

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 40P1-81

DIST. 4 REGION

W.P. No. 280-88-01

CONT. No. 89-61

W. O. No.

STR. SITE No.

HWY. No. 403

LOCATION Garden Ave Culvert

No of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FOUNDATION INVESTIGATION REPORT

CONTRACT NO 89-61



Ministry of
Transportation and
Communications

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Note: For the purpose of this contract this report supercedes all other foundation reports prepared by or for the Ministry in connection with the above-noted project.

EXPLANATION OF TERMS USED IN REPORT

2

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m^2	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

Foundation Investigation Report
For
Garden Avenue Culvert
0.2 km North of Hwy. # 2
W.P. 280-88-01, Site
Hwy. 403, District 4, Burlington

INTRODUCTION

This report contains the results of a foundation investigation carried out for the proposed Garden Avenue Culvert, during the period of 1988 02 17-25. The fieldwork consisted of four sampled boreholes and four dynamic cone penetration tests. The borings were advanced by employing a continuous flight auger machine, mounted on an all-terrain vehicle and equipped with 82 mm I.D. hollow stem augers.

SITE DESCRIPTION

The structure site is located north of Hwy. #403 on Garden Avenue, in the Township of Brantford, some 0.2 km North of Hwy 2 .

The surrounding terrain is relatively flat, cultivated agricultural land with a depression towards the proposal site.

SUBSURFACE CONDITIONS

General

Uniform subsoil conditions were found to exist across the site in general. Apart from the existing Garden Avenue roadway material, the subsoil consists of a deep deposit (21 - 22 m) of stratified silty clay with traces of sand followed by dolomite type bedrock. The boundary between the overburden and bedrock, together with the field and laboratory test results are shown on the Record of Borehole Sheets contained in the Appendix. The stratigraphical profile shown on Drawing No. 2808801-A is based on this information. The drawing also shows the locations and elevations of the borings. A detailed description of the encountered subsurface conditions is given below.

Silty Clay Trace of Sand

This stratum was intersected in all borings and extends from immediately below the ground surface to the bedrock for a depth of about 21-22 m. The material in the deposit is stratified and classified as silty clay with traces of sand. The stratification is rather random

- 2 -

and ranges in thickness from 5 mm to about 50 mm. The plasticity of the respective layers varies from low to medium. Occasional silt seams were also observed throughout the stratum. The Atterberg Limit test results for the overall deposit are plotted on the plasticity chart (Figure 1). The consistency of the stratum varies randomly from firm to very stiff. This assessment is based on a number of field vane and laboratory unconfined tests. Physical properties from field and laboratory tests are summarized below:

	<u>Range</u>
Natural Moisture Content (w)	13 - 36%
Liquid Limit (W_L)	17 - 43%
Plastic Limit (W_p)	11 - 22%
Undrained Shear Strength (C_u)	
Unconfined	18 - 58 kPa
Field Vane	19 - Over 100 kPa
Unit Weight (γ)	19.1 - 19.8 KN/m ³
Sensitivity (Based on field vane tests)	2 - 4

Bedrock

Bedrock was encountered at depths of about 21 - 22 m below ground level and consists of moderately fractured, hard, light grey to white dolomite.

Groundwater Conditions

The following groundwater levels were observed at the boring locations:

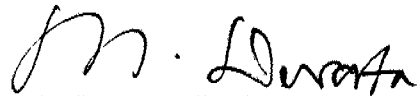
- B.H. #1 - Elevation 205.1 (7 days after the completion of drilling)
- B.H. #2 - Elevation 205.3 (2 days after the completion of drilling)
- B.H. #3 - Elevation 204.7 (2 days after the completion of drilling)
- B.H. #4 - Elevation 203.3 (N.A.)

It is pointed out that the subsoil is relatively impermeable therefore, a considerable time is required for the water levels to stabilize.

For design and construction purposes, it should be assumed that the groundwater level at this site is probably at Elevation 206±. Seasonal changes may also influence the groundwater levels.



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


M. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX

RECORD OF BOREHOLE No 1

METRIC

W P 280-88-01 LOCATION Sta. 10 + 280.0 16 m Left of Garden Avenue ORIGINATED BY GB
 DIST 4 HWY 403 BOREHOLE TYPE Cone Test, Hollow Stem Auger COMPILED BY GB
 DATUM Geodetic DATE 88 02 29 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100				
205.7	Ground Surface															
0.0																
			1	SS	8											0 20 (80)
			2	SS	8											
	Silty Clay		3	SS	16											
			4	SS	4											
	Stratified		5	SS	5											
	Trace of Sand		6	SS	8											
			7	SS	6											
	Occasional		8	SS	6											
	Silt Seams															
			9	SS	2											
	Firm		10	TW	PM											
	to		11	SS	4											
	Stiff															
			12	SS	5											
			13	SS	5											
			14	SS	9											
			15	SS	15											
			16	SS	9											
184.2			17	SS	60/	15 cm										
21.5	Moderately Fractured		18	RC	REC											
183.1	Dolomite Bedrock		19	BXL	100%											
22.6	End of Borehole															

