE

No. of PAGES - —

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

memorandum

Ontario

To: E.C. Lane
Head, Structural Section
Eastern Region

Date: 1986 09 10

From: Foundation Design Section
Room 315, Central Building

RE: W.P. 43-79-01
High Mast Lighting Pole Foundation
Pole C-2 (Revised Location)
Hwy. 417 & Alta Vista Drive
District 9 - Ottawa

Further to your request of July 8, 1986, this Section has carried out additional fieldwork at the above-noted site. Specifically, an additional borehole was advanced at the revised location of HML Pole C-2-10. The proposed pole location has been relocated to Sta. 31 + 555, o/s 38.5 m Rt of Hwy. 417 centreline.

The additional fieldwork was carried out on August 19 and 20, 1986 and consisted of advancing one borehole to a depth of 5.2 m at the previously noted location.

Attached is the Record of Borehole sheet for B.H. C-2 (Revised). The following is a summary of the stratigraphy which was found at this particular location.

Depth (m) From - To	Description
0.0 - 2.1	Fill (Si Cl and Sa, with Gr.)
2.1 - 2.4	Original topsoil
2.4	Shale bedrock

The general recommendations presented in the Foundation Investigation and Design Report for this project (issued on July 30, 1986) should be applied to the design of this HML foundation. However, the design parameters for pole C-2 should be altered as follows:

Elev. (m) From - To	Type of Soil	ϕ	qu psi	γ pcf
59.4 - 57.0	Fill	-	-	125
57.0 - 56.7	High. w shale	-	80	135
56.7 - 55.7	Slight. w shale	-	700	140
55.7 -	Unweath. shale	-	2500	150

.....2

If you have any questions or require further information please do not hesitate to contact the undersigned.

L. Politano
Project Foundations Engineer

for

M. Devata
Chief Foundations Engineer
(East)

MD/mmj

Attach.

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No C2 REVISED LOCATION

METRIC

W P 43-79-01 LOCATION Co-ords: N 5 030 908; E 370 631.5 ORIGINATED BY DBM

DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger; BXL Rock Core & Cone Test COMPILED BY LP

DATUM Geodetic DATE 86 08 19 - 20 CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
59.4	Ground Surface										
0.0	Silty Clay and sand, with gravel (Fill)		1	SS	29	▼	59				
			2	SS	3		58				
57.0	Topsoil (Silty Clay with Org.)		3	SS	*		57				
2.3	High Weathered Shale Bedrock		1A	RC							Rec = 88% Rqd = 35%
	Slightly weath. Unweathered		2A	RC			56				Rec =100% Rqd = 0%
			3A	RC							Rec = 94% Rqd = 83%
54.2			4A	RC			55				Rec = 93% Rqd = 72%
5.2	End of Borehole										

* Spoon bouncing

+3, ×5 : Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 43-79-01 DIST 9

HWY 417 STR SITE

Alta Vista Drive Interchange
High Mast Lighting

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GEOCRES 31G5-144

DATE JUL 30 1988

FOUNDATION INVESTIGATION REPORT

For

Alta Vista Drive Interchange

High Mast Lighting

W.P. 43-79-01, Hwy. 417

District 9, Ottawa

INTRODUCTION

This report summarizes the factual information obtained from a foundation investigation carried out at the above-noted site between 86-05-22 and 86-05-28. The fieldwork consisted of advancing one borehole at each of the 10 high mast locations. The boreholes involved the sampling of the overburden and coring the shale bedrock for depths of up to 3 m. Each of the boreholes were accompanied by a dynamic cone penetration test.

SITE DESCRIPTION

The site is located along Hwy 417 from approximately 540 m east to 320 m west of the Alta Vista Drive interchange. The site is located in the eastern end of Ottawa in the Regional Municipality of Ottawa-Carleton (RMOC). Land use in the vicinity of the site is primarily developed as urban-commercial. Topography across the site is generally flat.

The site lies on a glacial till plain characterized by till and silty clay deposits. The underlying bedrock consists of black shale of the Billings Formation.

SUBSURFACE CONDITIONS

General

The predominant material across the site consists of a heterogeneous mixture of silty clay, sand, and gravel (glacial till). The deposit is generally cohesive and the fines can be described as plastic silt to a silty clay of low plasticity. The deposit, however, may include random seams of non-cohesive material. When excavated into, the non-cohesive material may cave-in if below the groundwater table and if the sides of the excavation are not supported.

Other non-cohesive materials were also encountered across the site. It should be noted that any non-cohesive soil which is below the prevailing groundwater level will experience cave-in and sloughing when excavated into.

Bedrock at this site consists of black shale of the Billings Formation. A description of the recovered core, prepared by MTC Geologist E. Magni, is included in the Appendix for reference.

The borehole logs for each of the 10 boreholes (BH C-1 to BH C-10) are included in the Appendix. Dwg. 437901-A, also in the Appendix, is a plan of the site indicating the location of the boreholes.

The following is a description of the subsurface conditions encountered across the site.

Fill

Fill material was encountered in BH C-1 to C-5 and C-8. The fill was found to extend from the ground surface down to depths ranging between 0.4 and 2.4 m. Both cohesive and non-cohesive fill was encountered at this site.

In BH C-2 to C-5 , the fill material consists of a silty clay with varying amounts of sand and gravel. It should be noted that in BH C-3, large shale rock fragments were encountered within the fill material.

Atterberg Limits tests were carried out on 6 samples of fill material from various locations across the site. The results are shown on the log sheets and are summarized in the Appendix on Figure 1. The results indicate that this material is considered to generally be a silty clay of low plasticity. (One sample did however consist of a silty clay of intermediate plasticity).

Grain size distribution tests were carried out on 3 samples of this material, with the following results:

BH #	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
C-2 1	10	48	30	12
C-2 2	13	31	41	15
C-5 1	12	44	28	16

In BH C-1 and C-8, the fill material consists of a sand with various proportions of gravel and silt.

Silty Clay

A deposit of silty clay was encountered in BH C-1, C-2, C-4, C-5, C-7, C-9 and C-10. The upper boundary of this deposit varies in depth from 0 to 1.5 m below the ground surface. The lower boundary of this cohesive deposit ranges between 1.1 and 2.1 m in depth below the ground surface.

Figure 2 in the Appendix illustrates the results of 6 Atterberg Limits tests carried out on samples of this material. The results can be summarized as follows:

	Range (%)
Moisture Content (W)	10.5-38
Liquid Content (W_L)	19.5-44
Plastic Limit (Wp)	15-31.5
Index of Plasticity (Ip)	3.5-25

As can be noted in Figure 2, this deposit consists of a silty clay of low to intermediate plasticity.

Based on visual identification this deposit contains trace to some sand, gravel. Occasional boulders may also be encountered in this deposit.

Based on the interpretation of Standard Penetration Test 'N' values, this cohesive deposit is considered to have a consistency ranging from firm to hard.

It should be noted that in BH C-10, the silty clay was found as the surficial material. At this location the deposit contains pieces of decaying wood. Two organic content tests indicated in 8.4 and 4.9% organic matter in the deposit.

Sand with Silt

In BH C-4, a 0.6 m thick deposit of dense sand with silt was encountered. A grain size distribution test was carried out on a sample of this non-cohesive material with the following results: 13% gravel, 50% sand, 29% silt, and 8% clay.

It should be noted that when this deposit is excavated into and is subjected to an unbalanced hydrostatic pressure, loss of material into the excavation may result.

Glacial Till

Glacial till was encountered in all boreholes with the exception of BH C-3. The upper boundary of this deposit was found at a depth ranging 0.3 to 2.1 m below the ground surface. The bottom boundary lies on the bedrock and was found at depths ranging between 2.7 and 6.3 m.

Figure 3 in the Appendix shows the results of 17 Atterberg Limits tests carried out on samples of this material from across the site. The results can be summarized as follows:

	Range %
Moisture Content (W)	6-14.5
Liquid Limit (W_L)	11.5-25
Plastic Limit (W_P)	10-17.5
Index of Plasticity (I_P)	0.5-5.5

Based on these results, the fines of this deposit can be considered to be a plastic silt (ML group) to silty clay of low plasticity (CL group).

Based on the interpretation of Standard Penetration Test 'N' values, the consistency of this generally cohesive deposit can be considered to range from stiff to hard.

