

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 30M4-69

DIST. 4 REGION

W.P. No. 318-89-00 (B)

CONT. No. 91-83
(see also: 92-46)

W. O. No.

STR. SITE No. 36-324C
36-325C
36-326C
36-327C

HWY. No. Q.E.W.

LOCATION Hwy 20 to Pineland Ave

No. of PAGES -

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

REMARKS:

G.I.-30 SEPT. 1976

FOUNDATION INVESTIGATION REPORT

CONTRACT NO 91-83



Ministry of
Transportation

INDEX

<u>Page No.</u>	<u>DESCRIPTION</u>
1	Index
2	Abbreviations & Symbols
3 - 19	Foundation Investigation Report for Proposed Culverts & Culvert Extensions W.P.318-89-00(B) Site 36-324C to 36-327C Hwy. Q.E.W. District 4, Burlington

Note: For purposes of the contract, this report supersedes all other Foundation Reports prepared by, or for the Ministry in connection with the above-mentioned project.

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

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

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

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

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

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

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

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

JOINTING AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

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

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

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

W.P. 318-89-00 (B)
Proposed Culverts and Culvert Extensions
Hwy Q.E.W., District 4, Burlington

SITE DESCRIPTION AND GEOLOGY

The site is located at Hwy Q.E.W. and north of Q.E.W. in a private property (The Confederation Park) between Hwy. 20 and Grays Road. This section of the Q.E.W. is located within the Town of Stoney Creek in the Regional Municipality of Hamilton - Wentworth.

The Q.E.W. in this area follows the shoreline of Lake Ontario and lies mainly in the "Iroquois Plain" physiographic Region. The Iroquois Plain is generally composed of fairly shallow sandy materials deposited in the bed of Lake Iroquois. The area is also referred to as the Niagara Fruit Belt (Reference: Champman and Putnam, "The physiography of Southern Ontario; 3rd Edition, 1984).

The bedrock at this site is Shale of Queenston Formation. The depth of bedrock at this site is in the range of 10m or deeper below the ground surface.

FIELD AND LABORATORY WORK

A foundation investigation for the Stoney Creek culvert extension (Station 22+400) was conducted during 90 07 16 and 90 07 18. On 90 08 16 another request was received from the Structural Section (Central Region) for an additional four new culverts (Culverts 1, 2, 3 and 7).

The additional field work was conducted between 90 10 23 and 90 10 29 and consisted of drilling nine (9) boreholes. Continuous flight auger machines equipped with 82 mm ID hollow-stem augers were used to drill boreholes 102, 106, 107, 108 and 110. Since boreholes 101, 103, 104 and 105 were located in either swamp or in a water pond, a CME 45 skid mounted drilling machine equipped with 82mm ID hollow stem auger was used to drill those boreholes from a raft. Four (4) boreholes were accompanied by cone tests.

The boreholes are identified as 101 through 108, 110, C1 and C2. All boreholes except Borehole C1 were either terminated in overburden or at probable bedrock. Bedrock was proved in Borehole C1 by obtaining bedrock core.

Survey details were provided by the Central Region Surveys & Plans Section.

The sampling program consisted of split spoon samples collected at 0.8m to 1.5m intervals. They provided Standard Penetration Test (N) values for assessment of the in-situ state of compaction of the non-cohesive materials, and for an indication of shear strength of cohesive material. These samples also provided material for identification purposes.

The laboratory testing program for representative samples consisted of:

- Grain size analyses
- Natural Moisture Content determinations, and
- Atterberg Limit determination.

The lab results are shown on the attached log sheets.

SUBSURFACE CONDITIONS:

The record of borehole sheets in the Appendix illustrate the subsurface conditions and the ground surface elevations at the borehole locations. The locations of the boreholes are shown on Drawing No. 3188900B-A.*

The subsurface conditions at the site are quite variable. All boreholes encountered cohesive glacial till at depths ranging from 1.4m to 9.5m below ground surface. Due to the presence of swamps at proposed culverts 1,2 and 3 and due to the construction of highways the soil above till material is variable and consists of fill, organic silt or peat materials.

* SHEET NO 21-1 OF THE CONTRACT DWG'S

Following are the brief soil description at each culvert location. For details of soil conditions at each location, borehole logs should be referred to.

Site A (Culvert 1)

Three boreholes, Boreholes 101, 102 and 103 were advanced at this location. Borehole 101 was drilled on the north side of the proposed culvert in a pond, Borehole 102 was located approximately at the middle of the culvert, and Borehole 103 on the south side of the proposed culvert in a swamp. In Boreholes 101 and 103 very soft organic clayey silt to organic silty clay with peat layers was encountered to depths 3.0m and 2.4m (Elev. 73.1m to 73.9) below pond and swamp surface respectively. This deposit had very low strength in the upper portion and the auger and spoon sank in the upper 1.5m to 2m. Standard penetration N-values achieved in the lower portion of the deposit was 1 blow/0.3m. In Borehole 101 the organic deposit was underlain by a 1.2m thick loose silty sand stratum which was underlain by silty clay till. In Borehole 103 the organic deposit was directly underlain by silty clay till.

Borehole 102 encountered a 3.7m thick silty sand fill with a thin layer of fibrous peat at the bottom. The fill was underlain by silty clay glacial till. Standard Penetration, N-value achieved in the fill material ranged from 2 blows to 14 blows/0.3m. The value decreased with depth. Based on N-value the fill was found to be very loose to compact.

A cohesive glacial till was encountered in all three boreholes at depths ranging from 2.4m to 4.5m (Elevation 71.6m to 74.1m). The Standard penetration, N-value, ranged from 3 blows to 51 blows/0.3m. The lower N-values were occasional, and generally the N-value ranged from 17 to 29 blows/0.3m which suggest that the material is very stiff.

Site B (Culvert 2 & 3)

Four boreholes were drilled at this site. Boreholes 104 and 105 were advanced in a swamp on the north side of the proposed culvert. Borehole 106 was drilled between the centre and the south side of the culvert and Borehole 107 was advanced on the south side of the proposed culvert. Boreholes 104 and 105 encountered organic silty clay to depths 2.5m and 3.2m respectively (elevations 72.8m to 73.5m) below the swamp surface. In Borehole 104 the organic deposit had very low strength and the split spoon sank with the weight of the A-rod. In Borehole 105 Standard Penetration resistance was in the range of 2 blows to 6 blows/0.3m. Based on the SPT results the consistency of the deposit is very soft to firm. The organic deposit was underlain by silty clay till.

At Boreholes 106 and 107, a cohesive fill extends 1.4m to 2.1m (elevations 77.0m to 78.1m) below the ground surface. The fill consisted of silty clay material. Standard Penetration test, N-values ranged from 19 to 27 blows/0.3m which suggests that the fill is very stiff.

Underlying the organic material in Boreholes 104 & 105, and fill material in Boreholes 106 and 107, all boreholes encountered a cohesive till. The till consisted of silty clay with traces of sand and gravel. The standard penetration test, N-value ranged from 4 to 64 blows/0.3m which suggests that the till is in firm to hard state. However, the low N-value is occasional, and the more typical N-values ranged from 19 to 28 blows/0.3m which suggests that the till is very stiff.

Site C (Culvert 7 and Stoney Creek Culvert)

Four Boreholes were drilled at this site. The boreholes were designated as Boreholes 108, 110, C1 and C2. Borehole 108 was drilled on the north side and Borehole 110 was drilled on the south side of the proposed Culvert 7. Boreholes C1 and C2 were drilled earlier for Stoney Creek Culvert extensions.

All boreholes encountered fill material as a surficial layer. The fill extended to depths ranging from 2.7m to 5.9m below the ground surface. The fill consisted of silty clay material. In Borehole 108 a 2.9m thick silty clay fill was underlain by a 3m thick non-cohesive silty sand fill. The Standard Penetration Test, N-value recorded in the cohesive fill ranged from 6 to 31 blows/0.3m which suggests a firm to hard but generally firm state, while the non-cohesive fill recorded N-values between 4 to 5 blows/0.3m which suggests loose state.

Underlying the fill material Boreholes 108 and C2 encountered a layer of silty clay which ranged in thickness from 2.6m to 4.4m. A 1m thick coarse sand layer was also encountered underlying the silty clay layer in Borehole 108. Standard Penetration Test, N-value recorded in this stratum ranged from 2 to 13 blows/0.3m. However, low N-values between 2 to 3 blows/0.3m were achieved in Borehole 108 only, which suggests that the consistency of the material at this location is soft. In Borehole C2 the N-value ranged from 10 to 13 blows/0.3m which indicates that the soil is stiff at this location. The silty clay layer was underlain by silty clay till.

A cohesive glacial till was encountered at a depth of 9.5m and 10m below the ground surface (elevation 67.7m to 68m) in Boreholes 108 and C2 respectively, and at depths 1.7m and 2.7m below the ground surface (elevation 74.3) in Boreholes 110 and C1. The glacial till consisted of silty clay with a trace of sand and trace of gravel. The Standard Penetration Test, N-value recorded in this stratum ranged from 12 to 78 blows/0.3m. The more typical N-value ranged from 10 to 15 blows/0.3. This suggests that the consistency of this material is stiff to hard but generally stiff. All boreholes were terminated in this material.

Bedrock was proved in C1 where a 2m long bedrock core was obtained. The bedrock was classified as Shale of Queenston Formation.

MISCELLANEOUS

The field work for this project was carried out under the supervision of Ken Ahmad Foundation Engineer and Marie Josee Roy, Engineering Student. The equipment used was owned and operated by Master Soil Investigation Inc. and Longyear Canada Inc.

This report was written by Ken Ahmad, Foundation Engineer, reviewed by D. Dundas, Senior Foundation Engineer and approved by M. Devata, Chief Foundation Engineer.



Ken Ahmad

Ken Ahmad, P. Eng.
Foundation Engineer

M. Devata

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

APPENDIX

RECORD OF BOREHOLE No 101

1 OF 1

METRIC

W.P. 318-89-00 (B) LOCATION N 4,789,582.0; E 284,127.0 ORIGINATED BY KA
 DIST 4 HWY QEW BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
 DATUM Geodetic DATE 1990 10 29 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER *CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
76.1	Pond Surface																
0.0	Water																W.L. on 1990 10 29
75.5	Pond Bottom																
0.6	Organic Clayey Silt with Fibrous Peat Layers		1	SS	1		75									w=376	
			2	SS	3		74										
72.8	Silty Clay Zone						73										
3.3	Silty Sand Trace Clay, Loose, Grey		3	SS	5		72										1 34 42 23
			4	SS	6		71										
71.6							70										
4.5	Silty Clay Till Trace Sand, Very Stiff, Grey (Glacial Till)		5	SS	23		69										2 15 43 40
			6	SS	23		68										
							67										
66.9			7	SS	27												
9.2	End of Borehole																

RECORD OF BOREHOLE No 102 1 OF 1 METRIC

W.P. 318-89-00 (B) LOCATION N 4,789,562.0; E 284,112.0 ORIGINATED BY KA
 DIST 4 HWY QEW BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
 DATUM Geodetic DATE 1990 10 25 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W _p	W		
77.8	Ground Surface												
0.0	Silty Sand Fill Trace organic, Occ. wood chips Very Loose to Compact Brown to Greyish Brown with Organic Stains		1	SS	14								0 44 43 13
			2	SS	9								
			3	SS	2								
74.1	Fibrous Peat Layer		4	SS	4								
3.7			5	SS	8								
			6	SS	19								1 8 34 57
	Silty Clay Till Trace Sand, Stiff to Very Stiff Brown to Greyish Brown (Glacial Till)		7	SS	29								
			8	SS	25								
68.2			9	SS	26								6 16 41 37
9.6	End of Borehole * W.L. Not Established												

RECORD OF BOREHOLE No 103

1 OF 1

METRIC

W.P. 318-89-00 (8) LOCATION N 4.789,537.0; E 284.096.0 ORIGINATED BY KA
 DIST 4 HWY QEW BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
 DATUM Geodetic DATE 1990 10 29 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER # CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
76.3	Swamp													
0.0	Water						76							W.L. on 1990 10 29
	Organic Silty Clay Very Soft with layers of fibrous Peat		1	SS	PM		75							
73.9			2	SS	1		74							
2.4			3	SS	3		73							0 13 52 35
	Soft V. Stiff		4	SS	26		72							2 13 39 46
	Silty Clay Till Trace Sand, Trace Gravel Brown to Greyish Brown (Glacial Till)		5	SS	17		71							
			6	SS	18		70							
	V. Stiff Hard		7	SS	51		69							
67.3							68							
9.0	End of Borehole													
	PM = Pushed Manually													

RECORD OF BOREHOLE No 104

1 OF 1

METRIC

W.P. 318-89-00 (B) LOCATION N 4,789,441.0; E 284,075.0

ORIGINATED BY KA

DIST 4 HWY QEW BOREHOLE TYPE Hollow Stem Auger

COMPILED BY KA

DATUM Geodetic DATE 1990 10 26

CHECKED BY DD

[illegible]

+3, x3: Numbers refer to Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 105

1 OF 1

METRIC

W.P. 318-89-00 (B) LOCATION N 4,789,408.0; E 284,072.0 ORIGINATED BY KA
 DIST 4 HWY QEW BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
 DATUM Geodetic DATE 1990 10 26 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
76.0	Swamp																
0.0	Organic Silty Clay Occasional Fibrous Peat Layers Trace Sand Soft to Firm, Black		1	SS	2		75										W.L. on 1990 10 26
			2	SS	2		74										
72.8			3	SS	6		73										1 13 56 30
3.2			4	SS	33		72										3 15 40 42
			5	SS	34		71										
	Silty Clay Till						70										2 16 42 40
	Trace Sand, Trace Gravel		6	SS	26		69										
	Very Stiff to Hard						68										
	(Glacial Till)		7	SS	24		67										
66.9			8	SS	67												
9.1	End of Borehole																
	Probable Bedrock																

RECORD OF BOREHOLE No 106

1 OF 1

METRIC

W.P. 318-89-00 (B) LOCATION N 4,789,321.0; E 284,062.0 ORIGINATED BY KA
DIST 4 HWY QEW BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
DATUM Geodetic DATE 1990 10 24-25 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID UNIT MOISTURE CONTENT UNIT			UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W _p W W _L	10 20 30			
78.4	Ground Surface													
0.0	Silty Clay (Possible Fill) Trace Sand, Trace Gravel V. Stiff		1	SS	23	DRY *	78							
77.0			2	SS	19		77							4 22 46 28
1.4			3	SS	7		76							
			4	SS	8		75							
	Silty Clay Till Trace Sand, Trace Gravel Firm to Hard Grey to Brown (Glacial Till)		5	SS	23		74							
			6	SS	19		73							0 14 41 45
			7	SS	25		72							
			8	SS	32		71							
68.8							70							
9.6	End of Borehole						69							

RECORD OF BOREHOLE No 107

1 OF 1

METRIC

W.P. 318-89-00 (B) LOCATION N 4,789,273.0; E 284,057.0 ORIGINATED BY KA
 DIST 4 HWY QEW BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
 DATUM Geodetic DATE 1990 10 24 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
80.2	Pavement																
0.0	Silty Clay Fill, with Sand Very Stiff, Grey		1	SS	27		80										
			2	SS	19		79										
78.1	Silty Clay Till Trace Sand, Trace Gravel Firm to Hard (Glacial Till)		3	SS	13		78										
2.1			4	SS	13		77										1 12 47 40
			5	SS	6		76										
			6	SS	7		75										
			7	SS	19		74										
			8	SS	34		73										
			9	SS	22		72										3 21 44 32
							71										
70.5																	
9.5	End of Borehole • Not Established																

RECORD OF BOREHOLE No 108

1 OF 1

METRIC

W.P. 318-89-00 (B) LOCATION N 4.789,055.0; E 285,087.0 ORIGINATED BY KA
DIST 4 HWY QEW BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
DATUM Geodetic DATE 1990 10 23 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
77.2	Ground Surface													
0.0	Silty Clay Fill with Sand, Trace Gravel Very Stiff to Hard Brown		1	SS	31									4 18 53 25
			2	SS	13									0 20 49 31
			3	SS	11									W.L. on 1990 10 29
			4	SS	5									1 35 43 21
	Silty Sand Fill with Organics Trace Clay, Trace Cinders Loose		5	SS	5									1 32 44 23
			6	SS	4									
			7	SS	5									
71.3			8	SS	3									
5.9	Silty Clay with partially to completely decomposed organics Soft (Possibly Old Swamp)		9	SS	2									
			10	SS	3									
	Coarse sand layer													
67.7														
9.5	Silty Clay Till Occ. Sand Seams, Trace Gravel Very Stiff, Grey (Glacial Till)		11	SS	20									1 25 53 21
65.8														
11.4	End of Borehole Hammer Bouncing Possible Bedrock													

RECORD OF BOREHOLE No 110

1 OF 1

METRIC

W.P. 318-89-00 (B) LOCATION N 4.788,976.0; E 284.996.0 ORIGINATED BY KA
 DIST 4 HWY QEW BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
 DATUM Geodetic DATE 1990 10 23 CHECKED BY DD

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT		UNIT WEIGHT 7 kn/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100	20 40 60 80 100	W _p W W _L	WATER CONTENT (%) 10 20 30		
77.0	Ground Surface											
0.0	Silty Clay Fill											
	Trace Sand, Trace Gravel		1	SS	6							
	Occ. Wood Chips, Black Stains											
	Firm to Stiff		2	SS	9							0 20 45 35
74.3			3	SS	7							
2.7			4	SS	28							1 13 40 46
	Silty Clay Till		5	SS	18							
	Trace Sand, Trace Gravel		6	SS	12							
	Occ. Sand Seams, Occ. Clay Zones		7	SS	14							
	Stiff to V. Stiff		8	SS	20							2 6 38 54
	(Glacial Till)											
			9	SS	19							
67.7	Till Shale Complex		10	SS	60							W.L. on 1990 10 29
9.3	End of Borehole Hammer Bouncing Possible Bedrock											

+3, x³ : Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No C1

1 OF 1

METRIC

W.P. 318-89-00 LOCATION N 4 788 997; E 285 028 ORIGINATED BY BL
DIST 4 HWY Q.E.W BOREHOLE TYPE Hollow Stem Auger, Cone Test, NQ Core COMPILED BY MJR
DATUM Geodetic DATE 90-07-16 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
76.0	Ground Surface												
0.0	Silty Clay Fill Trace Sand, Trace Gravel												
74.3			1	SS	23								
1.7	Brown Grey		2	SS	15								1 14 47 38
	Silty Clay Till Trace Sand, Trace Gravel Very Stiff		3	SS	17								
			4	SS	17								
68.1			5	SS	85	/30cm							
7.9	Moderate to Highly Weathered Sound		6	SS	80	/5cm							
	Bedrock Shale (Queenston Formation)		7	RC	REC	100%							RQD = 67%
66.1													
9.9	End of Borehole												

RECORD OF BOREHOLE No C2

1 of 1

METRIC

W.P. 318-89-00 LOCATION N 4 789 029; E 285 089 ORIGINATED BY MJR
DIST 4 HWY Q.E.W BOREHOLE TYPE Hollow Stem Auger, Cone Test COMPILED BY MJR
DATUM Geodetic DATE 90-07-18 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
78.0	Ground Surface													
0.0	Silty Clay Fill Trace Sand, Trace Gravel Stiff to Very Stiff		1	SS	8									
			2	SS	18									
			3	SS	11									
72.4			4	SS	10									
5.6	Silty Clay Stiff		5	SS	13									
			6	SS	11									
68.0			7	SS	78									
10.0	Silty Clay Till Trace Sand, Trace Gravel Hard													
65.8	Probable Bedrock at El. 65.8m													
12.2	End of Borehole Hammer Bouncing • W.L. Not Established													

+3, x3: Numbers refer to
Sensitivity

20
15-25 (%) STRAIN AT FAILURE
10



Ministry
of
Transportation

FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

CONT 91-83

WP	318-89-00 (B)	DIST	4
HWY	Q.E.W.	STR SITE	36-324C
			36-325C
			36-326C
			36-327C
	Proposed Culvert and Culvert Extension		

DISTRIBUTION

V.F. Boehnke (3)
G. Cautillo
J. Cullen (2)
A. Wittenberg
K.G. Bassi
S.J. Dunham
E.A. Joseph
B. Steeves (Cover Only)
I. Bullen (Cover Only)
File✓

1990 11 15

V. F. Boehnke
Head, Structural Section
Structural Section
Central Region

Attn.: K. Wong

Re.: W.P. 318-89-00 (B)
Proposed Culverts and Culvert Extensions
Hwy Q.E.W., District 4, Burlington

Dear Sirs:

We are pleased to submit the foundation report for the above-captioned project at Q.E.W. between Hwy. 20 and Grays Road. The report is applicable to the proposed culvert structures only.