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 2

METRIC

W P 280-88-01 LOCATION Sta. 10 + 266.0 10 m Right of Garden Avenue ORIGINATED BY DG
 DIST 4 HWY 403 BOREHOLE TYPE Cone Test, Hallow Stem Auger COMPILED BY GB
 DATUM Geodetic DATE 88 03 01 CHECKED BY _____

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100	20 40 60 80 100	W _p	W	W _L		
205.9	Ground Surface												
0.0													
	Silty Clay		1	SS	5								
			2	SS	10								
			3	SS	8								
			4	SS	3								
	Stratified		5	SS	5								
	Trace of Sand		6	SS	9								0 0 66 34
			7	SS	8								
	Occasional		8	SS	5								
	Silt Seams		8b	TW	PH							19.1	
			9	SS	6								
	Firm to Stiff		10	SS	8								
			11	SS	7								
			12	SS	8								0 0 (100)
			13	SS	8								
			14	SS	13								
183.6			15b	SS									
22.3	Refusal Probable Bedrock End of Borehole		15a	SS	69								

OFFICE REPORT ON SOIL EXPLORATION

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

RECORD OF BOREHOLE No 3

METRIC

W P 280-88-01 LOCATION Sta. 10 + 282.0 44 m Left of C Garden Avenue ORIGINATED BY DG
 DIST 4 HWY 403 BOREHOLE TYPE Cone Test, Hollow Stem Auger COMPILED BY GB
 DATUM Geodetic DATE 88 03 01 CHECKED BY GB

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa O UNCONFINED + FIELD VANE • QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE								
205.8	Ground Surface											
0.0												
	Silty Clay		1	SS	6							
			2	SS	8							
			3	SS	12							
			4	SS	4							
	Stratified Trace of Sand		5	SS	5							
			6	SS	5							
	Occasional Silt Seams		7	SS	15							
			8	SS	7							
			8b	TW	PH							
	Firm to Stiff		9	SS	4							
			10	SS	6							
			11	SS	2							
			12	SS	7							
			13	SS	5							
			14	SS	7							
184.5												
21.3	Refusal Probable Bedrock End of Borehole											