Figure 4 in the Appendix shows in envelope form the results of grain size distribution tests carried out on 15 samples of this material from across the site. The results can be summarized as follows:

	Range
Gravel	4-34%
Sand	26-58%
Silt	17-51%
Clay	3-25%

This glacial till can be described as a heterogeneous mixture of silty clay, sand and gravel. As previously noted, the general nature of the deposit is cohesive. However, random seams and zones of non-cohesive silt or sand may be encountered within the deposit. If these seams are encountered below the groundwater table loss of material within these seams may result.

Several cobbles and boulders were encountered in this deposit during the subsurface investigation. It is characteristic for a glacial deposit of this type to include varying numbers of cobbles and boulders.

Shale Bedrock

Bedrock was encountered and proven at all borehole locations. Bedrock across this site is found at elevations ranging from Elev. 54.6 (BH C-1) to 58.0 (BH C-4). Bedrock surface was enountered at depths ranging between 2.4 and 6.3 m below the ground surface.

The extent of the weathered zones, core recovery, and Rock Quality Designation (RQD) are shown on the log sheets and are also presented in a detailed core description prepared by MTC geologist E. Magni in the Appendix.

Bedrock across this site consists of black shale of the Billings Formation. The shale contains about 5% limestone in the form of seams 25 to 50 mm thick.

Groundwater Conditions

The groundwater levels were determined at the time of the investigation by measuring in the open boreholes 24 hours after the boreholes were opened. The following groundwater elevations were determined:

BH	Elevation (m)
C-1	57.2
C-2	58.5
C-3	58.8
C-4	60.7
C-5	60.1
C-6	59.9
C-7	59.0
C-8	60.2
C-9	59.8
C-10	59.9

DISCUSSION AND RECOMMENDATIONS

In conjunction with the proposed interchange improvement at Alta Vista Drive, it is proposed to provide illumination utilizing 10 high mast light pole installations. The following table indicates the location and pole height of each installation.

Pole	Station	Offset (m)		Pole Height (m)
C- 1-10	31+413.5	31	Lt	25
C- 2-10	+555	22.5	Rt	30
C- 3-10	+626	99	Rt	30
C- 4-10	+703	66	Lt	30
C- 5-10	+737	56	Rt	30
C- 6-10	+849	116	Lt	30
C- 7-10	+846	60.5	Rt	30
C- 8-10	+951	31	Lt	30
C- 9-10	32+098	36	Lt	25
C-10-10	+248	28	Lt	25

Design

Each high mast light pole will be supported on a single concrete caisson. For the design of the caisson, the Structural Office has decided to adopt the design method described by Broms in the following two papers:

Broms, B.B.
"Lateral Resistance of Piles in Cohesive Soils",
Journal of the Soil Mechanics and Foundations Division, ASCE, Vol. 90, No. SM2, Paper 3825, March 1964.

Broms, B.B.
"Lateral Resistance of Piles in Cohesionless Soils",
Journal of the Soil Mechanics and Foundations Division, ASCE, Vol. 90, No. SM3, Paper 3909, May 1964.

The contribution of fill material should be ignored from a lateral resistance point of view at those locations where fill presently exists or is proposed.

Also, it should be assumed that material (fill or native soil) in the zone of frost penetration does not provide any lateral resistance. At this site the depth of frost penetration for earth cover is 1.8 m.

The soil parameters in TABLE 1 are recommended for the design of the high mast light foundations. The design parameters are presented in Imperial Units since the design example provided by the structural office utilized Imperial Units throughout.

For the data given in TABLE 1, the following should be noted:

ϕ = apparent angle of friction for non-cohesive soils
q_u = unconfined compressive strength in psi ($q_u = 2\ C_u$)
γ = bulk unit weight in pcf

TABLE 1

Pole	Elev. (m) From - to	Type of Soil	Denseness or Consistency	ϕ	q_u psi	γ pcf
C-1	57.9-57.4	Fill	--	--	--	125
	57.4-56.0	Cohesive	Stiff	--	15	125
	56.0-54.5	Cohesive	V.Stiff	--	45	135
	54.5-54.2	Highly w. shale	--	--	80	135
	54.2-53.0	Slight w. shale	--	--	700	140
	53.0-	Unweath. shale	--	--	2500	150
C-2	59.3-57.8	Fill	--	--	--	125
	57.8-56.6	Cohesive	V.Stiff	--	30	125
	56.6-56.0	Highly w. shale	--	--	80	135
	56.0-	Unweath. shale	--	--	2500	150
C-3	60.3-57.9	Fill	--	--	--	125
	57.9-57.0	Highly w. shale	--	--	80	135
	57.0-	Unweath. shale	--	--	2500	150
C-4	61.8-61.2	Fill	--	--	--	125
	61.2-60.4	Cohesive	Hard	--	50	130
	60.4-59.8	Non-Cohesive	Dense	35°	--	125
	59.8-58.0	Cohesive	Hard	--	60	135
	58.0-57.0	Slight w. shale	--	--	700	140
	57.0-	Unweath. shale	--	--	2500	150
C-5	60.8-60.3	Fill	--	--	--	125
	60.3-59.0	Cohesive	Firm	--	15	125
	59.0-57.1	Cohesive	Hard	--	50	135
	57.1-	Unweath. shale	--	--	2500	150

Pole	Elev. (m) From - to	Type of Soil	Denseness or Consistency	ϕ	q_u psi	γ pcf
C-6	60.5-60.2	Peat	--	--	--	100
	60.2-59.8	Non-Cohesive	Compact	35°	--	125
	59.8-56.8	Cohesive	V.Stiff	--	40	135
	56.8-56.0	High. w. shale	--	--	80	135
	56.0-	Unweath. shale	--	--	2500	150
C-7	60.7-60.1	Non-Cohesive	Compact	30°	--	125
	60.1-58.6	Cohesive	Firm	--	8	125
	58.6-56.7	Cohesive	Stiff	--	20	130
	56.7-	Unweath. shale	--	--	2500	150
C-8	60.8-60.0	Fill	--	--	--	125
	60.0-56.0	Cohesive	Stiff	--	30	130
	56.0-54.5	Cohesive	Hard	--	60	135
	54.5-53.0	High. w. shale	--	--	100	140
	53.0-	Unweath. shale	--	--	2500	150
C-9	59.7-58.0	Cohesive	Firm	--	8	125
	58.0-54.9	Cohesive	Stiff	--	18	130
	54.9-54.4	High. w. shale	--	--	80	135
	54.4-53.0	Unweath. shale	--	--	2500	150
	53.0-52.0	Slight w. shale	--	--	700	140
	52.0-	Unweath. shale	--	--	2500	150
C-10	59.9-58.8	Organics	--	--	--	115
	58.8-57.2	Cohesive	V.Stiff	--	50	135
	57.2-55.6	Slight w. shale	--	--	700	140
	55.6-	Unweath. shale	--	--	2500	150

Notes

1. If rock anchors or dowels are required for additional stability, the following bond stresses can be used:

highly weathered shale	15 psi
slightly weathered shale	30 psi
unweathered shale	100 psi

2. As previously noted, the strength contribution of existing or proposed fill material, or the upper 1.8 m frost penetration zone should be neglected in the design.

3. Groundwater levels at the time of the investigation (May 86) were as follows:

BH	Elevation (m)
C-1	57.2
C-2	58.5
C-3	58.8
C-4	60.7
C-5	60.1
C-6	59.9
C-7	59.0
C-8	60.2
C-9	59.8
C-10	59.9

4. When shale bedrock is exposed degradation of the exposed surface occurs very quickly. Degradation will result in strength loss of the rock mass. It is recommended that the concrete for the caissons be poured within 4 hours after the hole in the shale bedrock has been opened.

5. In zones where the soil is slightly plastic or non-plastic, and below the groundwater table, it is possible that the sides of an unsupported augered hole will cave-in. If cave-in, and as a result disturbance occurs, the lateral strength of the soil may be drastically reduced. Zones of this type of material are encountered throughout the stratigraphy.

   Therefore, given the nature of the subsoils across the site, it is recommended that all caissons be constructed utilizing a temporary liner which can be withdrawn as the concrete is poured.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of D. Madill, Student Engineer, utilizing equipment owned and operated by Marathon Soil Drilling Ltd. of Ottawa.

The rock core description included in this report was prepared by E. Magni, MTC Geologist.

This report was written by L. Politano and reviewed by M. Devata.