SITE DESCRIPTION AND GEOLOGY

The site is located at Hwy Q.E.W. and north of Q.E.W. in a private property (The Confederation Park) between Hwy. 20 and Grays Road. This section of the Q.E.W. is located within the Town of Stoney Creek in the Regional Municipality of Hamilton - Wentworth.

The Q.E.W. in this area follows the shoreline of Lake Ontario and lies mainly in the "Iroquois Plain" physiographic Region. The Iroquois Plain is generally composed of fairly shallow sandy materials deposited in the bed of Lake Iroquois. The area is also referred to as the Niagara Fruit Belt (Reference: Champman and Putnam, "The physiography of Southern Ontario; 3rd Edition, 1984).

The bedrock at this site is Shale of Queenston Formation. The depth of bedrock at this site is in the range of 10m or deeper below the ground surface.

FILED AND LABORATORY WORK

A foundation investigation for the Stoney Creek culvert extension (Station 22+400) was conducted during 90 07 16 and 90 07 18. On 90 08 16 another request was received from the Structural Section (Central Region) for an additional four new culverts (Culverts 1,2,3 and 7).

The additional field work was conducted between 90 10 23 and 90 10 29 and consisted of drilling nine (9) boreholes. Continuous flight auger machines equipped with 82 mm ID hollow-stem augers were used to drill boreholes 102, 106, 107, 108 and 110. Since boreholes 101, 103, 104 and 105 were located in either swamp or in a water pond, a CME 45 skid mounted drilling machine equipped with 82mm ID hollow stem auger was used to drill those boreholes from a raft. Four (4) boreholes were accompanied by cone tests.

The boreholes are identified as 101 through 108, 110, C1 and C2. All boreholes except Borehole C1 were either terminated in overburden or at probable bedrock. Bedrock was proved in Borehole C1 by obtaining bedrock core.

Survey details were provided by the Central Region Surveys & Plans Section.

The sampling program consisted of split spoon samples collected at 0.8m to 1.5m intervals. They provided Standard Penetration Test (N) values for assessment of the in-situ state of compaction of the non-cohesive materials, and for an indication of shear strength of cohesive material. These samples also provided material for identification purposes.

The laboratory testing program for representative samples consisted of:

- Grain size analyses
- Natural Moisture Content determinations, and
- Atterberg Limit determination.

The lab results are shown on the attached log sheets.

SUBSURFACE CONDITIONS:

The record of borehole sheets in the Appendix illustrate the subsurface conditions and the ground surface elevations at the borehole locations. The locations of the boreholes are shown on Drawing No. 3188900B-A.

The subsurface conditions at the site are quite variable. All boreholes encountered cohesive glacial till at depths ranging from 1.4m to 9.5m below ground surface. Due to the presence of swamps at proposed culverts 1,2 and 3 and due to the construction of highways the soil above till material is variable and consists of fill, organic silt or peat materials.

Following are the brief soil description at each culvert location. For details of soil conditions at each location, borehole logs should be referred to.

Site A (Culvert 1)

Three boreholes, Boreholes 101, 102 and 103 were advanced at this location. Borehole 101 was drilled on the north side of the proposed culvert in a pond, Borehole 102 was located approximately at the middle of the culvert, and Borehole 103 on the south side of the proposed culvert in a swamp. In Boreholes 101 and 103 very soft organic clayey silt to organic silty clay with peat layers was encountered to depths 3.0m and 2.4m (Elev. 73.1m to 73.9) below pond and swamp surface respectively. This deposit had very low strength in the upper portion and the auger and spoon sank in the upper 1.5m to 2m. Standard penetration N-values achieved in the lower portion of the deposit was 1 blow/0.3m. In Borehole 101 the organic deposit was underlain by a 1.2m thick loose silty sand stratum which was underlain by silty clay till. In Borehole 103 the organic deposit was directly underlain by silty clay till.

Borehole 102 encountered a 3.7m thick silty sand fill with a thin layer of fibrous peat at the bottom. The fill was underlain by silty clay glacial till. Standard Penetration, N-value achieved in the fill material ranged from 2 blows to 14 blows/0.3m. The value decreased with depth. Based on N-value the fill was found to be very loose to compact.

A cohesive glacial till was encountered in all three boreholes at depths ranging from 2.4m to 4.5m (Elevation 71.6m to 74.1m). The Standard penetration, N-value, ranged from 3 blows to 51 blows/0.3m. The lower N-values were occasional, and generally the N-value ranged from 17 to 29 blows/0.3m which suggest that the material is very stiff.

Site B (Culvert 2 & 3)

Four boreholes were drilled at this site. Boreholes 104 and 105 were advanced in a swamp on the north side of the proposed culvert. Borehole 106 was drilled between the centre and the south side of the culvert and Borehole 107 was advanced on the south side of the proposed culvert. Boreholes 104 and 105 encountered organic silty clay to depths 2.5m and 3.2m respectively (elevations 72.8m to 73.5m) below the swamp surface. In Borehole 104 the organic deposit had very low strength and the split spoon sank with the weight of the A-rod. In Borehole 105 Standard Penetration resistance was in the range of 2 blows to 6 blows/0.3m. Based on the SPT results the consistency of the deposit is very soft to firm. The organic deposit was underlain by silty clay till.

At Boreholes 106 and 107, a cohesive fill extends 1.4m to 2.1m (elevations 77.0m to 78.1m) below the ground surface. The fill consisted of silty clay material. Standard Penetration test, N-values ranged from 19 to 27 blows/0.3m which suggests that the fill is very stiff.

Underlying the organic material in Boreholes 104 & 105, and fill material in Boreholes 106 and 107, all boreholes encountered a cohesive till. The till consisted of silty clay with traces of sand and gravel. The standard penetration test, N-value ranged from 4 to 64 blows/0.3m which suggests that the till is in firm to hard state. However, the low N-value is occasional, and the more typical N-values ranged from 19 to 28 blows/0.3m which suggests that the till is very stiff.

Site C (Culvert 7 and Stoney Creek Culvert)

Four Boreholes were drilled at this site. The boreholes were designated as Boreholes 108, 110, C1 and C2. Borehole 108 was drilled on the north side and Borehole 110 was drilled on the south side of the proposed Culvert 7. Boreholes C1 and C2 were drilled earlier for Stoney Creek Culvert extensions.

All boreholes encountered fill material as a surficial layer. The fill extended to depths ranging from 2.7m to 5.9m below the ground surface. The fill consisted of silty clay material. In Borehole 108 a 2.9m thick silty clay fill was underlain by a 3m thick non-cohesive silty sand fill. The Standard Penetration Test, N-value recorded in the cohesive fill ranged from 6 to 31 blows/0.3m which suggests a firm to hard but generally firm state, while the non-cohesive fill recorded N-values between 4 to 5 blows/0.3m which suggests loose state.

Underlying the fill material Boreholes 108 and C2 encountered a layer of silty clay which ranged in thickness from 2.6m to 4.4m. A 1m thick coarse sand layer was also encountered underlying the silty clay layer in Borehole 108. Standard Penetration Test, N-value recorded in this stratum ranged from 2 to 13 blows/0.3m. However, low N-values between 2 to 3 blows/0.3m were achieved in Borehole 108 only, which suggests that the consistency of the material at this location is soft. In Borehole C2 the N-value ranged from 10 to 13 blows/0.3m which indicates that the soil is stiff at this location. The silty clay layer was underlain by silty clay till.

A cohesive glacial till was encountered at a depth of 9.5m and 10m below the ground surface (elevation 67.7m to 68m) in Boreholes 108 and C2 respectively, and at depths 1.7m and 2.7m below the ground surface (elevation 74.3) in Boreholes 110 and C1. The glacial till consisted of silty clay with a trace of sand and trace of gravel. The Standard Penetration Test, N-value recorded in this stratum ranged from 12 to 78 blows/0.3m. The more typical N-value ranged from 10 to 15 blows/0.3. This suggests that the consistency of this material is stiff to hard but generally stiff. All boreholes were terminated in this material.

Bedrock was proved in C1 where a 2m long bedrock core was obtained. The bedrock was classified as Shale of Queenston Formation.

RECOMMENDATIONS

General

It is proposed to construct three new box culverts and to extend two existing box culverts at Hwy Q.E.W. and in a presently private property north of Hwy Q.E.W. between Grays Road and Hwy 20, in District 4, Burlington.

Culvert 1 will be a concrete box culvert and will replace an existing steel pipe culvert which is located under Park Road, in Confederation Park. The new culvert will be about 53m long and will be longer than the existing pipe culvert. The new culvert will extend towards the south into an existing swamp, and will be constructed under the new North Service Road of the Q.E.W. The grade of new South Service Road will be 79.2m. Therefore, the embankment height will be about 2 m above the culvert obvert. The culvert opening will be about 6.5m wide and 1.0m high with invert elevation at 76.2m (on the north side). Both north and south head walls will have 8.5m wide faces with 5m long wing wall oriented at 45 degrees with respect to the face of the headwall.

Culvert 2 will be the extension of an existing culvert which is about 150m long and is underlying the Q.E.W. core and collector lanes as well as the south-east ramp. The proposed extension will be on the north side of the westbound collector lane of the Q.E.W. in a swamp and will be about 45m long. The proposed extension will be connecting the existing culvert at an angle to the existing culvert alignment, moving the outlet towards northwest. The extension of this culvert will be underlying a future North Service Road to the West ramp. The final grade of the road at this location will be 78.5m and the embankment height above the culvert obvert will be about 2m. The culvert inner dimension will be 2.4m by 1.8m. The invert elevation will be 74.6m (on the north side).

Culvert 3 will be a new concrete box culvert. The culvert will be straight, about 175m long and will be located just east of the existing Culvert 2. The layout of Culvert 3 will be in such a way that on the north side it will be laid side by side to the proposed Culvert 2 extension and on the south side it will be 60m away from Culvert 2. The northern 45m of the culvert will be in the swamp area. The northern portion of the culvert (about 45m) will be underlying proposed North Service Road to West ramp. The rest of the culvert will be underlying the existing Q.E.W. core and collector lanes as well as the south to east ramp. There will be no major changes in the grade within the existing highway limits. However, on the north side of the culvert (about 45m) where a north service road to west ramp will be constructed the grade will be raised to elevation 78.5m. The embankment height over Culvert 3 obvert in the north side will be about 1m. The inner dimension of

the culvert will be 4.5m wide and 1.0m high. The invert elevation on the north side will be 76.3m.

The north headwall for Culvert 2 and Culvert 3 will be combined. The face of the headwall will be about 9m wide and wing walls will be 5m long and oriented at 45 degrees with respect to the culvert face.

On the south side Culvert 3 will be isolated from Culvert 2. The south head wall will be required only for Culvert 3. The face of the head wall will be 5.5m wide and the wing walls will be 5m long and oriented at 45 degrees with respect to the culvert face.

Culvert 7 will be a new concrete box culvert. The culvert will be located close to existing Stoney Creek Culvert on its west side. This culvert will be about 155m long. The borehole on the north side of the proposed culvert encountered a thick deposit of soft material. The culvert will be underlying existing Q.E.W., North Service Road, South Service Road and Park Road. There will be no major changes in the grade over the culvert except at a few locations (which is presently a grassed area) the grade will be raised between 0.9m on the north side to about 1.5m on the south side. The inner dimension of the culvert will be 5.8m by 3.2m. The invert elevation on the north side will be 73.4m.

The face of the north headwall will be 5.8m wide. The wing walls will be 7m and 10m long and will be oriented parallel to the culvert alignment. The south headwall will have only a west wing, which will be 5m long and perpendicular to the culvert alignment.

Stoney Creek Culvert is located near Station 22+400 just east of proposed Culvert 7. The culvert at present is in three segments which are underlying the Q.E.W. core and collector lanes. It is proposed to construct extensions between these segments to form one culvert. The proposed foundation elevations for the north extension and south extensions are 73.5m and 73.6m respectively. The proposed culvert extension on the north side is supposed to be 4.2m high, 6m wide, 4.5m long on the west side and 8m long on the east side. The south culvert extension is proposed to be 4.3m high, 6m wide, 21m long on the west side and 15.6m on the east side.

Structure Foundations

The Culvert and Retaining structures can be founded on competent native soil or engineered fill where soft material is encountered.

Soft material (mostly organic) and/or loose material was encountered on the north and south sides of Culvert 1, on the north side of Culvert 2 and 3 (within a length of 45m) and on the north side of Culvert 7 (probable horizontal extent could be 45m). In

order to remove the soft or loose material, shoring consisting of sheet piling or where possible soldier piling with lagging may have to be installed at locations and depths as shown in the attached figures (Figure 1 through 4). Alternatively open excavations may be feasible at some locations. The excavation should be backfilled with crushed stone or with Granular and compacted according to MTO standards. The backfilling will be brought to the underside of the culvert bedding.

Subgrade preparation Culvert 1

At Culvert 1 soft material will have to be removed from a depth and extent as shown on the attached Figure 1. The excavation/backfilling operation should be proposed by the contractor for review. However, it is anticipated that it may consist of:

- fully enclosed shoring and full dewatering
- partially enclosed shoring and partial dewatering
- open excavation without dewatering, as detailed below:

The excavation scheme could involve installation of shoring (sheet piles or soldier piles/lagging or combination of both, whichever is more economical and practical, such as on the north side sheet piles may be more practical because of an existing pond) to the elevation given in Table 1 and shown on Figure 1. The shoring will encompass the entire construction area. The removal of soft material can be carried out on both sides of Park Road and if required should be brought as close to the Park Road as defined by the "Probable Limit of Excavation" on Figure 1. At the time of excavation if it is determined that the organic deposit is also present under Park Road or if it is realized that it is more convenient to carry out complete excavation in the entire area, consideration may be given to excavating the portion of the Park Road above the proposed Culvert 1, down to the firm ground elevation.

After the soft material is removed backfilling will be done using free-draining granular material such as Granular 'A' or crushed stone and compacted according to MTO Standards.

It is assumed that for this scheme a detour for Park Road will be available. If not, then a road protection scheme may be required.

If, depending on the economics, consideration is given to open excavation. The excavation would be in stages. Once the soft material is removed from one area, backfilling will be carried out using 19mm crushed stone. The open excavation and the subsequent backfilling operation will be carried out below water.

Subgrade preparation Culvert 2 & 3

At culvert 2 and 3 the southern extent of the soft material is likely to be the northern limit of the existing westbound collector lane of Q.E.W. However, this will have to be determined at the time of excavation. Since the invert elevation of Culvert 2 is lower than the water table at this location, it will be required that a dewatering scheme is implemented in order to construct the culvert. The excavation scheme will probably require installation of sheet pile as a shoring. Once the soft material is removed, Granular 'A' or crushed stone will be used to backfill the excavation.

Subgrade preparation Culvert 7

At proposed Culvert 7, soft material was encountered on the north side. The southern extent of the soft material is likely to be the northern limit of the North Service Road. However, this will have to be determined at the time of excavation.

General Recommendations For All Sites

For removal of soft or loose material to elevation shown in Table 1, consideration may be given to open excavation. Temporary excavation below the water table can be maintained at 2H:1V and above the water table at 1H:1V. This scheme may not be practical due to property constraints. Alternatively, shoring can be utilized which will consists of either sheet pile or soldier pile with lagging. In any case the adjacent roadway may have to be protected by utilizing shoring in order to stage construction and maintain traffic.

TABLE 1

Culvert No	Invert Elevation (m)	Bottom of Excavation Elev. (m)	Excavation Depth (m)	Shoring Tip Elev. (m)
1	76.2	73.0 to 74.0	2.5	71.5 to 73.0
2	74.6	72.5	3.2	70.5
3	76.4	72.5	3.2	70.5
7	73.4	71.0	2.4	69.0

If the founding surface is prepared as recommended, the following design values can be utilized for the design of proposed culvert foundations (For Culverts 1,2,3,7 and Stoney Creek Culvert extension) and headwall foundations for the purposes of the OHBDC.