+³, x⁵: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

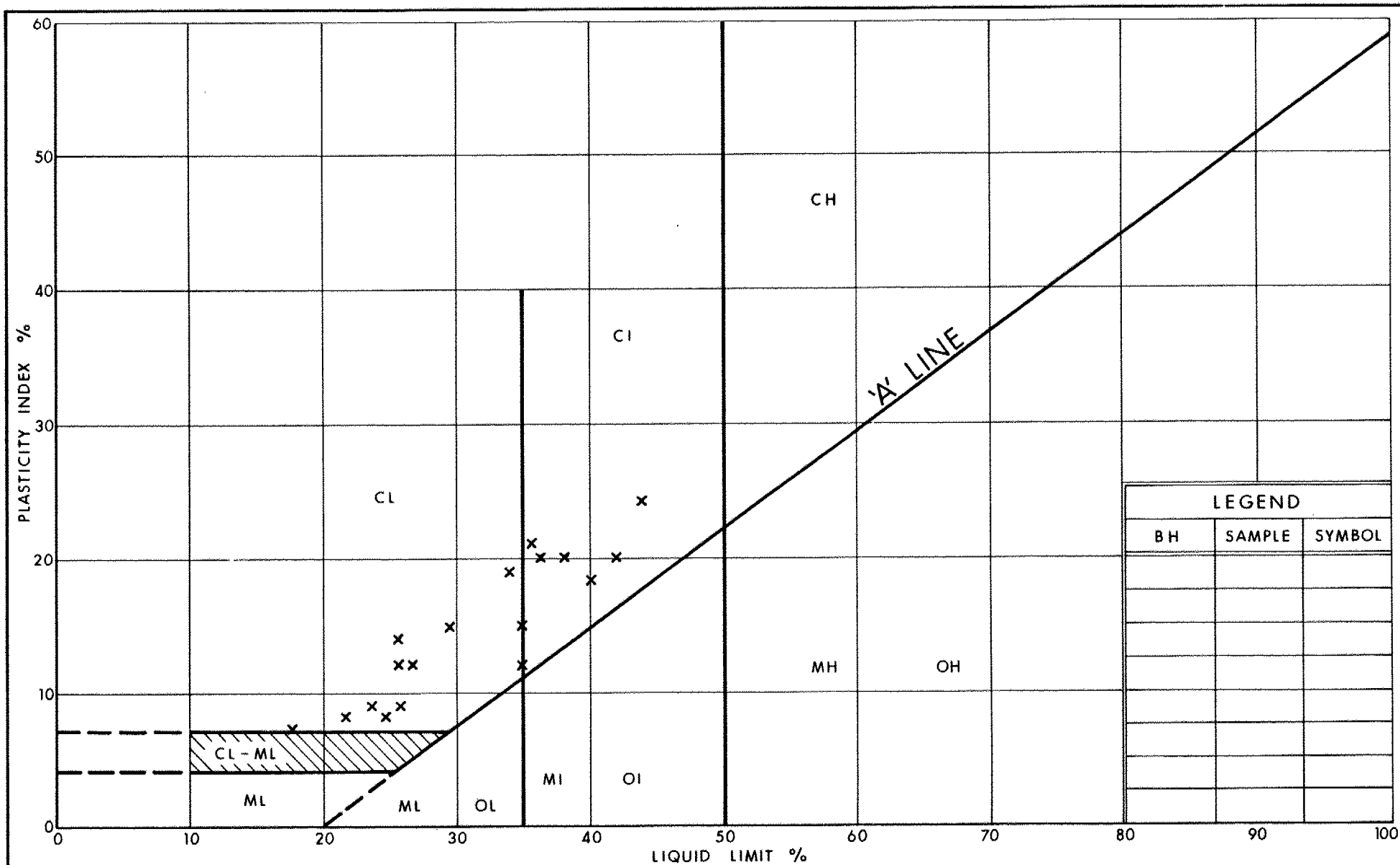
RECORD OF BOREHOLE No 4

METRIC

W P 280-88-01 LOCATION Sta. 10 + 2740 32 m Right of Garden Avenue ORIGINATED BY DC
 DIST 4 HWY 403 BOREHOLE TYPE Cone Test, Hollow Stem Auger COMPILED BY GB
 DATUM Geodetic DATE 88 03 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 W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
205.5	Ground Surface										
0.0											
	Silty Clay		1	SS	12		206	Frozen			
			2	SS	13						
			3	SS	8						
	Stratified Trace of Sand		4	SS	8		204				
			5	SS	12						
			6	SS	7		202				
			7	SS	13						
	Occasional Silt Seams		8	SS	12		200				
			9	SS	12						
			9b	TW	PH		198				
			10	SS	12						
	Firm to Stiff		11	SS	9		196				
			12	SS	8		194				
			13	SS	7		192				
			14	SS	8		190				
			15	SS	12		188				
184.1	Trace of Gravel		16	SS	13		186				
22.4	Moderately Fractured		17	RC	BXL	REC 100%	184				
182.8	Dolomite Bedrock										
23.7	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION



ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

280-98-01

WP ~~66-67-08~~

DIST 4

HWY 403

STR SITE

Garden Avenue Culvert
7.8 km East of Hwy. #2

DISTRIBUTION

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Foundation Investigation Report
For
Garden Avenue Culvert
7.8 km East of Hwy. #2
W.P. ~~66-67-08~~, Site *260-88-01*
Hwy. 403, District 4, Burlington

INTRODUCTION

This report contains the results of a foundation investigation carried out for the proposed Garden Avenue Culvert, during the period of 1988 02 17-25. The fieldwork consisted of four sampled boreholes and four dynamic cone penetration tests. The borings were advanced by employing a continuous flight auger machine, mounted on an all-terrain vehicle and equipped with 82 mm I.D. hollow stem augers.

SITE DESCRIPTION

The structure site is located north of Hwy. #403 on Garden Avenue, in the Township of Brantford, some 7.8 km east of Highway 2.

The surrounding terrain is relatively flat, cultivated agricultural land with a depression towards the proposal site.

SUBSURFACE CONDITIONS

General

Uniform subsoil conditions were found to exist across the site in general. Apart from the existing Garden Avenue roadway material, the subsoil consists of a deep deposit (21 - 22 m) of stratified silty clay with traces of sand followed by dolomite type bedrock. The boundary between the overburden and bedrock, together with the field and laboratory test results are shown on the Record of Borehole Sheets contained in the Appendix. The stratigraphical profile shown on Drawing No. 666708-A is based on this information. The drawing also shows the locations and elevations of the borings. A detailed description of the encountered subsurface conditions is given below.

Silty Clay Trace of Sand

This stratum was intersected in all borings and extends from immediately below the ground surface to the bedrock for a depth of about 21-22 m. The material in the deposit is stratified and classified as silty clay with traces of sand. The stratification is rather random

and ranges in thickness from 5 mm to about 50 mm. The plasticity of the respective layers varies from low to medium. Occasional silt seams were also observed throughout the stratum. The Atterberg Limit test results for the overall deposit are plotted on the plasticity chart (Figure 1). The consistency of the stratum varies randomly from firm to very stiff. This assessment is based on a number of field vane and laboratory unconfined tests. Physical properties from field and laboratory tests are summarized below:

	<u>Range</u>
Natural Moisture Content (w)	13 - 36%
Liquid Limit (W_L)	17 - 43%
Plastic Limit (W_p)	11 - 22%
Undrained Shear Strength (Cu)	
Unconfined	18 - 58 kPa
Field Vane	19 - Over 100 kPa
Unit Weight (γ)	19.1 - 19.8 KN/m ³
Sensitivity (Based on field vane tests)	2 - 4

Bedrock

Bedrock was encountered at depths of about 21 - 22 m below ground level and consists of moderately fractured, hard, light grey to white dolomite.

