



October 25, 2013

FOUNDATION INVESTIGATION REPORT

**REPLACEMENT OF EVELYN CREEK BRIDGE
SITE NO. 39W-100
HIGHWAY 11, TOWNSHIP OF DEVITT, ONTARIO
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5150-05-00**

Submitted to:
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REPORT





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**FOUNDATION REPORT REPLACEMENT OF EVELYN CREEK BRIDGE
HIGHWAY 11, SITE NO. 39W-100, GWP 5150-05-00**

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PART A

**FOUNDATION INVESTIGATION REPORT
REPLACEMENT OF EVELYN CREEK BRIDGE - SITE NO. 39W-100
HIGHWAY 11, TOWNSHIP OF DEVITT, ONTARIO
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5150-05-00**



1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by LEA Consulting Ltd. (LEA) on behalf of the Ministry of Transportation, Ontario (MTO) to provide detailed foundation engineering services for the replacement of the Evelyn Creek Bridge (Site No. 39W-100), located on Highway 11 (east of Hearst, Ontario) in the Township of Devitt.

The purpose of this investigation is to establish the subsurface conditions at the location of the proposed replacement structure, a culvert, including the associated approach embankments, by borehole drilling, in situ testing and laboratory testing on selected soil samples. The location of the investigation area is shown in plan on Drawing 1.

2.0 SITE DESCRIPTION

The Evelyn Creek Bridge site is situated in the Township of Devitt on Highway 11 approximately 3.7 km east of Val Côté, Ontario. The surrounding land is generally flat and gently slopes down towards the creek and from the highway towards the creek banks on either side of the existing bridge. The area is vegetated with grass and small shrubs. The creek is about 5 m wide at the existing bridge location and flows in a northerly direction.

The existing structure is a two-lane, single-span steel girder bridge with concrete deck and timber substructure/wing walls, constructed in 1960. The structure is supported on timber piles, likely founded in the native cohesionless soils. The existing roadway surface is at about Elevation 237.8 m as it crosses the creek. The existing embankment side slopes are generally formed at about 2 Horizontal to 1 Vertical (2H:1V).

A creek water level at Elevation 235.2 m was measured by others on October 24, 2011. The creek water levels measured by Golder during the field investigations, which took place in October 2012 and July 2013, were Elevation 235.3 m and 235.9 m, respectively.

3.0 INVESTIGATION PROCEDURES

The fieldwork for this subsurface investigation was carried out on October 19 and 20, 2012, June 6, 18, 19, 24, 25 and July 10, 2013, at which time eight boreholes, Boreholes E1 to E8, were advanced at the site. The boreholes were advanced using both a CME 55 track-mounted drill rig supplied and operated by Landcore Drilling Inc. of Sudbury, Ontario, and a D-25 semi-portable drill rig supplied and operated by Walker Drilling Ltd. of Barrie, Ontario. Boreholes E1 and E6 were advanced at the toes of slope, on the northwest and northeast sides of the creek, respectively, in the vicinity of the proposed north wing walls. Boreholes E3 and E4 were advanced through the existing Highway 11 embankment on the west side of the proposed replacement culvert structure. Boreholes E2 and E5 were advanced through the existing Highway 11 embankment along the east side of the proposed replacement (culvert) structure. Boreholes E7 and E8 were advanced for the proposed embankment approaches up to about 20 m from the replacement structure. The borehole locations are shown on Drawing 1.

The boreholes were advanced using 108 mm inner diameter hollow-stem augers and/or NW casing and a NQ size core barrel where coring through cobbles/boulders was required. Soil samples were obtained at intervals of depth of about 0.75 m to 1.5 m, using a 50 mm outer diameter split-spoon sampler operated by an automatic



hammer (track rig) or cathead hammer (D-25 rig), in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586). Field vane shear tests were carried out in cohesive soils (strata) for determination of undrained shear strengths (ASTM D2573) using an MTO Standard 'N' size vane. All open boreholes were backfilled upon completion in accordance with Ontario Regulation 903 Wells (as amended).

The groundwater conditions were observed in the open boreholes during and immediately following the drilling operations and a standpipe piezometer was installed in Borehole E1 to permit monitoring of the groundwater level. The piezometer consists of a 50 mm diameter polyvinyl chloride (PVC) pipe, with a 1.5 m long slotted screen, sealed within a sand filter pack at a selected depth interval within the borehole. Below the piezometer screen the borehole was backfilled with bentonite pellets, and above the sand filter pack and piezometer screen the annulus surrounding the piezometer pipe was partially backfilled with bentonite pellets to create a seal, then backfilled to near surface with cuttings from the borehole and bentonite. A seal of bentonite was placed to ground surface. The piezometer installation details and water level readings are indicated on the Record of Borehole sheets contained in Appendix A. The non-instrumented boreholes were backfilled with bentonite as per Ontario Regulation 903 (as amended) upon completion of drilling. The piezometer was decommissioned on June 25, 2013, in accordance with the regulations.

The fieldwork was supervised on a full-time basis by a member of Golder's staff, who located the boreholes in the field, directed the drilling and sampling operations and logged the boreholes. The soil samples were identified in the field, placed in labelled containers and transported to Golder's Sudbury Laboratory for further examination and laboratory testing. Index and classification tests, consisting of water content, Atterberg limits and grain size distribution, were carried out on selected soil samples. The geotechnical laboratory testing was completed according to applicable MTO LS standards. The results of the laboratory testing are shown on the Record of Borehole sheets in Appendix A and on figures contained in Appendix B.

A sample of the creek water was obtained during the field investigation using appropriate sampling protocols and submitted to a specialist analytical laboratory under chain of custody procedures for testing for a suite of inorganic parameters. The results of the analytical testing are summarized in Table B1 in Appendix B.

The borehole locations and elevations were measured in the field by Golder personnel, relative to existing site features and surveyed to stakes placed in the field by J.D. Barnes Ltd. The borehole locations (referenced to the MTM NAD83 co-ordinate system), ground surface elevations (referenced to Geodetic datum) and borehole depths are shown on Drawing 1, presented on the Record of Borehole sheets in Appendix A, and are summarized below.



Borehole Number	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)	Borehole Depth (m)
E1	5499526.1	351274.2	236.1	21.4
E2	5499510.9	351281.0	237.8	17.1
E3	5499510.6	351270.4	237.7	21.5
E4	5499507.0	351267.6	237.7	19.9
E5	5499502.5	351284.5	237.7	18.6
E6	5499523.8	351286.1	236.1	19.9
E7	5499513.4	351250.4	237.8	15.8
E8	5499505.5	351299.6	237.8	15.8

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on NOEGTS¹ Mapping, the subsoils in the vicinity of the Evelyn Creek Bridge site generally consist of clayey till deposited as a ground moraine.

Published literature indicates that the site is located in the Quetico Subprovince of the Superior Province (OGS, 1991)². The bedrock of this domain consists of muscovite-bearing granitic rocks (peraluminous), and may include biotite granite. Beyond the muscovite-bearing granitic boundary, bedrock consists of meta-sedimentary rocks.

4.2 Subsurface Conditions

The borehole locations, ground surface elevations and interpreted stratigraphic conditions at the site are shown on Drawings 1 and 2. The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are presented on the Record of Borehole sheets, contained in Appendix A. The results of geotechnical laboratory testing are also presented on Figures B1 to B8, contained in Appendix B. The results of the in situ field tests (i.e., SPT 'N'-values and undrained shear strengths from the field vanes) as presented on the Record of Borehole sheets and in Section 4 are uncorrected. The stratigraphic boundaries shown on the Record of Borehole sheets, and on the interpreted stratigraphic profiles and cross-sections on Drawings 1 and 2, are inferred from non-continuous sampling, observation of drilling progress and the soil cuttings and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

In summary, the subsoil conditions encountered at the site generally consist of the existing pavement structure and fill comprising the existing embankment, underlain by a deposit of peat/organic clay, which was also

¹ Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Map Reference Number 42GNW.

² Ontario Geological Survey, 1991, Geology of Ontario.. ,Special Volume 4, Part 1. Eds P.C. Thurston, H.R. Williams, R.H. Sutcliffe and G.M. Stott, Ministry of Northern Development and Mines, Ontario.



encountered from ground surface at the toe of the existing embankment slope. Underlying the organic deposit the boreholes penetrated a deposit of soft to stiff clay, underlain by a deposit of very soft to stiff sandy clayey silt to silt, underlain by deposits of loose to dense gravelly sand and silt to sand and silt and very dense sand and silt till. Boulders were encountered within the sand and silt deposit in one borehole.

4.2.1 Asphalt, Concrete

Boreholes E2 to E4, advanced through the approach slabs, penetrated a 100 mm to 150 mm thick layer of asphalt, underlain by a 230 mm to 280 mm thick layer of concrete. A 420 mm and 115 mm void was noted below the concrete in Boreholes E2 and E3.

Boreholes E5, E7 and E8, advanced through the roadway approach embankments and shoulder, penetrated an asphalt layer ranging between 120 mm to 150 mm thick.

4.2.2 Fill

Embankment fill consisting of brown, gravelly sand to silty sand to sand was encountered below the concrete in Borehole E4, at the bottom of the void in Boreholes E2 and E3 and underlying the asphalt in Boreholes E5, E7 and E8. The surface of the fill was encountered between Elevation 237.7 m and 237.0 m and ranges in thickness from 1.8 m to 2.2 m.

The SPT 'N'-values measured within the fill deposit range from 4 blows to 31 blows per 0.3 m of penetration indicating a loose to dense relative density.

The results of grain size distribution testing completed on two samples of the sand fill are shown on Figure B1 in Appendix B.

The natural moisture content measured on two samples of the fill are about 9 per cent and 12 per cent.

4.2.3 Peat/Organic Silt

A deposit of black, fibrous to amorphous peat or organic silt was encountered from ground surface in Boreholes E1 and E6 north of the roadway area and underlying the fill in Boreholes E3, E4, E5 and E8. The top of this organic layer was encountered between Elevation 236.1 m and 235.1 m, and the thickness of the deposit ranges between 0.4 m and 2.0 m.

The SPT 'N'-values measured within the organic deposit range from 1 blow to 14 blows per 0.3 m of penetration, suggesting a very soft to stiff consistency.

Atterberg limits testing carried out on two samples of the organic silt returned liquid limits of about 101 per cent and 131 per cent, plastic limits of about 43 per cent and 74 per cent and a plasticity index of about 58 per cent. The results of the Atterberg limits test are shown in the plasticity chart on Figure B2 in Appendix B and indicate that the material is comprised of organic silt of high plasticity.



The natural moisture content measured on four samples of the organic deposit ranges from about 42 per cent to 130 per cent. The organic content measured on one sample of the organic silt is 7.2 per cent.

4.2.4 Clay

A deposit of brown to grey clay was encountered underlying the fill and/or organic deposit in Boreholes E1, E2, E4, E7 and E8. The top of the clay deposit was encountered between Elevation 235.6 m and Elevation 234.7 m, and the thickness of the deposit ranges between 1.4 m and 3.1 m.

SPT 'N'-values measured within the clay deposit range from 2 blows to 13 blows per 0.3 m of penetration. In situ field vane tests carried out within this stratum measured undrained shear strengths ranging from 35 kPa to greater than 100 kPa with the calculated sensitivity ranging from about 6 to 9. The SPT 'N'-values together with the in situ vane test result suggest that the clay deposit generally has a firm to stiff consistency.

The grain size distributions for two samples of the clay deposit are shown on Figure B3 in Appendix B.