Factored Bearing Capacity at U.L.S. = 225 kPa
Bearing Capacity at S.L.S Type II = 150 kPa

For head and wing walls consideration can be given to Reinforced Earth walls. Such walls can tolerate differential settlement. In order to reduce the loading on retaining structures the height of the retaining walls may be reduced or the retaining wall may be completely eliminated if the culvert is further extended and the embankment is sloped at 2H:1V. This will be subject to property constraints.

Higher bearing capacity may be available if excessive settlement is tolerable. As an alternative if a higher bearing capacity is required with minimal settlement, this may be achieved by constructing a thicker engineered fill or a deep foundation. If this alternative is required the Foundation Design Section should be contacted for recommendation.

Backfilling/ Lateral Pressure

Above the bedding level, backfilling to the culverts should consist of suitable material compacted in accordance with MTO Standards and conform to OPSD-803.02. For fill below groundwater elevations or below existing roadways, it is recommended that Granular 'A' or 'B' should be used. The backfill operations should be carried out simultaneously on both sides of the culverts as per MTO specifications. The following properties are recommended for the calculation of lateral pressure.

Granular 'A': $\gamma = 22.8 \text{ kN/m}^3$, $\phi = 35^\circ$, $K_o = 0.43$, $K_a = 0.27$
Granular 'B': $\gamma = 21.2 \text{ kN/m}^3$, $\phi = 30^\circ$, $K_o = 0.50$, $K_a = 0.33$

If the structure is to be designed as a rigid frame then the coefficient of earth pressure at rest (K_o) should be used behind rigidly attached head or wing walls.

Lateral Resistance

Sliding resistance between the base of concrete footings and underlying material should be calculated in accordance with Section 6-7.3.3.2 of the OHBDC assuming unfactored angle of internal friction, $\phi = 35^\circ$ for granular material such as Granular 'A' or crushed stone. It is not anticipated that lateral resistance calculations will be required for the culvert foundations.

Parameters for Shoring Design

The shoring should be designed using the parameters given in the following table.

Locations	Elev (m) From - To	Soil Type	ϕ Degrees	Cu kPa	γ kN/m ³
BH 101	75.5 - 72.8	Cohesive	0	5	18.0
	72.8 - 71.6	Non-Cohesive	28	0	20.0
	71.6 - Below	Cohesive	0	120	21.2
BH 102	77.8 - 74.1	Non-Cohesive	28	0	19.0
	74.1 - Below	Cohesive	0	100	21.2
BH 103	76.3 - 73.9	Cohesive	0	10	18.0
	73.9 - Below	Cohesive	0	100	21.2
BH 104	75.6 - 73.5	Cohesive	0	5	18.0
	73.5 - 71.5	Cohesive	0	30	21.0
	71.5 - Below	Cohesive	0	150	21.2
BH 105	76.0 - 72.8	Cohesive	0	15	18.5
	72.8 - Below	Cohesive	0	150	21.2
BH 106	78.4 - 73.0	Cohesive	0	60	19.0
	73.0 - Below	Cohesive	0	150	21.2
BH 107	80.2 - 73.0	Cohesive	0	60	20.0
	73.0 - Below	Cohesive	0	150	21.2

BH 108	77.2 - 74.3	Cohesive	0	75	20.0
	74.3 - 71.3	Non-Cohesive	28	0	20.0
	71.3 - 68.6	Cohesive	0	15	19.0
	68.6 - 67.7	Non-Cohesive	28	0	20.0
	67.7 - Below	Cohesive	0	150	21.2
BH 110	77.0 - 74.0	Cohesive	0	30	19.0
	74.0 - Below	Cohesive	0	75	21.0
BH C1	76.0 - 74.0	Cohesive	0	75	19.0
	74.0 - Below	Cohesive	0	75	21.0
BH C2	78.0 - 72.4	Cohesive	0	40	19.0
	72.4 - Below	Cohesive	0	75	21.2

Parameters may be interpolated between boreholes.

Stability and Settlement

If the soft material is removed and replaced with compacted granular fill as recommended in this report, no stability problems are anticipated for the proposed height of permanent embankment. The existing box culverts (Culvert 3 and Stoney Creek Culvert) and existing steel pipe culvert (at proposed Culvert 1) has performed satisfactorily without any sign of structural distress. Total and differential settlement will be negligible if the foundation is constructed in accordance with the recommendation provided.

CONSTRUCTION CONSIDERATIONS

Temporary Diversion

To facilitate the construction of the culvert, a temporary diversion of the Creek should be considered.

Dewatering

Once the sheet piles are driven in relative impervious layers to elevations as shown in the attached figures (Figure 1 to 4), dewatering may be required before (north of culvert 1), during and after excavation of soft material. Normal sump pumping will adequately dewater the excavation. However, it will be up to the contractor to determine the dewatering method to achieve proper dewatering.

Excavation

Where excavation is carried out without sheet piles (i.e. in firm ground), temporary excavation will be stable at 1H:1V above water table and 2H:1V below water table. If the excavation is carried out close to the pavement, it will be required to keep the traffic at least 1m away from the paved edge (adjacent to the excavation) by utilizing temporary barriers.

Bedding

Bedding under the culvert foundation shall consist of a 0.6m thick layer of Granular 'A' material. The bedding should be compacted as per MTO standards.

Cambering

Proper cambering should be provided by raising the culvert up to 150mm in the centre while maintaining flat gradient towards the inlet, and gradually increasing the slope towards the outlet. Refer to Figure 5 for details.

Construction Joints

Where it is proposed to extend the existing culverts, proper joints will be required between the old and new culverts. Such joints should be able to accommodate differential settlement and provide proper seal.

Transition Zone Treatment

Where a deep sub-excavation is carried out adjacent to the roadway to remove the soft material, proper tapering should be maintained before backfilling, to avoid a differential frost heave. When a proper tapering is maintained there is no abrupt change in the subgrade material within the frost depth. This should be done according to MTO Standard. If there is a property constraints the tapering can be steeper.

Erosion Protection

If head and wing walls are not incorporated in the design erosion protection will be required at each culvert inlet and outlet. The erosion protection may consist of a rock blanket. Also a clay seal at the inlet and a filter blanket at the outlet may be required. Contact the Foundation Design Section if details are required (i.e. if head and wing walls are not used).

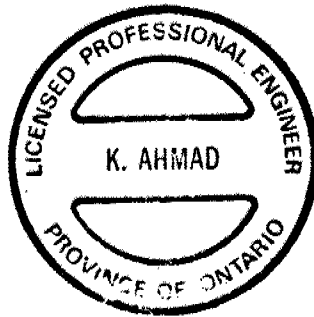
Weeping Holes

In order to relieve excess hydrostatic pressure behind the wall, weep-holes should be provided at 6m or less centre to centre.

MISCELLANEOUS

The field work for this project was carried out under the supervision of Ken Ahmad Foundation Engineer and Marie Josee Roy, Engineering Student. The equipment used was owned and operated by Master Soil Investigation Inc. and Longyear Canada Inc.

This report was written by Ken Ahmad, Foundation Engineer, reviewed by D. Dundas, Senior Foundation Engineer and approved by M. Devata, Chief Foundation Engineer.



A handwritten signature in cursive script, reading "Ken Ahmad".

Ken Ahmad, P. Eng.
Foundation Engineer

A handwritten signature in cursive script, reading "M.S. Devata".

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

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

STRESS AND STRAIN

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

PHYSICAL PROPERTIES OF SOIL

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

* MINIMUM PENETRATION FOR DEWATERING PURPOSES.
FURTHER ASSESSMENT IS REQUIRED FOR STABILITY OF
THE SHORING USING PARAMETERS IN THE REPORT.

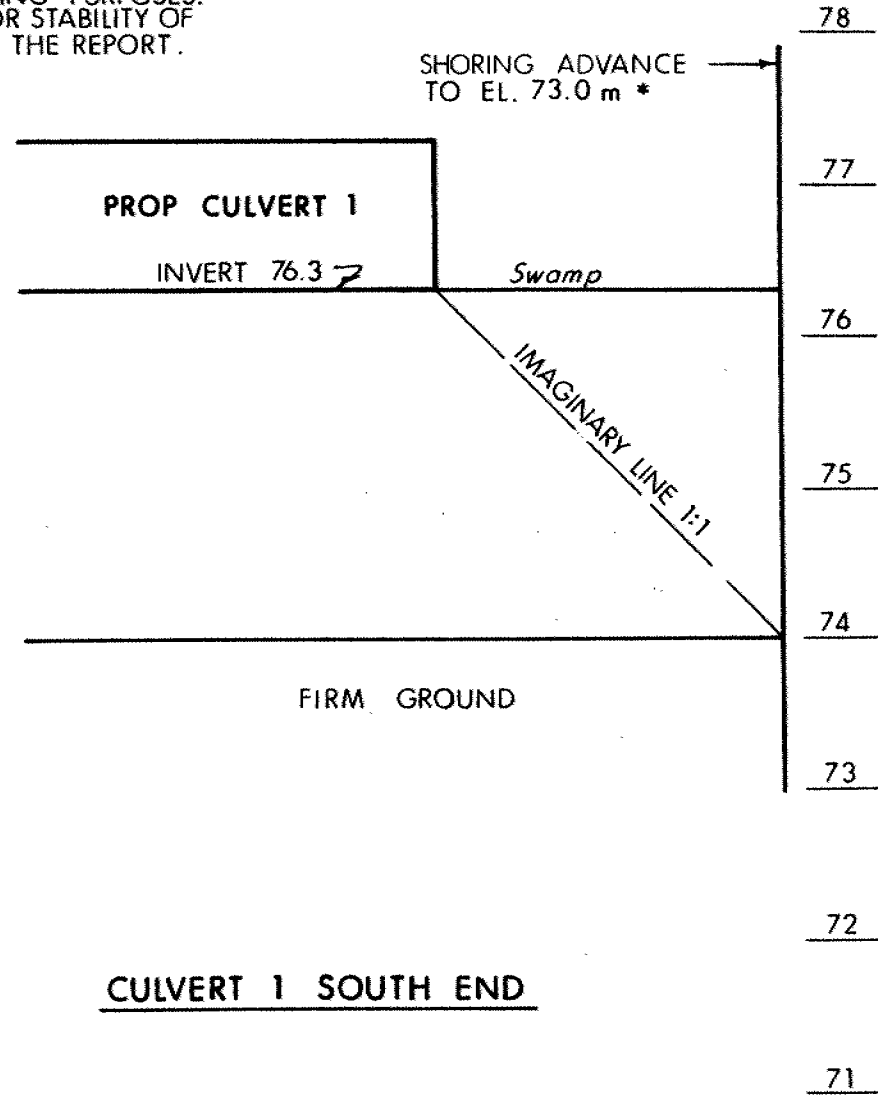
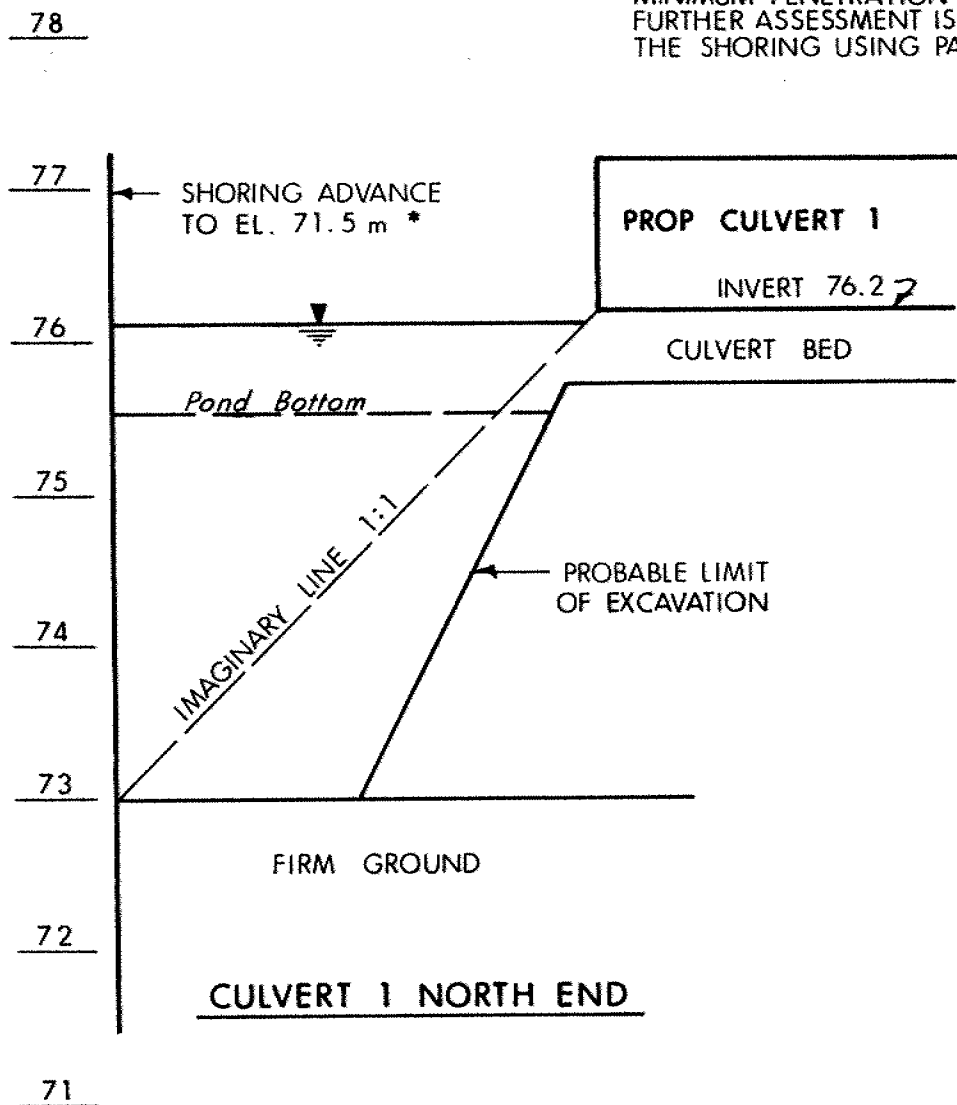
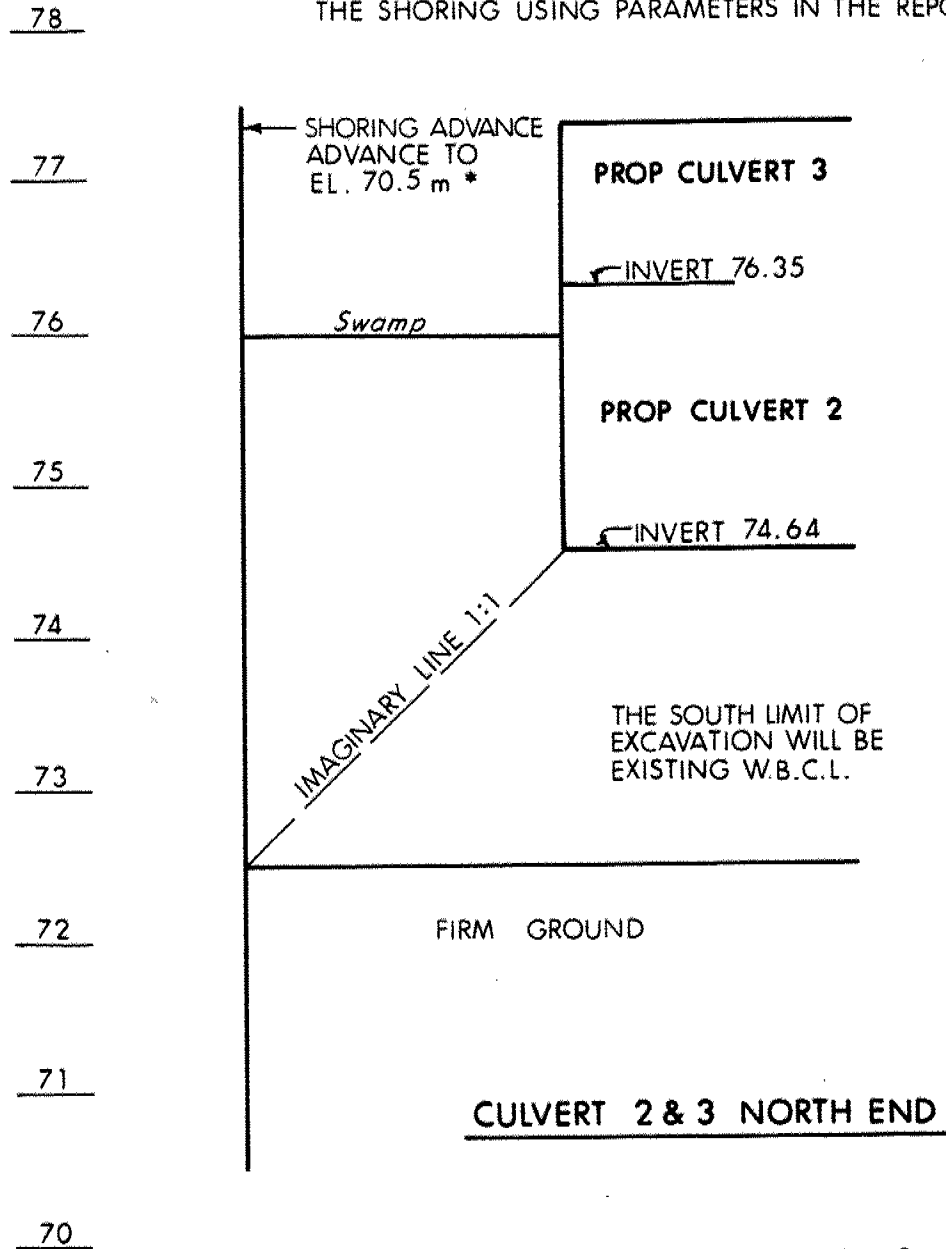


FIG 1

* MINIMUM PENETRATION FOR DEWATERING PURPOSES.
FURTHER ASSESSMENT IS REQUIRED FOR STABILITY OF
THE SHORING USING PARAMETERS IN THE REPORT.



FOR NORTH ELEVATION REFER TO FIG 3

FIG 2

* MINIMUM PENETRATION FOR DEWATERING PURPOSES.
FURTHER ASSESSMENT IS REQUIRED FOR STABILITY OF
THE SHORING USING PARAMETERS IN THE REPORT.