Groundwater Conditions

The following groundwater levels were observed at the boring locations:

- B.H. #1 - Elevation 205.1 (7 days after the completion of drilling)
- B.H. #2 - Elevation 205.3 (2 days after the completion of drilling)
- B.H. #3 - Elevation 204.7 (2 days after the completion of drilling)
- B.H. #4 - Elevation 203.3 (N.A.)

It is pointed out that the subsoil is relatively impermeable therefore, a considerable time is required for the water levels to stabilize.

For design and construction purposes, it should be assumed that the groundwater level at this site is probably at Elevation 206±. Seasonal changes may also influence the groundwater levels.

DISCUSSION AND RECOMMENDATIONS

It is proposed to construct a 6.1 x 3 m, 73 m long concrete culvert at this location. The profile grade of Garden Avenue is set at Elev. 214.5 some 8.5 m above the average ground level at the culvert location. The subsoil at the site was found to consist of a 21 - 22 m deep, firm to stiff, stratified silty clay and followed by dolomite type bedrock.

Structure Foundation

The encountered subsurface conditions (low bearing capacity and settlement considerations) do not favour spread footing type foundations. Therefore, piled foundations are recommended. End-bearing steel 'H' piles driven to bedrock (El. 184±) appear to be the most practical solution. The pile tips should be reinforced with driving shoes. The maximum allowable load for the particular section chosen may be assumed for design purposes: 1150 kN (HP 310 x 110) and 900 kN (HP 310 x 79).

For the purposes of the O.H.B.D.C. the following values are recommended.

	HP 310 x 110	HP 310 x 79
Factored Capacity at U.L.S.	1600 kN	1150 kN
Capacity at U.L.S. Type II	1150 kN	900 kN

Earth pressures should be computed as per Subsection 6.6.1.2.1 of the code. Yielding foundation conditions should be considered to apply.

The Granular 'A' or 'B' backfill should be in accordance with the latest revision of Special Provision No. 121. The following parameters are recommended for the granular backfill.

	Gran. 'A'	Gran. 'B'
Angle of Internal Friction:	$\phi = 35^\circ$	$\phi = 30^\circ$
Unit Weight (kN/m^3):	$\gamma = 22.8$	$\gamma = 21.2$

Approach Embankments

Up to 8.5 m high fills will be required to realize the proposed profile grade. Stability analyses in terms of total stresses have

indicated that half height berms are required to prevent any rotational failure induced by the weight of the fill material. It is our understanding that the embankment height may be reduced to a certain elevation.

The berm length requirements are as follows:

<u>Fill Height</u>	<u>Berm Length</u>
5.5 m	0 m
6.0 m	2.0 m
7.0 m	5.5 m
8.0 m	8.5 m
9.0 m	12.5 m
10.0 m	18.0 m

The material in the embankment should consist of well compacted acceptable material and should be placed in accordance with Special Provision No. 120.17.

The slopes of the embankment (core and berm) should not be steeper than 2H : 1V.

The silty clay subsoil will settle due to the superimposed embankment loading. The magnitude of the settlements for different embankment heights are as follows:

<u>Fill Height (m)</u>	<u>Settlement (m)</u>
3.0	0.18
5.0	0.27
7.0	0.34
9.0	0.40
10.0	0.47

The settlement will take place over a long period of time. In order to minimize the effect of these settlements on the performance of the pavement, it is recommended that the approach embankments be built in advance of the final grading and paving for as long a period as possible.

Other Considerations

The pile caps should be located not less than 1.2 m below finished ground level so as to provide for frost protection.

The concrete for the pile caps should be formed 'in the dry'. No major dewatering problems are anticipated due to the relatively impermeable nature of the subsoil. Topsoil and/or any soft surficial material should be removed in accordance with current M.T.O. practices.

If any of the existing footings interfere with the new piling, they should be removed to their full extent.

The proposed culvert should be designed and constructed according to current M.T.O. standards.

Miscellaneous

The fieldwork for this project was supervised by Mr. D. Green, Trainee Engineer and by Mr. G. Beauchesne, Co-op Student. The equipment used was owned and operated by Master Soil Investigation Ltd. This report was written by Mr. P. Payer with the assistance of G. Beauchesne and reviewed by Mr. K.G. Selby.



