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W. O. No.

STR. SITE No.

HWY. No. QEW

LOCATION QEW / MISSISSAUGA RD., H.M.L.

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

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REPORT ON

**FOUNDATION INVESTIGATION
HIGH MAST LIGHTING
W.P. 167-86-00
MISSISSAUGA ROAD INTERCHANGE
QUEEN ELIZABETH WAY (QEW)**

Submitted to:

**Morrison Hershfield Limited
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971-8040

TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
1.0 INTRODUCTION	1
2.0 SITE DESCRIPTION	1
3.0 INVESTIGATION PROCEDURES.....	1
4.0 SUBSURFACE CONDITIONS	2
5.0 GEOTECHNICAL RECOMMENDATIONS	4

List of Abbreviations

List of Symbols

Record of Borehole Sheets

Figure 1

1.0 INTRODUCTION

This report presents the results of the geotechnical investigation carried out for the proposed high mast lighting foundations as part of the QEW / Mississauga Road interchange project. The investigation and analysis has been carried out in accordance with the Terms of Reference for the work and the Ontario Highway Bridge Design Code (1991).

2.0 SITE DESCRIPTION

The site is located at the interchange of Mississauga Road and the QEW in Mississauga, Ontario. The study area for the high mast lighting extends between Stations 16+750 and 17+550. The ground surface in the general area is relatively level with the exception of the cut made for Mississauga Road under the QEW.

3.0 INVESTIGATION PROCEDURES

The field work was carried out on December 18 and 19, 1997 at which time four boreholes were put down within the study area at the location shown on the attached Figure 1. The boreholes were extended using a bombardier mounted drill rig supplied and operated by K&S Drilling. Soil samples were obtained at regular (0.75 m) intervals of depth as part of the Standard Penetration Test using 50 mm diameter split spoon samplers.

Two of the boreholes were put down at the staked locations of two of the high mast light (HML) poles. Additional information was obtained from one borehole put down at the proposed overhead sign location which is in close proximity to one of the HML poles and one borehole put down for a proposed culvert in close proximity to one other HML pole. All boreholes are located on the north side of the QEW.

The locations of HML poles were revised after completion of the investigation. The revised locations for the western seven HML are in relative close proximity to the boreholes as drilled.

4.0 SUBSURFACE CONDITIONS

In general, the subsoils encountered at the site consist of surficial topsoil underlain at some locations by fill materials which are in turn underlain by clayey silt till. Shale bedrock of the Georgian Bay Formation was encountered at 2.1 m depth at three borehole locations and at 3.7 m depth at the fourth borehole location. The following table summarizes the subsoil conditions encountered in the boreholes:

<i>Borehole Number</i>	<i>Ground Surface</i>	<i>Approximate Chainage and Offset</i>	<i>Depth (m)</i>	<i>Stratigraphy / Comments</i>
1	Approximately 1.0 m above adjacent QEW grade	16 + 780 / 28 m R	0.0 - 0.3 0.3 - 2.1 2.1 - 4.6 4.6	Topsoil Stiff to very stiff, grey clayey silt, trace sand and gravel. TILL. "N" = 11 @ 0.8 m; "N" = 26 @ 1.5 m Weathered to fresh, grey shale with limestone/dolomite interlayers. BEDROCK End of borehole; borehole dry on completion of drilling
2	Approximately 0.5 m below adjacent QEW grade	17 + 200 / 35 m R	0.0 - 0.25 0.25 - 0.9 0.9 - 2.1 2.1 - 3.0 3.0	Topsoil Very stiff clayey silt. FILL. Very stiff to hard, grey clayey silt, trace sand and gravel. TILL. "N" = 21 @ 0.8 m; "N" = 71 @ 1.5 m Weathered to fresh, grey shale with limestone/dolomite interlayers. BEDROCK (25 minutes to auger 0.8 m) End of borehole; borehole dry on completion of drilling
3	Approximately 1.2 m below adjacent QEW grade	17 + 365 / 35 m R	0.0 - 0.25 0.25 - 2.1 2.1 - 2.9 2.9	Topsoil Hard, grey clayey silt, trace sand and gravel. TILL. "N" = 50 @ 0.8 m; "N" = 87 @ 1.5 m Weathered, grey shale. BEDROCK End of borehole; auger refusal; borehole dry on completion of drilling
4	Approximately 0.6 m below adjacent QEW grade	17 + 450 / 30 m R	0.0 - 0.6 0.6 - 3.6 3.6 - 3.9 3.9	Brown sand gravel. FILL Firm to very stiff, grey to brown, silty clay, trace organics. FILL Grey shale. BEDROCK End of borehole; borehole dry on completion of drilling