Atterberg limits testing carried out on five samples of the clay deposit yielded liquid limits ranging from about 50 per cent to 67 per cent, plastic limits ranging from about 19 per cent to 22 per cent and plasticity indices ranging from about 29 per cent to 45 per cent. The results of the Atterberg limits testing are shown on the plasticity chart on Figure B4 and indicate that the deposit is classified as clay of high plasticity.

The natural moisture content measured on five samples of the clay deposit ranges from about 26 per cent to 38 per cent.

4.2.5 Sandy Clayey Silt to Silt

A deposit of grey sandy clayey silt to silt, containing trace to some gravel was encountered underlying the clay and/or the organic deposit in all of the boreholes. The surface of this deposit was encountered between Elevation 234.7 m and 231.9 m, and where penetrated, the thickness of the deposit ranges from 6.1 m to 14.0 m. Borehole E8 did not penetrate the deposit after exploring for 9.9 m. In Borehole E1, approximately 6.1 m of heaved material was noted inside the augers when advanced to a depth of 15.8 m and in Borehole E5, approximately 1.5 m of heaved material was noted inside the augers at a depth of 15.8 m. A sand and silt seam was encountered within this deposit at 7.9 m below ground surface (Elevation 230.1 m) in Borehole E2.

SPT 'N'-values measured within this deposit range from 0 blows (weight of hammer) to 36 blows per 0.3 m of penetration. In situ field vane tests carried out in this deposit measured undrained shear strengths ranging from 19 kPa to 98 kPa with calculated sensitivities ranging from 1 to 4. The in situ vane test results, together with the SPT 'N'-values, suggest that the clayey silt to silt deposit generally has a soft to very stiff consistency.

The grain size distributions of sixteen samples of the sandy clayey silt to silt deposit are shown on Figure B5 in Appendix B.

Atterberg limits testing carried out on twelve samples of the clayey silt to silt yielded liquid limits ranging from about 15 per cent to 32 per cent, plastic limits ranging from about 11 per cent to 19 per cent, and plasticity indices ranging from about 4 per cent to 15 per cent. The results of the Atterberg limits testing are shown on the



plasticity chart on Figure B6 and indicate that the deposit consists of clayey silt of low plasticity to silt of slight plasticity. One sample was determined to be non-plastic.

The natural moisture content measured on samples of the sandy clayey silt to silt deposit ranges from about 12 per cent to 51 per cent.

The grain size distribution of a sample of the sand and silt seam is shown on Figure B7 in Appendix B. The natural moisture content measured on the sample of the sand and silt seam is about 20 per cent.

4.2.6 Boulders

In Borehole E3, at the bottom of the clayey silt deposit, a 0.3 m boulder was encountered at Elevation 225.1 m. Within the underlying gravely sand and silt deposit discussed further below, a 1.1 m boulder was encountered at Elevation 222.8 m.

4.2.7 Sand and Silt to Gravely Sand and Silt

A deposit of grey sand and silt to gravely sand and silt was encountered below the sandy clayey silt to silt in Boreholes E3 to E7. The surface of this deposit was encountered between Elevations 227.4 m and 224.4 m and the thickness of the deposit ranges from 1.6 m to 4.7 m. Borehole E7 was terminated after exploring the deposit for 5.4 m.

The measured SPT 'N' values within the sand and silt deposit range from 6 blows to 47 blows per 0.3 m of penetration, indicating a loose to dense relative density.

The grain size distributions for three samples of the sand and silt deposit are shown on Figure B7 in Appendix B

An Atterberg limits test on a sample from this deposit indicated that the material is non-plastic.

The natural moisture content measured on three samples of the sand and silt deposit range from about 14 per cent to 44 per cent.

4.2.8 Sand and Silt (Till)

A deposit of grey sand and silt to gravel and sand and silt till was encountered below the sandy clayey silt to silt deposit in Boreholes E1 and E2 and below the sand and silt or gravely sand and silt deposits in Borehole E3 to E6. The surface of this deposit was encountered between 224.5 m and 218.3 m and the boreholes were terminated after exploring the deposit between 3.5 m and 5.2 m into the deposit.

Difficult casing advancement was noted throughout this till deposit and coring techniques were required to advance the borehole at several depths throughout. A 0.2 m size cobble was encountered in Borehole E2 at a depth of 14.9 m below ground surface (Elevation 222.9 m).

The measured SPT 'N' values within the till deposit range from 71 blows to greater than 100 blows per 0.3 m of penetration, indicating a very dense relative density.

The grain size distributions for five samples of the till deposit are shown on Figure B8 in Appendix B.



The natural moisture content measured on five samples of the till deposit range from about 9 per cent to 13 per cent.

4.3 Groundwater Conditions

Groundwater levels were measured in the open boreholes during and upon completion of drilling and a piezometer was installed in Borehole E1 and sealed within the clay and sandy clayey silt to silt deposits. The measured groundwater levels in the open boreholes and piezometer are presented below.

Borehole	Installation	Date	Groundwater Depth (m)	Groundwater Elevation (m)
E1	Open Borehole	October 20, 2012	1.2	234.9
	Piezometer	December 13, 2012	1.1	235.0
	Piezometer	June 25, 2013	0.5	235.6
E2	Open Borehole	October 19, 2012	2.4	235.4
E3	Open Borehole	June 25, 2013	3.7	234.0
E4	Open Borehole	June 19, 2013	2.7	235.0
E5	Open Borehole	June 18, 2013	3.0	234.7
E6	Open Borehole	July 10, 2013	3.6	232.5
E7	Open Borehole	June 19, 2013	8.8	229.0
E8	Open Borehole	June 19, 2013	11.4	226.4

Groundwater levels encountered in the boreholes during and shortly after drilling may not be representative of static groundwater levels since the groundwater levels in the boreholes may not have stabilized. Groundwater (and creek water) levels in the area are subject to seasonal fluctuations and to fluctuations after precipitation events and snowmelt. The water level in Evelyn Creek was measured at Elevation 235.3 m on October 20, 2012, and at Elevation 235.9 m on July 26, 2013.

5.0 CLOSURE

The field drilling program was supervised by Mr. Indulis Dumpis and Mr. Ed Savard. This Detail Foundation Investigation Report was prepared by Mr. Adam Core, E.I.T. and Mr. Evan Childerhose, P.Eng., and the technical aspects were reviewed by Ms. Sarah Coyne, P.Eng. Messrs. Fintan Heffernan, P.Eng., and Jorge Costa, P.Eng., Designated MTO Foundations Contacts and Principals with Golder, conducted independent quality control reviews of this report.



Report Signature Page

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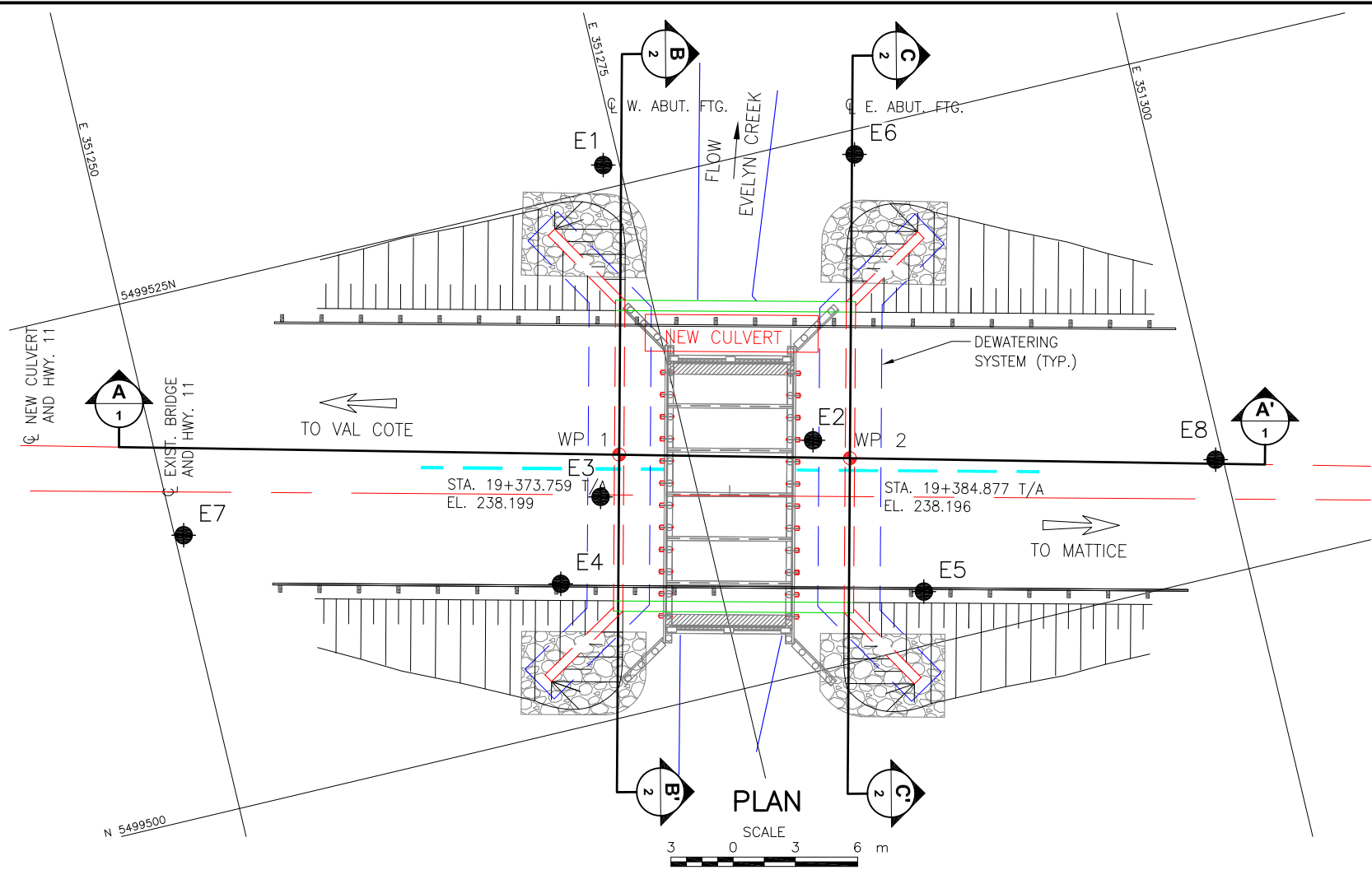


Jorge M.A. Costa, P.Eng.
Designated MTO Contact, Principal

AC/EC/SEMC/JMAC/kp

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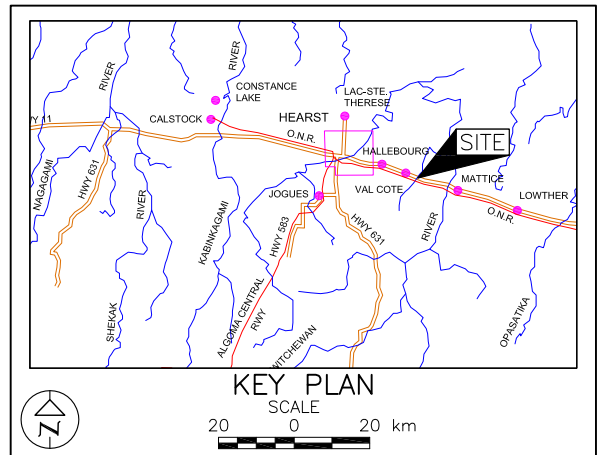
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STATIONS IN KILOMETRES + METRES.

