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FOUNDATION INVESTIGATION AND DESIGN REPORT OVERHEAD SIGNS HIGHWAY 401 FROM AVENUE ROAD TO BAYVIEW AVENUE TORONTO, ONTARIO G.W.P. 5-98-00

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December 2007 06-1111-060-3

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FOUNDATION INVESTIGATION REPORT
OVERHEAD SIGNS
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TORONTO, ONTARIO
G.W.P. 5-98-00

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield (MH) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services associated with the rehabilitation/widening of Highway 401 eastbound and westbound core lanes between Avenue Road and Bayview Avenue, in the City of Toronto. Foundation engineering services are required for the widening of Hogg's Hollow bridge, replacement of the retaining walls associated with Hogg's Hollow bridge, new high mast light poles, new trichord overhead signs, and replacement of a noise barrier wall.

This report addresses the foundation investigation carried out for four new trichord overhead signs at the following locations:

- Highway 401 Eastbound Collector Lanes, Station 20+759;
- Highway 401 Westbound Core Lanes, Station 20+921;
- Highway 401 Westbound Core Lanes, Station 21+510; and
- Highway 401 Westbound Core Lanes, Station 22+350.

The terms of reference and scope of work for the foundation investigation are outlined in MTO's Request for Proposal for Agreement No. 2005-E-0035 dated January 2005, and in Section 6.8 of MH's *Technical Proposal* for G.W.P. 5-98-00.

2.0 SITE DESCRIPTION

The section of Highway 401 between Avenue Road and Bayview Avenue crosses the West Don River valley immediately to the west of Yonge Street. The ground surface elevation immediately adjacent to the West Don River banks is at about Elevation 134 m; the valley slopes rise approximately 33 m to 40 m, to about Elevation 167 m at the western crest of the valley, and about Elevation 174 m at the eastern crest of the valley. To the west and east of the West Don River valley, the "tableland" is relatively flat; at about Elevation 167 m to 171 m to the west of the river valley, and about Elevation 174 m to 178 m to the east of the river valley.

3.0 INVESTIGATION PROCEDURES

A subsurface investigation was carried out for the proposed overhead signs in June and August 2007, at which time four boreholes (Boreholes 07-9, 07-11, 07-16 and 07-17) were advanced using truck-mounted and track-mounted drill rigs, supplied and operated by Walker Drilling Ltd. of Utopia, Ontario. The borehole locations are shown on Drawing 1.

The boreholes were advanced to depths ranging from 6.7 m to 15.4 m, using solid stem augers. Soil samples were obtained at 0.75 m and 1.5 m intervals of depth, using 50 mm outside diameter split-spoon samplers driven by either a manual or an automatic hammer (as noted on each borehole record) in accordance with the Standard Penetration Test (SPT) procedure.

The water level in the open boreholes was observed throughout the drilling operations. Upon completion, the boreholes were backfilled to ground surface using bentonite gravel, in accordance with Ontario Regulation 903.

The field work was supervised on a full-time basis by a member of Golder's staff who located the boreholes in the field, obtained service clearances, directed the drilling, sampling, and in situ testing operations, and logged the boreholes. The soil samples were identified in the field, placed in labelled containers and transported to Golder's laboratory in Mississauga for further examination and testing. Index and classification tests consisting of water contents, Atterberg limits and grain size distributions were carried out on selected soil samples.

The northings, eastings and elevations of the as-drilled borehole locations were measured in the field by a member of Golder's technical staff, relative to site features. The borehole locations (including MTM NAD83 northing and easting coordinates) and ground surface elevations (referenced to geodetic datum) are summarized below and are shown on Drawing 1.

Borehole Number	***MTM NAD83 Northing (m)***	***MTM NAD83 Easting (m)***	***Ground Surface Elevation (m)***
07-9	4,845,857.2	312,048.4	171.1
07-11	4,845,445.6	311,625.5	169.5
07-16	4,845,280.9	311,586.8	171.1
07-17	4,846,396.8	312,693.2	172.0

4.0 SITE GEOLOGY AND STRATIGRAPHY

4.1 Regional Geological Conditions

The Avenue Road to Bayview Avenue area of Highway 401 is located within the Peel Plain physiographic region, as delineated in *The Physiography of Southern Ontario*[1]. A surficial till sheet, which generally follows the surface topography, is generally present throughout much of this area. The till is typically comprised of clayey silt to silty clay, with occasional sand to silt zones; it is mapped in this area as the Halton Till. Shallow, localized deposits of loose sand and silt and/or soft clay can overlie this uppermost till sheet, and these represent relatively recent deposits, formed in small glacial meltwater ponds scattered throughout the Peel Plain and concentrated near river valleys, such as the West Don River valley. The recent sand, silt and clay and uppermost till deposits in this area overlie and are interbedded with stratified deposits of sand, silt and clay.

4.2 Site Stratigraphy

Four boreholes (Boreholes 07-9, 07-11, 07-16 and 07-17) were advanced at this site at the locations shown on Drawing 1. The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are summarized on the Record of Borehole sheets; the results of the laboratory testing are also shown on Figures 1 to 5. The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole location.

A description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2.1 Asphalt / Fill

All of the boreholes were drilled through the existing pavement structure, and encountered 90 mm to 320 mm of asphalt/concrete, in turn underlain by approximately 0.3 m to 1.2 m of road base fill comprised of sand and gravel, to sand, some gravel, to silty sand, trace gravel. One measured Standard Penetration Test (SPT) "N" value of 24 blows per 0.3 m of penetration indicates that the sand and gravel fill has a compact relative density.

In Boreholes 07-9, 07-11 and 07-17, the granular fill was underlain by a 2.3 m to 3.1 m thick layer of clayey silt fill. The base of the clayey silt fill was encountered between Elevations

[1] Chapman, L.J. and D.F. Putnam. *The Physiography of Southern Ontario*, Ontario Geological Survey Special Volume 2, Third Edition, 1984. Accompanied by Map P.2715, Scale 1:600,000.

166.5 m and 168.2 m in these boreholes. The clayey silt fill contains trace to some sand and trace gravel; the results of grain size distribution tests conducted on two selected samples of this material are shown on Figure 1. The lower portion of the clayey silt fill in Borehole 07-17 also contains dark brown to black organic matter; an organic content of 4.7 per cent (by weight) was measured on a sample of this portion of the fill.

Atterberg limits tests were conducted on three selected samples of the clayey silt fill and measured plastic limits of 12 to 15 per cent, liquid limits of 19 to 29 per cent, and plasticity indices of 7 to 14 per cent. These results, which are plotted on a plasticity chart on Figure 2, confirm that this fill material is a clayey silt of low plasticity.

The measured SPT "N" values within the clayey silt fill were between 10 and 29 blows per 0.3 m of penetration, indicating that this material has a stiff to very stiff consistency.