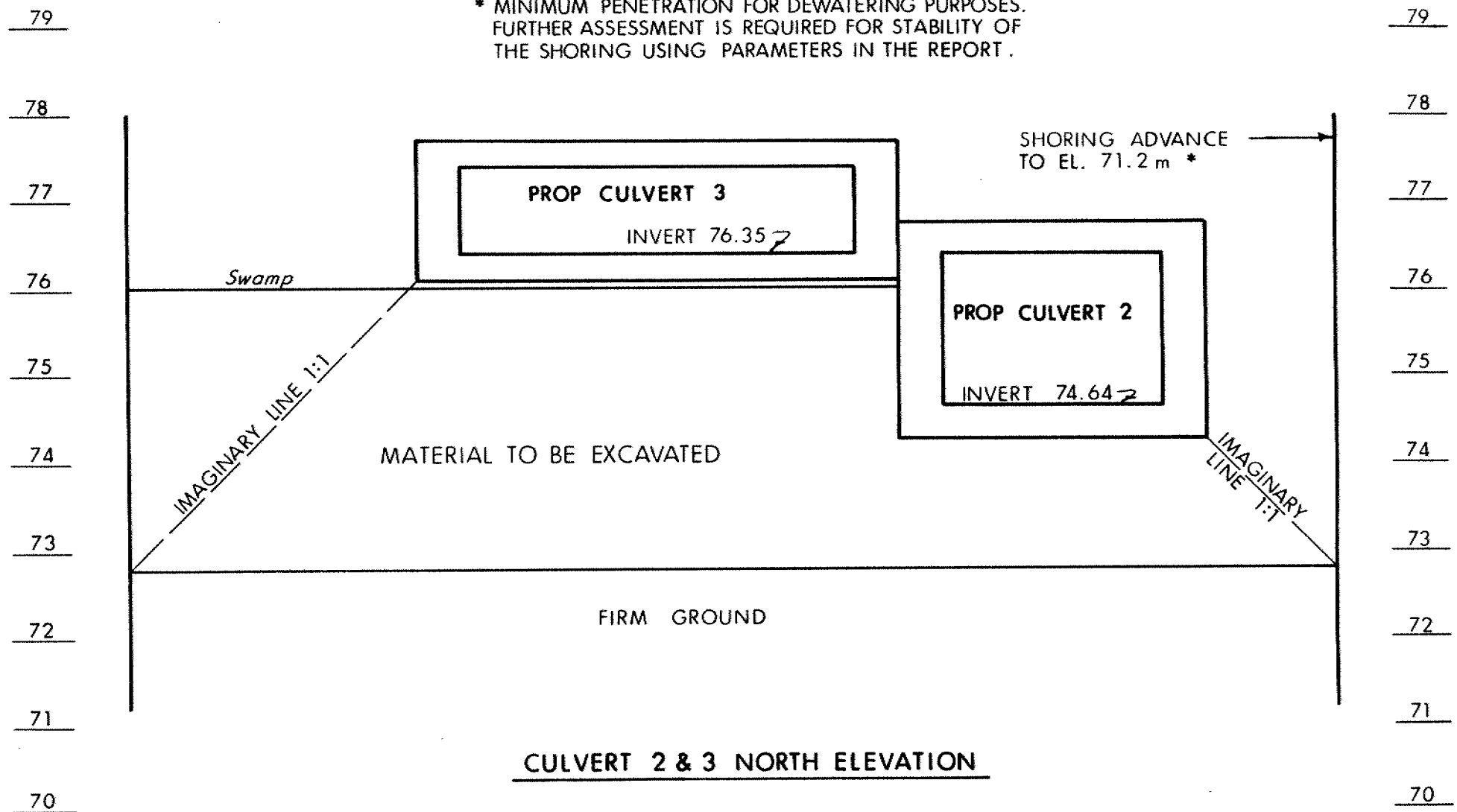
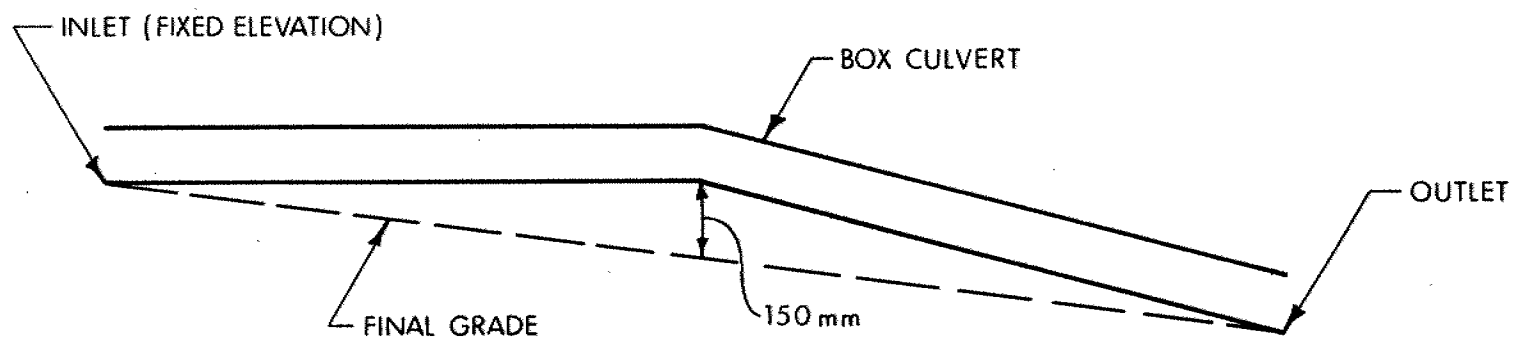


FIG 3



CAMBERING DETAIL

FIG 5

RECORD OF BOREHOLE No 101

1 OF 1

METRIC

W.P. 318-89-00 (B) LOCATION N 4,789,582.0; E 284,127.0 ORIGINATED BY KA
DIST 4 HWY QEW BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
DATUM Geodetic DATE 1990 10 29 CHECKED BY DD

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					
76.1	Pond Surface																
0.0	Water																W.L. on 1990 10 29
75.5	Pond Bottom																
0.6	Organic Clayey Silt with Fibrous Peat Layers		1	SS	1											w=376	
	Silty Clay Zone		2	SS	3												
72.8																	
3.3	Silty Sand Trace Clay, Loose, Grey		3	SS	5												1 34 42 23
71.6			4	SS	6												
4.5	Silty Clay Till Trace Sand, Very Stiff, Grey (Glacial Till)		5	SS	23												2 15 43 40
			6	SS	23												
66.9			7	SS	27												
9.2	End of Borehole																

RECORD OF BOREHOLE No 102

1 OF 1

METRIC

W.P. 318-89-00 (B) LOCATION N 4,789,562.0; E 284,112.0 ORIGINATED BY KA
DIST 4 HWY QEW BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
DATUM Geodetic DATE 1990 10 25 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID UNIT MOISTURE CONTENT UNIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	w _p	w	w _L		
77.8	Ground Surface													
0.0	Silty Sand Fill Trace organic, Occ. wood chips Very Loose to Compact Brown to Greyish Brown with Organic Stains		1	SS	14	*	77							0 44 43 13
			2	SS	9		76							
			3	SS	2		75							
			4	SS	4		74							
74.1	Fibrous Peat Layer		5	SS	8		73							1 8 34 57
3.7	Silty Clay Till Trace Sand, Stiff to Very Stiff Brown to Greyish Brown (Glacial Till)		6	SS	19		72							
			7	SS	29		71							
			8	SS	25		70							
			9	SS	26		69							6 16 41 37
68.2														
9.6	End of Borehole * W.L. Not Established													

RECORD OF BOREHOLE No 103

1 OF 1

METRIC

W.P. 318-89-00 (B) LOCATION N 4,789,537.0; E 284,096.0 ORIGINATED BY KA
 DIST 4 HWY QEW BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
 DATUM Geodetic DATE 1990 10 29 CHECKED BY OD

SOIL PROFILE			SAMPLES			GROUND WATER # CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
76.3	Swamp																
0.0	Water																
	Organic Silty Clay		1	SS	PM												W.L. on 1990 10 29
	Very Soft																
	with layers of fibrous Peat		2	SS	1												
73.9																	
2.4			3	SS	3												0 13 52 35
	Soft																
	V. Stiff		4	SS	26												2 13 39 46
	Silty Clay Till																
	Trace Sand, Trace Gravel																
	Brown to Greyish Brown		5	SS	17												
	(Glacial Till)		6	SS	18												
	V. Stiff																
	Hard		7	SS	51												
67.3																	
9.0	End of Borehole																
	PM = Pushed Manually																

RECORD OF BOREHOLE No 104

1 OF 1

METRIC

W.P. 318-89-00 (B) LOCATION N 4,789,441.0; E 284,075.0 ORIGINATED BY KA
DIST 4 HWY QEW BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
DATUM Geodetic DATE 1990 10 26 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER # CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT 7 KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
76.0	Swamp																
0.0 75.6	Water																W.L. on 1990 10 26
0.4	Organic Silty Clay Very Soft Occasional Fibrous peat layers		1	SS	*												
73.5			2	SS	7												
2.5			3	SS	4												
			4	SS	28												
			5	SS	22												
			6	SS	33												
			7	SS	31												
66.8																	
9.2	End of Borehole * Spoon sank with the weight of rod.																

RECORD OF BOREHOLE No 105

1 OF 1

METRIC

W.P. 318-89-00 (B) LOCATION N 4,789,408.0; E 284,072.0 ORIGINATED BY KA
DIST 4 HWY QEW BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
DATUM Geodetic DATE 1990 10 26 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER # CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
76.0	Swamp																
0.0	Organic Silty Clay Occasional Fibrous Peat Layers Trace Sand Soft to Firm, Black																W.L. on 1990 10 26
72.8			1	SS	2		75										1 13 56 30
3.2			2	SS	2		74										3 15 40 42
			3	SS	6		73										
			4	SS	33		72										
			5	SS	34		71										
	Silty Clay Till Trace Sand, Trace Gravel Very Stiff to Hard (Glacial Till)		6	SS	26		70										2 16 42 40
			7	SS	24		69										
							68										
66.9			8	SS	57		67										
9.1	End of Borehole Probable Bedrock																

RECORD OF BOREHOLE No 106

1 OF 1 METRIC

W.P. 318-89-00 (B) LOCATION N 4,789,321.0; E 284,062.0 ORIGINATED BY KA
 DIST 4 HWY QEW BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
 DATUM Geodetic DATE 1990 10 24-25 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
78.4	Ground Surface													
0.0	Silty Clay (Possible Fill) Trace Sand, Trace Gravel V. Stiff		1	SS	23	DRY *	78							
77.0							77							
1.4			2	SS	19		76							4 22 46 28
			3	SS	7		75							
							74							
	Silty Clay Till Trace Sand, Trace Gravel Firm to Hard Grey to Brown (Glacial Till)		4	SS	8		73							0 14 41 45
			5	SS	23		72							
			6	SS	19		71							
			7	SS	25		70							
68.8			8	SS	32		69							
9.6	End of Borehole													

RECORD OF BOREHOLE No 107

1 OF 1

METRIC

W.P. 318-89-00 (8) LOCATION N 4,789,273.0; E 284,057.0 ORIGINATED BY KA
DIST 4 HWY GEW BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
DATUM Geodetic DATE 1990 10 24 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC UNIT W _p	NATURAL MOISTURE CONTENT W	LIQUID UNIT W _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100					
80.2	Pavement																
0.0	Silty Clay Fill, with Sand Very Stiff, Grey		1	SS	27	*	80										1 12 47 40
			2	SS	19		79										
78.1	Brown Grey Silty Clay Till Trace Sand, Trace Gravel Firm to Hard (Glacial Till)		3	SS	13		78										
2.1			4	SS	13		77										
			5	SS	6		76										
			6	SS	7		75										
			7	SS	18		74										
			8	SS	34		73										
			9	SS	22		72										
70.6							71										
9.6	End of Borehole * Not Established																

RECORD OF BOREHOLE No 108

1 OF 1

METRIC

W.P. 318-89-00 (B) LOCATION N 4,789,055.0; E 285,087.0 ORIGINATED BY KA
 DIST 4 HWY QEW BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
 DATUM Geodetic DATE 1990 10 23 CHECKED BY DD

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	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W _p	W	W _L		
77.2 0.0	Ground Surface													
	Silty Clay Fill with Sand, Trace Gravel Very Stiff to Hard Brown		1	SS	31		76							4 18 53 25
			2	SS	13		75							0 20 49 31
			3	SS	11		74							W.L. on 1990 10 29
	Silty Sand Fill with Organics Trace Clay, Trace Cinders Loose		4	SS	5		73							1 35 43 21
			5	SS	5		72							
			6	SS	4		71							1 32 44 23
71.3 5.9			7	SS	5		70							
	Silty Clay with partially to completely decomposed organics Soft (Possibly Old Swamp)		8	SS	3		69							
			9	SS	2		68							
	Coarse sand layer		10	SS	3		67							
67.7 9.5			11	SS	20		66							1 25 53 21
	Silty Clay Till Occ. Sand Seams, Trace Gravel Very Stiff, Grey (Glacial Till)													
65.8 11.4	End of Borehole Hammer Bouncing Possible Bedrock													

RECORD OF BOREHOLE No 110

1 OF 1

METRIC

W.P. 318-89-00 (8) LOCATION N 4,788,976.0; E 284,996.0 ORIGINATED BY KA
DIST 4 HWY QEW BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
DATUM Geodetic DATE 1990 10 23 CHECKED BY DD

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
77.0	Ground Surface															
0.0	Silty Clay Fill Trace Sand, Trace Gravel Occ. Wood Chips, Black Stains Firm to Stiff		1	SS	6											0 20 45 35
74.3			2	SS	9											
2.7			3	SS	7											
	Silty Clay Till Trace Sand, Trace Gravel Occ. Sand Seams, Occ. Clay Zones Stiff to V. Stiff (Glacial Till)		4	SS	28											1 13 40 46
			5	SS	18											
			6	SS	12											
			7	SS	14											
			8	SS	20											2 6 38 54
			9	SS	19											
67.7	Till Shale Complex		10	SS	60	/15cm										W.L. on 1990 10 29
9.3	End of Borehole Hammer Bouncing Possible Bedrock															

RECORD OF BOREHOLE No C1

1 OF 1

METRIC

W.P. 318-89-00 LOCATION N 4 788 997; E 285 028 ORIGINATED BY BL
 DIST 4 HWY Q.E.W BOREHOLE TYPE Hollow Stem Auger, Cone Test, NQ Core COMPILED BY MJR
 DATUM Geodetic DATE 90-07-16 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
76.0	Ground Surface												
0.0	Silty Clay Fill Trace Sand, Trace Gravel												
74.3													
1.7	Brown Gray		1	SS	23								
			2	SS	15								
	Silty Clay Till Trace Sand, Trace Gravel Very Stiff		3	SS	17								
			4	SS	17								
68.1			5	SS	85	/30cm							
7.9	Moderate to Highly Weathered		6	SS	80	/5cm							
	Bedrock Shale (Queenston Formation)		7	RC	REC	100%							
66.1													
9.9	End of Borehole												

RECORD OF BOREHOLE No C2

1 OF 1

METRIC

W.P. 318-89-00 LOCATION N 4 789 029; E 285 089 ORIGINATED BY MJR
 DIST 4 HWY G.E.W. BOREHOLE TYPE Hollow Stem Auger, Cone Test COMPILED BY MJR
 DATUM Geodetic DATE 90-07-18 CHECKED BY DD

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					
78.0	Ground Surface																
0.0	Silty Clay Fill Trace Sand, Trace Gravel Stiff to Very Stiff		1	SS	8	*											
			2	SS	18												
	Brown Grey																
			3	SS	11												4 15 44 37
72.4																	
5.6			4	SS	10												5 14 38 43
	Silty Clay																
	Stiff		5	SS	13												
			6	SS	11												
68.0																	
10.0	Silty Clay Till Trace Sand, Trace Gravel Hard		7	SS	78												
65.8	Probable Bedrock at El. 65.8m																
12.2	End of Borehole Hammer Bouncing * W.L. Not Established																

METRIC

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

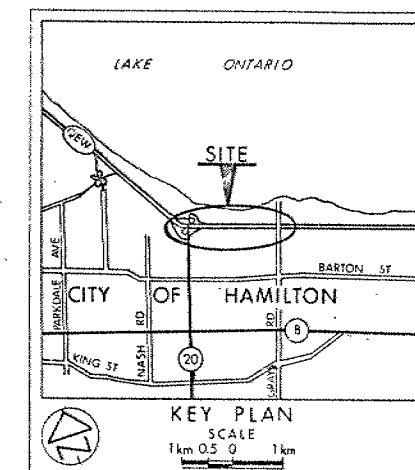
CONT No
WP No 318-89-00B

PROPOSED CULVERTS

BORE HOLE LOCATIONS & SOIL STRATA



SHEET



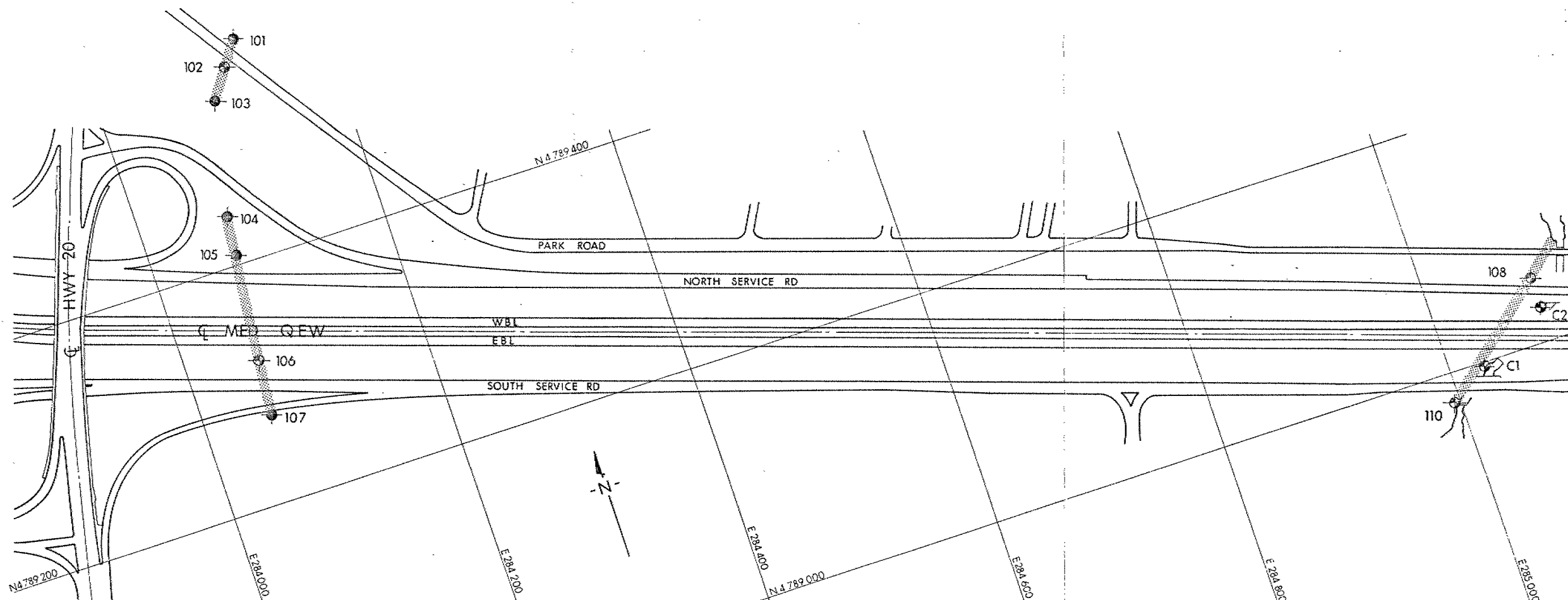
- LEGEND**
- Bore Hole
 - ⊕ Dynamic Cone Penetration Test (Cone)
 - Bore Hole & Cone
 - N Blows/0.3m (Std Pen Test, 475 J/blow)
 - CONE Blows/0.3m (60° Cone, 475 J/blow)
 - W L at time of investigation

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
101	76.1	4 789 582.0	284 127.0
102	77.8	4 789 562.0	284 112.0
103	76.3	4 789 537.0	284 096.0
104	76.0	4 789 441.0	284 075.0
105	76.0	4 789 408.0	284 072.0
106	78.4	4 789 321.0	284 062.0
107	80.2	4 789 273.0	284 057.0
108	77.2	4 789 055.0	285 087.0
110	77.0	4 788 976.0	284 996.0
C 1	76.0	4 788 997.0	285 028.0
C 2	78.0	4 789 029.0	285 089.0

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 30M4-69			
Hwy No	QEW	DIST	4
SUBMD	KA	CHECKED	DATE 19901114
DRAWN	SO	CHECKED	APPROVED
SITE			DWG 3188900B-A



PLAN

SCALE
0 50m

NOTE - FOR SUBSOIL INFORMATION REFER
TO RECORD OF BORE HOLE

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 30M4-69

DIST. 4 REGION

W.P. No. 318-89-00(A)

CONT. No. 92-46
(see also: 91-83)

W. O. No.

STR. SITE No.