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

for M. G. Selby
for K.G. Selby, P. Eng.
Chief Foundation Engineer
(West)

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

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_f	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

STRESS AND STRAIN

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

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{\min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $\frac{w_L - w_p}{w - w_p}$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{\max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m^2	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

RECORD OF BOREHOLE No 1

METRIC

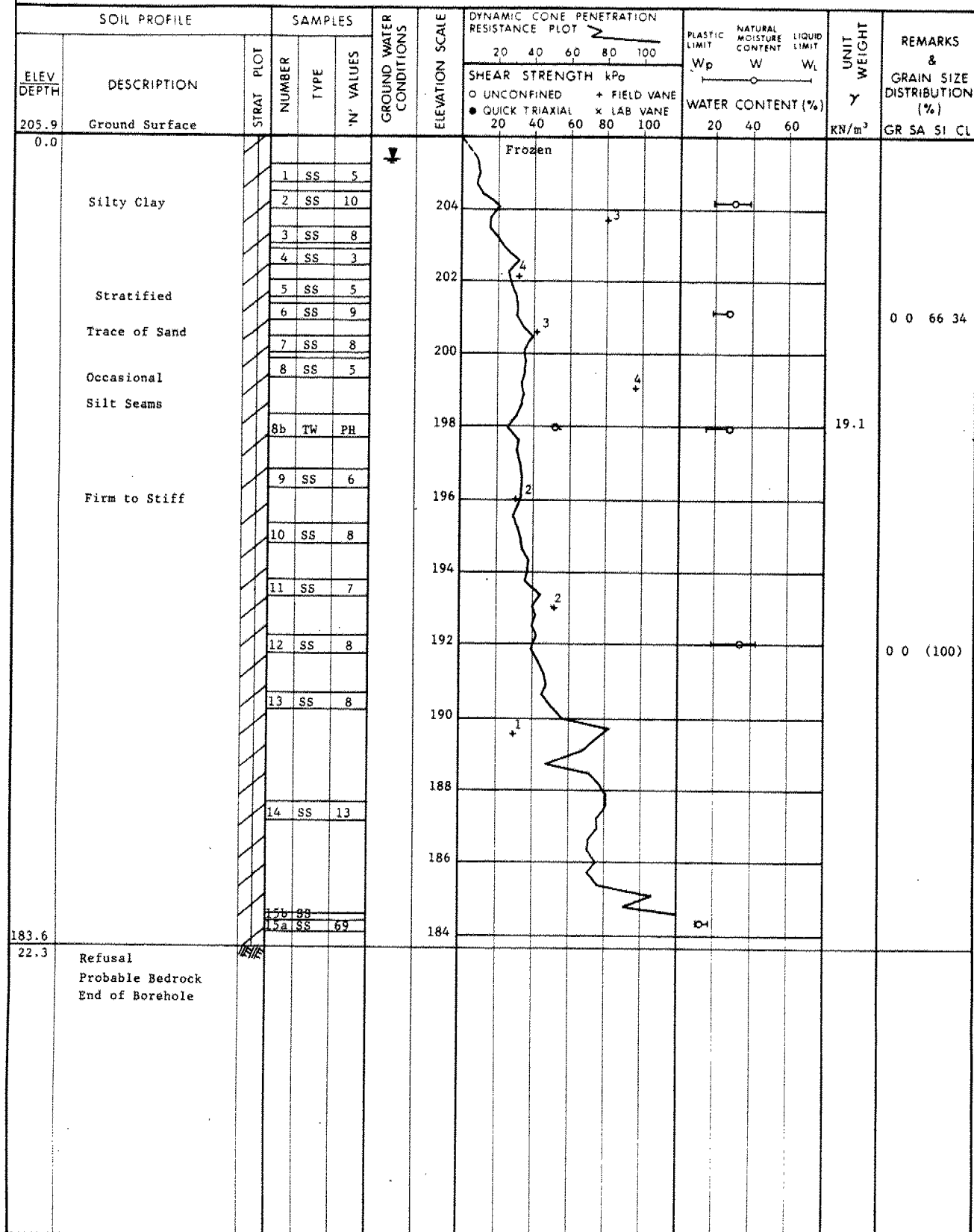
W P 66-67-08 LOCATION Sta. 10 + 280.0 16 m Left of Garden Avenue ORIGINATED BY GB
DIST 4 HWY 403 BOREHOLE TYPE Cone Test, Hollow Stem Auger COMPILED BY GB
DATUM Geodetic DATE 88 02 29 CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20 40 60 80 100	20 40 60 80 100					
205.7	Ground Surface												
0.0													
	Silty Clay		1	SS	8								0 20 (80)
			2	SS	8								
	Stratified		3	SS	16								
	Trace of Sand		4	SS	4								
			5	SS	5								
	Occasional Silt Seams		6	SS	8								
			7	SS	6								
			8	SS	6								
	Firm to Stiff		9	SS	2								
			10	TW	PM							19.8	0 5 71 24
			11	SS	4								
			12	SS	5								
			13	SS	5								
			14	SS	9								
			15	SS	15								
			16	SS	9								0 0 (100)
184.2			17	SS	60/15 cm								
21.5	Moderately Fractured		18	RC	REC								
183.1	Dolomite Bedrock		19	BXL	100%								
22.6	End of Borehole												

RECORD OF BOREHOLE No 2

METRIC

W P 66-67-08 LOCATION Sta. 10 + 266.0 10 m Right of Garden Avenue ORIGINATED BY DG
 DIST 4 HWY 403 BOREHOLE TYPE Cone Test, Hallow Stem Auger COMPILED BY GB
 DATUM Geodetic DATE 88 03 01 CHECKED BY