4.2.2 Clayey Silt Till

A glacial till deposit was encountered directly below the pavement structure in Borehole 07-16, and below the pavement structure and clayey silt fill in Boreholes 07-9, 07-11 and 07-17. The surface of the till deposit was encountered at Elevations 166.5 m and 170.5 m (at depths of 3.1 m and 0.6 m below the Highway 401 pavement grade) in Boreholes 07-11 and 07-16 which were drilled west of the West Don River valley, and at Elevations 166.5 m and 168.2 m (at depths of 4.6 m and 3.8 m below the Highway 401 pavement grade) in Boreholes 07-9 and 07-17 which were drilled east of the West Don River valley. The till deposit ranges in thickness from 1.5 m to 7.6 m in Boreholes 07-9 and 07-11, in which it was fully penetrated. In Boreholes 07-16 and 07-17, where the till deposit was not fully penetrated, it is at least 8.7 m and 4.4 m thick, respectively.

This till deposit consists of clayey silt with sand to some sand, and trace gravel. The results of grain size distribution tests completed on four selected samples of this cohesive till are shown on Figure 3. Atterberg limits testing was carried out on six selected samples of the deposit, and measured plastic limits of 11 to 15 per cent, liquid limits of 16 to 27 per cent, and plasticity indices of 5 to 12 per cent. These results, which are plotted on a plasticity chart on Figures 4, confirm that the till deposit consists of clayey silt of low plasticity.

The measured SPT "N" values within the clayey silt till range from 13 to 95 blows per 0.3 m of penetration, to 50 blows per 0.08 m of penetration, indicating that the till has a stiff to hard (but typically hard) consistency.

4.2.3 Silty Sand to Sandy Silt

A cohesionless soil deposit was encountered below the clayey silt till in Boreholes 07-9 and 07-11. The surface of the cohesionless deposit was encountered at Elevation 158.9 m (at a depth of 12.2 m) in Borehole 07-9, and at Elevation 164.9 m (at a depth of 4.6 m) in Borehole 07-11. Both of these boreholes were terminated within the deposit, which has a thickness of at least 2.1 m to 3.2 m.

The deposit ranges in composition from silty sand, to sand and silt, to sandy silt, containing trace gravel and clay. The result of a grain size distribution test completed on one selected sample of this deposit is shown on Figure 5.

The measured SPT "N" values within the silty sand to sandy silt deposit vary from 19 to 27 blows per 0.3 m of penetration in Borehole 07-11, where this deposit has a compact relative density, and from 70 to 84 blows per 0.15 m of penetration in Borehole 07-9, where this deposit has a very dense relative density.

4.3 Groundwater Conditions

Boreholes 07-11 and 07-16 were dry on completion of drilling. In Borehole 07-9 located immediately east of the West Don River valley, the water level in the open borehole on completion of drilling was at a depth of 11.9 m (Elevation 159.2 m), immediately above the base of the clayey silt till deposit. In Borehole 07-17, also located east of the West Don River valley, the water level in the open borehole on completion of drilling was at a depth of 7.6 m (Elevation 164.4 m), also within the clayey silt till deposit.

The groundwater level in this area is expected to follow the surface topography of the West Don River valley. Based on water level monitoring completed in previous boreholes advanced at the site, the stabilized groundwater level in the "tableland" to the west of the river valley is typically at or below about Elevation 167 m (at a depth of approximately 3 m to 5 m below the ground surface), while the stabilized groundwater level in the "tableland" to the east of the river valley varies from about Elevation 164.5 m to 170.5 m (at a depth of about 1.5 m to 5 m below the ground surface), generally rising toward the east.

The groundwater level is expected to fluctuate seasonally and is expected to rise during periods of high precipitation.

5.0 CLOSURE

This Foundation Investigation Report was prepared by Mr. Matthew Kelly and reviewed by Ms. Lisa Coyne, P.Eng., an Associate and geotechnical engineer with Golder. Mr. Jorge Costa, P.Eng., a Principal of and Designated MTO Contact for Golder, conducted an independent quality review of the report.

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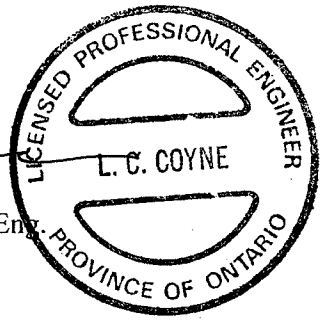

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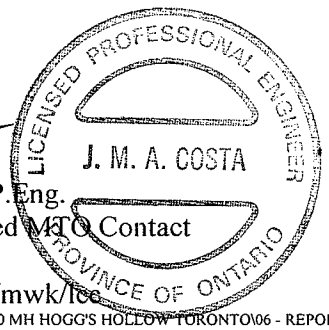

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PART B

FOUNDATION DESIGN REPORT
OVERHEAD SIGNS
HIGHWAY 401 FROM AVENUE ROAD TO BAYVIEW AVENUE
TORONTO, ONTARIO
G.W.P. 5-98-00

6.0 ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides foundation design recommendations for four proposed overhead signs along Highway 401 between Avenue Road and Bayview Avenue in Toronto. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the subsurface investigation for this project. The interpretation and recommendations provided are intended to provide the designers with sufficient information to design the proposed sign foundations. Where comments are made on construction, they are provided in order to highlight those aspects which could affect the planning of the project, and for which special provisions or operational constraints may be required during construction. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods, scheduling and the like.

6.2 Caisson Foundations for Overhead Signs

Caisson foundations for overhead sign supports should be designed in accordance with the requirements in MTO's *Sign Support Manual*. The *Sign Support Manual* includes a standard caisson foundation design (Section 4 and Standard Drawings SS118-3, SS118-4 and SS118-5), in which the caisson are extended 5 m below the design frost depth (i.e. a total length of 6.2 m below grade for this project). The standard design is based on the following minimum soil conditions:

- **Case 1 (Cohesionless Soils):** Sand with a friction angle of 28 degrees surrounding the upper two-thirds of the portion of the caisson foundation below the frost depth, and sand with a friction angle of 30 degrees surrounding the lower third of the portion of the caisson below the design frost depth.

- **Case 2 (Cohesive Soils):** Soft clay with an undrained shear strength of 25 kPa surrounding the upper two-thirds of the portion of the caisson foundation below the frost depth, and "soft" clay with an undrained shear strength of 50 kPa surrounding the lower third of the portion of the caisson below the design frost depth.

The standard foundation design provided in MTO's *Sign Support Manual* does not apply to sites where extensive poor fill materials or materials softer than those of Case 2 are present. For such subsurface conditions, a site-specific design is required.