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HIGHWAY 11
EVELYN CREEK CULVERT
BOREHOLE LOCATION AND
SOIL STRATA

SHEET
44

Golder Associates Ltd.
SUDBURY, ONTARIO, CANADA



LEGEND

- Borehole
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Recovery
- WL upon completion of drilling

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
E1	236.1	5499526.1	351274.2
E2	237.8	5499510.9	351281.0
E3	237.7	5499510.6	351270.4
E4	237.7	5499507.0	351267.6
E5	237.7	5499502.5	351284.5
E6	236.1	5499523.8	351286.1
E7	237.8	5499513.4	351250.4
E8	237.8	5499505.5	351299.6

NOTES

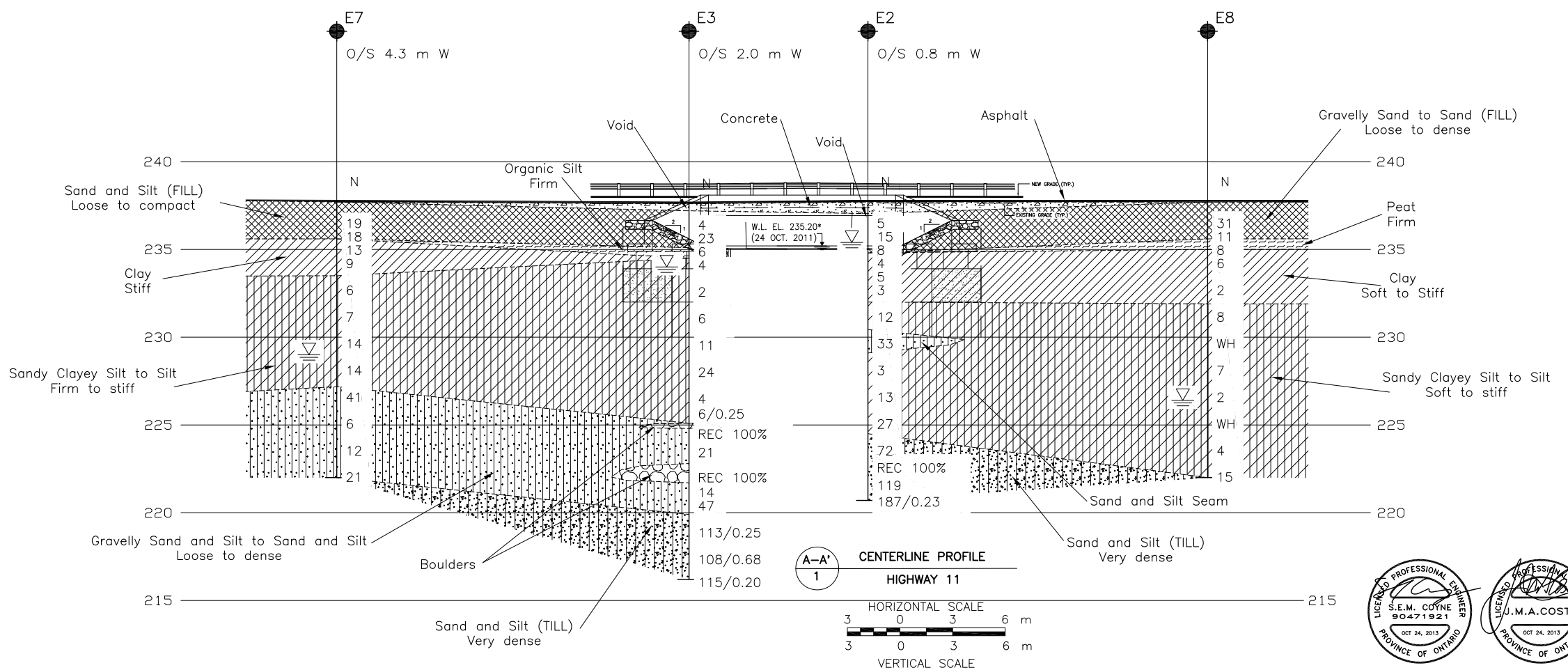
This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

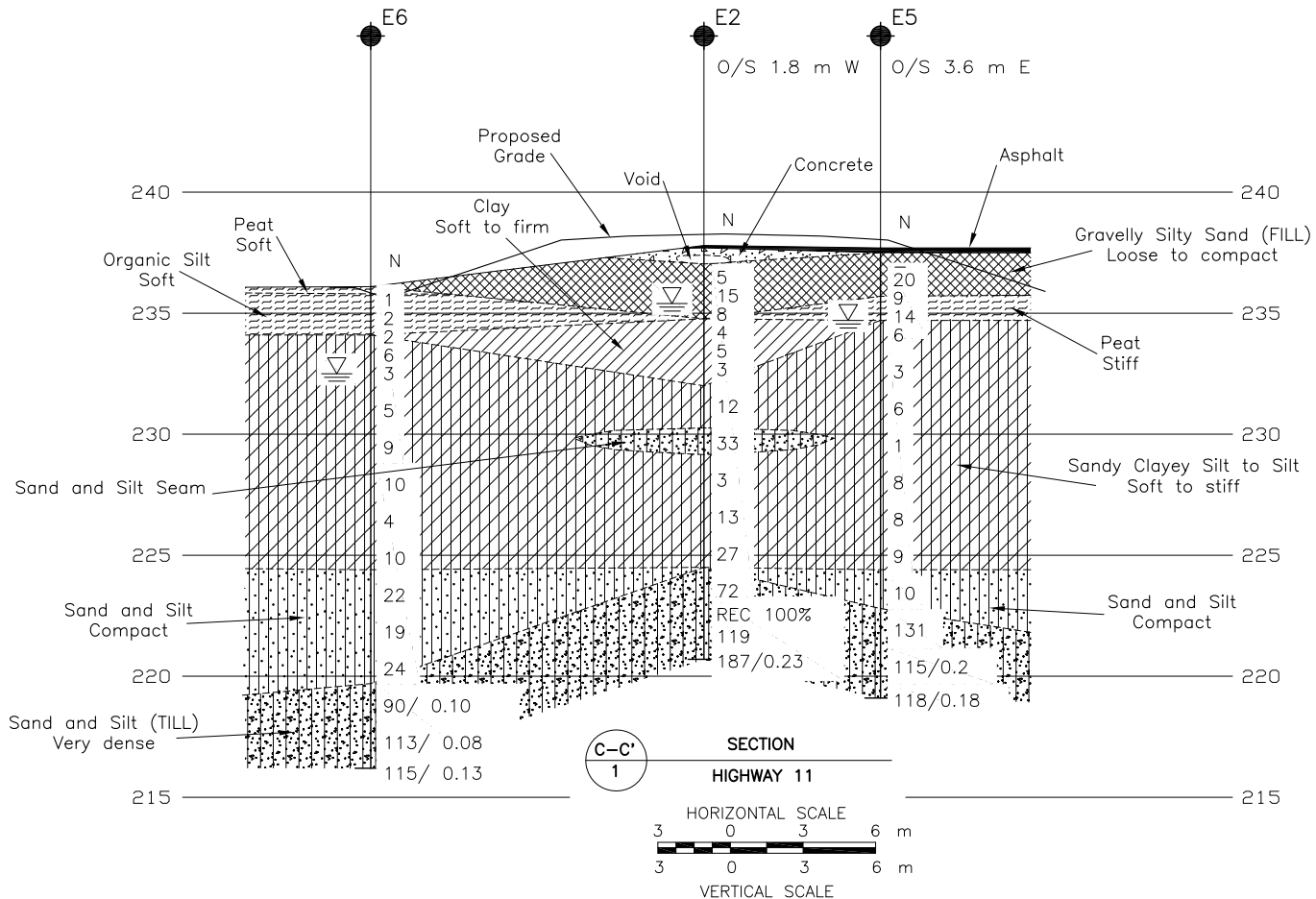
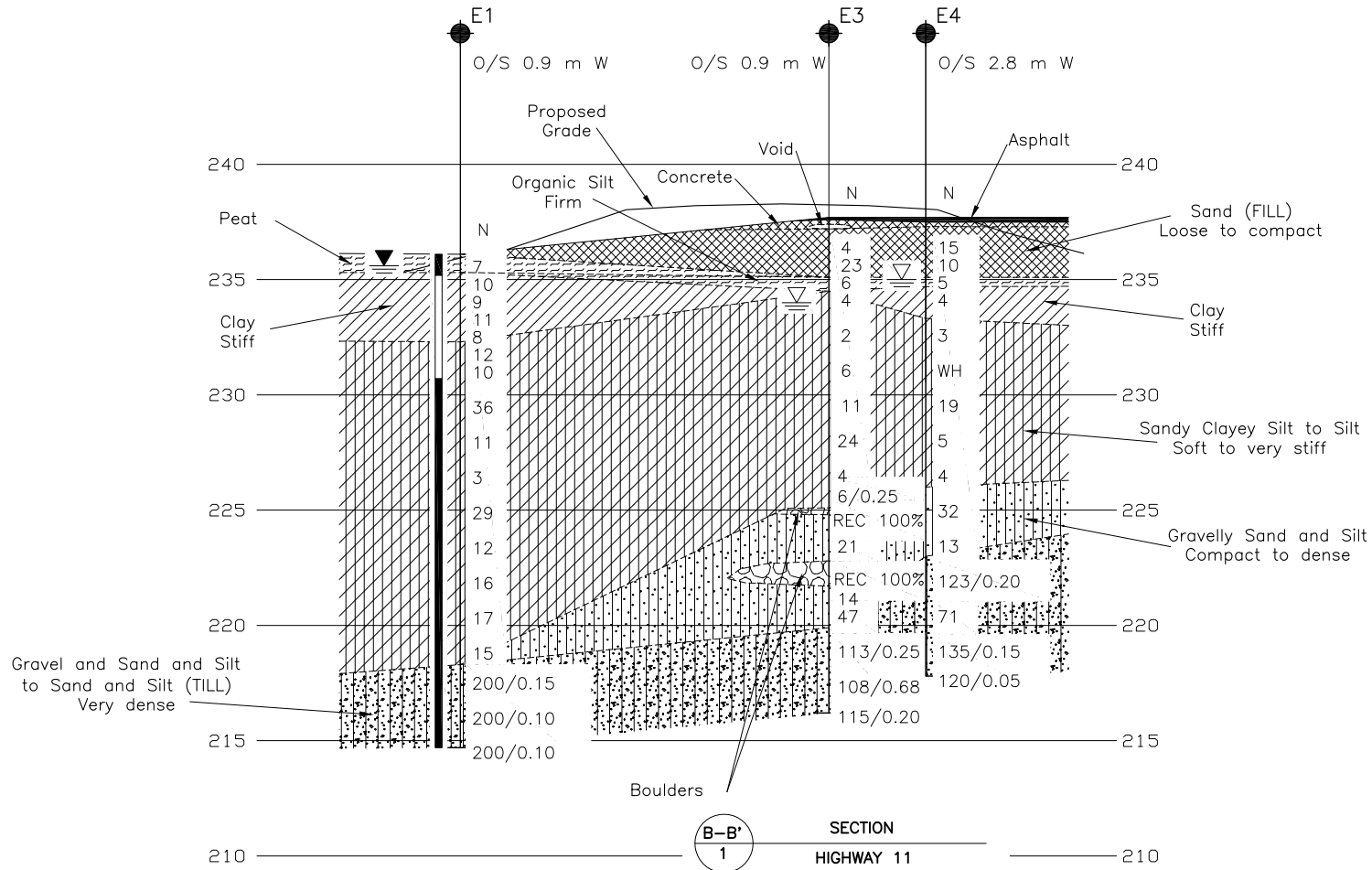
The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS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

REFERENCE

Base plans provided in digital format by LEA Consulting Ltd., drawing file no. 8960-Evelyn-S01.dwg, received Apr. 29, 2013 and x8960 EVE xsections.dwg received Oct. 22, 2013.