RECORD OF BOREHOLE No 3

METRIC

W P 66-67-08 LOCATION Sta. 10 + 282.0 44 m Left of C Garden Avenue ORIGINATED BY DG
 DIST 4 HWY 403 BOREHOLE TYPE Cone Test, Hollow Stem Auger COMPILED BY GB
 DATUM Geodetic DATE 88 03 01 CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	VALUES		20 40 60 80 100	20 40 60 80 100	W _p	W	W _L		
205.8	Ground Surface												
0.0													
	Silty Clay		1	SS	6								
			2	SS	8								
	Stratified		3	SS	12								
	Trace of Sand		4	SS	4								
			5	SS	5								
	Occasional		6	SS	5								
	Silt Seams		7	SS	15								
			8	SS	7								
			8b	TW	PH								
	Firm to Stiff		9	SS	4							19.7	
			10	SS	6								
			11	SS	2								
			12	SS	7								
			13	SS	5								
			14	SS	7								
184.5													
21.3	Refusal Probable Bedrock End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION

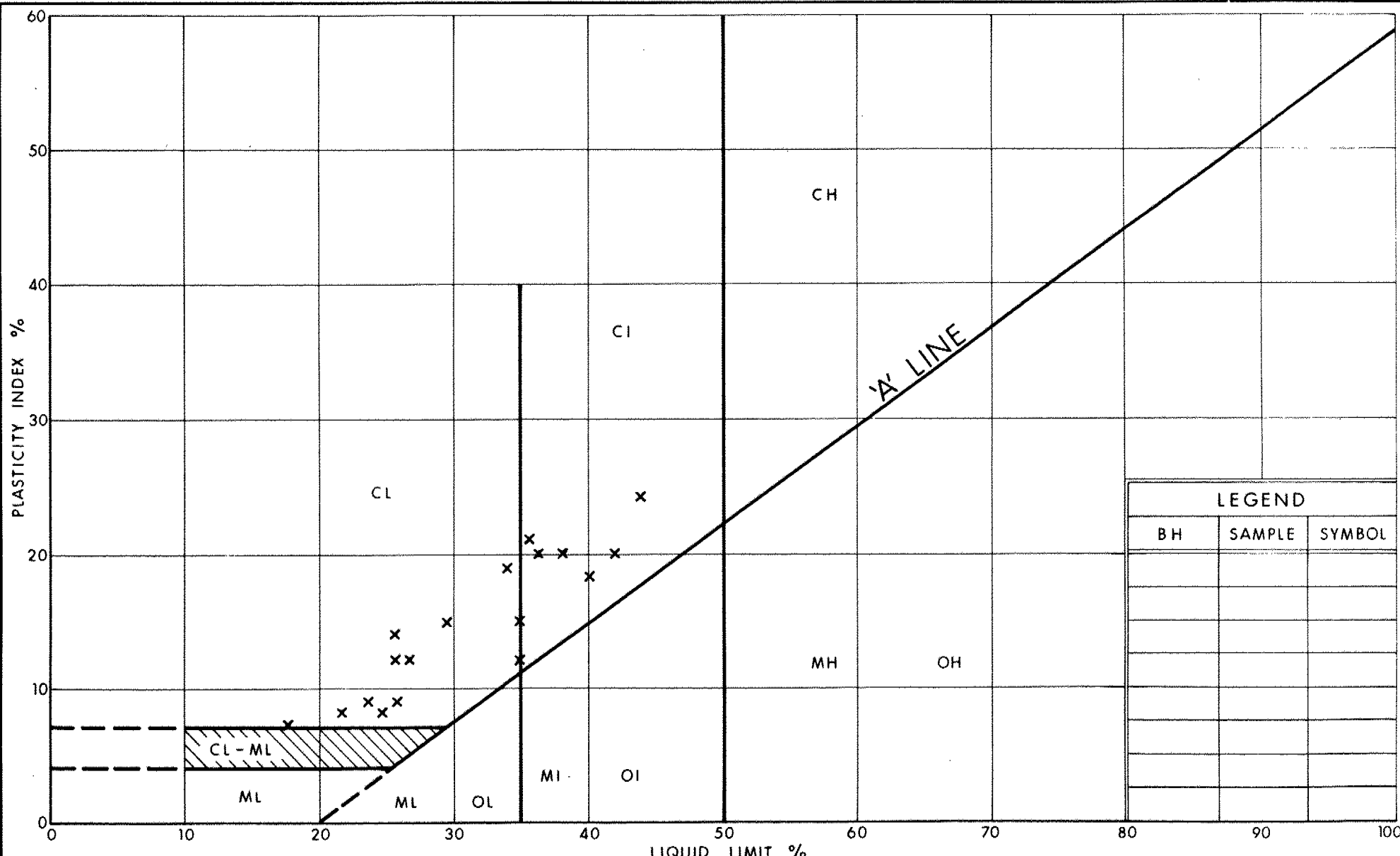
RECORD OF BOREHOLE No 4

METRIC

W P 66-67-08 LOCATION Sta. 10 + 2740 32 m Right of E Garden Avenue ORIGINATED BY DG