HWY. No. Q.E.W.

LOCATION Hwy 20 to Pinelands Ave
H.M.L. & Overhead Signs

No. of PAGES -

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FOUNDATION INVESTIGATION REPORT

CONTRACT NO. 92-46



Ontario

**Ministry of
Transportation**

INDEX

<u>Page No:</u>	<u>DESCRIPTION</u>
1	Index
2	Abbreviations & Symbols
3 - 34	Foundation Investigation Report for Proposed Culverts & Culvert Extensions W.P. 318-89-00(B), Site 36-324C to 36-327C Hwy. Q.E.W., District 4 Burlington High Mast Lighting W.P. 318-89-00, Site - Hwy. Q.E.W., District 4 Burlington

Note: For purposes of the contract, this report supersedes all other Foundation Reports prepared by, or for the Ministry in connection with the above mentioned project.

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 1" 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'_{v0}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

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

W.P. 318-89-00 (B)
Proposed Culverts and Culvert Extensions
Hwy Q.E.W., District 4, Burlington

SITE DESCRIPTION AND GEOLOGY

The site is located at Hwy Q.E.W. and north of Q.E.W. in a private property (The Confederation Park) between Hwy. 20 and Grays Road. This section of the Q.E.W. is located within the Town of Stoney Creek in the Regional Municipality of Hamilton - Wentworth.

The Q.E.W. in this area follows the shoreline of Lake Ontario and lies mainly in the "Iroquois Plain" physiographic Region. The Iroquois Plain is generally composed of fairly shallow sandy materials deposited in the bed of Lake Iroquois. The area is also referred to as the Niagara Fruit Belt (Reference: Champman and Putnam, "The physiography of Southern Ontario; 3rd Edition, 1984).

The bedrock at this site is Shale of Queenston Formation. The depth of bedrock at this site is in the range of 10m or deeper below the ground surface.

FIELD AND LABORATORY WORK

A foundation investigation for the Stoney Creek culvert extension (Station 22+400) was conducted during 90 07 16 and 90 07 18. On 90 08 16 another request was received from the Structural Section (Central Region) for an additional four new culverts (Culverts 1, 2, 3 and 7).

The additional field work was conducted between 90 10 23 and 90 10 29 and consisted of drilling nine (9) boreholes. Continuous flight auger machines equipped with 82 mm ID hollow-stem augers were used to drill boreholes 102, 106, 107, 108 and 110. Since boreholes 101, 103, 104 and 105 were located in either swamp or in a water pond, a CME 45 skid mounted drilling machine equipped with 82mm ID hollow stem auger was used to drill those boreholes from a raft. Four (4) boreholes were accompanied by cone tests.

The boreholes are identified as 101 through 108, 110, C1 and C2. All boreholes except Borehole C1 were either terminated in overburden or at probable bedrock. Bedrock was proved in Borehole C1 by obtaining bedrock core.

Survey details were provided by the Central Region Surveys & Plans Section.

The sampling program consisted of split spoon samples collected at 0.8m to 1.5m intervals. They provided Standard Penetration Test (N) values for assessment of the in-situ state of compaction of the non-cohesive materials, and for an indication of shear strength of cohesive material. These samples also provided material for identification purposes.

The laboratory testing program for representative samples consisted of:

- Grain size analyses
- Natural Moisture Content determinations, and
- Atterberg Limit determination.

The lab results are shown on the attached log sheets.

SUBSURFACE CONDITIONS:

The record of borehole sheets in the Appendix illustrate the subsurface conditions and the ground surface elevations at the borehole locations. The locations of the boreholes are shown on Drawing No. 3188900B-A.*

The subsurface conditions at the site are quite variable. All boreholes encountered cohesive glacial till at depths ranging from 1.4m to 9.5m below ground surface. Due to the presence of swamps at proposed culverts 1,2 and 3 and due to the construction of highways the soil above till material is variable and consists of fill, organic silt or peat materials.

* SHEET NO 379-1 OF THE CONTRACT DWG'S

Following are the brief soil description at each culvert location. For details of soil conditions at each location, borehole logs should be referred to.

Site A (Culvert 1)

Three boreholes, Boreholes 101, 102 and 103 were advanced at this location. Borehole 101 was drilled on the north side of the proposed culvert in a pond, Borehole 102 was located approximately at the middle of the culvert, and Borehole 103 on the south side of the proposed culvert in a swamp. In Boreholes 101 and 103 very soft organic clayey silt to organic silty clay with peat layers was encountered to depths 3.0m and 2.4m (Elev. 73.1m to 73.9) below pond and swamp surface respectively. This deposit had very low strength in the upper portion and the auger and spoon sank in the upper 1.5m to 2m. Standard penetration N-values achieved in the lower portion of the deposit was 1 blow/0.3m. In Borehole 101 the organic deposit was underlain by a 1.2m thick loose silty sand stratum which was underlain by silty clay till. In Borehole 103 the organic deposit was directly underlain by silty clay till.

Borehole 102 encountered a 3.7m thick silty sand fill with a thin layer of fibrous peat at the bottom. The fill was underlain by silty clay glacial till. Standard Penetration, N-value achieved in the fill material ranged from 2 blows to 14 blows/0.3m. The value decreased with depth. Based on N-value the fill was found to be very loose to compact.

A cohesive glacial till was encountered in all three boreholes at depths ranging from 2.4m to 4.5m (Elevation 71.6m to 74.1m). The Standard penetration, N-value, ranged from 3 blows to 51 blows/0.3m. The lower N-values were occasional, and generally the N-value ranged from 17 to 29 blows/0.3m which suggest that the material is very stiff.

Site B (Culvert 2 & 3)

Four boreholes were drilled at this site. Boreholes 104 and 105 were advanced in a swamp on the north side of the proposed culvert. Borehole 106 was drilled between the centre and the south side of the culvert and Borehole 107 was advanced on the south side of the proposed culvert. Boreholes 104 and 105 encountered organic silty clay to depths 2.5m and 3.2m respectively (elevations 72.8m to 73.5m) below the swamp surface. In Borehole 104 the organic deposit had very low strength and the split spoon sank with the weight of the A-rod. In Borehole 105 Standard Penetration resistance was in the range of 2 blows to 6 blows/0.3m. Based on the SPT results the consistency of the deposit is very soft to firm. The organic deposit was underlain by silty clay till.

At Boreholes 106 and 107, a cohesive fill extends 1.4m to 2.1m (elevations 77.0m to 78.1m) below the ground surface. The fill consisted of silty clay material. Standard Penetration test, N-values ranged from 19 to 27 blows/0.3m which suggests that the fill is very stiff.

Underlying the organic material in Boreholes 104 & 105, and fill material in Boreholes 106 and 107, all boreholes encountered a cohesive till. The till consisted of silty clay with traces of sand and gravel. The standard penetration test, N-value ranged from 4 to 64 blows/0.3m which suggests that the till is in firm to hard state. However, the low N-value is occasional, and the more typical N-values ranged from 19 to 28 blows/0.3m which suggests that the till is very stiff.

Site C (Culvert 7 and Stoney Creek Culvert)

Four Boreholes were drilled at this site. The boreholes were designated as Boreholes 108, 110, C1 and C2. Borehole 108 was drilled on the north side and Borehole 110 was drilled on the south side of the proposed Culvert 7. Boreholes C1 and C2 were drilled earlier for Stoney Creek Culvert extensions.

All boreholes encountered fill material as a surficial layer. The fill extended to depths ranging from 2.7m to 5.9m below the ground surface. The fill consisted of silty clay material. In Borehole 108 a 2.9m thick silty clay fill was underlain by a 3m thick non-cohesive silty sand fill. The Standard Penetration Test, N-value recorded in the cohesive fill ranged from 6 to 31 blows/0.3m which suggests a firm to hard but generally firm state, while the non-cohesive fill recorded N-values between 4 to 5 blows/0.3m which suggests loose state.

Underlying the fill material Boreholes 108 and C2 encountered a layer of silty clay which ranged in thickness from 2.6m to 4.4m. A 1m thick coarse sand layer was also encountered underlying the silty clay layer in Borehole 108. Standard Penetration Test, N-value recorded in this stratum ranged from 2 to 13 blows/0.3m. However, low N-values between 2 to 3 blows/0.3m were achieved in Borehole 108 only, which suggests that the consistency of the material at this location is soft. In Borehole C2 the N-value ranged from 10 to 13 blows/0.3m which indicates that the soil is stiff at this location. The silty clay layer was underlain by silty clay till.

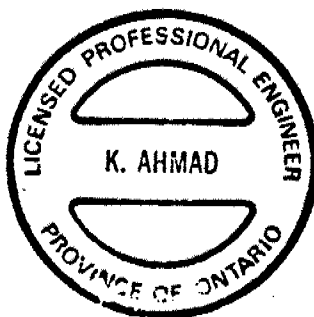
A cohesive glacial till was encountered at a depth of 9.5m and 10m below the ground surface (elevation 67.7m to 68m) in Boreholes 108 and C2 respectively, and at depths 1.7m and 2.7m below the ground surface (elevation 74.3) in Boreholes 110 and C1. The glacial till consisted of silty clay with a trace of sand and trace of gravel. The Standard Penetration Test, N-value recorded in this stratum ranged from 12 to 78 blows/0.3m. The more typical N-value ranged from 10 to 15 blows/0.3. This suggests that the consistency of this material is stiff to hard but generally stiff. All boreholes were terminated in this material.

Bedrock was proved in C1 where a 2m long bedrock core was obtained. The bedrock was classified as Shale of Queenston Formation.

MISCELLANEOUS

The field work for this project was carried out under the supervision of Ken Ahmad Foundation Engineer and Marie Josee Roy, Engineering Student. The equipment used was owned and operated by Master Soil Investigation Inc. and Longyear Canada Inc.

This report was written by Ken Ahmad, Foundation Engineer, reviewed by D. Dundas, Senior Foundation Engineer and approved by M. Devata, Chief Foundation Engineer.



Ken Ahmad

Ken Ahmad, P. Eng.
Foundation Engineer

M. S. Devata

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

APPENDIX

RECORD OF BOREHOLE No 101

1 OF 1

METRIC

W.P. 318-89-00 (B) LOCATION N 4,789,582.0; E 284,127.0 ORIGINATED BY KA
 DIST 4 HWY QEW BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
 DATUM Geodetic DATE 1990 10 29 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER • CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT 7 KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100		W _P W W _L				
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE		WATER CONTENT (%) 10 20 30				
76.1	Pond Surface													
0.0	Water													W.L. on 1990 10 29
75.5	Pond Bottom													
0.6	Organic Clayey Silt with Fibrous Peat Layers						75							
			1	SS	1								w=376	
			2	SS	3									
72.8	Silty Clay Zone						73							
3.3	Silty Sand Trace Clay, Loose, Grey		3	SS	5									1 34 42 23
71.6			4	SS	6		72							
4.5	Silty Clay Till Trace Sand, Very Stiff, Grey (Glacial Till)						71							
			5	SS	23									2 15 43 40
								70						
			6	SS	23			69						
							68							
66.9			7	SS	27		67							
9.2	End of Borehole													

RECORD OF BOREHOLE No 102

1 OF 1

METRIC

W.P. 318-89-00 (B) LOCATION N 4,789,562.0; E 284,112.0 ORIGINATED BY KA
 DIST 4 HWY QEW BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
 DATUM Geodetic DATE 1990 10 25 CHECKED BY DD

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					
77.8	Ground Surface													
0.0	Silty Sand Fill Trace organic, Occ. wood chips Very Loose to Compact Brown to Greyish Brown with Organic Stains		1	SS	14		77							
			2	SS	9		76							0 44 43 13
			3	SS	2		75							
74.1	Fibrous Peat Layer		4	SS	4		74							
3.7			5	SS	8		73							
			6	SS	19		72							
	Silty Clay Till Trace Sand, Stiff to Very Stiff Brown to Greyish Brown (Glacial Till)		7	SS	29		71							
			8	SS	25		70							
68.2			9	SS	26		69							6 16 41 37
9.6	End of Borehole * W.L. Not Established													

RECORD OF BOREHOLE No 103

1 OF 1

METRIC

W.P. 318-89-00 (B) LOCATION N 4,789,537.0; E 284,096.0 ORIGINATED BY KA
 DIST 4 HWY QEW BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
 DATUM Geodetic DATE 1990 10 29 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER • CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W _P W W _L	WATER CONTENT (%) 10 20 30		
76.3	Swamp												
0.0	Water						76						W.L. on 1990 10 29
	Organic Silty Clay Very Soft with layers of fibrous Peat		1	SS	PM		75						
			2	SS	1		74						
73.9			3	SS	3		73						0 13 52 35
2.4	Soft V. Stiff		4	SS	26		72						2 13 39 46
	Silty Clay Till Trace Sand, Trace Gravel Brown to Greyish Brown (Glacial Till)		5	SS	17		71						
			6	SS	18		69						
	V. Stiff Hard		7	SS	51		68						
67.3													
9.0	End of Borehole PM = Pushed Manually												

RECORD OF BOREHOLE No 104

1 OF 1

METRIC

W.P. 318-89-00 (B) LOCATION N 4,789,441.0; E 284,075.0 ORIGINATED BY KA
DIST 4 HWY QEW BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
DATUM Geodetic DATE 1990 10 26 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	50	80	100					
76.0	Swamp																
0.0 75.6	Water																W.L. on 1990 10 26
0.4	Organic Silty Clay Very Soft Occasional Fibrous peat layers		1	SS	•												
73.5			2	SS	7												
2.5			3	SS	4												
	Firm V. Stiff		4	SS	28												2 38 40 20
	Silty Clay Till Trace Sand, Trace Gravel Firm to Hard, Brown		5	SS	22												
	(Glacial Till) V. Stiff Hard		6	SS	33												2 17 40 41
66.8			7	SS	31												
9.2	End of Borehole • Spoon sank with the weight of rod.																