L. Politano, P.Eng.
Project Foundations Engineer

M. Devata, P.Eng.
Chief Foundations Engineer
(East)

July 1986

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 (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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

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

e	1, %	VOID RATIO
n	1, %	POROSITY
w	1, %	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_p	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_p	%	PLASTICITY INDEX = $w_L - w_P$
I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
e_{max}	1, %	VOID RATIO IN LOOSEST STATE
e_{min}	1, %	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

DESCRIPTION OF ROCK CORE - W.P. 43-79-01

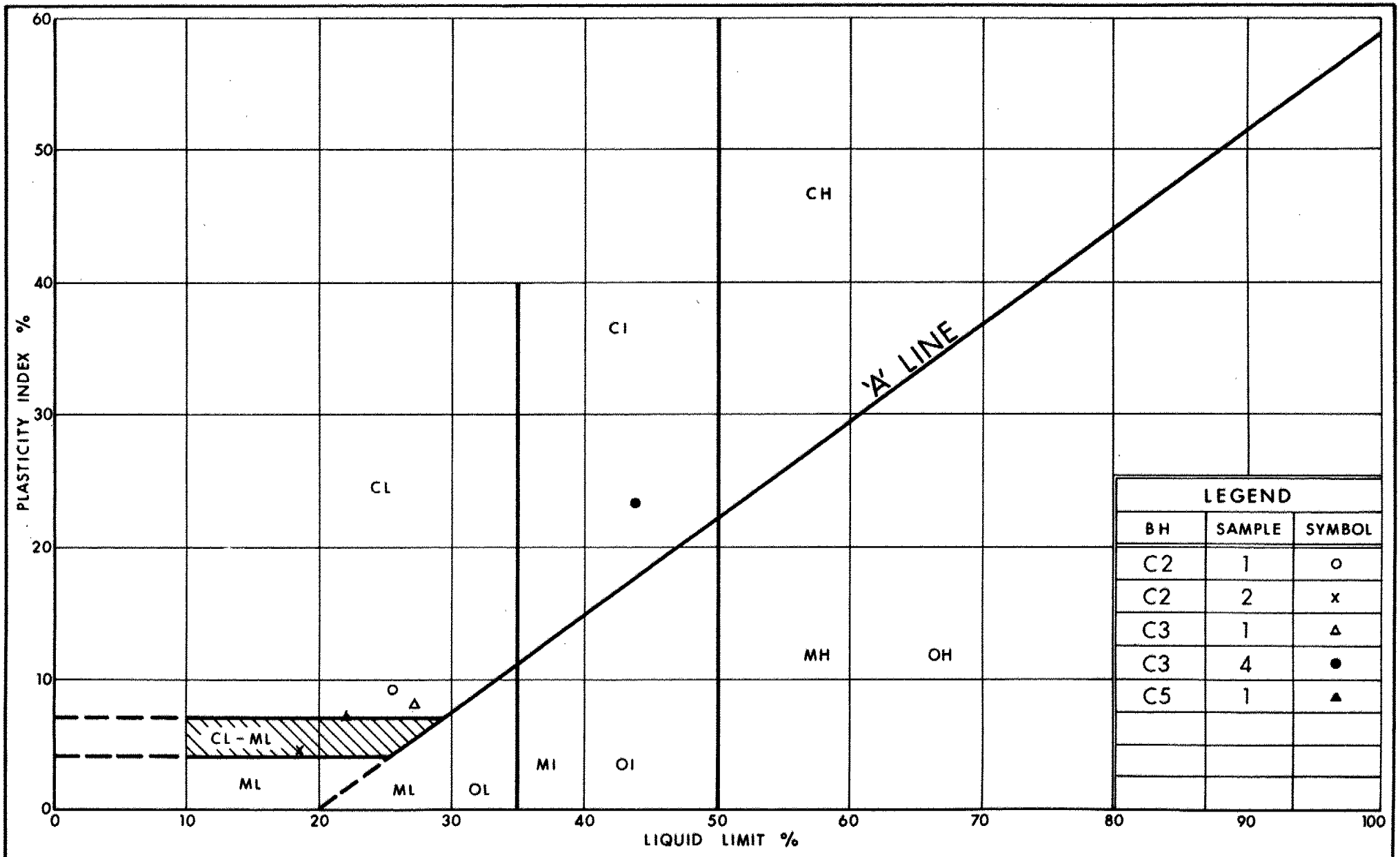
BOREHOLE NUMBER				CORE DESCRIPTION	
	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
C1	3.30 - 4.88 4.88 - 6.40	98 97	89 95	3.30 - 6.40	SHALE, black, unweathered, medium spaced joints
C2	3.05 - 4.57 4.57 - 5.31 5.31 - 6.17	97 97 100	40 0 68	3.05 - 6.17	SHALE, black, unweathered, closely to medium spaced joints
C3	2.74 - 4.27 4.27 - 5.64	93 96	50 48	2.74 - 5.64	SHALE, black, unweathered, medium spaced joints
C4	3.86 - 5.08 5.08 - 6.60	88 97	71 77	3.86 - 6.60	SHALE, black, unweathered, widely spaced joints
C5	3.66 - 5.26 5.26 - 6.63	97 98	71 89	3.66 - 6.63	SHALE, black, unweathered, medium spaced joints
C6	3.66 - 4.24 4.24 - 5.74 5.74 - 6.63	91 97 97	48 49 80	3.66 - 4.01 4.01 - 6.63	SHALE, black, slightly weathered, very closely spaced joints SHALE, black, unweathered, widely spaced joints
C7	4.11 - 5.54 5.54 - 7.06	98 80	84 67	4.11 - 7.06	SHALE, black, unweathered, widely spaced joints, with weathered zone about 5.49 to about 5.79 m (core loss)
C8	6.55 - 7.77 7.77 - 9.37	90 100	21 92	6.55 - 7.77 7.77 - 9.37	SHALE, black, slightly weathered, closely spaced with sections of very closely spaced joints SHALE, black, unweathered, medium spaced joints

* CR = CORE RECOVERY ; RQD = ROCK QUALITY DESIGNATION

DESCRIPTION OF ROCK CORE - W.P. 43-79-01

BOREHOLE NUMBER				CORE DESCRIPTION	
	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
C9	5.23 - 6.77 6.77 - 7.70 7.70 - 8.43	95 84 100	100 11 0	5.23 - 6.93 6.93 - 8.43	SHALE, black, unweathered, medium spaced joints SHALE, black, unweathered, very closely spaced joints, shear zone with smooth slicken sided shear surfaces
C10	2.77 - 4.27 4.27 - 5.49	100 92	10 52	2.46 - 3.22 3.22 - 5.49	SHALE, black, slightly weathered, closely spaced joints SHALE, black, unweathered, medium spaced joints