NO.	DATE	BY	REVISION
Geocres No. 42G-45			
HWY. 11	PROJECT NO. 11-1191-0008		DIST.
SUBM'D. EC	CHKD.	DATE: OCT 2013	SITE: 39W-100
DRAWN: TB	CHKD. SEMC	APPD. JMAC	DWG. 1



METRIC
DIMENSIONS ARE IN METRES AND/OR
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STATIONS IN KILOMETRES + METRES.

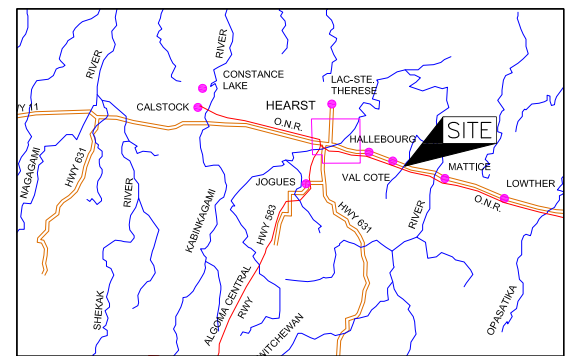
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WP No. 5150-05-00

HIGHWAY 11
EVELYN CREEK BRIDGE
SOIL STRATA

SHEET
45



Golder Associates Ltd.
SUDBURY, ONTARIO, CANADA



KEY PLAN
SCALE
20 0 20 km

LEGEND

- Borehole
- Seal
- Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% Recovery
- WL in piezometer, measured on June 25, 2013.
- WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
E1	236.1	5499526.1	351274.2
E2	237.8	5499510.9	351281.0
E3	237.7	5499510.6	351270.4
E4	237.7	5499507.0	351267.6
E5	237.7	5499502.5	351284.5
E6	236.1	5499523.8	351286.1

NOTES

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NO.	DATE	BY	REVISION
Geocres No. 42G-45			
HWY. 11	PROJECT NO. 11-1191-0008		DIST.
SUBM'D. EC	CHKD.	DATE: OCT 2013	SITE: 39W-100
DRAWN: TB	CHKD. SEMC	APPD. JMAC	DWG. 2



APPENDIX A

Record of Boreholes (E1 to E8)



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
FoS	factor of safety

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 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

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	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_α	secondary compression index
m_v	coefficient of volume change
C_v	coefficient of consolidation (vertical direction)
C_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
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 = $\tan \delta$
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

* Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

Notes: 1
2

$$\tau = c' + \sigma' \tan \phi'$$

$$\text{shear strength} = (\text{compressive strength})/2$$



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
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
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, 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)

A electronic cone penetrometer with a 60° conical tip and a project 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) Non-Cohesive (Cohesionless) Soils

Density Index	N
Relative Density	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 (LV-laboratory vane test)
γ	unit weight

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

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand

PROJECT 11-1191-0008				RECORD OF BOREHOLE No E1				1 OF 2 METRIC					
W.P. 5150-05-00				LOCATION N 5499526.1; E 351274.2				ORIGINATED BY ID					
DIST _____ HWY 11				BOREHOLE TYPE 108 mm ID Continuous Flight Hollow Stem Augers, NW Casing				COMPILED BY EC					
DATUM Geodetic				DATE October 20, 2012				CHECKED BY SEMC					
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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60	W _p W W _L	WATER CONTENT (%)		
236.1	GROUND SURFACE												
0.0	PEAT (Fibrous) Firm Black Moist		1	SS	7								
235.3													
0.8	CLAY, trace sand Stiff Brown to grey Moist to wet Trace organics to 2.1 m depth.		2	SS	10								
			3	SS	9								
			4	SS	11								
			5	SS	8								
232.3													
3.8	Sandy CLAYEY SILT to SILT, trace to some gravel Soft to hard Grey Wet		6	SS	12								
			7	SS	10								
			8	SS	36								
			9	SS	11								
			10	SS	3								
			11	SS	29								
			12	SS	12								
			13	SS	16								

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+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

SUD_MTO 003 1111910008DET.GPJ GAL-MISS.GDT 22/10/13 DATA INPUT:


PROJECT 11-1191-0008			RECORD OF BOREHOLE No E1				2 OF 2 METRIC									
W.P. 5150-05-00		LOCATION N 5499526.1; E 351274.2				ORIGINATED BY ID										
DIST _____ HWY 11		BOREHOLE TYPE 108 mm ID Continuous Flight Hollow Stem Augers, NW Casing				COMPILED BY EC										
DATUM Geodetic		DATE October 20, 2012				CHECKED BY SEMC										
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 (%)			
	--- CONTINUED FROM PREVIOUS PAGE ---															
	Sandy CLAYEY SILT to SILT, trace to some gravel Soft to hard Grey Wet		14	SS	17											
	Approximately 6.1 m of heave encountered at 15.8 m depth.															
218.3			15	SS	15											
17.8	GRAVEL and SAND and SILT, trace clay (TILL) Very dense Grey Moist		16	SS	200/0.15											34 31 31 4
			17	SS	200/0.1											
214.7																
21.4	END OF BOREHOLE		18	SS	200/0.1											
	Note: 1. Water level at a depth of 1.2 m below ground surface (Elev. 234.9 m) upon completion of drilling. 2. Water level in piezometer at a depth of 1.1 m below ground surface (Elev. 235.0 m) on December 13, 2012. 3. Water level in piezometer at a depth of 0.5 m below ground surface (Elev. 235.6 m) on June 25, 2013.															

PROJECT 11-1191-0008				RECORD OF BOREHOLE No E2				1 OF 2 METRIC					
W.P. 5150-05-00				LOCATION N 5499510.9; E 351281.0				ORIGINATED BY ID					
DIST _____ HWY 11				BOREHOLE TYPE NW Casing, NQ Coring				COMPILED BY EC					
DATUM Geodetic				DATE October 19, 2012				CHECKED BY SEMC					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT		UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60	W _p W W _L	WATER CONTENT (%)		
237.8	GROUND SURFACE												
0.0	ASPHALT (100 mm)												
237.4	CONCRETE (280 mm)												
	VOID (420 mm)												
237.0													
0.8	Gravelly sand (FILL) Loose to compact Brown Moist to wet		1	SS	5		237						
			2	SS	15		236						
			3	SS	8		235						
234.8													
3.0	CLAY, trace sand Soft to firm Brown to grey Wet Trace organics to 3.7 m depth.		4	SS	4		234						
			5	SS	5		233						
			6	SS	3		232						
232.0													
5.8	Sandy CLAYEY SILT to SILT, trace to some gravel Soft to hard Grey Wet		7	SS	12		231						
			8	SS	33		230						
	Sand and silt seam at 7.9 m depth.						229						
			9	SS	3		228						
			10	SS	13		227						
			11	SS	27		226						
							225						
224.5													
13.3	SAND and SILT, some gravel (TILL) Very dense Grey Wet		12	SS	72		224						
							223						

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

SUD_MTO 003 1111910008DET.GPJ GAL-MISS.GDT 22/10/13 DATA INPUT:




PROJECT <u>11-1191-0008</u>				RECORD OF BOREHOLE No E2				2 OF 2 METRIC										
W.P. <u>5150-05-00</u>		LOCATION <u>N 5499510.9; E 351281.0</u>				ORIGINATED BY <u>ID</u>												
DIST <u> </u> HWY <u>11</u>		BOREHOLE TYPE <u>NW Casing, NQ Coring</u>				COMPILED BY <u>EC</u>												
DATUM <u>Geodetic</u>		DATE <u>October 19, 2012</u>				CHECKED BY <u>SEMC</u>												
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)					
	--- CONTINUED FROM PREVIOUS PAGE ---						<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> ○ UNCONFINED + FIELD VANE </div> <div style="display: flex; justify-content: space-between;"> ● QUICK TRIAXIAL × REMOULDED </div>					<div style="display: flex; justify-content: space-between;"> W_p W W_L </div>						
220.7	SAND and SILT, some gravel (TILL) Very dense Grey Wet Refusal to further casing advancement at 14.9 m depth. Cored between 14.9 m and 15.1 m depth: Recovered cobble (200 mm thick).		1	RC	100%													
17.1			13	SS	119													
221			14	SS	187/0.23													
END OF BOREHOLE																		
Note: 1. Water level at a depth of 2.4 m below ground surface (Elev. 235.4 m) upon completion of drilling.																		

PROJECT 11-1191-0008				RECORD OF BOREHOLE No E3				1 OF 2 METRIC					
W.P. 5150-05-00				LOCATION N 5499510.6; E 351270.4				ORIGINATED BY EHS					
DIST _____ HWY 11				BOREHOLE TYPE NW Casing, NQ Coring				COMPILED BY EC					
DATUM Geodetic				DATE June 24 and 25, 2013				CHECKED BY AB					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W _p W W _L			
237.7	GROUND SURFACE												
0.0	ASPHALT (125 mm)												
	CONCRETE (260 mm)												
0.5	VOID (115 mm)												
	Sand, some gravel, trace silt (FILL)												
	Loose to compact												
	Brown												
	Moist to wet												
235.1			1	SS	4		237						
			2	SS	23		236						
			3A	SS	6								
234.5	ORGANIC SILT		3B				235						
	Firm												
	Black												
	Wet												
234.5	CLAYEY SILT to SILT, trace to some sand		4	SS	4		234						
	Soft to very stiff												
	Grey												
	Wet												
			5	SS	2		233						
			6	SS	6		232						
			7	SS	11		231						
			8	SS	24		230						
							229						
							228						
							227						
			9	SS	4								
							226						
225.1			10	SS	6/0.25		225						
	BOULDER		-	RC	REC 100%								
224.8													
	Gravelly SAND and SILT, trace clay												
	Compact to dense												
	Grey												
	Wet												
			11	SS	21		224						
							223						
222.8													

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

SUD_MTO 003 1111910008DET.GPJ GAL-MISS.GDT 22/10/13 DATA INPUT:

PROJECT		RECORD OF BOREHOLE No E3				2 OF 2 METRIC										
W.P. 11-1191-0008		LOCATION N 5499510.6; E 351270.4				ORIGINATED BY EHS										
DIST _____ HWY 11		BOREHOLE TYPE NW Casing, NQ Coring				COMPILED BY EC										
DATUM Geodetic		DATE June 24 and 25, 2013				CHECKED BY AB										
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	SHEAR STRENGTH kPa								
	--- CONTINUED FROM PREVIOUS PAGE ---															
14.9	BOULDER (Gneiss)		-	RC	REC 100%											
221.7						222										
16.0	Gravelly SAND and SILT, some gravel, trace clay Compact to dense Grey Wet		12	SS	14											
			13	SS	47											
219.9						221										
17.8	SAND and SILT, some gravel, trace clay (TILL) Very dense Grey Wet		14	SS	113/0.25											
						220										
						219										
						218										
			15	SS	108/0.1											
						217										
216.2																
21.5	END OF BOREHOLE		16	SS	115/0.2											
	Note: 1. Water level at a depth of 3.7 m below ground surface (Elev. 234.0 m) upon completion of drilling.															