RECORD OF BOREHOLE No 105

1 OF 1

METRIC

W.P. 318-89-00 (B) LOCATION N 4,789,408.0; E 284,072.0 ORIGINATED BY KA
DIST 4 HWY QEW BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
DATUM Geodetic DATE 1990 10 26 CHECKED BY DD

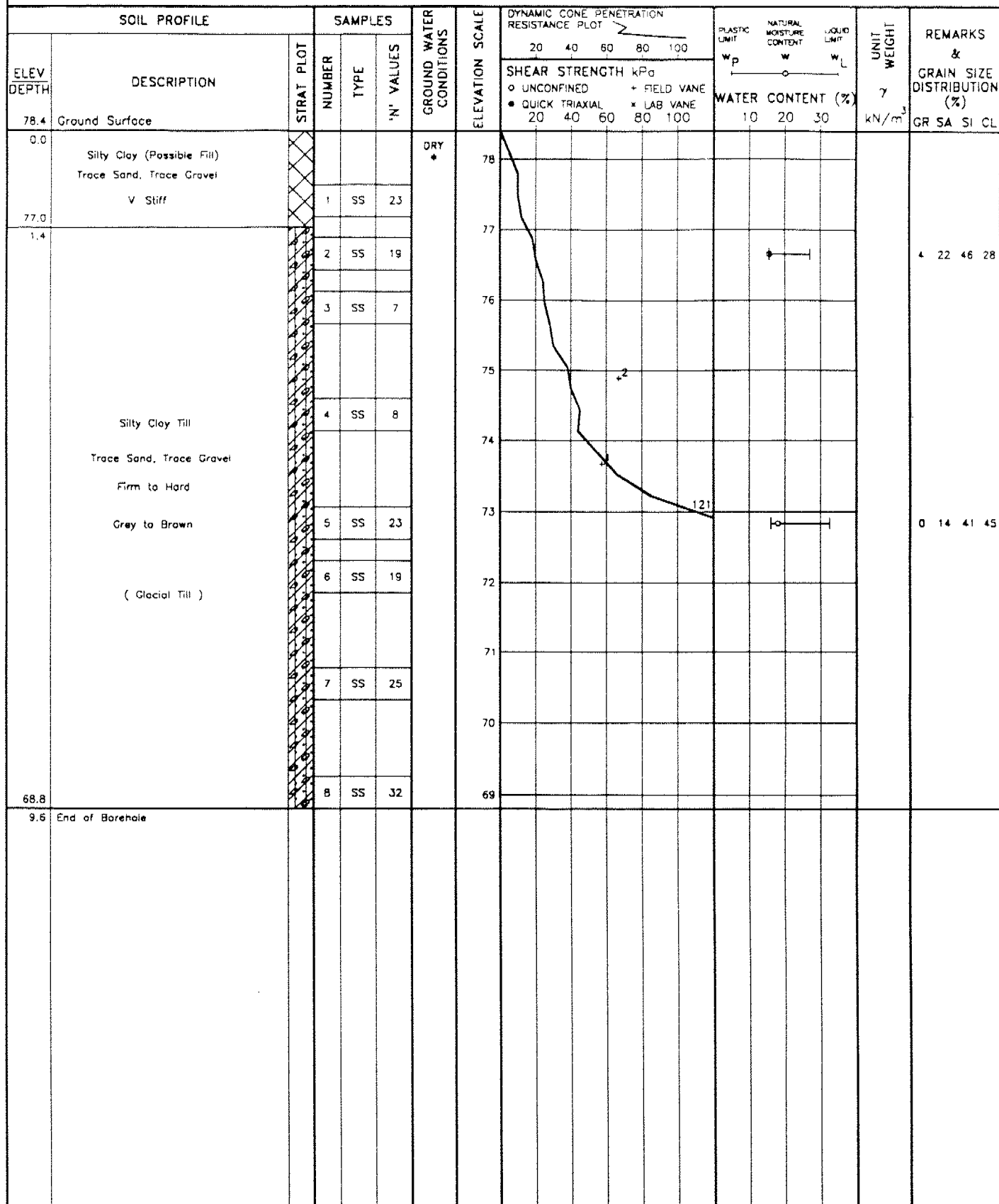
SOIL PROFILE			SAMPLES			GROUND WATER • CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100		w _p w w _L			
								SHEAR STRENGTH kPa		WATER CONTENT (%)			
								○ UNCONFINED + FIELD VANE • QUICK TRIAXIAL × LAB VANE					
76.0	Swamp							20 40 60 80 100	10 20 30				
0.0	Organic Silty Clay Occasional Fibrous Peat Layers Trace Sand Soft to Firm, Black		1	SS	2		75						W.L. on 1990 10 26
			2	SS	2		74						
			3	SS	6		73						1 13 56 30
72.8			4	SS	33		72						3 15 40 42
3.2			5	SS	34		71						
	Silty Clay Till						70						
	Trace Sand, Trace Gravel		6	SS	26		69						2 16 42 40
	Very Stiff to Hard						68						
	(Glacial Till)		7	SS	24		67						
66.9			8	SS	67								
9.1	End of Borehole												
	Probable Bedrock												

RECORD OF BOREHOLE No 106

1 OF 1

METRIC

W.P. 318-89-00 (B) LOCATION N 4,789,321.0; E 284,062.0 ORIGINATED BY KA
DIST 4 HWY QEW BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
DATUM Geodetic DATE 1990 10 24-25 CHECKED BY DD



RECORD OF BOREHOLE No 107

1 OF 1

METRIC

W.P. 318-89-00 (B) LOCATION N 4,789,273.0; E 284,057.0 ORIGINATED BY KA
 DIST 4 HWY QEW BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
 DATUM Geodetic DATE 1990 10 24 CHECKED BY DD

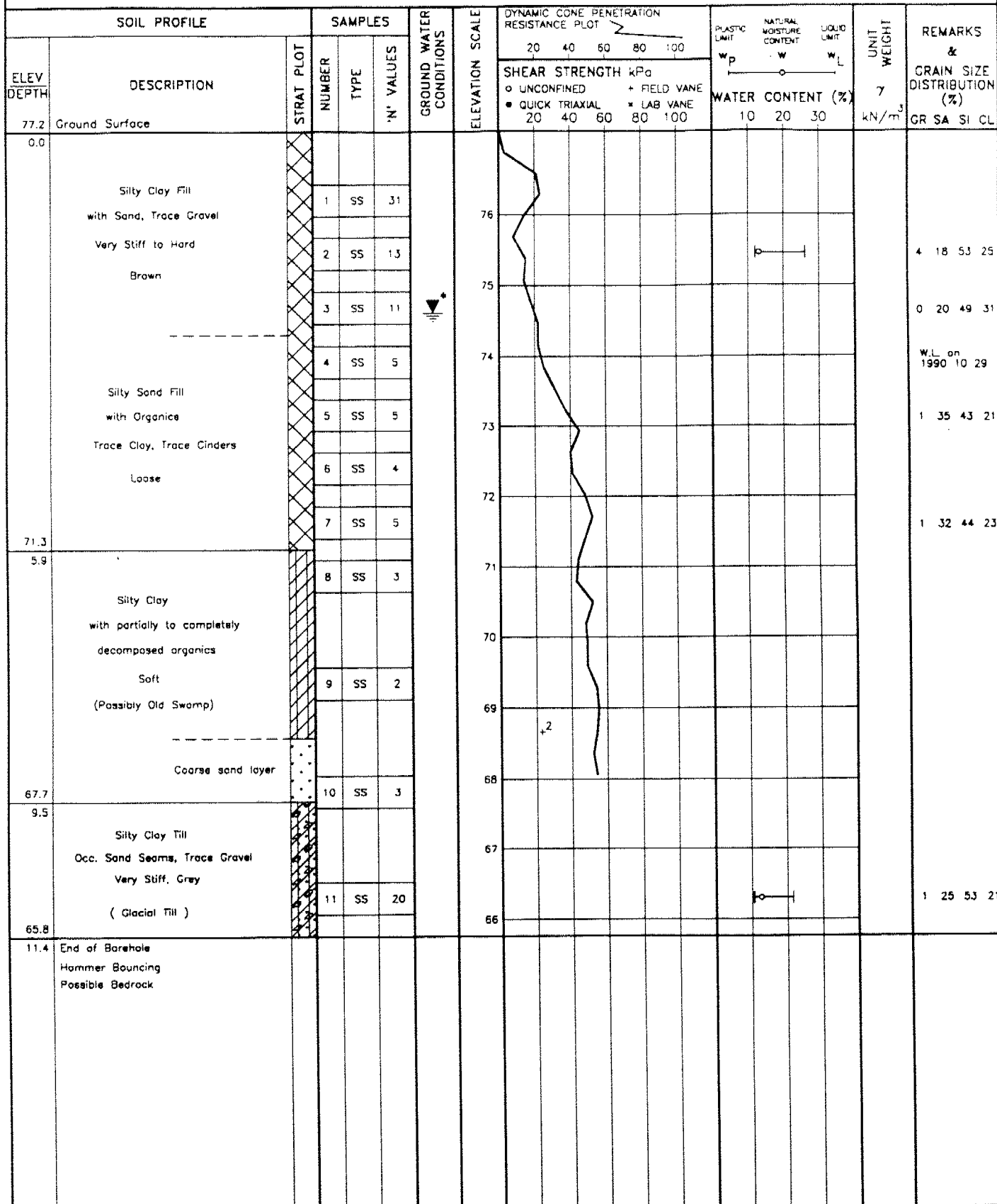
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100				
80.2	Pavement														
0.0	Silty Clay Fill, with Sand Very Stiff, Grey		1	SS	27	*									
78.1			2	SS	19										
2.1	Brown Grey Silty Clay Till Trace Sand, Trace Gravel Firm to Hard (Glacial Till)		3	SS	13										
			4	SS	13									1 12 47 40	
			5	SS	6										
			6	SS	7										
			7	SS	19										
			8	SS	34									3 21 44 32	
			9	SS	22										
70.6															
9.6	End of Borehole * Not Established														

RECORD OF BOREHOLE No 108

1 OF 1

METRIC

W.P. 318-89-00 (B) LOCATION N 4,789,055.0; E 285,087.0 ORIGINATED BY KA
DIST 4 HWY QEW BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
DATUM Geodetic DATE 1990 10 23 CHECKED BY 20



RECORD OF BOREHOLE No 110

1 OF 1

METRIC

W.P. 318-89-00 (B) LOCATION N 4,788,976.0; E 284,995.0 ORIGINATED BY KA
DIST 4 HWY QEW BOREHOLE TYPE Hollow Stem Auger COMPILED BY KA
DATUM Geodetic DATE 1990 10 23 CHECKED BY DD

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20 40 60 80 100	20 40 60 80 100	W _p	W		
77.0	Ground Surface											
0.0	Silty Clay Fill Trace Sand, Trace Gravel Occ. Wood Chips, Black Stains Firm to Stiff		1	SS	6							0 20 45 35
74.3			2	SS	9							
2.7			3	SS	7							1 13 40 46
	Silty Clay Till Trace Sand, Trace Gravel Occ. Sand Seams, Occ. Clay Zones Stiff to V. Stiff (Glacial Till)		4	SS	28							
			5	SS	18							
			6	SS	12							
			7	SS	14							
			8	SS	20							2 6 38 54
			9	SS	19							
67.7	Till Shale Complex		10	SS	60	15cm						W.L. on 1990 10 29
9.3	End of Borehole Hammer Bouncing Possible Bedrock											

RECORD OF BOREHOLE No C1

1 OF 1

METRIC

W.P. 318-89-00 LOCATION N 4 788 997; E 285 028 ORIGINATED BY BL
DIST 4 HWY Q.E.W BOREHOLE TYPE Hollow Stem Auger, Cone Test, NG Core COMPILED BY WJR
DATUM Geodetic DATE 90-07-16 CHECKED BY JS

SOIL PROFILE

SAMPLES

GROUND WATER CONDITIONS

ELEVATION SCALE

DYNAMIC CONE PENETRATION RESISTANCE PLOT

20 40 60 80 100

PLASTIC
UNIT

NATURAL
MOISTURE
CONTENT

LIQUID
UNIT

UNIT
WEIGHT

REMARKS & GRAIN SIZE DISTRIBUTION (%)

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC UNIT	NATURAL MOISTURE CONTENT	LIQUID UNIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
76.0	Ground Surface												
0.0	Silty Clay Fill												
	Trace Sand, Trace Gravel												
74.3			1	SS	23		75						
1.7	Brown Grey		2	SS	15		74						
	Silty Clay Till						73						1 14 47 38
	Trace Sand, Trace Gravel		3	SS	17		72						
	Very Stiff		4	SS	17		71						
68.1			5	SS	85	/30cm	70						
7.9	Moderate to Highly Weathered		6	SS	80	/5cm	69						
	Bedrock Shale		7	RC	REC	100%	68	120/30cm					RQD = 67%
66.1	(Queenston Formation)						67						
9.9	End of Borehole												

+3, x³: Numbers refer to
Sensitivity

20
15-25 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No C2

1 OF 1

METRIC

W.P. 318-89-00 LOCATION N 4 789 029; E 285 089 ORIGINATED BY MJR
 DIST 4 HWY O.E.W BOREHOLE TYPE Hollow Stem Auger, Cone Test COMPILED BY MJR
 DATUM Geodetic DATE 90-07-18 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
78.0	Ground Surface																
0.0	Silty Clay Fill Trace Sand, Trace Gravel Stiff to Very Stiff		1	SS	8												
			2	SS	18												
			3	SS	11												
72.4			4	SS	10												
5.6	Silty Clay Stiff		5	SS	13												
			6	SS	11												
68.0			7	SS	78												
10.0	Silty Clay Till Trace Sand, Trace Gravel Hard																
65.8	Probable Bedrock at El. 65.8m																
12.2	End of Borehole Hammer Bouncing • W.L. Not Established																

+3, x3: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

FOUNDATION INVESTIGATION REPORT
For
High Mast Lighting
Highway 20 to Grays Road
W.P. 318-89-00, Q.E.W.
District 4, Burlington

INTRODUCTION

This report summarizes the results of a foundation investigation conducted for the proposed high mast lighting along the Queen Elizabeth Way between Sta. 21+000 and Sta. 23+000 (approximately). The investigation was carried out at the request of Central Region Structural Section.

SITE DESCRIPTION

The site is located in the City of Hamilton along the Queen Elizabeth Way between Highway 20 (Centennial Parkway) and Grays Road.

The area is fairly flat and is located approximately 500 m to 1.0 km south of the Lake Ontario shoreline. The site lies within the physiographic region known as the Iroquois Plain (after Chapman and Putnam, 1984) a region characterized by sandy soils overlying cohesive glacial till. Land use in the area is industrial or recreational.

INVESTIGATION PROCEDURES

The field investigation for the high mast lighting was carried out between 90 07 11 and 90 07 19. The work consisted of eleven boreholes (BH's P5 through P15) advanced on the north and south shoulders of the QEW in line with the proposed high mast lighting locations. P5 through P15.

Subsurface information from previously conducted foundation investigations (W.P. 10-57-02, W.P. 10-57-06) in the vicinity of the QEW and Highway 20 was interpolated for high mast lighting poles P1 through P4.

The boreholes (P5 through P15) were advanced using a CME55 track-mounted auger machine equipped with 83 mm I.D. hollow stem augers and N-size casing. The boreholes were moved from the proposed light pole locations at QEW centreline to the shoulders due to traffic constraints. The subsurface informations were interpolated to determine conditions at the light pole locations.

Sampling was carried out at each borehole location by means of a 50 mm O.D. split spoon sampler driven into the soil according to the specifications of the Standard Penetration Test (ASTM D 1586). Dynamic cone penetration tests were carried out at BH's P5, P9 and P15. Vane tests were conducted in boreholes where soft cohesive soils were encountered. NQ size rock cores were obtained from BH's P9 and P11.

The elevations and co-ordinates of the boreholes were determined from the B-Plan provided to the Foundation Design Section.

Laboratory testing was carried out on representative samples to determine the physical properties of the soil and consisted of:

- Natural Moisture Content
- Atterberg Limits
- Grain Size Distribution
- Bulk Unit Weight

The results of the laboratory testing are plotted on the Record of Borehole sheets (Appendix).

SUBSURFACE CONDITIONS

General

The subsurface conditions across the site are fairly uniform. Generally, the overburden consists of a clayey silt to silty clay material. The colour of this layer in the upper 3 to 4 m is generally brown and changes into grey at lower elevations. In most cases, this layer is underlain by a red clayey silt material of glacial origin which overlies shale bedrock

of Queenston formation. The bedrock was confirmed by obtaining rock cores in BH's 9 and 11.

The Record of Borehole sheets (Appendix) illustrates the conditions at the borehole locations (BH P5 through P15). The log sheets should be referred to for detailed soil condition at each borehole location.

GROUNDWATER CONDITIONS

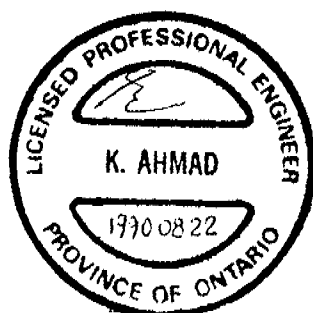
Groundwater was observed in all boreholes except for BH P5, P13 and P15. Water level was recorded at depths ranging from 0.6 m to 8.8 m below the existing ground levels. This corresponds to El. 70.3 m to 79.6 m. Generally, water level was found to be ranging between El. 77.0 m to 79.6 m. Probably the water level did not stabilize in the boreholes at the time of water level monitoring.

Record of Borehole sheets (Appendix) should be referred to for details of water level elevations at borehole locations.

MISCELLANEOUS

The fieldwork for this project was carried out under the supervision of B. Lane and M.J. Roy, Engineering Students, using equipment owned and operated by Master Soil Investigations Ltd. of Toronto.

The report was written by Ken Ahmad, Foundation Engineer, and Betty Bennett, Foundation Engineer, reviewed by D. Dundas, Senior Foundation Engineer, and approved by M. Devata, Chief Foundation Engineer.