* CR = CORE RECOVERY ; RQD = ROCK QUALITY DESIGNATION



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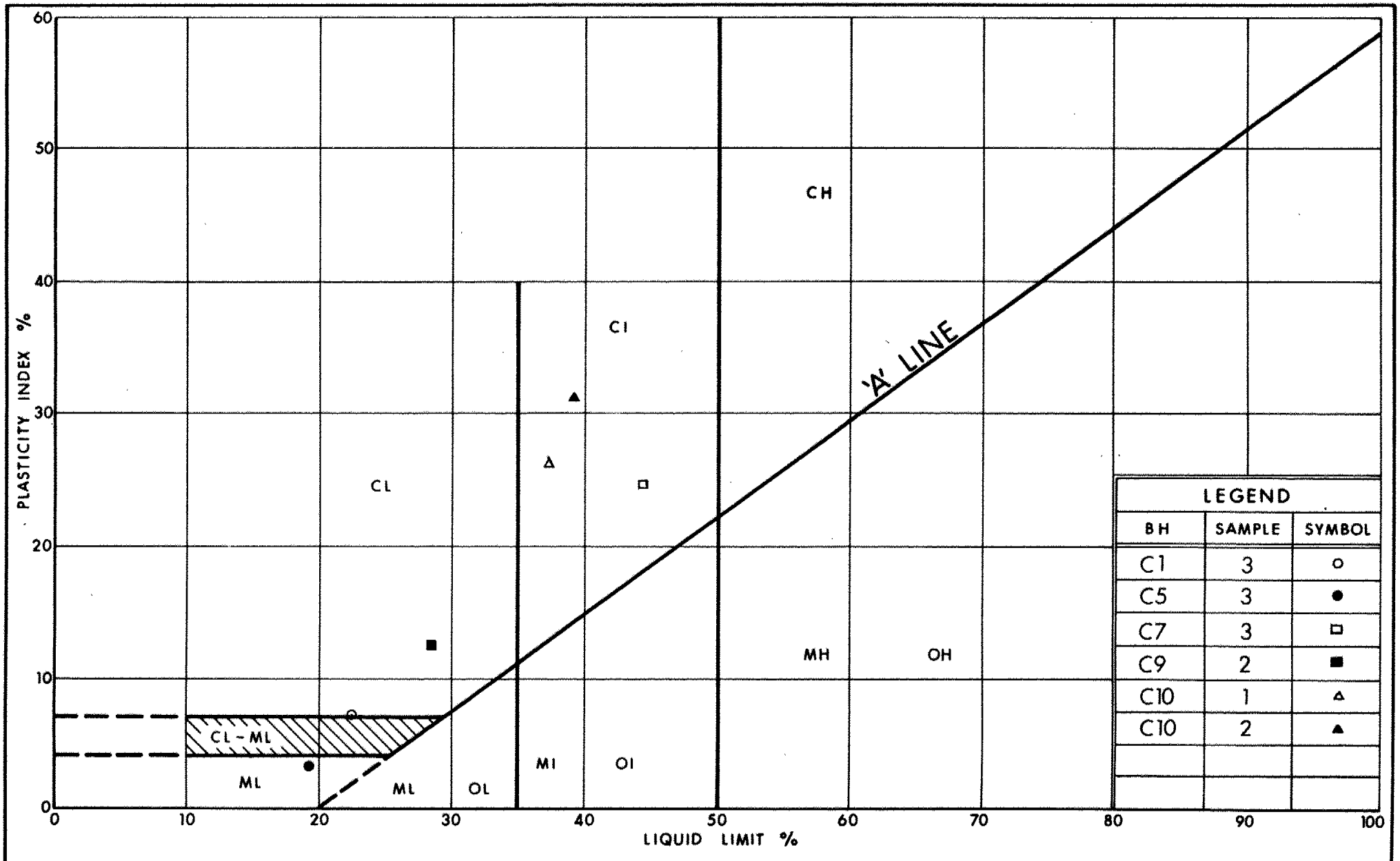
PLASTICITY CHART
SILTY CLAY (FILL)

FIG No 1
WP 43-79-01



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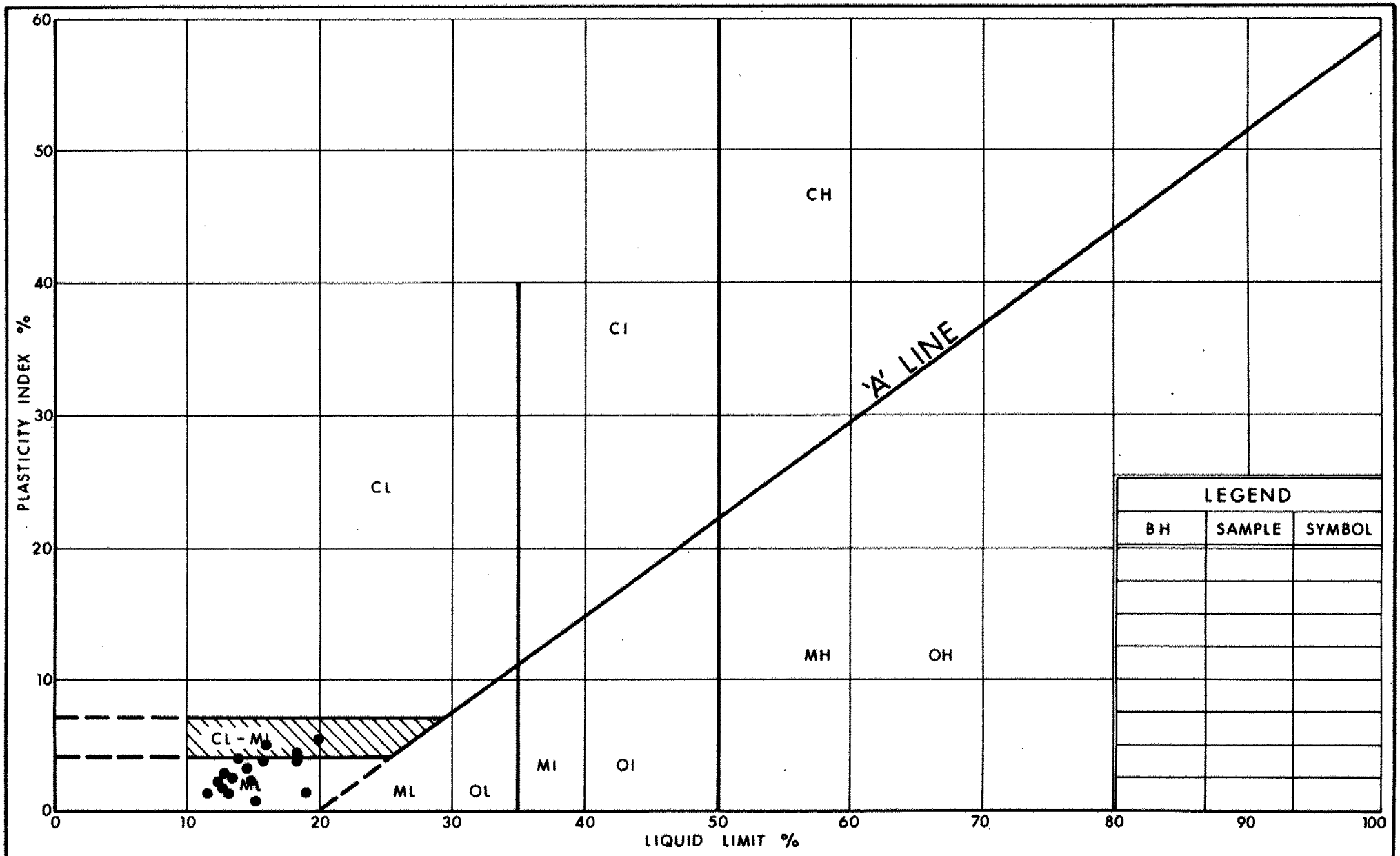
PLASTICITY CHART

SILTY CLAY TRACE TO SOME SAND, GRAVEL

FIG No 2

W P 43-79-01



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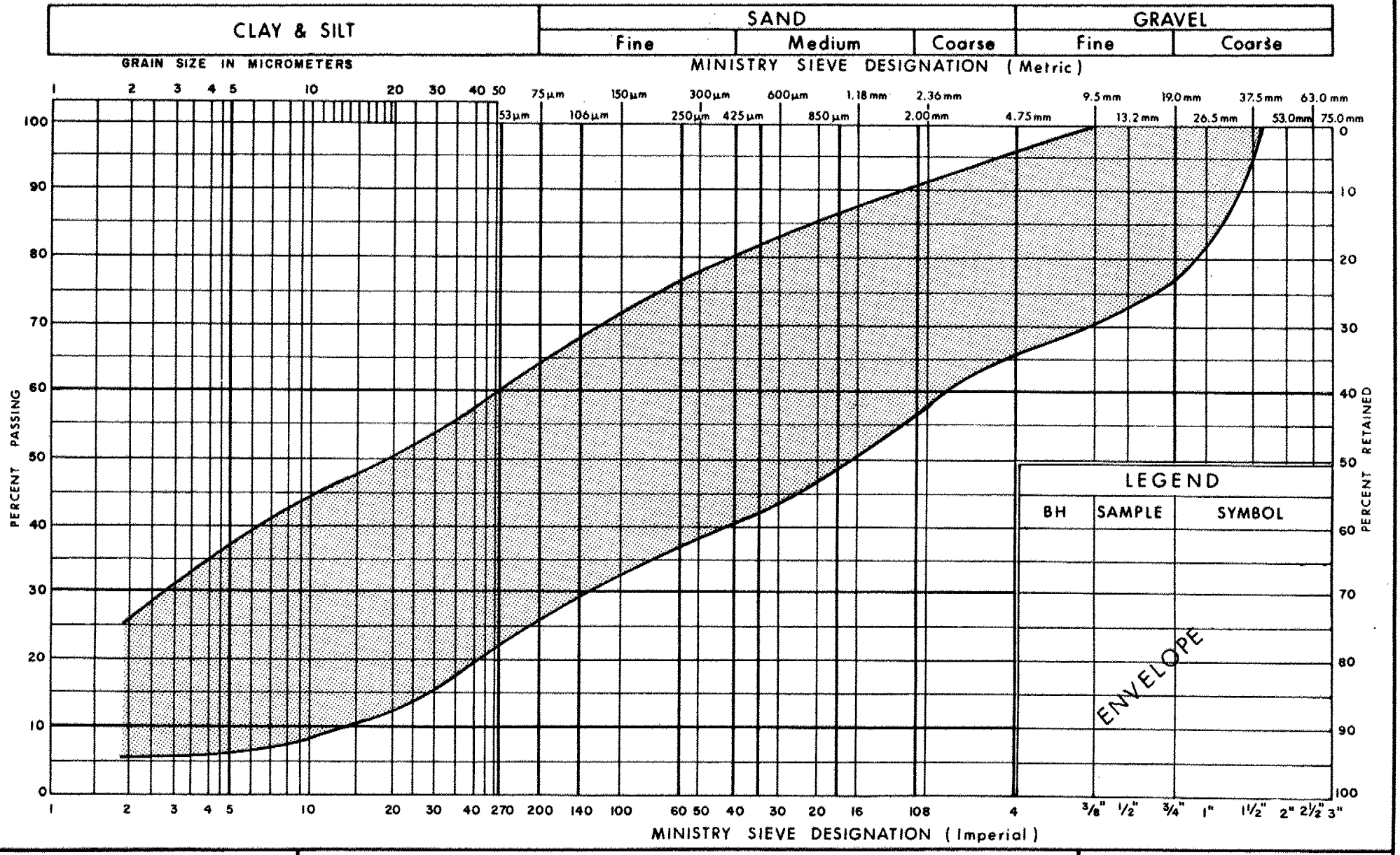
PLASTICITY CHART
HET MIXTURE OF SILTY CLAY, SAND, GRAVEL
(GLACIAL TILL)