PROJECT		11-1191-0008		RECORD OF BOREHOLE No E4		1 OF 2 METRIC	
W.P.		5150-05-00		LOCATION		N 5499507.0; E 351267.6	
DIST		HWY 11		BOREHOLE TYPE		NW Casing, NQ Coring	
DATUM		Geodetic		DATE		June 19, 2013	
						ORIGINATED BY EHS	
						COMPILED BY EC	
						CHECKED BY AB	
SOIL PROFILE				SAMPLES		DYNAMIC CONE PENETRATION RESISTANCE PLOT	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	
237.7	GROUND SURFACE						
0.0	ASPHALT (150 mm)						
	CONCRETE (230 mm)						
0.4	Sand, some gravel (FILL) Compact Brown Wet		1	SS	15		
			2	SS	10		
235.1			3	SS	5		
234.7	PEAT (Amorphous) Firm Black Wet						
3.0	CLAY, varved Stiff Grey Wet		4	SS	4		
233.3	Sandy CLAYEY SILT, trace gravel Very soft to stiff Grey Wet		5	SS	3		
4.4			6	SS	WH		
			7	SS	19		
			8	SS	5		
			9	SS	4		
226.0	SAND and SILT, trace to some gravel Compact to dense Grey Wet		10	SS	32		
11.7			11	SS	13		
223.0							
14.7							
						PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W_p W W_L WATER CONTENT (%)	
						UNCONFINED FIELD VANE QUICK TRIAXIAL REMOULDED SHEAR STRENGTH kPa	
						ELEVATION SCALE 20 40 60 80 100 20 40 60 80 100	
						UNIT WEIGHT γ kN/m³	
						REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	



+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE


SUD MTO 003 111910008DET.GPJ GAL-MISS.GDT 22/10/13 DATA INPUT:

PROJECT		11-1191-0008		RECORD OF BOREHOLE No E5		1 OF 2 METRIC							
W.P.		5150-05-00		LOCATION		N 5499502.5; E 351284.5							
DIST		HWY 11		BOREHOLE TYPE		108 mm ID Continuous Flight Hollow Stem Augers							
DATUM		Geodetic		DATE		June 18, 2013							
						ORIGINATED BY <u>EHS</u>							
						COMPILED BY <u>EC</u>							
						CHECKED BY <u>AB</u>							
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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)			
237.7	GROUND SURFACE												
0.0	ASPHALT (150 mm)												
0.2	Silty sand, trace gravel (FILL) Loose to compact Brown Moist		1	AS	-								1 78 (21)
			2	SS	20								
235.7			3A	SS	9								
2.0	PEAT (Amorphous) Stiff Black Wet		3B										
			4	SS	14								
234.7													
3.0	Sandy CLAYEY SILT to SILT, trace to some gravel Soft to stiff Grey Wet		5	SS	6								
			6	SS	3								
			7	SS	6								0 3 87 10
			8	SS	1								
			9	SS	8								
			10	SS	8								10 22 52 16
			11	SS	9								
224.4													
13.3	SAND and SILT Compact Grey Moist		12	SS	10								
222.8													

SUD_MTO_003 1111910008DET.GPJ GAL-MISS.GDT 22/10/13 DATA INPUT:

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+ 3, X 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE


PROJECT <u>11-1191-0008</u>		RECORD OF BOREHOLE No E5				2 OF 2 METRIC												
W.P. <u>5150-05-00</u>		LOCATION <u>N 5499502.5; E 351284.5</u>				ORIGINATED BY <u>EHS</u>												
DIST <u> </u> HWY <u>11</u>		BOREHOLE TYPE <u>108 mm ID Continuous Flight Hollow Stem Augers</u>				COMPILED BY <u>EC</u>												
DATUM <u>Geodetic</u>		DATE <u>June 18, 2013</u>				CHECKED BY <u>AB</u>												
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT 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 (%)					
--- CONTINUED FROM PREVIOUS PAGE ---																		
14.9	SAND and SILT, trace to some gravel, trace clay (TILL) Very dense Grey Moist Approximately 1.5 m of heave encountered at 15.8 m depth.		13	SS	131	222												
						221												
			14	SS	115/0.2										o			
						220												
219.1 18.6	END OF BOREHOLE Note: 1. Water level at a depth of 3.0 m below ground surface (Elev. 234.7 m) upon completion of drilling.		15	SS	118/0.2													

PROJECT 11-1191-0008				RECORD OF BOREHOLE No E6				1 OF 2 METRIC							
W.P. 5150-05-00				LOCATION N 5499523.8; E 351286.1				ORIGINATED BY EHS							
DIST _____ HWY 11				BOREHOLE TYPE 108 mm ID Continuous Flight Hollow Stem Augers				COMPILED BY EC							
DATUM Geodetic				DATE June 6 and July 10, 2013				CHECKED BY AB							
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			SHEAR STRENGTH kPa							
236.1	GROUND SURFACE							20 40 60 80 100							
0.0 235.8 0.3	PEAT (Fibrous) Soft Black Wet ORGANIC SILT Soft Black Wet		1	SS	1		236								
			2	SS	2		235								
			3	SS	2		234								
234.1	Sandy CLAYEY SILT to SILT, trace gravel Firm to stiff Grey Wet		4	SS	6		233								
2.0			5	SS	3		232								
			6	SS	5		231								
			7	SS	9		230								
			8	SS	10		229								
			9	SS	4		228								
			10	SS	10		227								
			11	SS	22		226								
224.4	SAND and SILT Compact Grey Wet		12	SS	19		225								
11.7							224								
							223								
							222								

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

SUD_MTO 003 1111910008DET.GPJ GAL-MISS.GDT 22/10/13 DATA INPUT:

PROJECT 11-1191-0008				RECORD OF BOREHOLE No E6				2 OF 2 METRIC									
W.P. 5150-05-00				LOCATION N 5499523.8; E 351286.1				ORIGINATED BY EHS									
DIST _____ HWY 11				BOREHOLE TYPE 108 mm ID Continuous Flight Hollow Stem Augers				COMPILED BY EC									
DATUM Geodetic				DATE June 6 and July 10, 2013				CHECKED BY AB									
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									
	--- CONTINUED FROM PREVIOUS PAGE ---																
219.7	SAND and SILT Compact Grey Wet		13	SS	24												
16.4	SAND and SILT, some gravel, trace clay (TILL) Very dense Grey Wet																
			14	SS	90/0.1												
			15	SS	113/0.1												
216.2	END OF BOREHOLE		16	SS	115/0.1												
19.9	Note: 1. Water level at a depth of 3.6 m below ground surface (Elev. 232.5 m) upon completion of drilling.																

SUD_MTO_003 1111910008DET.GPJ GAL-MISS.GDT 22/10/13 DATA INPUT:

SUD MTO 003 111910008DET.GPJ GAL-MISS.GDT 22/10/13 DATA INPUT:

+³, ×³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE



+³, ×³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE

SUD MTO 003 111910008DET.GPJ GAL-MISS.GDT 22/10/13 DATA INPUT:

SUD MTO 003 111910008DET.GPJ GAL-MISS.GDT 22/10/13 DATA INPUT:

PROJECT <u>11-1191-0008</u>		RECORD OF BOREHOLE No E8				2 OF 2 METRIC											
W.P. <u>5150-05-00</u>		LOCATION <u>N 5499505.5; E 351299.6</u>				ORIGINATED BY <u>EHS</u>											
DIST <u> </u> HWY <u>11</u>		BOREHOLE TYPE <u>108 mm ID Continuous Flight Hollow Stem Augers</u>				COMPILED BY <u>EC</u>											
DATUM <u>Geodetic</u>		DATE <u>June 19, 2013</u>				CHECKED BY <u>AB</u>											
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 (%)				
	--- CONTINUED FROM PREVIOUS PAGE ---						<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED </div>					<div style="display: flex; justify-content: space-between;"> W_p W W_L </div>					
222.0 15.8	END OF BOREHOLE Note: 1. Water level at a depth of 11.4 m below ground surface (Elev. 226.4 m) upon completion of drilling.	12	SS	15		222											



APPENDIX B

Laboratory Test Results



**DETAIL FOUNDATION REPORT REPLACEMENT OF EVELYN CREEK BRIDGE
HIGHWAY 11, SITE NO. 39W-100, GWP 5150-05-00**

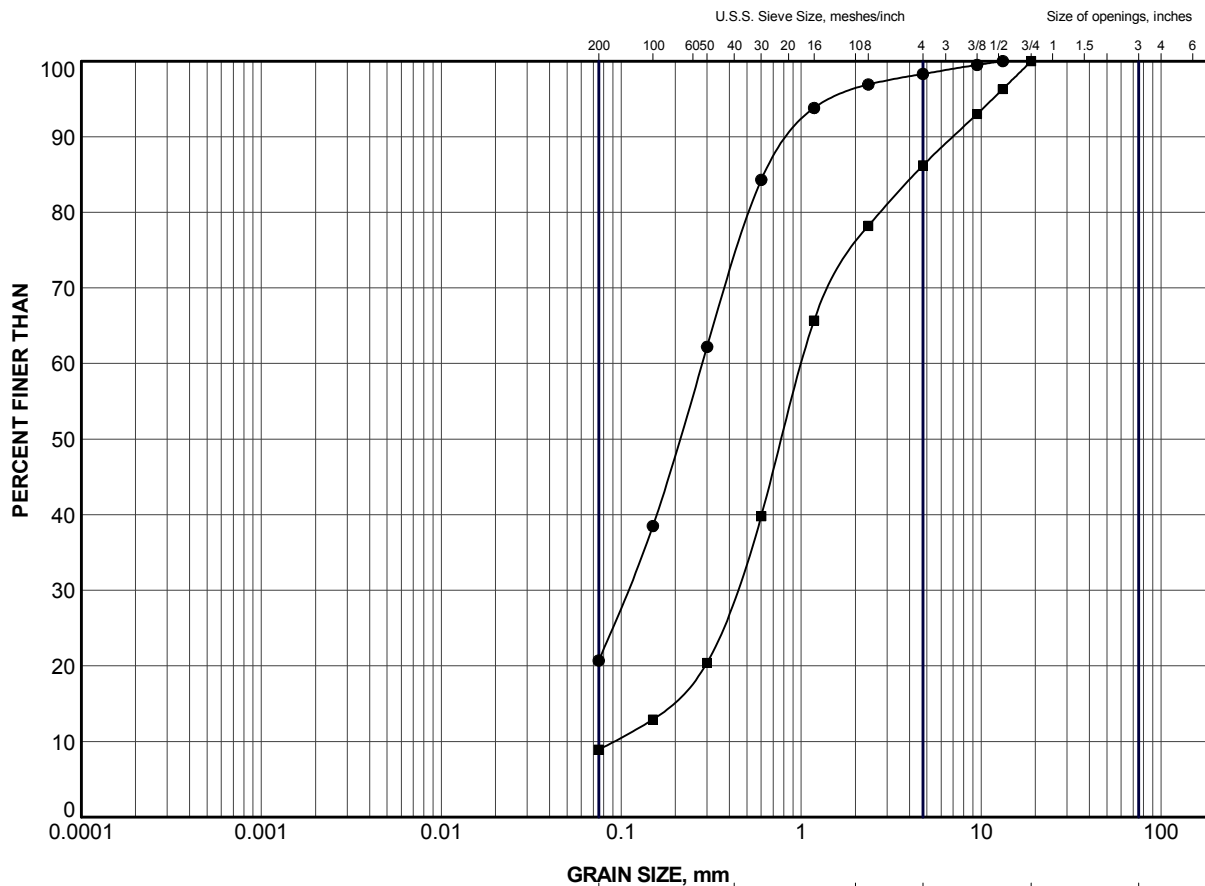
Table B1 - Summary of Analytical Testing of Creek Water