Based on the review of the borehole information, the soil conditions at the four proposed overhead sign locations have friction angles and/or undrained shear strengths that exceed the input parameters used in the modelling of the standard caisson foundations and, therefore, the standard caisson foundation design is suitable for these sites, as summarized below:

Approximate Sign Location	*Borehole No.*	*Standard Foundation Design*	*Site-Specific Foundation Design*
Highway 401 Eastbound Collector Lanes Station 20+759	07-16	✓	
Highway 401 Westbound Core Lanes Station 20+921	07-11	✓	
Highway 401 Westbound Core Lanes Station 21+510	07-9	✓	
Highway 401 Westbound Core Lanes Station 22+350	07-17	✓	

The standard foundation design may be checked using the following equations to calculate the unfactored passive lateral earth pressure, P_p (kPa), distributed along the depth of the caisson foundation:

$$P_p = K_p \gamma d_w \quad \text{above the groundwater table, and}$$
$$P_p = K_p \gamma d_w + K_p \gamma' (d - d_w) \quad \text{below the groundwater table,}$$

where K_p is the passive earth pressure coefficient;
γ is the bulk unit weight (kN/m^3);
γ' is the effective unit weight below the groundwater level (kN/m^3);
d is the depth below the ground surface (m); and
d_w is the depth to the groundwater level (m).

The stratigraphy and design parameters for the subsurface conditions encountered in the boreholes at the overhead sign locations are given in Table 1 following the text of this report.

In the design of the foundations, the passive resistance within the upper 1.2 m below ground surface should be neglected to account for frost action. The unfactored lateral resistance should be calculated assuming an equivalent width equal to three times the caisson diameter. A resistance factor of 0.5 should be applied to the unfactored lateral resistance to obtain the factored lateral geotechnical resistance at Ultimate Limit States (ULS).

Where an undrained shear strength, c_u, is provided for a cohesive soil layer in Table 1, the capacity of the caisson should be checked to determine whether the drained or undrained case will govern. In this case, the lateral resistance for the length of the caisson within the cohesive soil should be calculated assuming an unfactored passive lateral pressure distribution varying from 2 c_u at the surface to 9 c_u at and below a depth equivalent to three pile diameters, acting over the actual width of the caisson. A resistance factor of 0.5 should be applied to this calculated lateral resistance in order to obtain the factored lateral geotechnical resistance at ULS.

6.3 Construction Considerations

Deposits and lenses or interlayers of potentially water-bearing cohesionless soils are present within or below the clayey silt till at the site. "Perched" groundwater may also be encountered at the base of cohesionless fill materials, atop the underlying, less permeable clayey silt fill or till deposit. Wet cohesionless soils should be expected to run or flow into the caisson hole during or after drilling for the foundations. Therefore, temporary or permanent caisson liners are recommended to minimize ground loss during drilling and concrete placement.

It is recommended that a Non-Standard Special Provision (NSSP) be included in the Contract Documents to warn the Contractor of this condition, which may affect the installation of the overhead sign caisson foundations at this site. A sample NSSP to address this condition is included in Appendix A.

7.0 CLOSURE

This Foundation Design Report was prepared by Mr. Matthew Kelly and reviewed by Ms. Lisa Coyne, P.Eng., an Associate and Geotechnical Engineer with Golder. Mr. Jorge Costa, P.Eng., a Designated MTO Contact for Golder, conducted an independent review of the report.

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TABLE 1
GEOTECHNICAL DESIGN PARAMETERS FOR OVERHEAD SIGN FOUNDATIONS
HIGHWAY 401, AVENUE ROAD TO BAYVIEW AVENUE, TORONTO, ONTARIO
W.P. 5-98-00

Sign Location	Borehole Number	Stratum	Depth [1]	Elevation	Groundwater Elevation	Design Parameters [2, 3]				
						c_u	φ'	γ	γ'	K_p
Station 20+759 Highway 401 EB Collector Lanes	07-16	Fill / Very stiff clayey silt till	Above 2.1 m	Above 169 m	166.0 m	–	32	21	11	3.3
		Hard clayey silt till	Below 2.1 m	Below 169 m		–	35	21	11	3.7
Station 20+921 Highway 401 WB Core Lanes	07-11	Stiff clayey silt fill	Above 3.1 m	Above 166.5 m	166.0 m	75	28	20	10	2.8
		Hard clayey silt till	3.1 m – 4.6 m	166.5 m – 164.9 m		–	32	21	11	3.3
		Compact sand and silt	Below 4.6 m	Below 164.9 m		–	30	20	10	3.0
Station 21+510 Highway 401 WB Core Lanes	07-9	Stiff to very stiff clayey silt fill	Above 4.6 m	Above 166.5 m	162.0 m	75	28	20	10	2.8
		Hard clayey silt till / Very dense silty sand to sandy silt	Below 4.6 m	Below 166.5 m		–	35	21	11	3.7
Station 22+350 Highway 401 WB Core Lanes	07-17	Very stiff clayey silt fill	Above 2.3 m	Above 169.7 m	165.0 m	–	28	20	10	2.8
		Stiff clayey silt fill / Stiff clayey silt till	2.3 m – 4.5 m	169.7 m – 168.2 m		75	28	20	10	2.8
		Very stiff to hard clayey silt till	Below 4.5 m	Below 168.2		–	32	21	11	3.3

NOTES:

1. Depths are given for the borehole location; the ground surface elevation at the borehole location should be compared to the ground surface elevation at the actual sign support location, and the depths of the soil strata and depth to bedrock adjusted accordingly.
2. Design parameters: c_u = undrained shear strength (kPa);
   φ' = effective friction angle (degrees);
   γ = bulk unit weight (kN/m^3);
   γ' = effective unit weight below the groundwater level (kN/m^3); and
   K_p = passive earth pressure coefficient.
3. Although the passive resistance in the upper 1.2 m is neglected to account for frost action, φ' and K_p parameters are given in the event that the ground surface elevation varies significantly between the borehole and sign support locations.

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
SS	Split-spoon
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 Cone 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, 60º 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)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 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	c_u, s_u 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 (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

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LIST OF SYMBOLS

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

I. General

π	3.1416
in 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
v	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 stress (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 x acceleration due to gravity)

(a) Index Properties (continued)

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)

(b) 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

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_a	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	over-consolidation ratio = σ'_p/σ'_{vo}

(d) 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 δ
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

Golder Associates

RECORD OF BOREHOLE No 07-9

1 OF 2 **METRIC**

PROJECT 06-1111-060 | LOCATION N 4845857.2 ;E 312048.4 | ORIGINATED BY GPD

W.P. 5-98-00 | BOREHOLE TYPE Truck-Mount D-25, 108 mm Diameter Solid Stem Augers, Manual Hammer | COMPILED BY MK