FIG No 3
W P 43-79-01

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION

HET MIXTURE OF SILTY CLAY, SAND, GRAVEL
OCC BOULDERS (GLACIAL TILL)

FIG No 4
W P 43-79-01

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RECORD OF BOREHOLE No C-1 METRIC

W P 43-79-01 LOCATION Co-ords: N 5 030 959; E 370 477.5 ORIGINATED BY DBM
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger; BXL Core COMPILED BY DBM
DATUM Geodetic DATE 86-05-26 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
57.9	Ground Surface										
0.0	Sand with silt (Fill)		1	SS	16						
57.4											
0.5	Silty clay with sand Stiff		2	SS	9	▼	57.				
56.4											
1.5	Heterogeneous Mixture of silty clay, sand gravel. Occ. Boulders		3	SS	19		56.				
	(Glacial Till)		4	SS	27				○ ⊢		31 43 17 9
	Very Stiff						55.				
54.6			5	SS	14/10 cm*						
3.3	Highly weathered		1	RC	rec= 98%		54.				RQD=89%
	Shale Bedrock										
	Unweathered						53.				
			2	RC	rec= 97%						RQD=95%
51.5							52.				
6.4	End of Borehole										
	*Spoon Bouncing										

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

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

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No C-2 METRIC

W P 43-79-01 LOCATION CO-ORDS: N 5 030 922; E 370 628.5 ORIGINATED BY DBM
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger; BXL Core COMPILED BY DBM
DATUM Geodetic DATE 86 05 26; 86 05 27 CHECKED BY

ELEV / DEPTH (m)	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
59.3	Ground Surface										
0.0	Silty Clay and Sand, Trace Gravel (Fill)		1	SS	10		59				10 48 30 12
57.8			2	SS	9/10 cm*		58				13 31 41 15
1.5	Silty Clay, Trace Sand		3	SS	21						
57.2	Very Stiff										
2.1	Heterogeneous Mixture of Silty Clay, Sand, Gravel (Glacial Till) Hard		4	SS	52		57				
56.6											
2.7	Highly Weathered Shale Bedrock		1	RC	REC 97%		56				RQD= 40%
	Unweathered						55				
			2	RC	REC 97%						RQD= 0%
			3	RC	REC 100%		54				RQD= 68%
53.1											
6.2	End of Borehole										

* Piece of Concrete and Brick encountered

+3, ×5 : Numbers refer to Sensitivity

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

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No C4 METRIC

W P 43-79-01 LOCATION CO-ORDS: N 5 031 035.5; E 370 748.9 ORIGINATED BY DBM
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger; BXL Core COMPILED BY DBM
DATUM Geodetic DATE 86 05 24; 86 05 25 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
61.8	Ground Surface										
0.0 / 61.2	Silty Clay with Sand, Gravel (Fill)		1	SS	15				○ —		
0.6	Silty Clay with Trace Sand Organics Occ. Boulders Hard		2	SS	43	▼	61				
1.4 / 59.8	Sand with Silt, Trace Gravel, Clay Dense		3	SS	43		60				13 50 29 8
2.0	Heterogeneous Mixture Silty Clay, Sand, Gravel Occ. Boulders (Glacial Till)		4	SS	122		59				
58.0	Hard		5	SS	51				○ —		22 40 28 10
3.8	Shale Bedrock Unweathered		1	RC	REC 88%		58				RQD= 71%
			2	RC	REC 97%		57				RQD= 77%
55.2							56				
6.6	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No C5 METRIC

W P 43-79-01 LOCATION CO-ORDS: N 5 030 927; E 370 822 ORIGINATED BY DBM
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger; BXL Core COMPILED BY DBM
DATUM Geodetic DATE 86 05 27 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
60.8	Ground Surface										
0.0 / 60.3	Silty Clay and Sand (Fill)		1	SS	12						12 44 28 16
0.5	Silty Clay, Some Sand Trace Gravel Firm to Very Stiff		2	SS	4	▼	60				
59.0			3	SS	21						
1.8	Heterogeneous Mixture Silty Clay, Sand, Gravel Occ. Boulders (Glacial Till) Hard		4	SS	42		59				
57.1			5	SS	40		58				12 58 24 6
3.7	Shale Bedrock Unweathered		1	RC	REC 97%		57				RQD= 71%
			2	RC	REC 98%		56				RQD= 89%
54.2							55				
6.6	End of Borehole										

+3, ×5 : Numbers refer to Sensitivity

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

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No C6 METRIC

W P 43-79-01 LOCATION CO-ORDS: N 5 031 134; E 370 848 ORIGINATED BY DBM
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger; BXL Core COMPILED BY DBM
DATUM Geodetic DATE 86 05 24 CHECKED BY

ELEV / DEPTH (m)	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
60.5	Ground Surface										
0.0 / 60.2	Peat										
0.3	Sandy Silt		1	SS	3	▼	60				
	Heterogeneous Mixture of Silty Clay, Sand, and Gravel		2	SS	30				o H		33 38 20 9
	Occ. Boulders		3	SS	35		59		o H		
	(Glacial Till)		4	SS	32				o H		31 38 18 13
	Very Stiff to Hard		5	SS	22		58		o H		17 46 25 12
56.8											
3.7	Slightly Weathered		1	RC	REC 91%		57				RQD= 48%
	Shale Bedrock		2	RC	REC 97%		56				RQD= 49%
	Unweathered						55				
			3	RC	REC 97%						RQD= 80%
53.8							54				
6.7	End of Borehole.										