Further subsurface information was obtained from the results of four boreholes put down for the QEW overpass at Mississauga Road (Report S-500-516/55/T-103-1; GEOCRE 30M12-238 / 30M12-116. The approximate borehole locations are shown on the attached Figure 1. Copies of the borehole logs were not available; however, the following summarizes the subsurface conditions encountered:

Borehole Number	Ground Surface Elevation (ft)	Depth Below Ground Surface (ft)	Description	"N" Values	Recovery %
MTO 1	325.6	0.0 to 5.5 5.5 to 8.6 8.6 to 17.9	Very fine brown sand, trace silt Light brown clay with fine gravel Grey shale, slightly calcareous, with occasional solid mudstone beds, up to 6" thick	27 @ 2.5 ft 48 @ 5.0 ft 138 @ 7.5 ft	75 to 100
MTO 2	325.4	0.0 to 7.0 7.0 to 17.4	Clay / weathered shale Grey shale, slightly calcareous, with occasional mudstone beds up to 6" thick	30 @ 2.5 ft 25 @ 3.5 ft 50 @ 4.5 ft	68 to 93
MTO 3	325.2	0.0 to 7.5 7.5 to 16.0	Clay Grey shale, slightly calcareous, with occasional mudstone beds up to 6" thick	26 @ 2.5 ft 47 @ 4.8 ft 37 @ 5.5 ft 80 @ 7.0 ft	48 to 93
MTO 4	322.9	0.0 to 5.5	Clay / weathered shale Grey shale, slightly calcareous with occasional mudstone beds up to 6" thick	10 @ 0.5 ft 8 @ 1.5 ft 16 @ 2.5 ft 98 @ 5.0 ft	54 to 100

The anticipated conditions at the six western HML locations can be inferred from the results of the boreholes closest to each proposed HML. For the two eastern HML locations, the stratigraphy as indicated for Borehole 4 may be assumed except that the bedrock surface should be assumed to be at 4.5 m depth.

Grinding of the augers during drilling through the bedrock was noted indicating the presence of limestone/dolomite interlayers within the shale. It was possible to auger 2.5 m into the bedrock at the location of Borehole 1; however, considerable difficulty was met in advancing the augers to 0.9 m into the bedrock in Borehole 2 and refusal to further auger penetration was met at 0.8 m depth below bedrock surface in Borehole 3.

It should also be noted that although boulders were not encountered in the boreholes, boulders are inherently present within the glacial till deposit in this area.

5.0 GEOTECHNICAL RECOMMENDATIONS

Reference should be made to Special Provision No. 631F02ERS – Construction Specification for Concrete Footings for High Mast Poles.

The following parameters may be assumed for the design of the HML foundations based on the simplified stratigraphy.

High Mast Light Number	Approximate Station	Strata	Depth (m)	Design Parameters				
				c_u	c'	ϕ'	γ	Kp
1, 2 and 3	16 + 720	Topsoil	0.0 – 0.3	-	-	-	16	-
	16 + 890 and	Clayey silt till	0.3 – 2.1	75	-	30	21	3
	16 + 990	Shale bedrock	>2.1	-	10	40	23	4.6
4, 5 and 6	17 + 100	Topsoil	0.0 – 0.3	-	-	-	16	-
	17 + 230 and	Clayey silt till	0.3 – 2.1	150	-	32	21	3.2
	17 + 380	Shale bedrock	>2.1	-	10	40	23	4.6
7	17 + 520	Fill	0.0 – 3.5	-	-	28	19	3.8
		Shale bedrock	>3.5	-	10	40	23	4.6
8 and 9	17 + 690 and	Fill/Till	0.0 – 4.5	-	-	32	21	3.2
	17 + 830	Shale bedrock	>4.5	-	10	40	23	4.6