DIST Central HWY 401 | DATUM Geodetic | DATE June 5, 2007 | CHECKED BY LCC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
171.1	GROUND SURFACE						171				
0.0	Asphalt										
0.3	Concrete										
	Sand and gravel, trace silt (FILL) Compact Brown Moist		1	SS	24						
169.6							170				
1.5	Clayey silt, some sand, trace gravel, containing sand layers (FILL) Stiff to very stiff Brown Moist		2	SS	11				o		
			3	SS	22		169				6 82 10 2
			4	SS	23		168				
166.5							167				
4.6	CLAYEY SILT with sand to some sand, trace gravel (TILL) Very stiff to hard Brown Moist		5	SS	50/0.08		166				
			6	SS	81		165		o		
			7	SS	95		164		o		3 27 48 22
	Becoming grey and wet at 9.1m depth.		8	SS	62		163				
			9	SS	24	▽	162		o		
158.9							161				
12.2	Silty SAND to Sandy SILT, trace gravel Very dense Brown Moist		10	SS	70/0.15		160				
			11	SS	84/0.15		159				
							158				
							157				

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No 07-9

2 OF 2 **METRIC**

PROJECT 06-1111-060 | LOCATION N 4845857.2 ;E 312048.4 | ORIGINATED BY GPD

W.P. 5-98-00 | BOREHOLE TYPE Truck-Mount D-25, 108 mm Diameter Solid Stem Augers, Manual Hammer | COMPILED BY MK

DIST Central HWY 401 | DATUM Geodetic | DATE June 5, 2007 | CHECKED BY LCC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	— CONTINUED FROM PREVIOUS PAGE —										
155.7			12	SS	82/0.15		156				
15.4	END OF BOREHOLE										

NOTES:

1. Water level measured in open borehole at a depth of 11.9m (Elevation 159.2m) upon completion of drilling.

$+^3, \times^3$: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No 07-11

1 OF 1 **METRIC**

PROJECT 06-1111-060 | W.P. 5-98-00 | DIST Central HWY 401 | DATUM Geodetic

LOCATION N 4845445.6 ;E 311625.5 | BOREHOLE TYPE Truck-Mount D-25, 108 mm Diameter Solid Stem Augers, Manual Hammer | DATE June 7, 2007

ORIGINATED BY GPD | COMPILED BY MK | CHECKED BY LCC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
169.5	GROUND SURFACE										
0.0	Asphalt										
0.1	Sand and gravel, trace silt (FILL) Brown Moist										
168.7							169				
0.8	Clayey silt, some sand, trace gravel (FILL) Stiff Brown Moist		1	SS	10						
			2	SS	11		168				
			3	SS	15		167				
166.5											
3.1	CLAYEY SILT, some sand, trace gravel (TILL) Hard Brown Moist		4	SS	36		166				
164.9							165				
4.6	SAND and SILT, trace gravel and clay Compact Brown Moist		5	SS	19						2 50 42 6
							164				
			6	SS	27						
162.8							163				
6.7	END OF BOREHOLE										

NOTES:

1. Open borehole dry upon completion of drilling.

$+^3, \times^3$: Numbers refer to Sensitivity $O^{3\%}$ STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No 07-16

1 OF 1 **METRIC**

PROJECT 06-1111-060 | W.P. 5-98-00 | DIST Central HWY 401 | DATUM Geodetic

LOCATION N 4845280.9 ;E 311586.8 | BOREHOLE TYPE Track-Mount CME-55, 108 mm Diameter Solid Stem Augers, Automatic Hammer | DATE June 18, 2007

ORIGINATED BY SB | COMPILED BY MWK | CHECKED BY LCC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
171.1	GROUND SURFACE						171				
0.0	Asphalt										
0.2	Concrete										
170.5	Sand, some gravel (FILL) Compact Brown Moist										
0.6	CLAYEY SILT with sand, trace gravel, containing cobbles (TILL) Very stiff to hard Brown, becoming grey at 5.0 m depth Moist		1	SS	19		170				
			2	SS	25		169				
			3	SS	41				o		
			4	SS	50		168				
			5	SS	50		167		o		2 33 46 19
			6	SS	65		166				
			7	SS	60/0.15		165				
							164				
			8	SS	73/0.25		163		o		
161.8			9	SS	75/0.16		162		o		7 37 42 14
9.3	END OF BOREHOLE										

NOTES:

1. Open borehole dry upon completion of drilling.

$+^3, \times^3$: Numbers refer to Sensitivity $o^{3\%}$ STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No 07-17

1 OF 1 **METRIC**

PROJECT 06-1111-060 | LOCATION N 4846396.8 ;E 312693.2 | ORIGINATED BY SB

W.P. 5-98-00 | BOREHOLE TYPE Truck-Mount D-25, 108 mm Diameter Solid Stem Augers, Manual Hammer | COMPILED BY PKS

DIST Central HWY 401 | DATUM Geodetic | DATE August 27, 2007 | CHECKED BY LCC

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
172.0	GROUND SURFACE						
0.0	ASPHALT						
171.6	Sand and gravel (FILL)						
171.2	Silty sand, trace gravel (FILL) Compact Brown Moist		1	SS	29		171
0.8	Clayey silt, trace to some sand, trace gravel (FILL) Very stiff Mottled brown and grey Moist		2	SS	24		170
169.7							
2.3	Clayey silt, trace to some sand, trace gravel, containing organics (Possible FILL) Stiff Brown to black Moist		3	SS	13		169
			4	SS	11		
168.2							168
3.8	CLAYEY SILT, trace to some sand and gravel (TILL) Stiff to hard Grey-brown to grey Moist		5	SS	13		
			6	SS	28		167
							166
			7	SS	49		
						▽	165
163.8			8	SS	33		164
8.2	END OF BOREHOLE						

NOTE:

1. Water level measured in open borehole at depth of 7.6m (Elevation 164.4m) upon completion of drilling.

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH kPa (20 40 60 80 100)
- O UNCONFINED
- + FIELD VANE
- ● QUICK TRIAXIAL
- × REMOULDED

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%) (10 20 30)