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No C7 METRIC

W P 43-79-01 LOCATION CO-ORDS: N 5 030 973; E 370 929 ORIGINATED BY DBM
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger; BXL Core COMPILED BY DBM
DATUM Geodetic DATE 86 05 27; 86 05 28 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
60.7	Ground Surface										
0.0 / 60.1	Sand with Silt, Trace Gravel		1	SS	13						
0.6	Silty Clay and Sand, Trace Gravel, Organics		2	SS	5						7 42 38 13
58.6	Firm		3	SS	8	▼					
2.1	Heterogeneous Mixture of Silty Clay, Sand, Gravel Occ. Boulders (Glacial Till)		4	SS	25						
56.9	Stiff		5	SS	12						
3.8	Highly Weathered Shale Bedrock Unweathered		6	SS	36/15 cm*						
53.6			1	RC	REC 98%						RQD= 84%
			2	RC	REC 80%	**					RQD= 67%
7.1	End of Borehole										

* Spoon Bouncing

** 25 cm Core Lost in Hole

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No C8 METRIC

W P 43-79-01 LOCATION CO-ORDS: N 5 031 106; E 370 978 ORIGINATED BY DBM
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger; BXL Core COMPILED BY DBM
DATUM Geodetic DATE 85 05 28 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
60.8	Ground Surface										
0.0 / 60.0	Sand and Gravel (Fill)		1	SS	12	▼	60				
0.8	Heterogeneous Mixture of Silty Clay, Sand and Gravel Occ. Boulders (Glacial Till)		2	SS	28						
			3	SS	31		59				7 50 30 13
			4	SS	18		58		W H		
	Firm to Very Stiff		5	SS	6				W H		33 35 19 13
			6	SS	27		57		W H		14 48 21 17
	Hard		7	SS	18/28 cm*		56		W H		
			8	SS	90/15 cm				W H		
54.5			9	SS	65/13 cm*		55				
6.3	Highly Weathered Slightly Weathered		1	RC	REC 90%		54				RQD= 21%
	Shale Bedrock Unweathered		2	RC	REC 100%		53				RQD= 92%
51.4							52				
9.4	End of Borehole * Spoon Bouncing										

+3, ×5 : Numbers refer to Sensitivity

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

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No C9 METRIC

W P 43-79-01 LOCATION CO-ORDS: N 5 031 169; E 371 119.04 ORIGINATED BY DBM
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger; BXL Core COMPILED BY DBM
DATUM Geodetic DATE 85 05 22 CHECKED BY

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
59.7	Ditch Bottom										
0.0	Silty Clay, Some Sand Trace Gravel		1	SS	6		59				
			2	SS	8						
58.2	Firm						58				17 45 24 14
1.5	Heterogeneous Mixture of Silty Clay, Sand and Gravel		3	SS	11						
	Occ. Boulders (Glacial Till)		4	SS	18						34 36 20 10
	Stiff to Very Stiff		5	SS	11		57				
			6	SS	9		56				11 46 29 14
54.9			7	SS	12/25 cm*		55				19 45 25 11
4.8	Highly Weathered										
	Shale Bedrock		1	RC	REC 95%		54				RQD=100%
	Unweathered										
	Slightly Weathered		2	RC	REC 84%		53				RQD= 11%
51.2			3	RC	REC 100%		52				RQD= 0%
8.5	End of Borehole										
	* Spoon Bouncing										

+3, ×5 : Numbers refer to Sensitivity

15 20/10 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No C10 METRIC

W P 43-79-01 LOCATION CO-ORDS: N 5 031 186; E 371 273.5 ORIGINATED BY DBM
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger; BXL Core COMPILED BY DBM
DATUM Geodetic DATE 86 05 22 CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ Organic Content	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
59.9	Ground Surface										
0.0	Silty Clay with Organics, Roots, and Pieces of Wood		1	SS	10	*				4.9%	
										8.4%	
58.8	Firm		2	SS	8	*	59				
1.1	Heterogeneous Mixture of Silty Clay, Sand, Gravel Occ. Boulders (Glacial Till)		3	SS	28						9 26 51 14
57.2	Very Stiff		4	SS	28		58				3 35 37 25
2.7	Shale Bedrock		1	RC	REC 100%		57				RQD= 10%
	Slightly Weathered / Unweathered		2	RC	REC 92%		56				RQD= 52%
54.4							55				
5.5	End of Borehole										

* Spoon penetrated through a piece of wood

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

20
15 ⊹ 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO PH-0-207 82 04

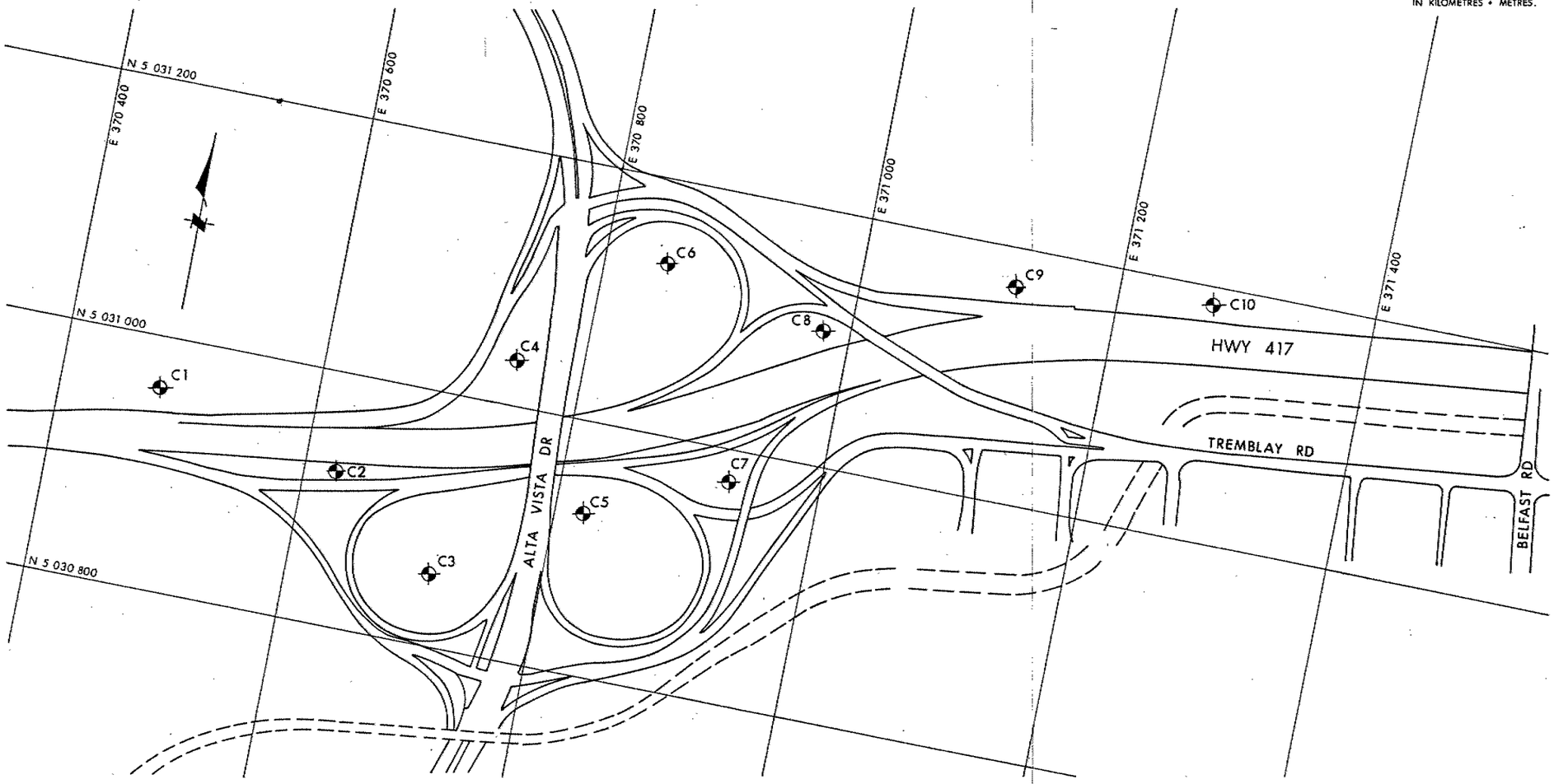
METRIC

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

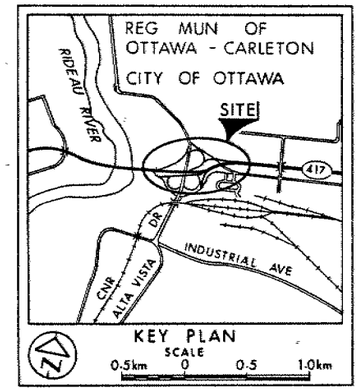
CONT No
WP No 43-79-01

HWY 417 & ALTA VISTA DR
HIGH MAST LIGHTING
BORE HOLE LOCATIONS & SOIL STRATA

SHEET



PLAN
SCALE
40m 20 0 40m



KEY PLAN
SCALE
0.5km 0 0.5 1.0km

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 86 05

BOREHOLE LOCATIONS

No	ELEVATION	CO-ORDINATES NORTH	EAST
C1	57.9	5 030 959.0	370 477.5
C2	59.3	5 030 922.0	370 628.5
C3	60.3	5 030 857.0	370 711.5
C4	61.8	5 031 035.5	370 748.9
C5	60.8	5 030 927.0	370 822.0
C6	60.5	5 031 134.0	370 848.0
C7	60.7	5 030 973.0	370 929.0
C8	60.8	5 031 106.0	370 978.0
C9	59.7	5 031 169.0	371 119.0
C10	59.9	5 031 186.0	371 273.5