DIST 4 HWY 403 BOREHOLE TYPE Cone Test, Hollow Stem Auger COMPILED BY CB
DATUM Geodetic DATE 88 03 01 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				NATURAL MOISTURE CONTENT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	W _p	W	W _L		
205.5	Ground Surface															
0.0																
			1	SS	12		206	Frozen								
			2	SS	13											
			3	SS	8											
			4	SS	8											
			5	SS	12											
			6	SS	7											
			7	SS	13											
			8	SS	12											
			9	SS	12											
			9b	TW	PH											
			10	SS	12											
			11	SS	9											
			12	SS	8											
			13	SS	7											
			14	SS	8											
			15	SS	12											
			16	SS	13											
			17	RC BXL	REC 100%											
184.1	Trace of Gravel															
22.4	Moderately Fractured															
182.8	Dolomite Bedrock															
23.7	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION



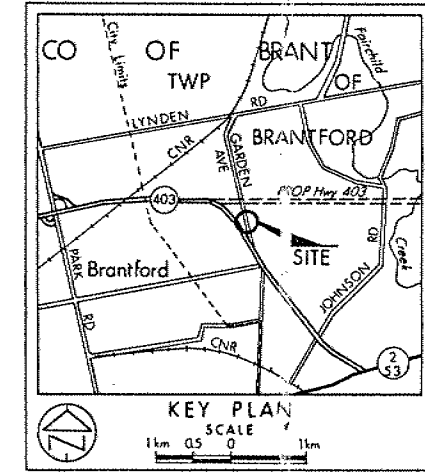
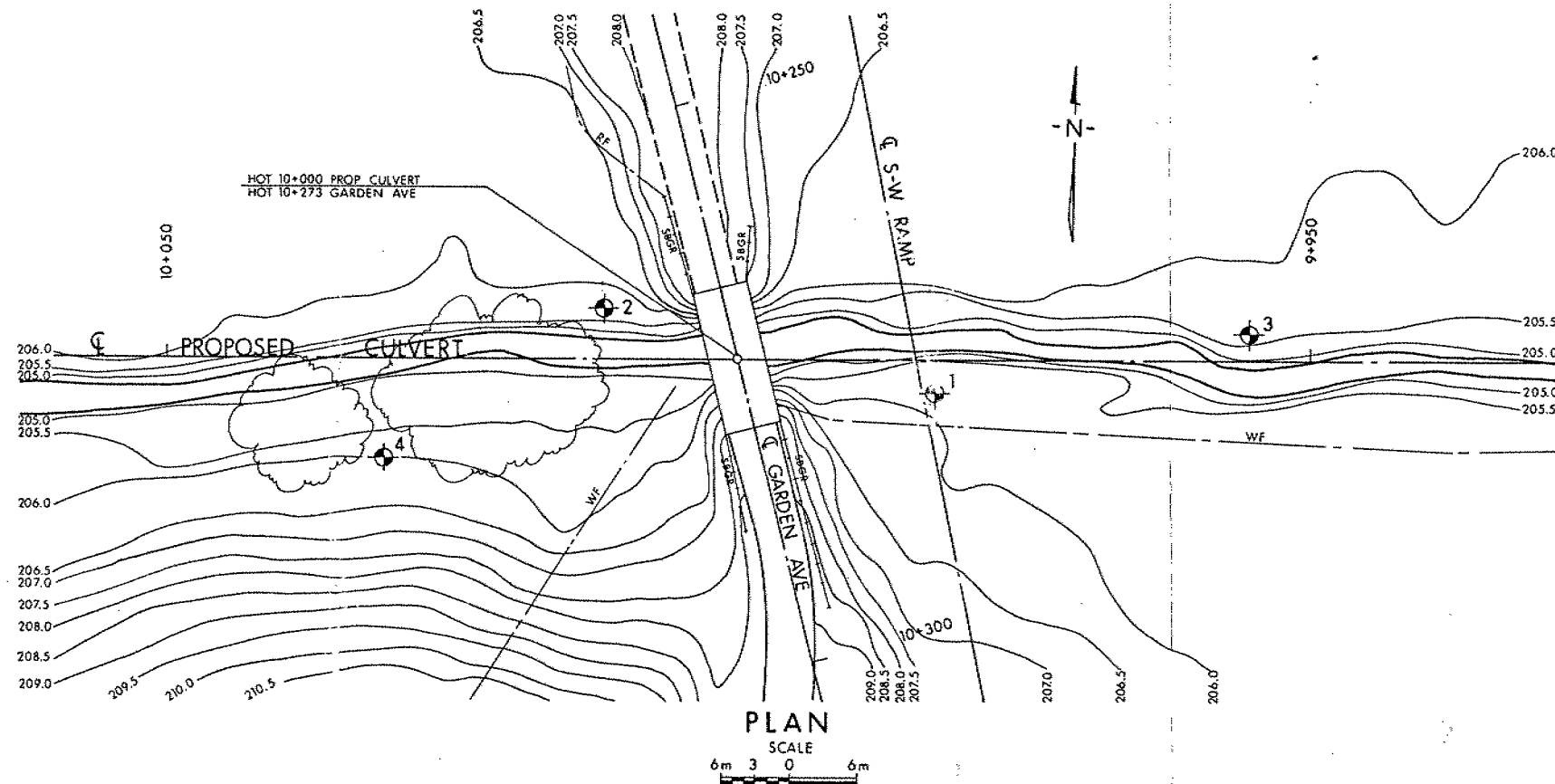
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.