UNIT WEIGHT γ kN/m³

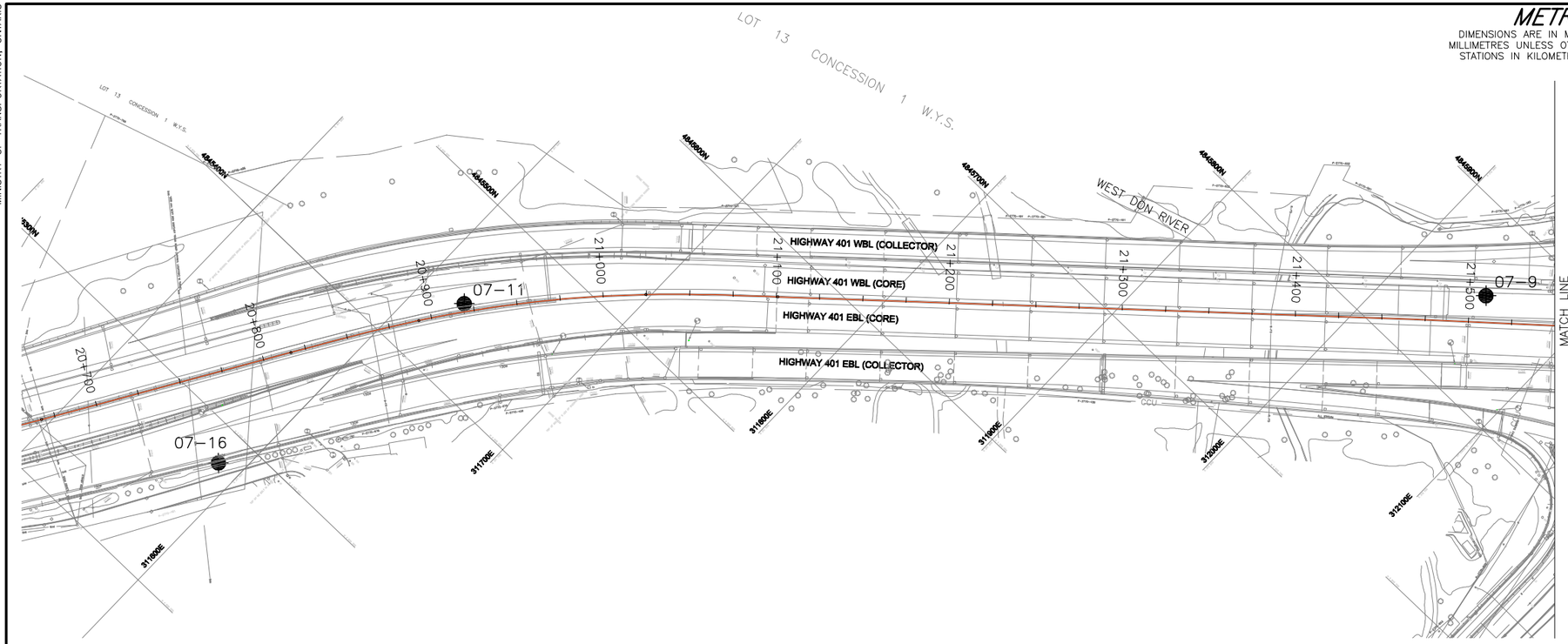
Org = 4.7%

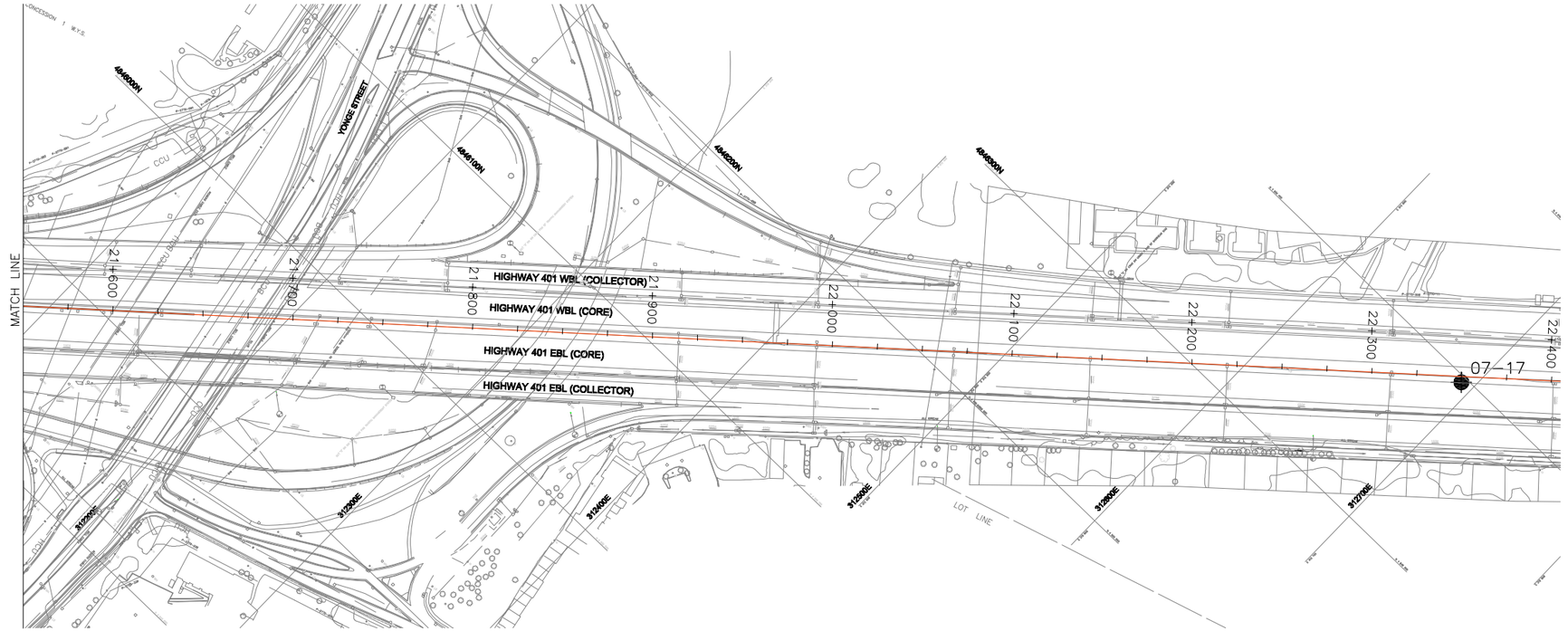
REMARKS & GRAIN SIZE DISTRIBUTION (%)

	GR	SA	SI	CL
2	38	42	18	
3	35	46	16	

$+^3, \times^3$: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

MINISTRY OF TRANSPORTATION, ONTARIO





PLAN
SCALE
30 0 30 60 m

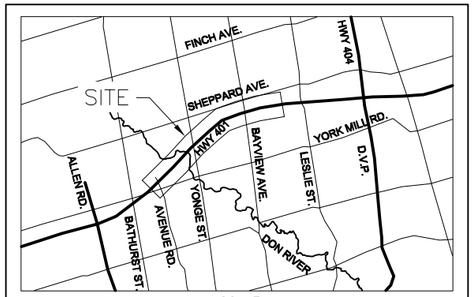
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 5–98–00

HIGHWAY 401
AVENUE ROAD TO BAYVIEW AVENUE
Overhead Signs
BOREHOLE LOCATIONS

SHEET

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



LEGEND

Borehole – Current Investigation

No.	ELEVATION	CO–ORDINATES	
		NORTHING	EASTING
07–9	171.1	4845857.2	312048.4
07–11	169.5	4845445.6	311625.5
07–16	171.1	4845280.9	311586.8
07–17	172.0	4846396.8	312693.2

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The complete foundation investigation and design report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Base plans provided in digital format by Morrison Hershfield Limited, received Aug. 09, 2007.

NO.	DATE	BY	REVISION

Geocres No.