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

Geocres No 31G5-144

HWY No 417			DIST 9
SUBM'D LP	CHECKED	DATE 86 07 23	SITE
DRAWN DT	CHECKED	APPROVED	DWG 437901-A

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 43-79-01 DIST 9

HWY 417 STR SITE -

Alta Vista Drive Interchange
Overhead Sign at
Sta. 31 + 576, Ramp W-N/S

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GEOCRES 31G5-144

DATE OCT 14 1986

FOUNDATION INVESTIGATION REPORT
For
Alta Vista Drive Interchange
Overhead Sign at
Sta. 31+576, Ramp W-N/S
W.P. 43-79-01, Hwy. 417
District 9, Ottawa

INTRODUCTION

This report summarizes the subsurface information obtained from a foundation investigation carried out at the above-noted site between 86-08-19 and 86-08-21. The investigation consisted of 2 sampled boreholes (BH 100 and BH 101) advanced to depths of 5.4 m ± below the ground surface.

Bedrock was proven in both boreholes by obtaining up to 3m of BX rock core.

SITE DESCRIPTION AND GEOLOGY

The site is located along Hwy. 417 at the Alta Vista Drive Interchange. The site is situated in the eastern end of Ottawa, Regional Municipality of Ottawa-Carleton (RMOC). Land use in the vicinity of the site is primarily developed as urban-commercial. Topography across the site is generally flat.

The site lies on a glacial till plain characterized by till and silty clay deposits. The underlying bedrock consists of black shale of the Billings Formation.

SUBSURFACE CONDITIONS

The boundaries between the soil types, in-situ test results, and groundwater conditions are shown on the Record of Borehole sheets BH 100 and BH 101 in the Appendix. Dwg. 437901-8 in the Appendix indicates the location of the two boreholes. The following is a summary of the subsurface conditions encountered at this site:

Extending from the ground surface down to a depth of 0.5 m± is a silty sand with organics. Based on visual examination of the recovered samples, it appears that this non-cohesive material is a fill. Within the predominant sand, fragments of shale bedrock were encountered as were occasional pieces of decaying wood. Standard Penetration Test 'N' values were obtained within this surficial material, however, they may be non-representative in view of the presence of the shale rock fragments and larger pieces of gravel.

Underlying this material and extending to the surface of the bedrock is a mixture of silty clay, with varying proportions of sand and gravel. This cohesive material also appears to be fill. Within this stratum, larger fragments of shale rock were encountered. Based on visual examination of the recovered samples it appears that this cohesive material behaves as a silty clay of low plasticity (CL Group)

Standard Penetration Test 'N' values obtained within this material may be non-representative in view of the shale rock fragments which are present. However, it generally appears that this fill material has been well-compacted.

Underlying the fill material is the bedrock at Elev. 57.6 ±. The bedrock at this site consists of black shale of the Billings Formation and is found to occur between 1.5 and 2.0 m below the ground surface.

In BH 100, it was possible to auger approximately 0.25 m into the weathered surface of the bedrock. In BH 101, however, it was possible to retrieve a split-spoon sample of the highly weathered surface of the bedrock and it was also possible to auger approximately 0.5 m into the surface of the rock formation.

The extent of the weathered zones, core recovery, and Rock Quality Designation (RQD) are shown in the Record of Borehole sheets and are also presented in a detailed rock core description prepared by MTC geologist E. Magni in the Appendix (Table A).

The groundwater level was measured in BH 101 24 hours after the borehole was opened. At this location, the groundwater level was found at Elev. 58.6 ±.

DISCUSSION AND RECOMMENDATIONS

In conjunction with the proposed improvement at the Hwy. 417 and Alta Vista Drive interchange, it is proposed to erect an overhead sign at Sta. 31+576 of the W-N/S Ramp. The left footing will be located 6.4 left of the ramp centreline, while the right footing will be situated 8.9 m right of the ramp centreline. The subsurface investigation for this project was requested by the Eastern Region Geotechnical Section in a memorandum dated 86 07 24.

The following are our recommendations for the design and construction of the overhead sign foundations which could consist of caissons, or alternatively, spread footings.

Alternative 1: Caissons

Each leg of the overhead sign can be supported on a single concrete caisson. For the design of such caissons, the Structural Office has decided to adopt the design method described by Broms in the following two papers:

Broms, B.B.
"Lateral Resistance of Piles in Cohesive Soils",
Journal of the Soil Mechanics and Foundations Division, ASCE, Vol. 90, No. SM2, Paper 3825, March 1964.

Broms, B.B.
"Lateral Resistance of Piles in Cohesionless Soils",
Journal of the Soil Mechanics and Foundations Division, ASCE, Vol. 90, No. SM3, Paper 3909, May 1964.

If such caissons are utilized for this project, the contribution of the fill material above the bedrock should be ignored from a lateral resistance point of view. Similarly, it should be assumed that material in the zone of frost penetration does not provide any lateral resistance. At this site the depth of frost penetration is considered to be 1.8 m.

For the design of the caissons, the following parameters should be used:

Caisson	Elev. (m) From - to	Type of Soil	qu kPa	γ kN/m^3
Left (BH 100)	59.7 - 59.1	Silty sand (fill)	-	19.5
	59.1 - 57.7	Silty clay (fill)	-	19.5
	57.7 - 57.0	Slight weath.shale	4,000	22.0
	57.0 -	Unweathered shale	17,000	23.5
Right (BH 101)	59.0 - 58.5	Silty sand (fill)	-	19.5
	58.5 - 57.6	Silty clay (fill)	-	19.5
	57.6 - 56.3	Highly weath.shale	500	22.0
	56.3 -	Unweathered shale	17,000	23.5

Where qu = unconfined compressive strength in kPa (qu = 2 Cu)

γ = bulk unit weight in kN/m^3

If caissons are utilized for the foundations and additional lateral stability is required, then rock anchors or dowels can be used. The following bond stresses can be assumed if such anchors or dowels are required:

Type of Rock	Bond Stress
Highly weathered shale	100 kPa
Slightly weathered shale	200 kPa
Unweathered shale	700 kPa

When shale bedrock becomes exposed to the atmosphere, degradation of the exposed surface occurs very quickly, particularly in the Billings shale. Degradation will result in strength loss of the rock mass. In view of this, it is recommended that the concrete for the caissons be poured within 4 hours after the shale in the caisson hole is exposed.

Alternative 2: Spread Footings

As an alternative, the overhead sign can be supported on spread footings founded on the shale bedrock. The following bearing capacities can be used in the design of such foundations:

Footing	Founding Elev.	Bearing Capacity ULS	SLS II
Left	57 or lower	1400 kPa	-
Right	57.0 - 56.3	700 kPa	450 kPa
	56.3 or lower	1400 kPa	-

To check against sliding between the concrete and the shale bedrock, an angle of friction of 24° can be used for the unweathered shale, while 22° can be used for the weathered shale.

If additional lateral stability is required for the spread footings, rock dowels can be used using the parameters previously given on Page 4. Alternatively, the footings could be keyed into the bedrock formation.

As already noted, Billings shale deteriorates very rapidly when exposed to the atmosphere. The excavations for the footings should be completed in one day. As soon as the excavation is exposed, the base and sides should be protected with a 150 mm concrete mat.

In order to prevent upheave forces on the footings, frost protection of 1.8 m earth cover, or equivalent, should be provided to the underside of the footing.

The excavation for the spread footings would extend below the groundwater level. However, the overburden primarily consists of a silty clay material. Any seepage into the excavation can be controlled by pumping from sumps.

MISCELLANEOUS

The fieldwork for this investigation was carried out during the period between 86 08 19 and 86 08 21 under the supervision of D. Madill (MTC Student Engineer) utilizing equipment owned and operated by Marathon Soil Drilling Inc. of Ottawa.

This report was prepared by L. Politano, Project Foundations Engineer, and was reviewed by M. Davata, Chief Foundations Engineer, (East).

L. Politano, P.Eng.
Project Foundations Engineer

M. Devata, P.Eng.
Chief Foundations Engineer
(East)

October 1986.