CONT No
WP No 66-67-08



GARDEN AVE - CULVERT
BORE HOLE LOCATIONS & SOIL STRATA

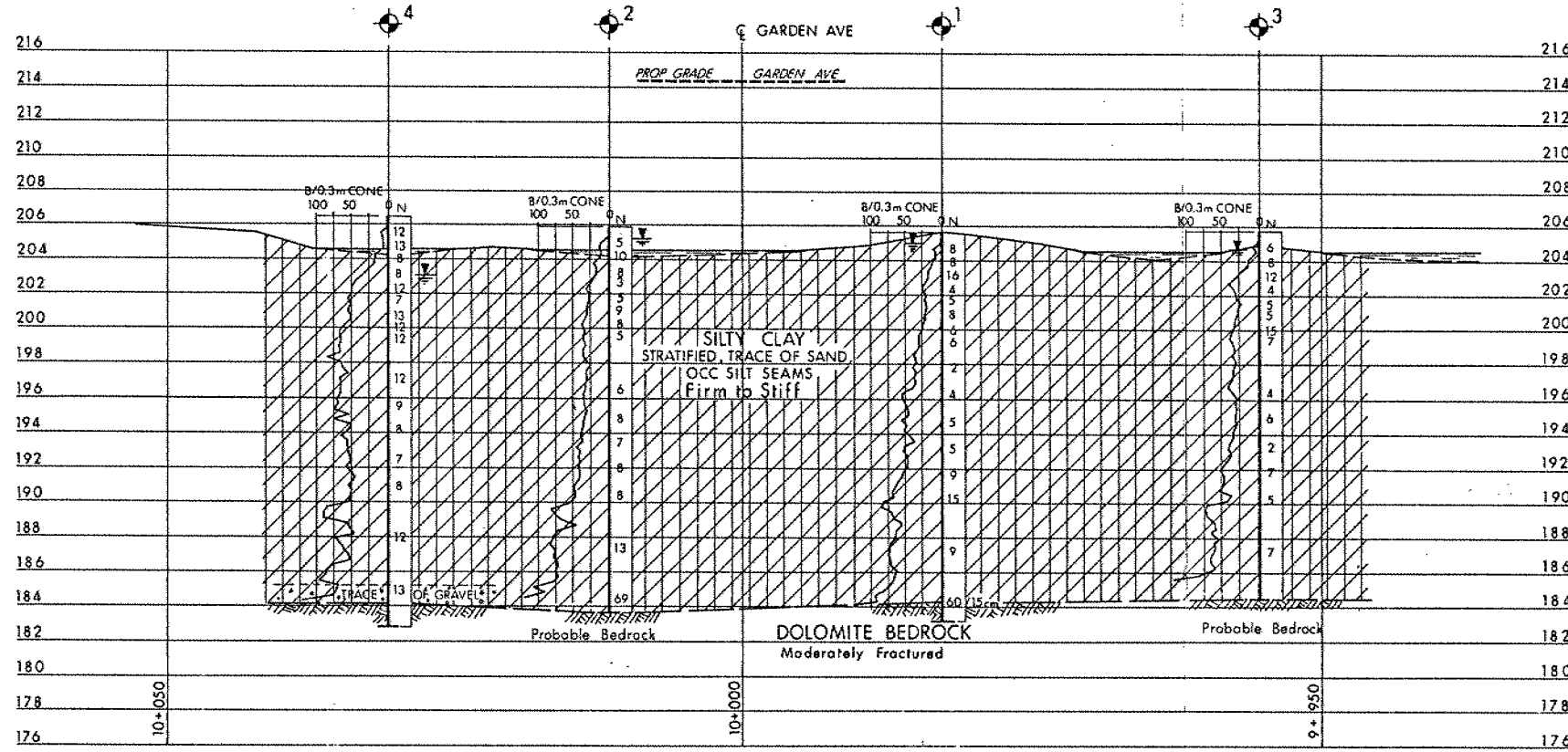
SHEET



LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊙ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation 88 02 & 03

No	ELEVATION	STATION	OFFSET
1	205.7	10+280.0	16.0 m LT
2	205.9	10+260.0	10.0 m RT
3	205.8	10+282.0	44.0 m LT
4	206.5	10+274.0	32.0 m 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 40P1-81

HWY No 403	DIST 4
SUBMD PP CHECKED	DATE 1988 05 20
DRAWN SO CHECKED	APPROVED
	DWG 666708-A