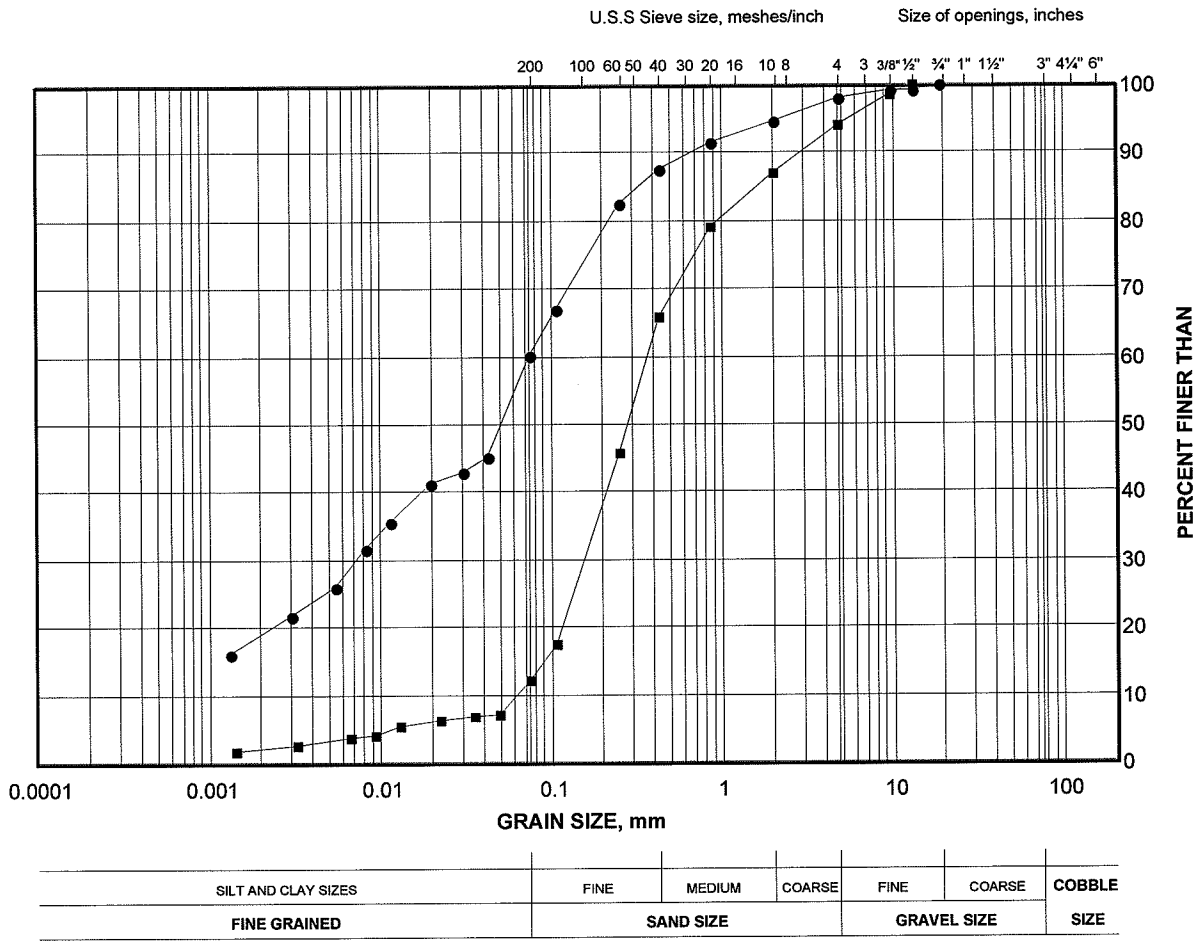
HWY. 401	PROJECT NO. 06–1111–060–3		DIST.
SUBM'D. PKS	CHKD. LCC	DATE: 11/8/2007	SITE:
DRAWN: RJ	CHKD. PKS	APPD. LCC	DWG. 1

PLOT DATE: November 8, 2007
FILENAME: T:\Projects\2006\06-1111-060 (Mt. Hoggs Hollow, Toronto)\-Bkx- Phase 5300 - Overhead Signs\061111060B0301.dwg

GRAIN SIZE DISTRIBUTION TEST RESULTS

Clayey Silt Fill

FIGURE 1



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	07-17	2	170.2
■	07-9	3	168.5