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 (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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

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

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

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

DESCRIPTION OF ROCK CORE - W.P. 43-79-01

BOREHOLE NUMBER				CORE DESCRIPTION	
	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
100	2.29 - 3.73 3.73 - 5.23	93 100	93 100	2.29 - 5.23	SHALE, dark grey, unweathered, medium to widely spaced joints
101	1.91 - 2.59 2.59 - 3.91	41 81	0 69	1.91 - 2.31 2.31 - 3.91	SHALE, brown, highly weathered SHALE, dark grey, unweathered, medium to widely spaced joints

* CR = CORE RECOVERY ; RQD = ROCK QUALITY DESIGNATION

TABLE A

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 100 METRIC

W P 43-79-01 LOCATION Ramp W-N/S @ Alta Vista Blvd. Sta. 31 + 577.0 ORIGINATED BY DBM
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger; BX Rock Core O/S 7.0 m Lt. & Cone Test COMPILED BY LP
DATUM Geodetic DATE 86 08 19, 21 CHECKED BY

ELEV / DEPTH (m)	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
59.7	Ground Surface							
0.0 / 59.1	Silty Sand with organics (possible fill)		1	SS	9	*	59	
0.6 / 57.7	Silty clay, sand, gravel with occ. shale fragments. (possible fill)		2	SS	18			
			3	SS	38		58	
2.0 / 54.5	Slightly Weathered Shale Bedrock Unweathered		4	SS	50//2 cm**		57	
			1A	RC				REC = 93% RQD = 93%
			2A	RC			56	REC = 100% RQD = 100%
5.2	End of Borehole						55	

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

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

PLASTIC LIMIT Wp | NATURAL MOISTURE CONTENT W | LIQUID LIMIT W_L
WATER CONTENT (%)

UNIT WEIGHT γ

* Groundwater level not established

** Spoon Bouncing

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

20
15 ⊹ 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 101 METRIC

W P 43-79-01 LOCATION Ramp W-N/S @ Alta Vista Blvd. Sta. 31 + 574.2 O/S 11.0 m Rt. ORIGINATED BY DBM
DIST 9 HWY 417 BOREHOLE TYPE Hollow Stem Auger; BX Rock Core & Cone Test COMPILED BY LP
DATUM Geodetic DATE 86 08 20 - 21 CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
59.0	Ground Surface										
0.0 / 58.5	Silty Sand with organics (possible fill)		1	SS	17	▼					
0.5 / 57.6	Silty clay, sand gravel with occ. shale fragments (possible fill)		2	SS	27		58				
1.4	Shale Bedrock Highly Weathered		3	SS	55/8 cm *						
			1A	RC			57				REC = 41% RQD = 0%
	Unweathered		2A	RC			56				REC = 81% RQD = 69%
			3A	RC			55				REC = 100% RQD = 80%
53.6							54				
5.4	End of Borehole										

* Spoon Bouncing

+3, ×5 : Numbers refer to Sensitivity

20
15 ⊹ 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

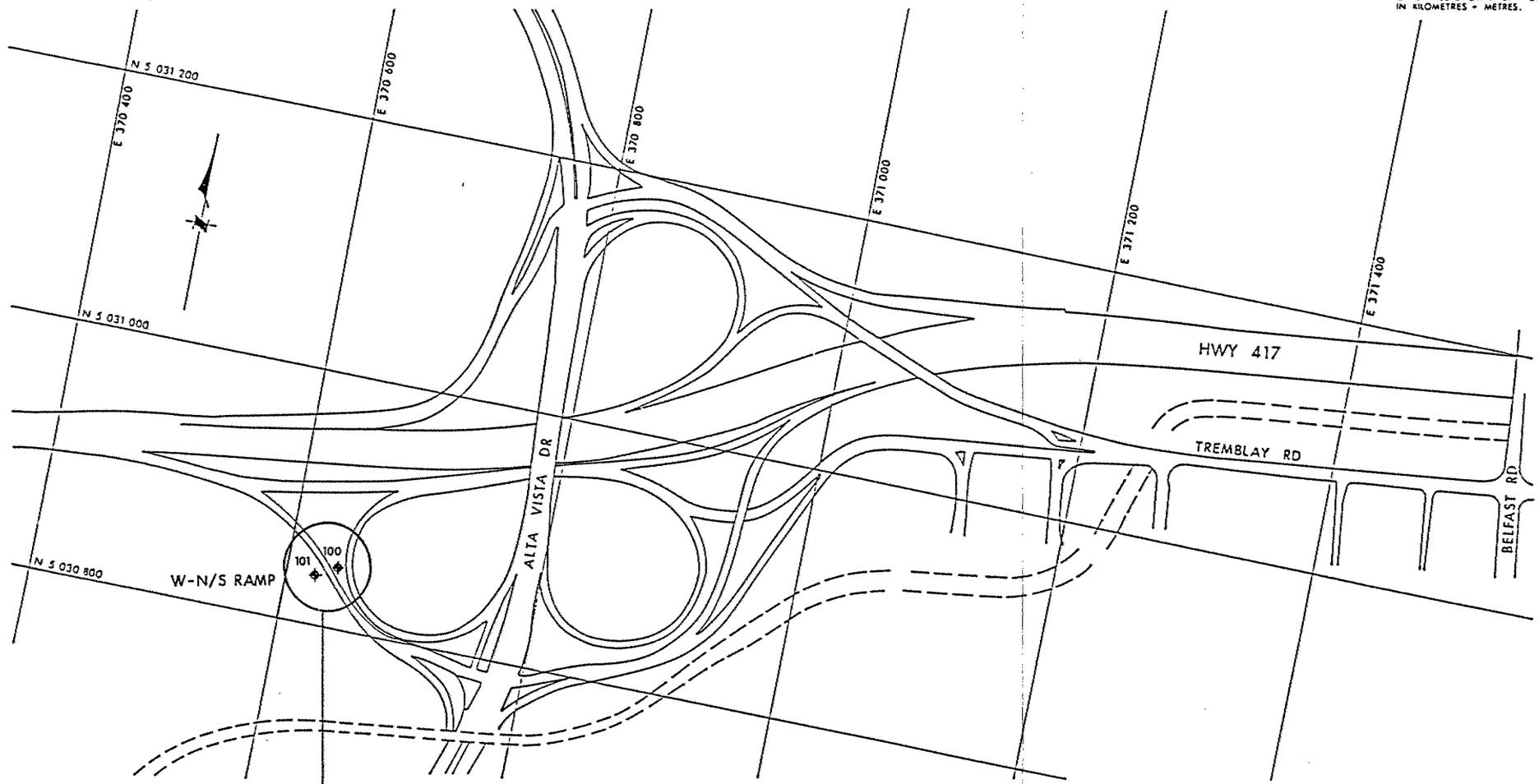
MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO PH-D-707 12 01

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

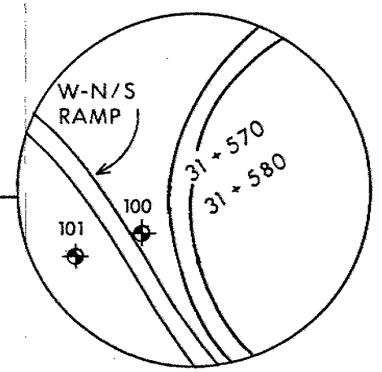
CONT No
WP No 43-79-01

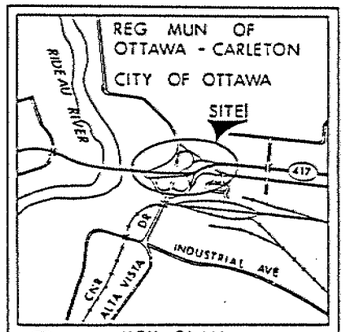
HWY 417 & ALTA VISTA DR
OVERHEAD SIGN
BORE HOLE LOCATIONS

SHEET



PLAN
SCALE
40m 20 0 40m





KEY PLAN
SCALE
0.5km 0 0.5 1.0km

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)
- WL at time of investigation 86 08

No	ELEVATION	STATION	OFFSET
100	59.7	31+577.0	7.0m Lt
101	59.0	31+574.2	11.0m Rt

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

Geocres No 31G5-144

HWY No 417	DIST 9
SUBM'D LP CHECKED	DATE 86 10 09 SITE
DRAWN DT CHECKED	APPROVED DWG 437901-8