Parameter	Units	Result
Resistivity	ohm-cm	13,000
Conductivity	µmho/cm	75
pH	pH	6.81
Sulphate	mg/L	Not Detected
Chloride	mg/L	2

Notes:

1. Sample obtained July 6, 2013
2. Analytical testing carried out by Maxxam Analytics Inc.


Prepared by: EC
Reviewed by: SFMC

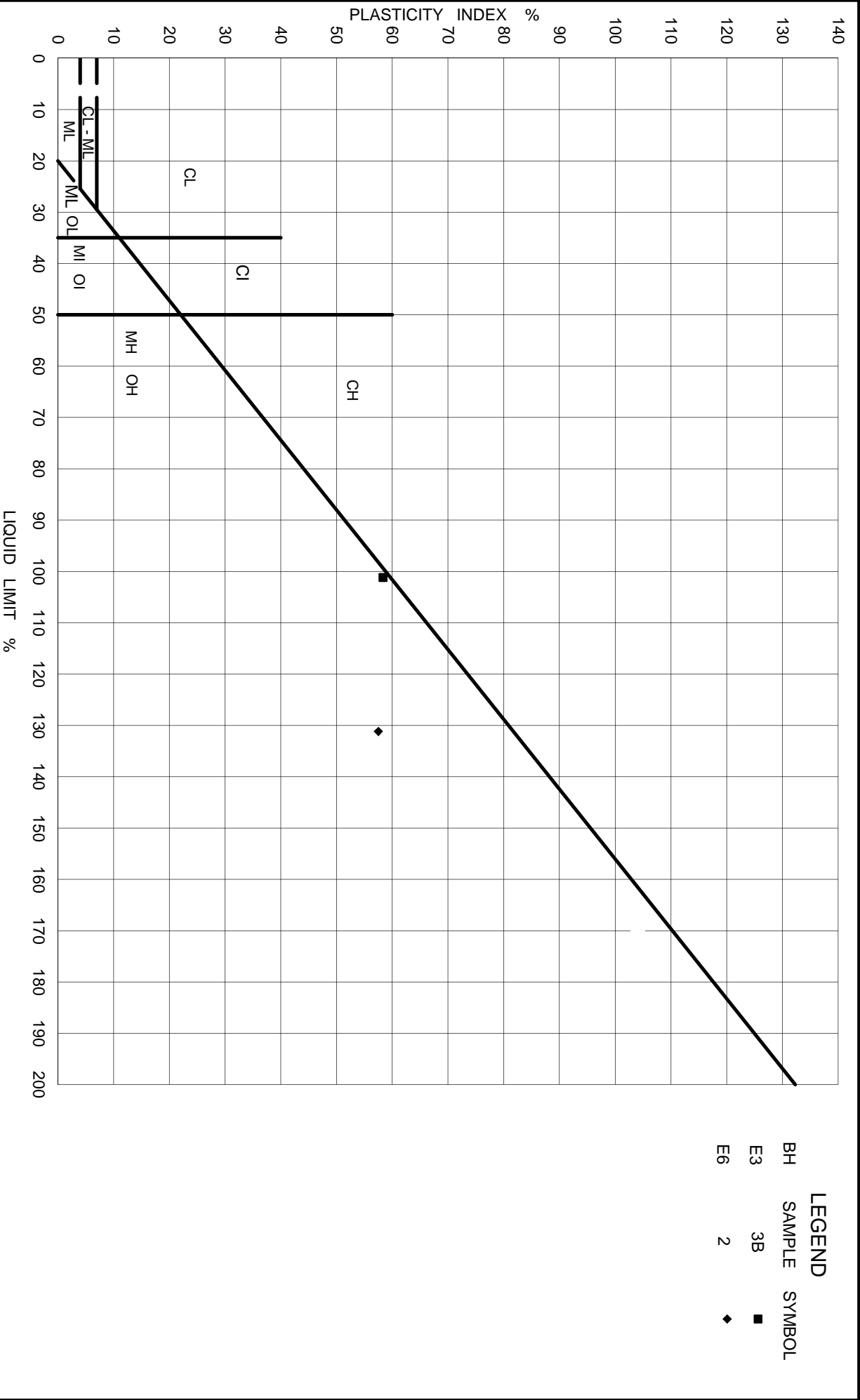


CLAY AND SILT	GRAIN SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	E5	1	237.2
■	E8	2A	236.2

PROJECT				
HIGHWAY 11 EVELYN CREEK CULVERT				
TITLE				
GRAIN SIZE DISTRIBUTION SILTY SAND to SAND (FILL)				
PROJECT No.		11-1191-0008		FILE No.
DRAWN		JJL	Oct 2013	SCALE N/A
CHECK		SEMC	Oct 2013	REV.
APPR		FJH	Oct 2013	
 Golder Associates SUDBURY, ONTARIO		FIGURE B1		



Ministry of Transportation
Ontario

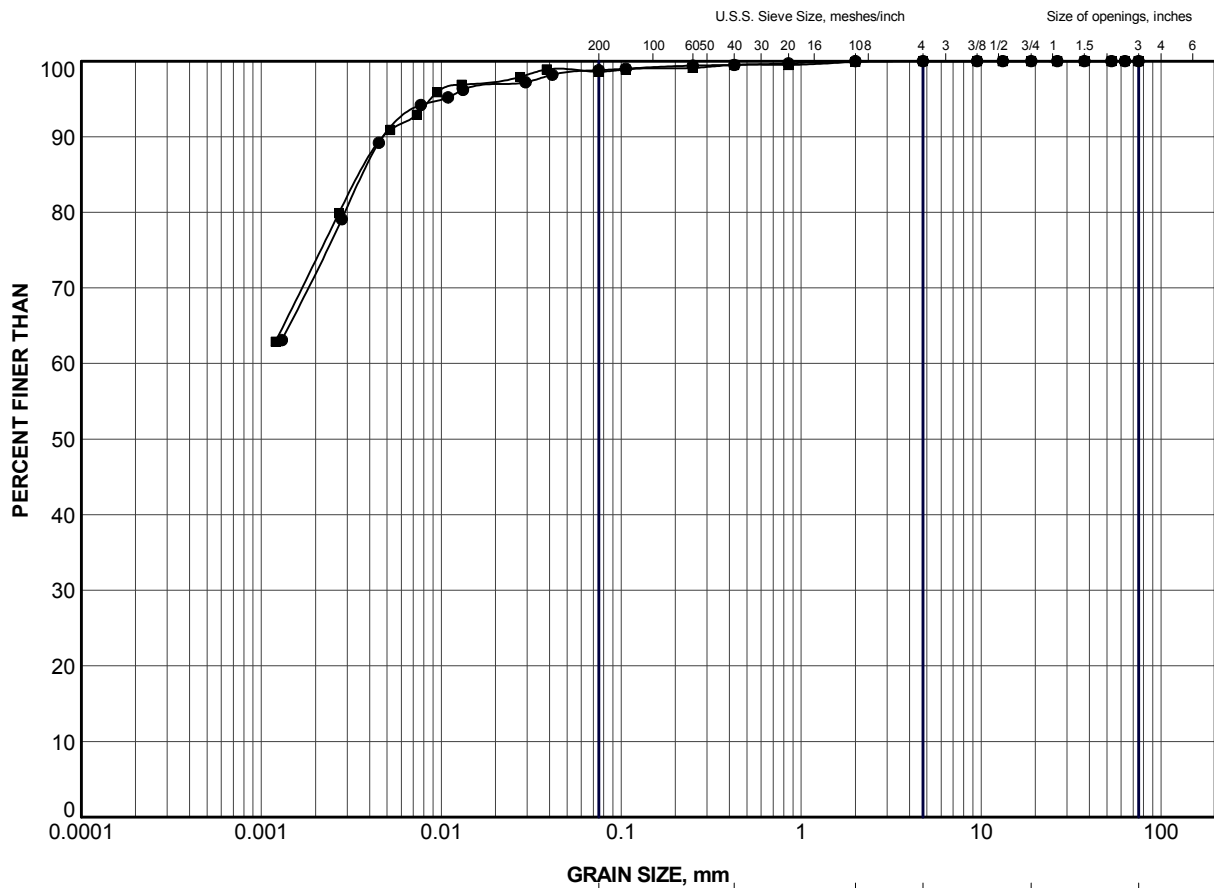
PLASTICITY CHART

ORGANIC SILT

Figure B2

Project No. 11-1191-0008


Checked By: SEMC

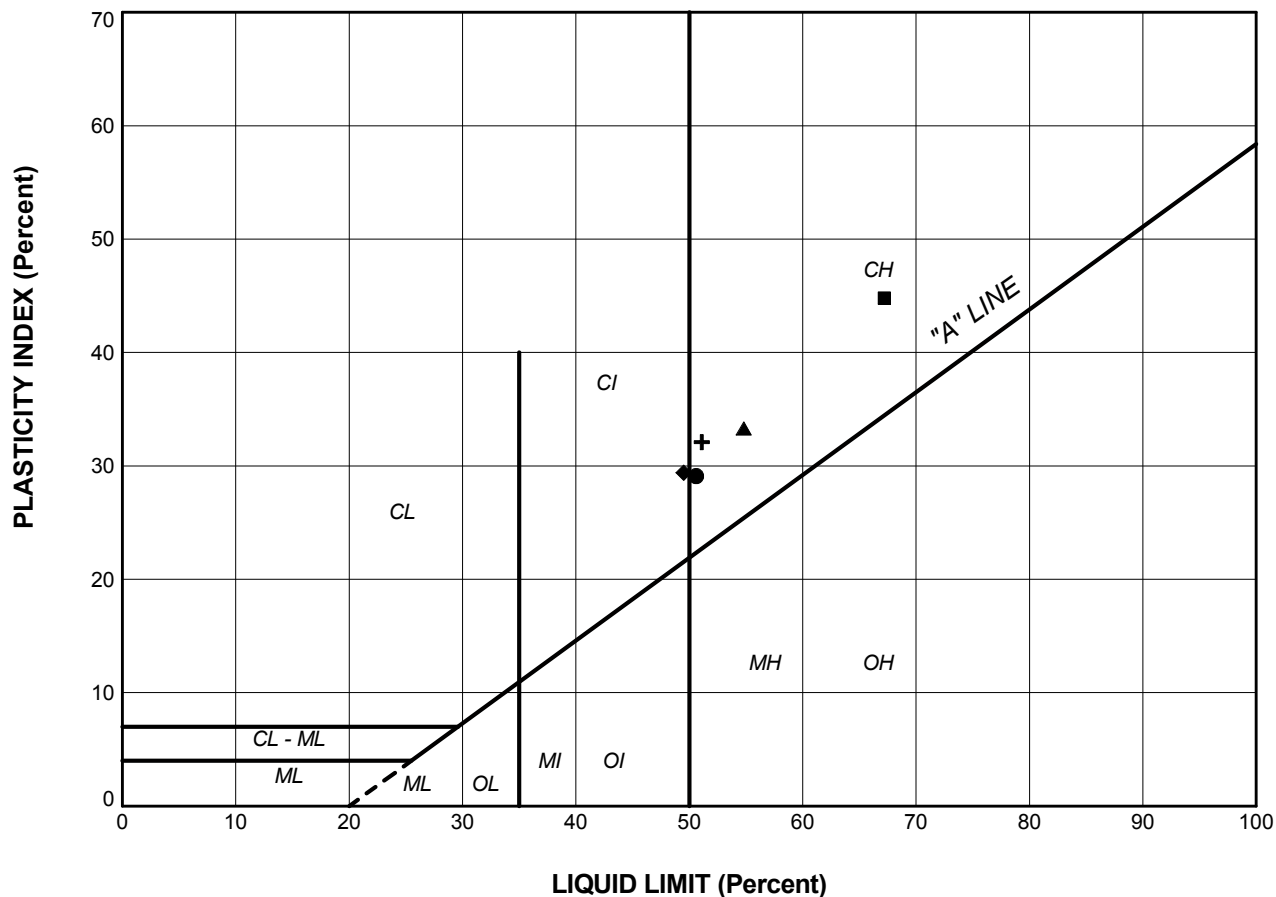


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	E1	3	234.3
■	E2	5	233.7

PROJECT						HIGHWAY 11 EVELYN CREEK CULVERT					
TITLE						GRAIN SIZE DISTRIBUTION CLAY					
PROJECT No.			11-1191-0008			FILE No.			1111910008DET.GPJ		
DRAWN	JJL	Oct 2013	SCALE	N/A	REV.						
CHECK	SEMC	Oct 2013									
APPR	FJH	Oct 2013									
 Golder Associates SUDBURY, ONTARIO			FIGURE B3								