Spencer Chumel

K. Ahmad, P.Eng.
Foundation Engineer

P. Bayat
for M. Devata, P.Eng.
Chief Foundation Engineer

APPENDIX

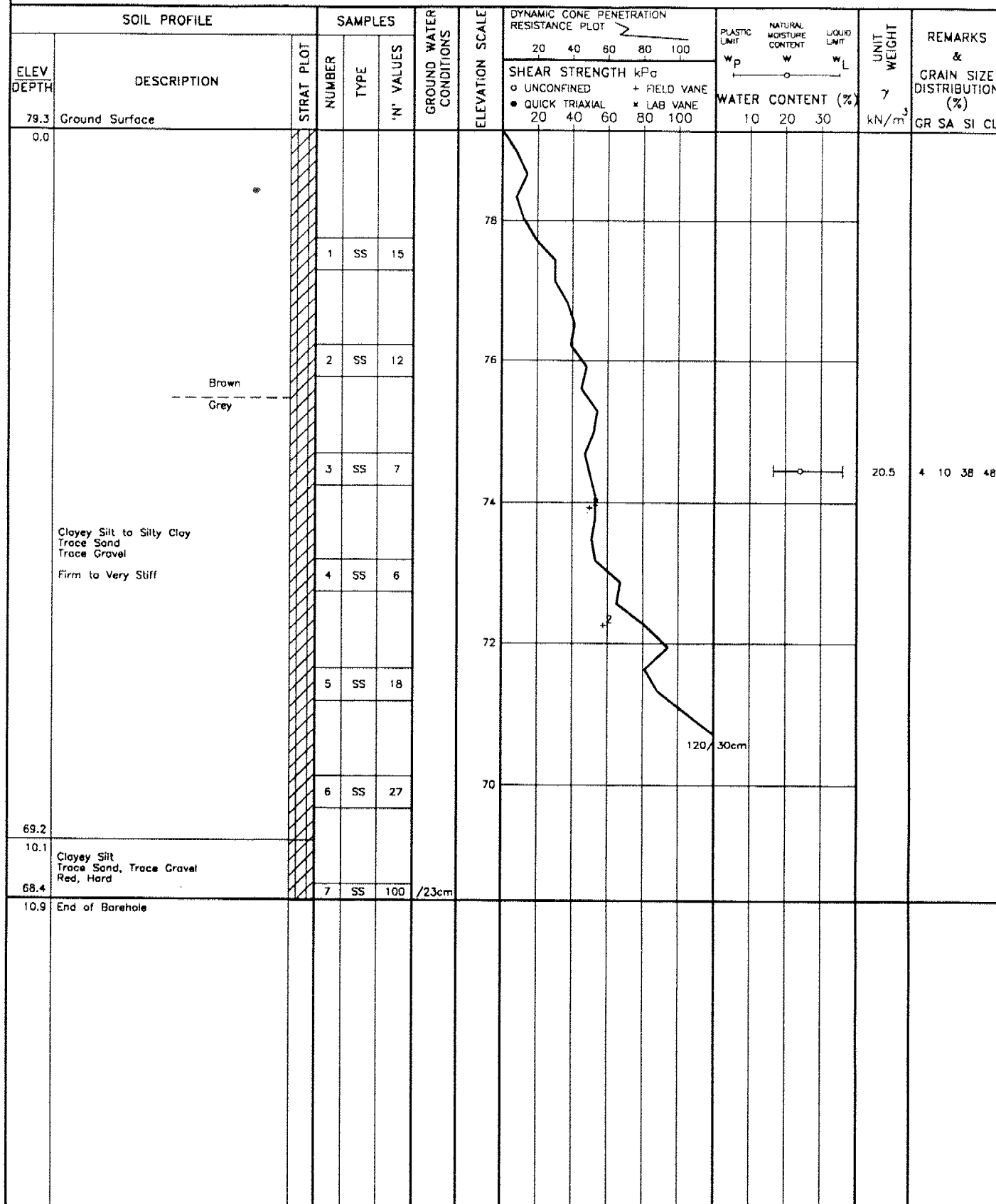
RECORD OF BOREHOLE No P5

1 OF 1

METRIC

24

W.P. 318-89-00 LOCATION N 4 789 275; E 284 209 ORIGINATED BY BL
DIST 4 HWY Q.E.W BOREHOLE TYPE Hollow Stem Auger, Cone Test COMPILED BY MJR
DATUM Geodetic DATE 90-07-11 CHECKED BY DD



RECORD OF BOREHOLE No P6

1 OF 1

METRIC 25

W.P. 318-89-00 LOCATION N 4 789 270; E 284 350 ORIGINATED BY MJR
DIST 4 HWY Q.E.W BOREHOLE TYPE Hollow Stem COMPILED BY MJR
DATUM Geodetic DATE 90-07-19 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)		
								20 40 60 80 100		20 40 60 80 100		10 20 30					
80.9	Ground Surface																
0.0	With Organics																
	Black		1	SS	4												
	Grey																
			2	SS	2								19.5	1 7 52 40			
			3	SS	5												
			4	SS	4												
	Clayey Silt to Silty Clay																
	Trace Sand																
	Trace Gravel																
	Very Soft to Hard		5	SS	8												
			6	SS	19												
			7	SS	40												
68.7																	
68.5	Bedrock *		8	SS	108	/23cm											
12.4	End of Borehole																
	* Weathered Shale Queenston Formation																

+3, x3: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No P7

1 OF 1

METRIC 26

W.P. 318-89-00 LOCATION N 4 789 188, E 284 472 ORIGINATED BY BL
DIST 4 HWY Q.E.W BOREHOLE TYPE Hollow Stem Auger COMPILED BY MJR
DATUM Geodetic DATE 90-07-11 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa										
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	* LAB VANE	WATER CONTENT (%)						
80.2	Ground Surface						20	40	60	80	100							
0.0	Clayey Silt to Silty Clay Trace Sand Trace Gravel Grey Soft to Very Stiff		1	SS	12													
					2	SS	4											
					3	SS	3											
					4	SS	3											
					5	SS	6											
70.7	Clayey Silt Trace Sand, Trace Gravel Red, Hard		6	SS	45													
9.5																		
69.2			7	SS	110	/10cm												
11.1	End of Borehole																	

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No P8

1 OF 1

METRIC 27

W.P. 318-89-00 LOCATION N 4 789 182; E 284 615 ORIGINATED BY MJR
 DIST 4 HWY Q.E.W. BOREHOLE TYPE Hollow Stem Auger COMPILED BY MJR
 DATUM Geodetic DATE 90-07-19 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)		
								20	40	60	80	100			20	40	60
81.2	Ground Surface																
0.0	Silty Sand Trace Silt Trace Gravel Brown, Compact						80										
78.9			1	SS	19												
2.3							78										
			2	SS	12												
							76										
	Clayey Silt to Silty Clay Trace Sand Trace Gravel Grey Soft to Very Stiff		3	SS	4												
			4	SS	4												
			5	SS	8												
			6	SS	21												
71.2							72										
10.1	Clayey Silt Trace Sand, Trace Gravel Red, Hard																
70.4			7	SS	70	/15cm											
10.8	End of Borehole																

+3, x5. Numbers refer to
Sensitivity

20
15-25 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No P9

1 OF 1

METRIC 28

W.P. 318-89-00 LOCATION N 4 789 100; E 284 735 ORIGINATED BY BL
 DIST 4 HWY Q.E.W. BOREHOLE TYPE Hollow Stem Auger, Cone Test, NQ Core COMPILED BY MJR
 DATUM Geodetic DATE 90-07-12 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa					
79.7	Ground Surface							20 40 60 80 100					
0.0	Clayey Silt to Silty Clay Trace Sand Trace Gravel Brown Grey Firm to Very Stiff		1	SS	20								
			2	SS	13								
			3	SS	7								
			4	SS	11								
72.0			5	SS	125	/15cm							
7.7	Moderately to Highly Weathered Sound Shale Bedrock (Queenston Formation)		6	RC	REC	96%							
			7	RC	REC	96%							
69.4													
10.4	End of Borehole												

RECORD OF BOREHOLE No P10

1 OF 1

METRIC 29

W.P. 318-89-00 LOCATION N 4 789 099; E 284 865 ORIGINATED BY MJR
 DIST 4 HWY Q.E.W BOREHOLE TYPE Hollow Stem Auger COMPILED BY MJR
 DATUM Geodetic DATE 90-07-19 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					NATURAL MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W _p	W	W _L		
78.7	Ground Surface																
0.0																	
			1	SS	7												
			2	SS	6												
	Clayey Silt to Silty Clay Trace Sand Trace Gravel Firm to Hard		3	SS	6												
			4	SS	17												
			5	SS	35												
69.9																	
8.8	End of Borehole * Split spoon bouncing no recovery Probable Bedrock at El. 69.9m																

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

RECORD OF BOREHOLE No P11

1 OF 1

METRIC 30

W.P. 318-89-00 LOCATION N 4 789 015; E 284 992 ORIGINATED BY MJR
 DIST 4 HWY Q.E.W BOREHOLE TYPE Hollow Stem Auger, NQ Core COMPILED BY MJR
 DATUM Geodetic DATE 90-07-13 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					WATER CONTENT (%) w _p w w _L				
76.7	Ground Surface							20	40	60	80	100					
0.0	Silty Clay Trace Sand, Trace Gravel Trace Organics Firm (Fill)		1	SS	5												
74.4																	
2.3			2	SS	3		74								62 w=83	14.6 3 32 44 21	
	Organic Silt Trace Sand, Trace Gravel Occ. Wood Chips Occ. Silty Clay Pockets Soft		3	SS	4		72										
			4	SS	4		70								58 w=52.5	0 9 71 20	
69.6																	
7.0	Clayey Silt Trace Sand, Trace Gravel Red/Grey, Hard		5	SS	120	/23cm											
68.7																	
7.9			6	RC	REC	97%	68									RQD 53%	
	Moderately to Highly Weathered																
	Slightly Weathered																
	Sound		7	RC	REC	100%	66									RQD 65%	
	Shale Bedrock (Queenston Formation)																
65.5																	
11.2	End of Borehole																

+3, x⁵: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No P12

1 OF 1

METRIC 31

W.P. 318-89-00 LOCATION N 4 789 005; E 285 145 ORIGINATED BY MJR
DIST 4 HWY Q.E.W BOREHOLE TYPE Hollow Stem Auger COMPILED BY MJR
DATUM Geodetic DATE 90-07-18 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE						
78.8	Ground Surface							20 40 60 80 100	20 40 60 80 100						
0.0	Brown Grey Clayey Silt to Silty Clay Trace Sand Trace Gravel Grey Firm to Very Stiff		1	SS	28										
			2	SS	6										
			3	SS	6										
			4	SS	8										
			5	SS	9										
			6	SS	9										
			7	SS	18										
66.2			8	SS	22										
12.6	End of Borehole														

RECORD OF BOREHOLE No P13

1 OF 1

METRIC

32

W.P. 318-89-00 LOCATION N 4 788 938; E 285 282 ORIGINATED BY MJR
 DIST 4 HWY Q.E.W BOREHOLE TYPE Hollow Stem Auger COMPILED BY MJR
 DATUM Ceodetic DATE 90-07-17 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20	40	60	80	100	20	40	60		
79.1	Ground Surface																
0.0																	
	Trace Organics																
	Brown		1	SS	29												
	Grey																
			2	SS	13												
			3	SS	10												
	Clayey Silt to Silty Clay		4	SS	12												
	Trace Sand																
	Trace Gravel																
	Stiff to Hard																
			5	SS	10												
			6	SS	14												
			7	SS	18												
			8	SS	31												
66.5																	
12.6	End of Borehole																

RECORD OF BOREHOLE No P14

1 OF 1

METRIC 33

W.P. 318-89-00 LOCATION N 4 788 907; E 285 429 ORIGINATED BY MJR
DIST 4 HWY Q.E.W BOREHOLE TYPE Hollow Stem Auger COMPILED BY MJR
DATUM Geodetic DATE 90-07-18 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
79.1	Ground Surface																
0.0																	
			1	SS	30												
			2	SS	10												
			3	SS	8												
			4	SS	8												
			5	SS	10												
			6	SS	11												
			7	SS	14												
			8	SS	13												
66.5																	
12.6	End of Borehole																

+3, x5, Numbers refer to
Sensitivity

20
15-25 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No P15

1 OF 1

METRIC

34

W.P. 318-89-00

LOCATION N 4 788 846, E 285 522

ORIGINATED BY MJR

DIST 4 HWY Q.E.W

BOREHOLE TYPE Hollow Stem Auger, Cone Test

COMPILED BY MJR

DATUM Geodetic

DATE 90-07-17

CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
79.3	Ground Surface													
0.0														
			1	SS	39									
			2	SS	18									
			3	SS	9									
			4	SS	9									
			5	SS	12									
			6	SS	13									
			7	SS	13									
			8	SS	14									
66.6														
12.6	End of Borehole													

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

CONT 92-46

WP 318-89-00 DIST 4

HWY 20 STR SITE

High Mast Lighting
Highway 20 to Grays Road

DISTRIBUTION

V.F. Boehnke (3)
G. Cautillo
J. Cullen (2)
A. Wittenberg
K.G. Bassi
S. Dunham
E.A. Joseph
B. Steeves (Cover Only)
I. Bullen (Cover Only)
File

FOUNDATION INVESTIGATION REPORT

For

High Mast Lighting

Highway 20 to Grays Road

W.P. 318-89-00, Q.E.W.

District 4, Burlington

INTRODUCTION

This report summarizes the results of a foundation investigation conducted for the proposed high mast lighting along the Queen Elizabeth Way between Sta. 21+000 and Sta. 23+000 (approximately). The investigation was carried out at the request of Central Region Structural Section.

SITE DESCRIPTION

The site is located in the City of Hamilton along the Queen Elizabeth Way between Highway 20 (Centennial Parkway) and Grays Road.

The area is fairly flat and is located approximately 500 m to 1.0 km south of the Lake Ontario shoreline. The site lies within the physiographic region known as the Iroquois Plain (after Chapman and Putnam, 1984) a region characterized by sandy soils overlying cohesive glacial till. Land use in the area is industrial or recreational.

INVESTIGATION PROCEDURES

The field investigation for the high mast lighting was carried out between 90 07 11 and 90 07 19. The work consisted of eleven boreholes (BH's P5 through P15) advanced on the north and south shoulders of the QEW in line with the proposed high mast lighting locations. P5 through P15.

Subsurface information from previously conducted foundation investigations (W.P. 10-57-02, W.P. 10-57-06) in the vicinity of the QEW and Highway 20 was interpolated for recommendations at high mast lighting poles P1 through P4.

The boreholes (P5 through P15) were advanced using a CME55 track-mounted auger machine equipped with 83 mm I.D. hollow stem augers and N-size casing. The boreholes were moved from the proposed light pole locations at QEW centreline to the shoulders due to traffic constraints. The subsurface informations were interpolated to determine conditions at the light pole locations.

Sampling was carried out at each borehole location by means of a 50 mm O.D. split spoon sampler driven into the soil according to the specifications of the Standard Penetration Test (ASTM D 1586). Dynamic cone penetration tests were carried out at BH's P5, P9 and P15. Vane tests were conducted in boreholes where soft cohesive soils were encountered. NQ size rock cores were obtained from BH's P9 and P11.

The elevations and co-ordinates of the boreholes were determined from the B-Plan provided to the Foundation Design Section.

Laboratory testing was carried out on representative samples to determine the physical properties of the soil and consisted of:

- Natural Moisture Content
- Atterberg Limits
- Grain Size Distribution
- Bulk Unit Weight

The results of the laboratory testing are plotted on the Record of Borehole sheets (Appendix).

SUBSURFACE CONDITIONS

General

The subsurface conditions across the site are fairly uniform. Generally, the overburden consists of a clayey silt to silty clay material. The colour of this layer in the upper 3 to 4 m is generally brown and changes into grey at lower elevations. In most cases, this layer is underlain by a red clayey silt material of glacial origin which overlies shale bedrock

of Queenston formation. The bedrock was confirmed by obtaining rock cores in BH's 9 and 11.

The Record of Borehole sheets (Appendix) illustrates the conditions at the borehole locations (BH P5 through P15). The log sheets should be referred to for detailed soil condition at each borehole location.

GROUNDWATER CONDITIONS

Groundwater was observed in all boreholes except for BH P5, P13 and P15. Water level was recorded at depths ranging from 0.6 m to 8.8 m below the existing ground levels. This corresponds to El. 70.3 m to 79.6 m. Generally, water level was found to be ranging between El. 77.0 m to 79.6 m. Probably the water level did not stabilize in the boreholes at the time of water level monitoring.

Record of Borehole sheets (Appendix) should be referred to for details of water level elevations at borehole locations.

DISCUSSION

It is proposed to install fifteen high mast lighting poles along the QEW between Hwy. 20 and Grays Road. No significant grade changes are proposed. Therefore it is assumed that all HML caissons will be founded in original ground, clear of any cut or fill slopes.

The borehole locations are shown on the enclosed Drawing No. 3188900A-A.

Recommendations

The high mast lighting poles will be founded on single reinforced concrete caissons. The foundations should be designed in accordance with the methods described by B.B. 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 there are to be any elevation changes at the pole locations then, for design purposes, the most critical lowest surface elevations should be assumed. The following soil parameters are provided for the design of the high mast lighting caissons:

ϕ = apparent angle of internal friction for non-cohesive soils

q_u = unconfined compressive strength in kPa

γ = unit weight in kN/m³

The design values at each of the HML locations are provided as follows:

SOIL PARAMETERS AT EACH HIGH MAST LIGHT POLES

Table 1

<u>Light Pole</u>	<u>El. (m) From-To</u>	<u>WL. El. (m)</u>	<u>Soil Type</u>	<u>ϕ (Degree)</u>	<u>q_u (kPa)</u>	<u>γ (kN/m³)</u>
P1	81.2-77.7	80.5	Cohesive	0	350	21.2
	77.7-73.2		Cohesive	0	60	19.0
	73.2-68.3		Cohesive	0	350	21.0
P2	78.9-75.0	79.2	Cohesive	0	100	20.5
	75.0-66.1		Cohesive	0	200	20.5
	66.1-59.7		Cohesive	0	500	21.2
P3	78.7-72.0	76.7	Cohesive	0	200	20.0
	72.0-66.7		Cohesive	0	400	21.0
P4	80.6-73.2	76.7	Cohesive	0	150	20.0
	73.2-68.7		Cohesive	0	350	21.0
	68.7-65.5		Cohesive	0	500	21.2
P5	79.3-72.0	Dry	Cohesive	0	100	19.6
	72.0-69.2		Cohesive	0	150	20.0
	69.2-68.4		Cohesive	0	500	21.2
P6	80.9-72.0	78.6	Cohesive	0	50	19.5
	72.0-68.7		Cohesive	0	250	20.5
	Below 68.7		Shale Bedrock	0	750	22.5
P7	80.2-72.0	79.6	Cohesive	0	50	19.2
	72.0-70.7		Cohesive	0	200	21.2
	70.7-69.2		Cohesive	0	500	21.2
P8	81.2-78.9	77.2	Non-Cohesive	32	0	20.0
	78.9-72.0		Cohesive	0	50	20.0
	72.0-71.2		Cohesive	0	200	20.2
	71.2-70.4		Cohesive	0	500	21.2
P9	79.7-76.0	77.0	Cohesive	0	150	20.5
	76.0-72.2		Cohesive	0	100	20.5
	Below 72.0		Shale Bedrock	0	1000	22.5
P10	78.7-76.0	71.1	Cohesive	0	100	20.0
	76.0-73.5		Cohesive	0	50	20.0
	73.5-69.9		Cohesive	0	200	21.0
	Below 69.9		Shale Bedrock	0	750	22.5
P11	76.7-69.6	75.1	Cohesive	0	100	14.6
	69.6-68.7		Cohesive	0	200	20.5
	Below 68.7		Shale Bedrock	0	750	22.5
P12	78.8-76.5	72.2	Cohesive	0	200	20.5
	76.5-68.5		Cohesive	0	100	20.0
	68.5-66.2		Cohesive	0	200	20.5
P13	79.1-76.8	Dry	Cohesive	0	200	20.5
	76.8-68.0		Cohesive	0	150	20.0
	68.0-66.5		Cohesive	0	200	20.5
P14	79.1-76.8	70.3	Cohesive	0	200	21.2
	76.8-66.5		Cohesive	0	160	21.2
P15	79.3-76.0	Dry	Cohesive	0	200	21.0
	76.0-66.6		Cohesive	0	150	20.0

It should be assumed that material (fill or native soil) in the zone of frost penetration does not provide any lateral resistance. The depth of frost penetration at this site is 1.2 m.