c_u - undrained shear strength, kPa

c' - effective cohesion, kPa

ϕ' - effective angle of friction, degrees

γ - bulk unit weight, kN/m³

Kp - passive lateral earth pressure coefficient

The unfactored lateral earth pressure, P_p , distribution along the caisson acting over depth, d in m, may be calculated using the following expression and the parameters given above:

$$P_p = Kp \gamma d + 2 c' \sqrt{Kp}$$

Where an undrained shear strength, c_u , is provided, the undrained capacity for the length of the socket within the till may be calculated assuming ϕ' of zero and a lateral pressure distribution equivalent to 2 times the undrained shear strength.


The unfactored lateral resistance should be calculated assuming an equivalent pile width equal to 3 times the caisson diameter. A resistance factor of 0.5 should be applied to the lateral resistance as calculated to obtain the factored lateral geotechnical resistance.


The groundwater level should be assumed at 5 m depth below ground surface. The passive resistance in front of the caisson within the upper 1.2 m below ground surface should be neglected in the design of the foundations to account for frost action.

Sockets for the HML foundations will primarily be in bedrock. It is noted that refusal to further auger advance and / or spoon penetration during drilling through the bedrock was met in three of the four boreholes drilled. Augering through the bedrock for caisson construction will be relatively difficult given the anticipated limestone and dolomite layering within the shale bedrock and the caisson may have to be advanced using tricone/churn drilling techniques to break through the hard layers. In addition, although boulders were not encountered in the boreholes, boulders are inherent within the glacial till deposits in the general area and should be anticipated. The contractors' method of caisson construction should allow for break-up and removal of boulders.

Yours truly,

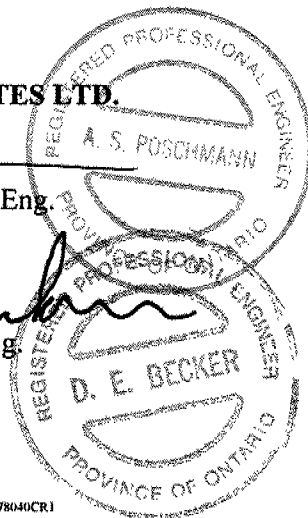
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WORD S/FINALDAT/OTHPRT/971-8040/1998/78040CR1



LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO	Drive open
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.).

Dynamic Penetration Resistance; N_d :

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT):

An electronic cone penetrometer with a 60° conical tip and a projected end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index (Relative Density)	N Blows/300 mm or Blows/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

Consistency	c_u, s_u kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO ₄	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane test (LV-laboratory vane test)
γ	unit weight

Note:

- Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I GENERAL

π	= 3.1416
$\ln x$,	natural logarithm of x
$\log_{10} x$ or $\log x$,	logarithm of x to base 10
g	acceleration due to gravity
t	time
F	factor of safety
V	volume
W	weight

II STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ϵ	linear strain
ϵ_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stresses (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress = $(\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation
*	Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density \times acceleration due to gravity)

(a) Index Properties (con't.)

w	water content
w_l	liquid limit
w_p	plastic limit
I_p	plasticity Index = $(w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(c) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(d) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (overconsolidated range)
C_s	swelling index
C_α	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	Overconsolidation ratio = σ'_p / σ'_{vo}

(e) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = $\tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3) / 2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3) / 2$
q	$(\sigma_1 - \sigma_3) / 2$ or $(\sigma'_1 - \sigma'_3) / 2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes: 1. $\tau = c' + \sigma' \tan \phi'$

2. Shear strength = (Compressive strength)/2

NS040001 BHS

W.P. 167-86-00

RECORD OF BOREHOLE 1

SHEET 1 OF 1

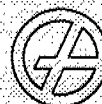
DIST.