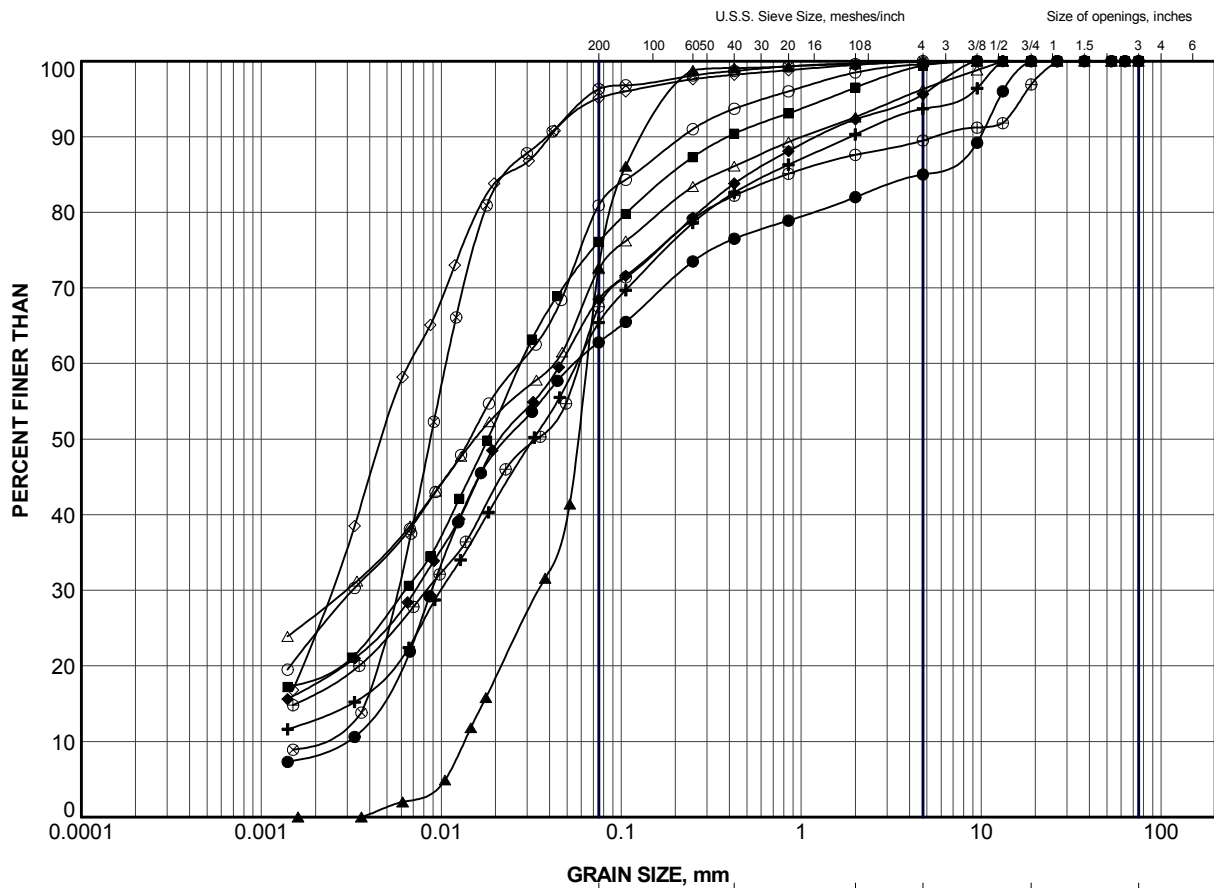


LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	E1	3	50.6	21.5	29.1
■	E2	5	67.2	22.4	44.8
▲	E4	4	54.8	21.5	33.3
+	E7	4	51.1	19.0	32.1
◆	E8	5	49.5	20.1	29.4

PROJECT			HIGHWAY 11 EVELYN CREEK CULVERT		
TITLE			PLASTICITY CHART CLAY		
PROJECT No.		11-1191-0008	FILE No.		1111910008DET.GPJ
DRAWN	JJL	Oct 2013	SCALE	N/A	REV.
CHECK	SEMC	Oct 2013	FIGURE B4		
APPR	FJH	Oct 2013			





LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	E1	6	232.0
■	E1	9	228.2
▲	E1	13	222.1
+	E2	9	228.4
◆	E2	11	225.3
◇	E3	5	232.8
○	E3	9	226.7
△	E4	9	226.7
⊗	E5	7	231.3
⊕	E5	10	226.7

PROJECT

HIGHWAY 11
EVELYN CREEK CULVERT

TITLE

GRAIN SIZE DISTRIBUTION

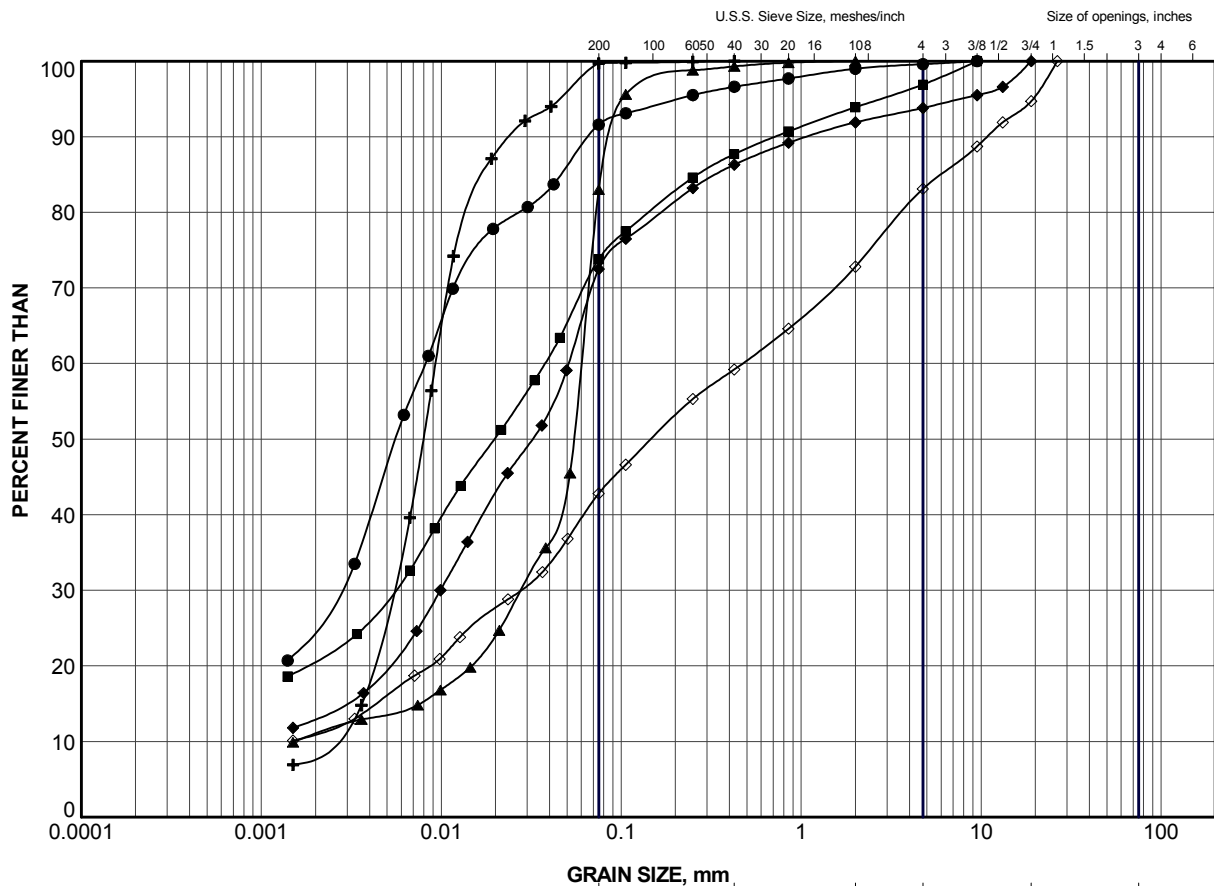
SANDY CLAYEY SILT to SILT



**Golder
Associates**
SUDBURY, ONTARIO

PROJECT No.	11-1191-0008	FILE No.	1111910008DET.GPJ
DRAWN	JJL	Oct 2013	SCALE N/A
CHECK	SEMC	Oct 2013	REV.
APPR	FJH	Oct 2013	