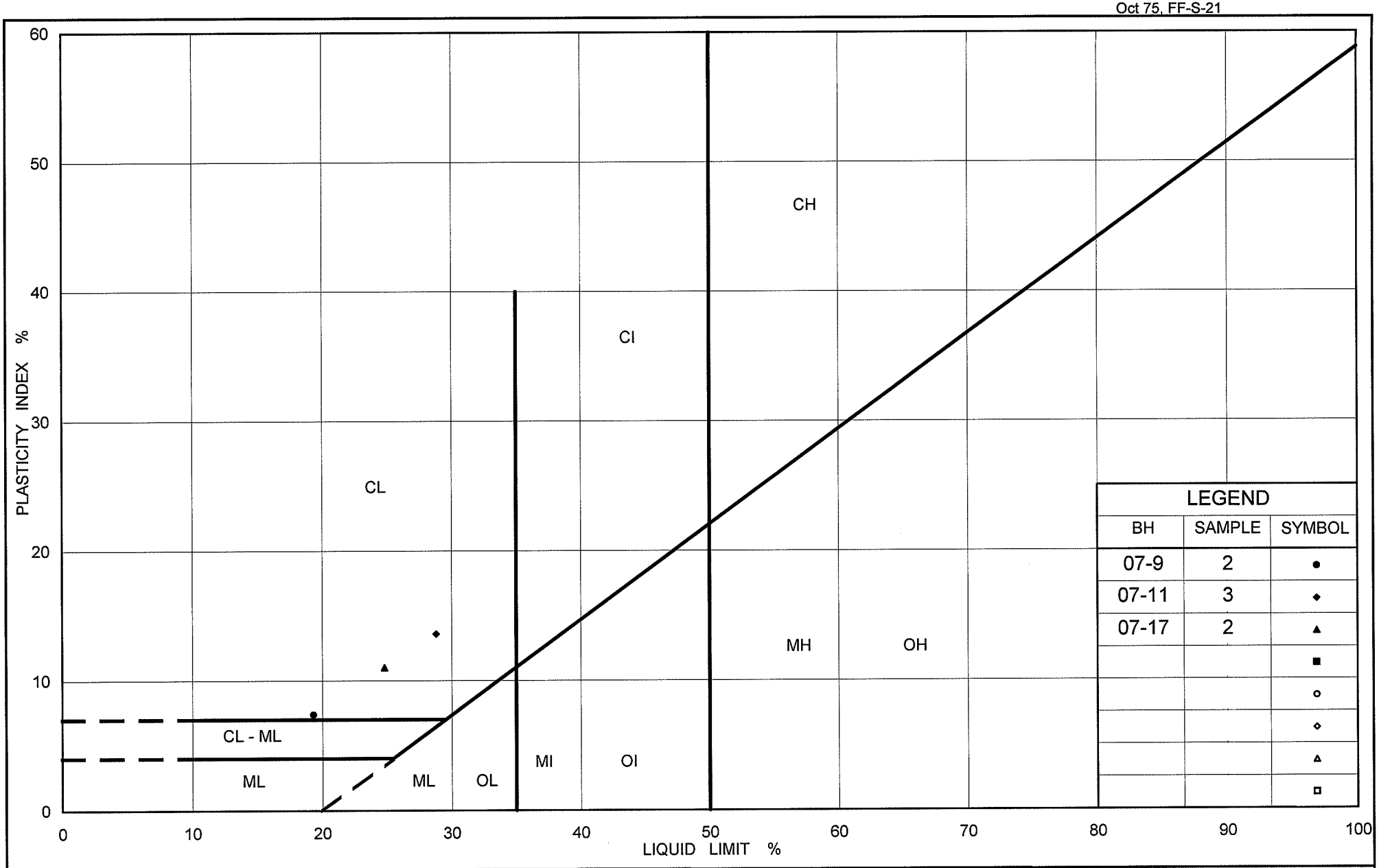
Project Number: 06-1111-060-3

Checked By: _____

Golder Associates

Date: 08-Nov-07

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt Fill

Figure No. 2

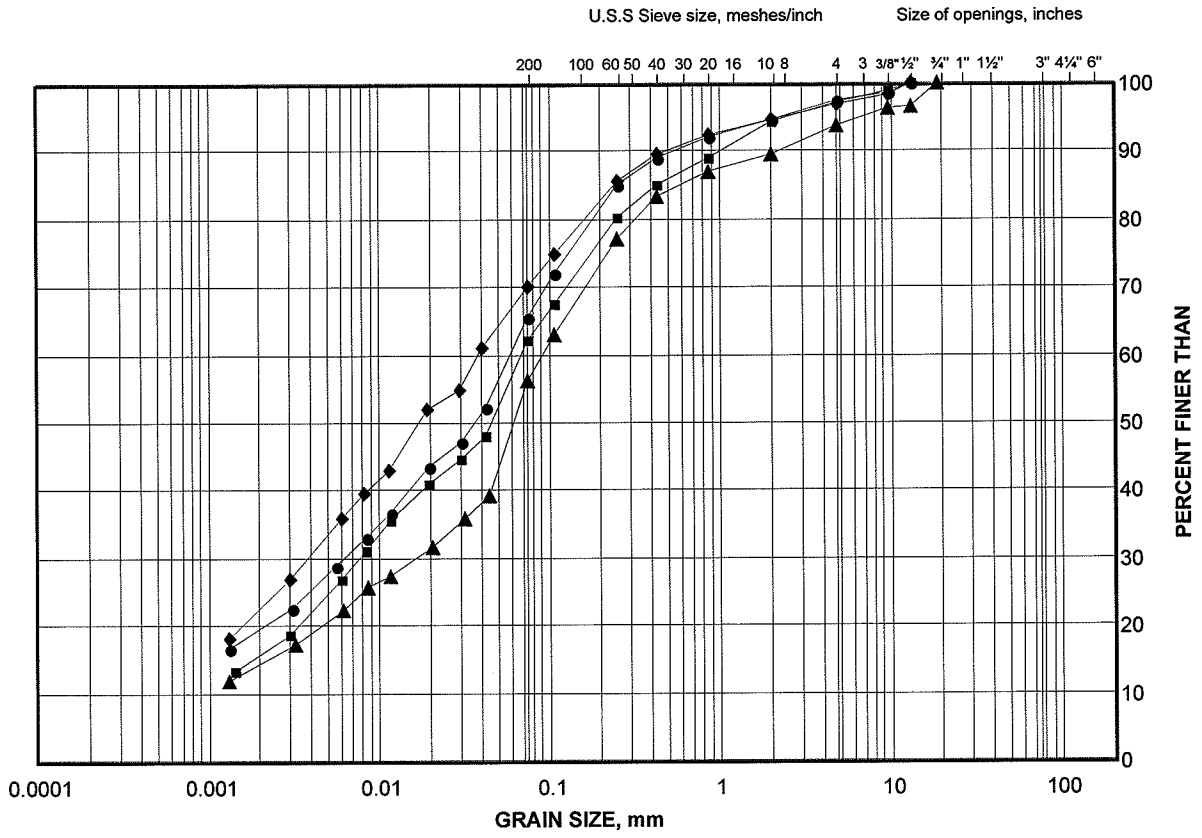
Project No. 06-1111-060-3

Checked By:

GRAIN SIZE DISTRIBUTION TEST RESULTS

Clayey Silt Till

FIGURE 3



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	07-16	5	167.0
■	07-17	6	167.1
◆	07-9	7	163.3
▲	07-16	9	161.9