BORING DATE: DEC 19/97

DATUM:

LOCATION: Sta. 16+780/28m Rt

PROJECT: 981-8040



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa nat V - + rem V - ⊕ U - ○	WATER CONTENT, PERCENT Wp -----○ W----- Wl			
0	POWER AUGER DRILL RIG	GROUND SURFACE									
		Topsoil	0.00								
1		Clayey Silt, trace sand and gravel Stiff to very stiff Grey (Glacial Till)	0.30	1	50 DO	11					
2			2	50 DO	26						
3		Shale with limestone and dolomite interbeds Weathered to fresh Grey	2.13	50 DO	50/ 03						
4											
5		END OF BOREHOLE	4.57								
6											
7											
8											
9											
10											

Open hole dry on
completion of
drilling.

DATA INPUT: PS MAR 12/98

SOILM6

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: JY

CHECKED: ASP

N804003 BHS

W.P. 167-86-00

RECORD OF BOREHOLE 3

SHEET 1 OF 1

DIST.

BORING DATE: DEC.18/97

DATUM:

LOCATION: Sta. 17+365/35m Rt.

PROJECT: 981-8040



DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa	nat V - + Q - ● rem V - ⊕ U - ○			WATER CONTENT, PERCENT Wp — W — Wl
0	POWER AUGER DRILL RIG	GROUND SURFACE										
		Topsoil		0.00								
				0.25								
1		Clayey Silt, trace sand and gravel Hard Grey (Glacial Till)		1	50 DO	50						
2			2	50 DO	67							
		Shale with limestone interbeds Weathered Grey		2.13	3	50 DO	60/ .06					
3		END OF BOREHOLE Refusal to further auger penetration		2.90								
4												
5												
6												
7												
8												
9												
10												

Open hole dry on
completion of
drilling.

DATA INPUT: PS MAR.12/98

SOILM6

DEPTH SCALE

1 to 50

Golder Associates

LOGGED: JY

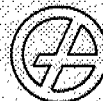
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NG040004 BHS

W.P. 167-86-00

RECORD OF BOREHOLE 4

SHEET 1 OF 1



DIST.

BORING DATE: DEC.19/97

DATUM:

LOCATION: Sta. 17+450/30m Rt

PROJECT: 981-8040

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa	nat V - + Q - ● rem V - ⊕ U - ○	WATER CONTENT, PERCENT Wp ——— W ——— Wi		
0	POWER AUGER DRILL RIG	GROUND SURFACE									
		Gravelly Sand Brown (Fill)	0.00	1	AS						
1		Silty Clay, trace sand and organics (wood fragments) Firm to very stiff Grey to brown (Fill)	0.61	2	50 DO	20					
2			3	50 DO	21						
3			4	50 DO	7						
4			5	50 DO	8						
		Shale Weathered Grey	3.66								
4		END OF BOREHOLE Refusal to further auger penetration	3.83								
5											
6											
7											
8											
9											
10											

Open hole dry on
completion of
drilling.