FIGURE B5.1

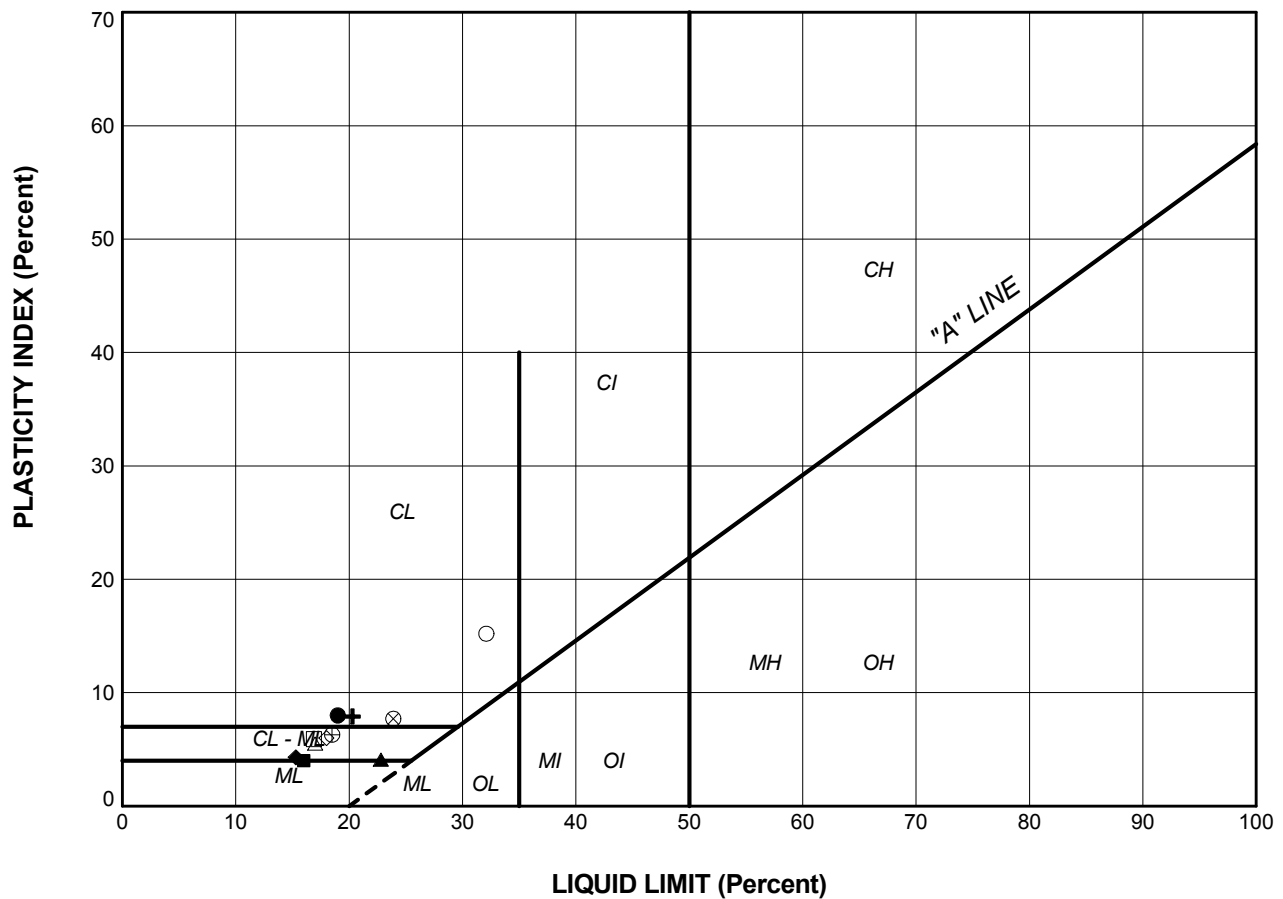


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND


SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	E6	5	232.8
■	E6	9	226.7
▲	E7	7	229.9
+	E8	6	231.4
◆	E8	8	228.4
◇	E8	11	223.8

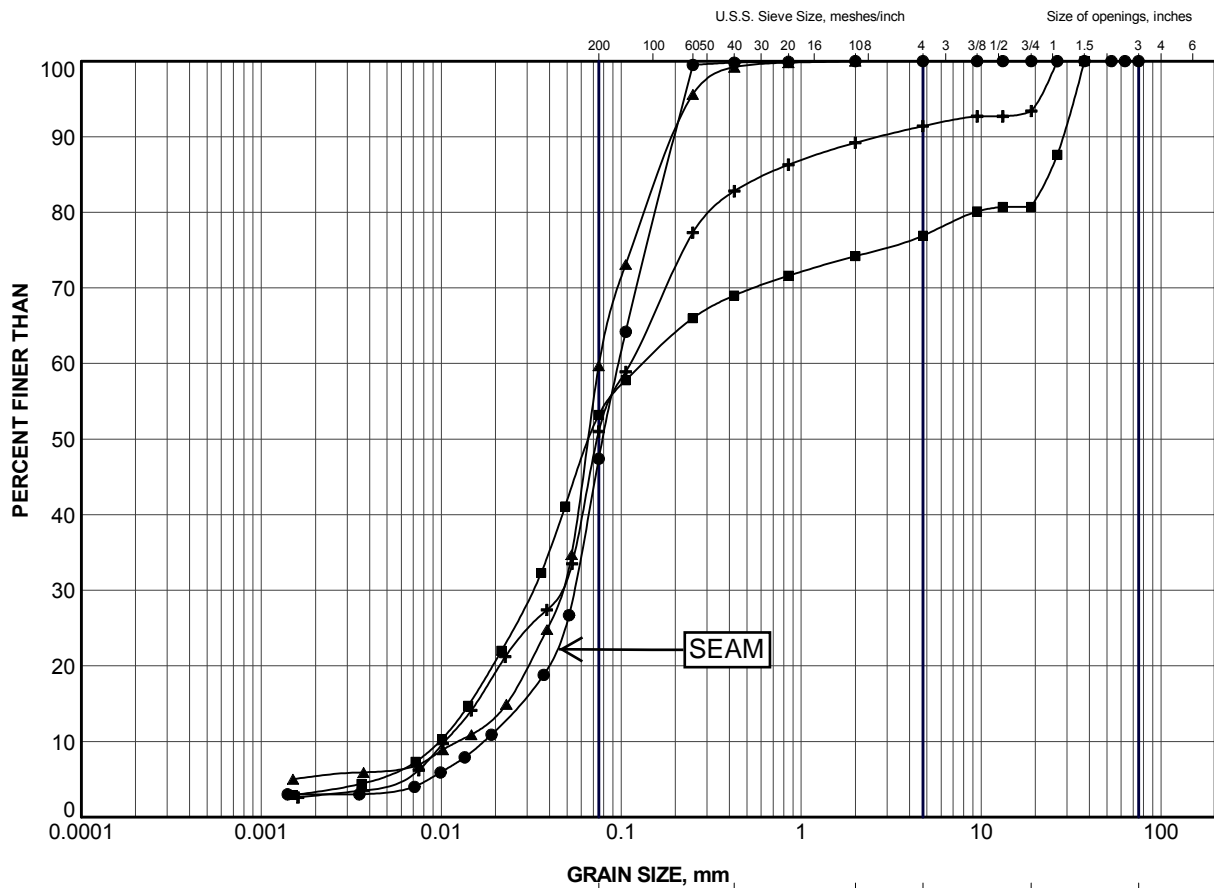
PROJECT						HIGHWAY 11 EVELYN CREEK CULVERT					
TITLE						GRAIN SIZE DISTRIBUTION SANDY CLAYEY SILT to SILT					
PROJECT No.			11-1191-0008			FILE No.			1111910008DET.GPJ		
DRAWN	JJL	Oct 2013	SCALE	N/A	REV.						
CHECK	SEMC	Oct 2013									
APPR	FJH	Oct 2013									
 Golder Associates SUDBURY, ONTARIO			FIGURE B5.2								



LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	E1	11	19.0	11.0	8.0
■	E2	9	16.0	12.0	4.0
▲	E3	5	22.8	18.7	4.1
+	E3	9	20.3	12.4	7.9
◆	E4	6	15.3	11.0	4.3
◇	E4	9	18.0	12.0	6.0
○	E5	6	32.1	16.9	15.2
△	E5	10	17.0	11.5	5.5
⊗	E6	5	23.9	16.2	7.7
⊕	E6	9	18.5	12.2	6.3
□	E8	8	16.9	11.0	5.9


PROJECT					HIGHWAY 11 EVELYN CREEK CULVERT				
TITLE					PLASTICITY CHART SANDY CLAYEY SILT to SILT				
PROJECT No. 11-1191-0008			FILE No. 1111910008DET.GPJ						
DRAWN	JJL	Oct 2013	SCALE	N/A	REV.				
CHECK	SEMC	Oct 2013							
APPR	FJH	Oct 2013							
 Golder Associates SUDBURY, ONTARIO			FIGURE B6						

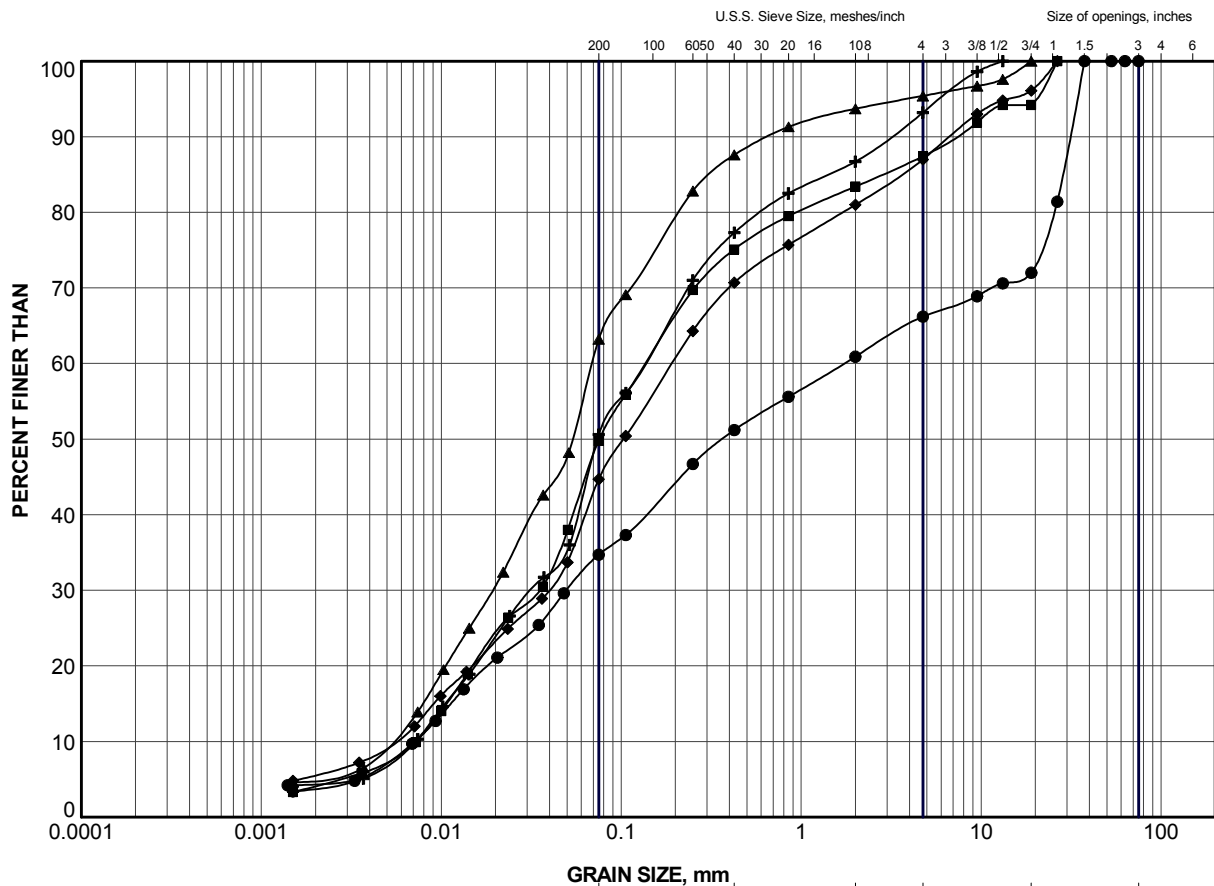


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	E2	8	229.9
■	E3	11	223.7
▲	E7	9	226.8
✚	E7	12	222.3

PROJECT					HIGHWAY 11 EVELYN CREEK CULVERT				
TITLE					GRAIN SIZE DISTRIBUTION SAND and SILT				
PROJECT No.		11-1191-0008		FILE No.		1111910008DET.GPJ			
DRAWN	JJL	Oct 2013	SCALE	N/A	REV.				
CHECK	SEMC	Oct 2013							
APPR	FJH	Oct 2013							
 Golder Associates SUDBURY, ONTARIO			FIGURE B7						



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	E1	16	217.7
■	E3	14	219.1
▲	E4	12	222.2
+	E5	14	220.7
◆	E6	14	219.0

PROJECT

HIGHWAY 11
EVELYN CREEK CULVERT

TITLE

GRAIN SIZE DISTRIBUTION

SAND and SILT (TILL)



**Golder
Associates**
SUDBURY, ONTARIO

PROJECT No.	11-1191-0008	FILE No.	1111910008DET.GPJ
DRAWN	JJL	Oct 2013	SCALE N/A
CHECK	SEMC	Oct 2013	REV.
APPR	FJH	Oct 2013	

FIGURE B8

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

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