Dewatering

It is expected that at many of the high mast pole locations, construction of the caisson will take place partially below groundwater level. Since the overburden soil is cohesive water seepage will be minor and could be handled by ordinary sump pump technique.

If the caissons are founded on cohesive material, it may be subject to basal heave. As a result, the contractor should be advised of the conditions to ensure that the stability of the soil along the sides and at the base of the caisson is maintained.

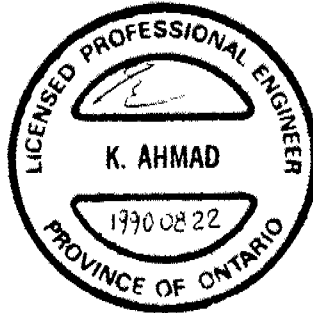
Construction Considerations

At present, a trunk sewer runs along the median of the QEW in close proximity to the proposed caisson foundation locations. Our concern about this was brought to the attention of the Structural and Electrical Sections at which time we suggested that the problem could be avoided by locating the High Mast Lights at the shoulders. However, we were advised that the High Mast Light pole locations had to be at the centreline of Q.E.W. due to property constraints. In the event that the sewer line is not re-aligned, considerable care should be taken to minimize disturbance of the sewer pipe. This can be achieved by exposing the sewer pipe with careful excavation and locating the High Mast Light caissons a minimum of 1 m from the sewer. In addition, the use of heavy equipment within 3.0 m of the sewer line should be avoided.

MISCELLANEOUS


The fieldwork for this project was carried out under the supervision of B. Lane and M.J. Roy, Engineering Students, using equipment owned and operated by Master Soil Investigations Ltd. of Toronto.

The report was written by Ken Ahmad, Foundation Engineer, and Betty Bennett, Foundation Engineer, reviewed by D. Dundas, Senior Foundation Engineer, and approved by M. Devata, Chief Foundation Engineer.



A handwritten signature in cursive script, appearing to read "Ken Ahmad".

K. Ahmad, P.Eng.
Foundation Engineer

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

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

STRESS AND STRAIN

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

PHYSICAL PROPERTIES OF SOIL

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

RECORD OF BOREHOLE No P5

1 OF 1

METRIC

W.P. 318-89-00 LOCATION N 4 789 275; E 284 209 ORIGINATED BY BL
 DIST 4 HWY Q.E.W BOREHOLE TYPE Hollow Stem Auger, Cone Test COMPILED BY MJR
 DATUM Geodetic DATE 90-07-11 CHECKED BY DD

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	SHEAR STRENGTH kPa						WATER CONTENT (%)
79.3	Ground Surface						20 40 60 80 100	20 40 60 80 100	10 20 30					
0.0	Brown Gray Clayey Silt to Silty Clay Trace Sand Trace Gravel Firm to Very Stiff		1	SS	15									
			2	SS	12									
			3	SS	7									
			4	SS	6									
			5	SS	18									
			6	SS	27									
69.2														
10.1	Clayey Silt Trace Sand, Trace Gravel Red, Hard		7	SS	100	/23cm								
58.4														
10.9	End of Borehole													

RECORD OF BOREHOLE No P6

1 OF 1

METRIC

W.P. 318-89-00 LOCATION N 4 789 270; E 284 350 ORIGINATED BY MJR
 DIST 4 HWY Q.E.W BOREHOLE TYPE Hollow Stem COMPILED BY MJR
 DATUM Geodetic DATE 90-07-19 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
80.9	Ground Surface																
0.0	With Organics																
	Black		1	SS	4												
	Grey																
			2	SS	2											19.5	1 7 52 40
			3	SS	5												
			4	SS	4												
	Clayey Silt to Silty Clay																
	Trace Sand																
	Trace Gravel																
	Very Soft to Hard		5	SS	8												
			6	SS	19												
			7	SS	40												
68.7																	
68.5	Bedrock *		8	SS	108	/23cm											
12.4	End of Borehole																
	* Weathered Shale Queenston Formation																

RECORD OF BOREHOLE No P7

1 OF 1

METRIC

W.P. 318-89-00 LOCATION N 4 789 188; E 284 472 ORIGINATED BY BL
 DIST 4 HWY Q.E.W BOREHOLE TYPE Hollow Stem Auger COMPILED BY MJR
 DATUM Geodetic DATE 90-07-11 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W _p	W	W _L		
80.2	Ground Surface																
0.0	Clayey Silt to Silty Clay Trace Sand Trace Gravel Grey Soft to Very Stiff		1	SS	12												
78			2	SS	4												
76			3	SS	3												
74			4	SS	3												
72			5	SS	6												
70.7	Clayey Silt Trace Sand, Trace Gravel Red, Hard		6	SS	45												
9.5			7	SS	110												
69.2																	
11.1	End of Borehole																

RECORD OF BOREHOLE No P8

1 OF 1

METRIC

W.P. 318-89-00 LOCATION N 4 789 182; E 284 615 ORIGINATED BY MJR
DIST 4 HWY Q.E.W. BOREHOLE TYPE Hollow Stem Auger COMPILED BY MJR
DATUM Geodetic DATE 90-07-19 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID UNIT MOISTURE UNIT UNIT CONTENT CONTENT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								20 40 60 80 100							

81.2	Ground Surface													
0.0	Silty Sand Trace Silt Trace Gravel Brown, Compact													
			1	SS	19									
78.9														
2.3			2	SS	12									
			3	SS	4									
	Clayey Silt to Silty Clay Trace Sand Trace Gravel Grey Soft to Very Stiff		4	SS	4								20.0	1 13 42 44
			5	SS	8									
			6	SS	21									
71.2														
10.1	Clayey Silt Trace Sand, Trace Gravel Red, Hard													
70.4			7	SS	70	/15cm								
10.8	End of Borehole													

RECORD OF BOREHOLE No P9

1 OF 1

METRIC

W.P. 318-89-00 LOCATION N 4 789 100; E 284 735 ORIGINATED BY BL
 DIST 4 HWY Q.E.W. BOREHOLE TYPE Hollow Stem Auger, Cone Test, NQ Core COMPILED BY MJR
 DATUM Geodetic DATE 90-07-12 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL UNIT MOISTURE CONTENT		UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W _p	W		
79.7	Ground Surface												
0.0													
	Clayey Silt to Silty Clay Trace Sand Trace Gravel		1	SS	20								
			2	SS	13								
			3	SS	7								
			4	SS	11								
72.0			5	SS	125	/15cm							
7.7			6	RC	REC	96%							
			7	RC	REC	96%							
69.4													
10.4	End of Borehole												

RECORD OF BOREHOLE No P10

1 OF 1

METRIC

W.P. 318-89-00 LOCATION N 4 789 099; E 284 865 ORIGINATED BY MJR
DIST 4 HWY Q.E.W BOREHOLE TYPE Hollow Stem Auger COMPILED BY MJR
DATUM Geodetic DATE 90-07-19 CHECKED BY DD

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					
78.7	Ground Surface																
0.0																	
			1	SS	7												
			2	SS	6												
	Clayey Silt to Silty Clay Trace Sand Trace Gravel Firm to Hard		3	SS	6												
			4	SS	17												
			5	SS	35												
69.9																	
8.8	End of Borehole * Split spoon bouncing no recovery Probable Bedrock at El. 69.9m																

RECORD OF BOREHOLE No P11

1 OF 1

METRIC

W.P. 318-89-00 LOCATION N 4 789 015; E 284 992 ORIGINATED BY MJR
 DIST 4 HWY Q.E.W BOREHOLE TYPE Hollow Stem Auger, NQ Core COMPILED BY MJR
 DATUM Geodetic DATE 90-07-13 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
76.7	Ground Surface																
0.0	Silty Clay Trace Sand, Trace Gravel Trace Organics Firm (Fill)		1	SS	5												
74.4																	
2.3			2	SS	3		74									14.6	3 32 44 21
	Organic Silt Trace Sand, Trace Gravel Occ. Wood Chips Occ. Silty Clay Pockets Soft		3	SS	4		72										
			4	SS	4		70										0 9 71 20
69.6																	
7.0	Clayey Silt Trace Sand, Trace Gravel Red/Grey, Hard		5	SS	120	/23cm											
68.7																	
7.9			6	RC	REC	97%	68										RQD 53%
	Moderately to Highly Weathered																
	Slightly Weathered																
	Sound		7	RC	REC	100%	66										RQD 65%
	Shale Bedrock (Queenston Formation)																
65.5																	
11.2	End of Borehole																

RECORD OF BOREHOLE No P12

1 OF 1

METRIC

W.P. 318-89-00 LOCATION N 4 789 005; E 285 145 ORIGINATED BY MJR
 DIST 4 HWY Q.E.W BOREHOLE TYPE Hollow Stem Auger COMPILED BY MJR
 DATUM Geodetic DATE 90-07-18 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
78.8	Ground Surface																
0.0																	
			1	SS	28												
			2	SS	6												
			3	SS	6												
			4	SS	8												
			5	SS	9												
			6	SS	9												
			7	SS	18												
			8	SS	22												
66.2																	
12.6	End of Borehole																

RECORD OF BOREHOLE No P13

1 OF 1

METRIC

W.P. 318-89-00 LOCATION N 4 788 938 E 285 282 ORIGINATED BY MJR
DIST 4 HWY Q.E.W BOREHOLE TYPE Hollow Stem Auger COMPILED BY MJR
DATUM Geodetic DATE 90-07-17 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT 7 KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
79.1	Ground Surface																
0.0																	
	Trace Organics																
	Brown		1	SS	29												
	Grey																
			2	SS	13												
			3	SS	10												
	Clayey Silt to Silty Clay		4	SS	12												
	Trace Sand																
	Trace Gravel																
	Stiff to Hard																
			5	SS	10												
			6	SS	14												
			7	SS	18												
66.5			8	SS	31												
12.6	End of Borehole																

RECORD OF BOREHOLE No P14

1 OF 1

METRIC

W.P. 318-89-00 LOCATION N 4 788 907; E 285 429 ORIGINATED BY MJR
 DIST 4 HWY Q.E.W. BOREHOLE TYPE Hollow Stem Auger COMPILED BY MJR
 DATUM Geodetic DATE 90-07-18 CHECKED BY DD

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
79.1	Ground Surface															
0.0																
			1	SS	30											
			2	SS	10											
			3	SS	8											
			4	SS	8											
			5	SS	10											
			6	SS	11											
			7	SS	14											
			8	SS	13											
66.5																
12.6	End of Borehole															

RECORD OF BOREHOLE No P15

1 OF 1

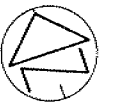
METRIC

W.P. 318-89-00 LOCATION N 4 788 846; E 285 522 ORIGINATED BY MJR
 DIST 4 HWY Q.E.W BOREHOLE TYPE Hollow Stem Auger, Cone Test COMPILED BY MJR
 DATUM Geodetic DATE 90-07-17 CHECKED BY DD

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100					
79.3	Ground Surface												
0.0													
			1	SS	39								
			2	SS	18								
			3	SS	9								
			4	SS	9								
			5	SS	12								
			6	SS	13								
			7	SS	13								
			8	SS	14								
66.6													
12.6	End of Borehole												

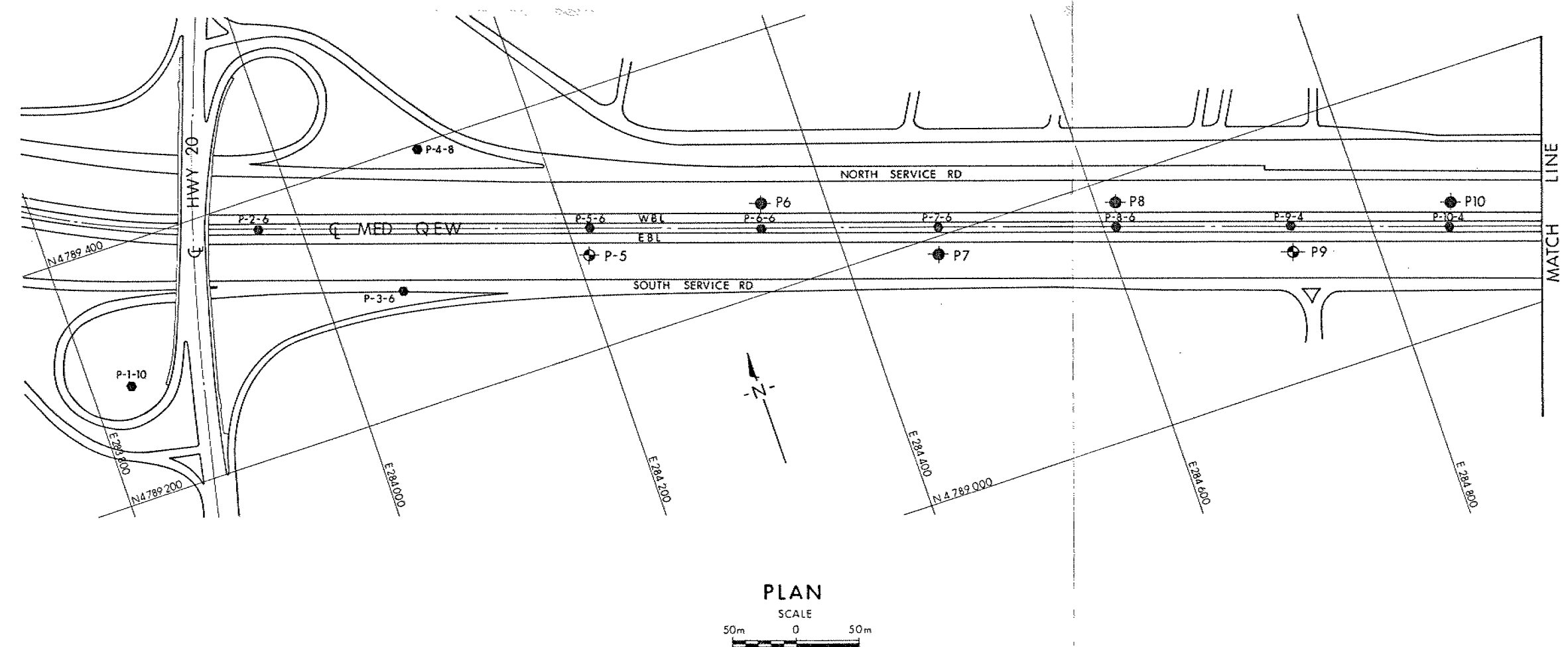
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.

CONT No
WP No 318-89-00A

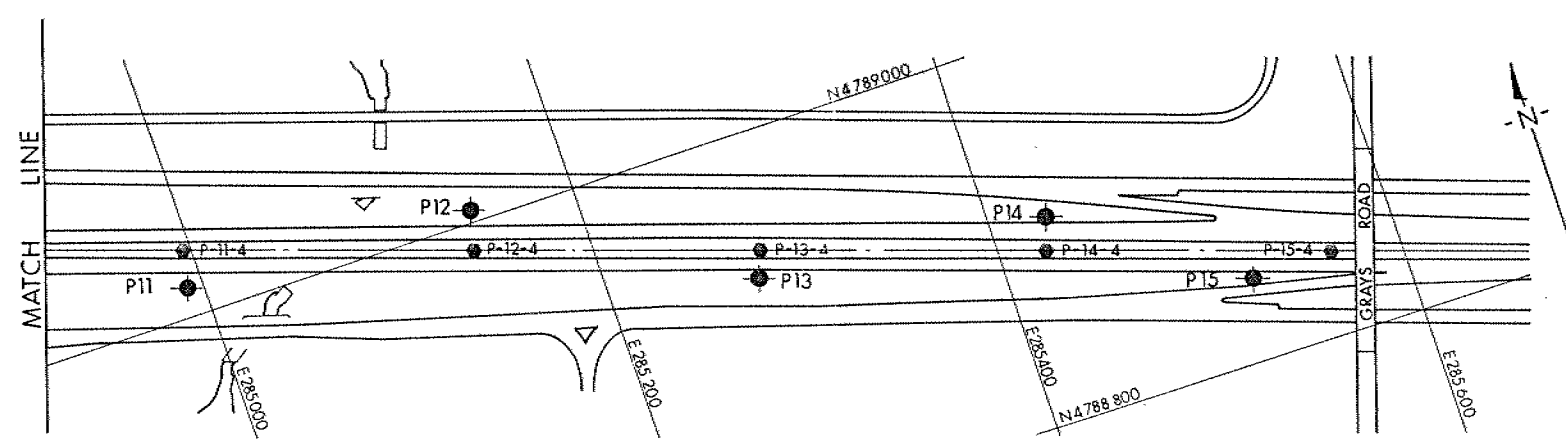


HIGH MAST LIGHTING
HWY 20 TO GRAYS RD
BORE HOLE LOCATIONS & SOIL STRATA

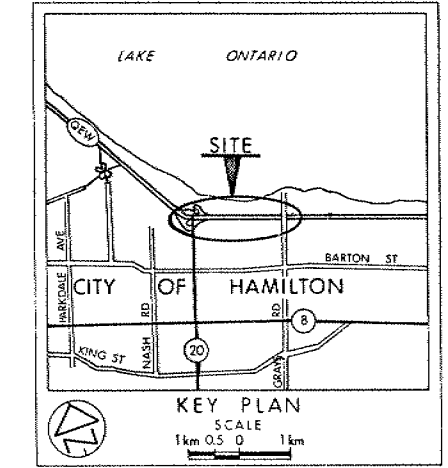
SHEET



PLAN
SCALE
50m 0 50m



NOTE - FOR SUBSOIL INFORMATION REFER
TO RECORD OF BORE HOLE



- 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
 - High Mast Lighting Pole

No	ELEVATION	CO-ORDINATES NORTH	EAST
P5	79.3	4 789 275.0	284 209.0
P6	80.9	4 789 270.0	284 350.0
P7	80.2	4 789 188.0	284 472.0
P8	81.2	4 789 182.0	284 615.0
P9	79.7	4 789 100.0	284 735.0
P10	78.7	4 789 099.0	284 865.0
P11	76.7	4 789 015.0	284 992.0
P12	78.8	4 789 005.0	285 145.0
P13	79.1	4 788 938.0	285 282.0
P14	79.1	4 788 907.0	285 429.0
P15	79.3	4 788 846.0	285 522.0

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 30M4-69

HWY No QEW	CHECKED	DATE 1990 08 17	DIST 4
SUBMIT K.A	CHECKED	APPROVED	SITE
DRAWN SO	CHECKED	APPROVED	DWG 3188900A-A