DATA INPUT: PS MAR.12/98

SOILM6

DEPTH SCALE

1 to 50

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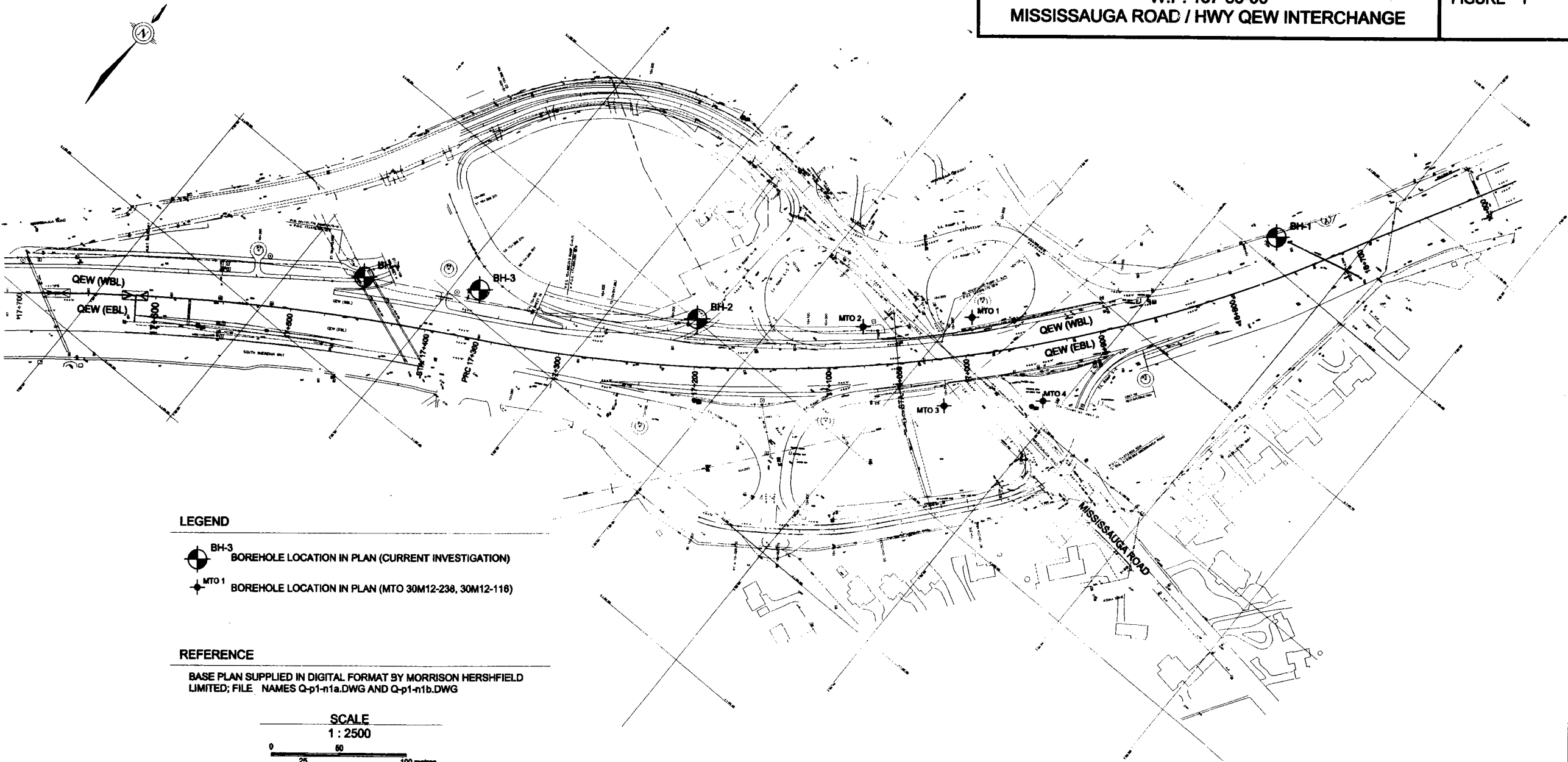
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OVERSIZE DRAWING(S)

BOREHOLE LOCATION PLAN
W.P. 167-86-00
MISSISSAUGA ROAD / HWY QEW INTERCHANGE

FIGURE 1

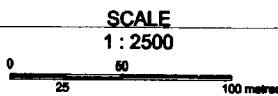


LEGEND

- BH-3 BOREHOLE LOCATION IN PLAN (CURRENT INVESTIGATION)
- MTO 1 BOREHOLE LOCATION IN PLAN (MTO 30M12-238, 30M12-118)

REFERENCE

BASE PLAN SUPPLIED IN DIGITAL FORMAT BY MORRISON HERSHFIELD LIMITED; FILE NAMES Q-p1-n1a.DWG AND Q-p1-n1b.DWG



Date FEBRUARY, 1998
Project 971-8040

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