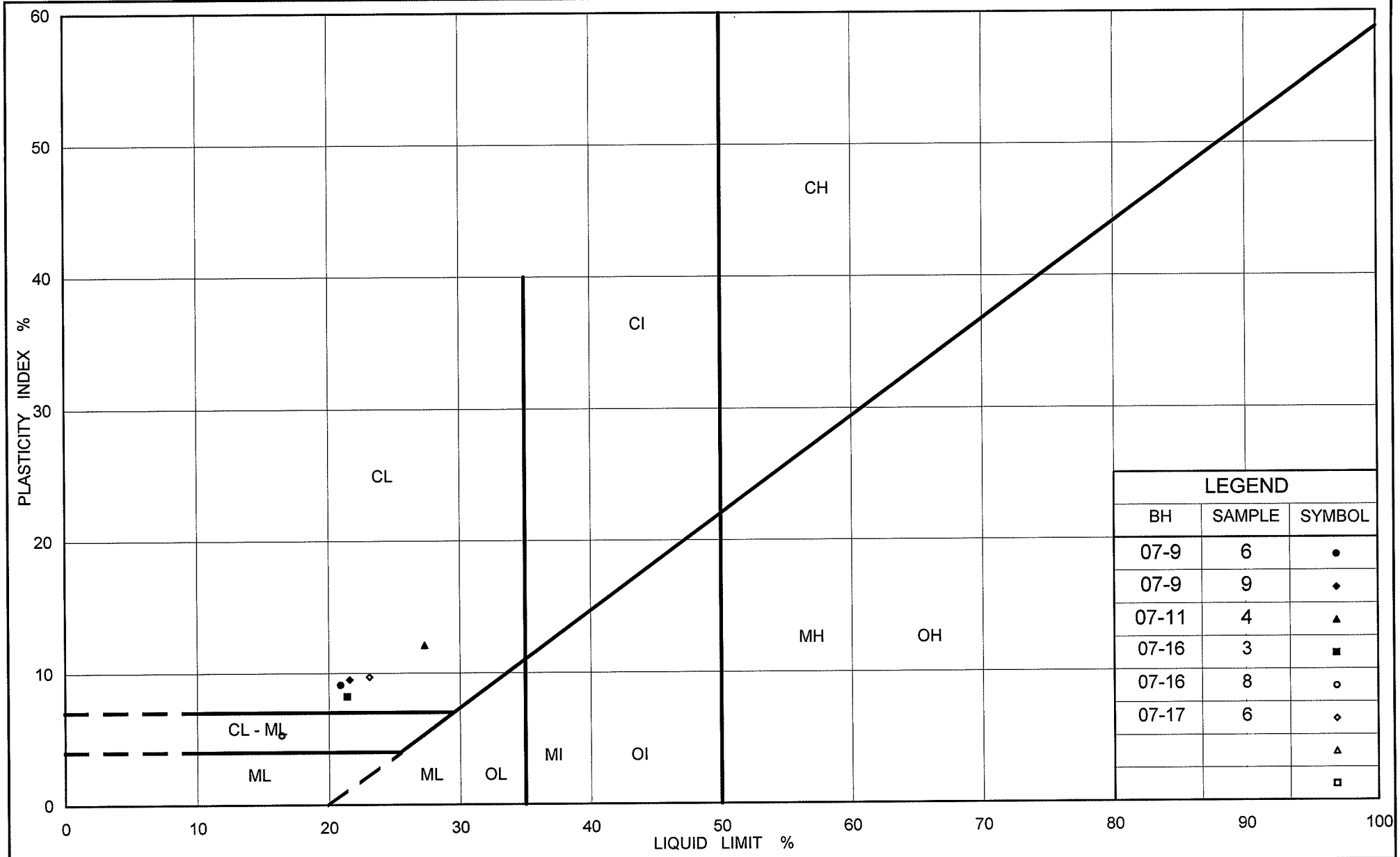
Project Number: 06-1111-060-3

Checked By: _____

Golder Associates

Date: 08-Nov-07

Oct 75, FF-S-21



Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt Till

Figure No. 4

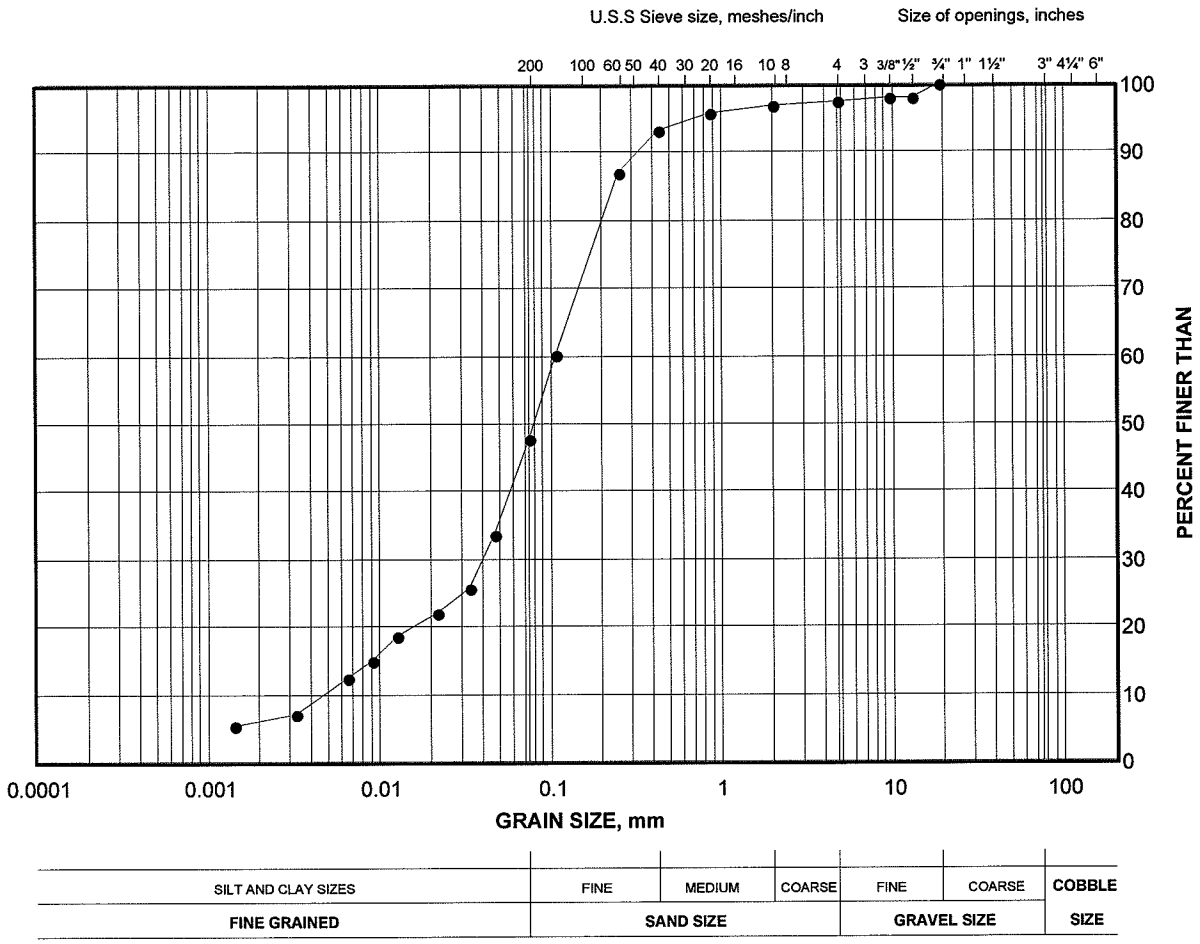
Project No. 06-1111-060-3

Checked By:

GRAIN SIZE DISTRIBUTION TEST RESULT

Sand and Silt

FIGURE 5



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	07-11	5	164.6

Project Number: 06-1111-060-3

Checked By: _____

Golder Associates

Date: 08-Nov-07

APPENDIX A

NON-STANDARD SPECIAL PROVISIONS

CONTROL OF OVERBURDEN SOILS AND GROUNDWATER DURING OVERHEAD SIGN FOUNDATION INSTALLATION - Item No.

Special Provision

Excavations for the overhead sign foundations will be advanced through fill materials (where present) into clayey silt to silty clay till and cohesionless sand to silt soils; lenses or layers of cohesionless soils should also be expected to be present within the till. The cohesionless soil deposits and lenses/interlayers should be expected to be unstable below the groundwater level. Where cohesionless soil deposits, layers or lenses are encountered, the caisson holes may have to be advanced using a temporary liner in order to minimize ground loss during drilling and concrete placement.

Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

END OF SECTION