REPORT

December 23, 2013

FOUNDATION INVESTIGATION REPORT

LITTLE EAST RIVER BRIDGE NO. 1, SITE NO. 44-174
HIGHWAY 592 - REPLACEMENT OF SIX STRUCTURES
MINISTRY OF TRANSPORTATION, ONTARIO
GWP 5265-07-00 WP 5265-07-01

Submitted to:
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GEOCRES No: 31E-330

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PART A

FOUNDATION INVESTIGATION REPORT

LITTLE EAST RIVER BRIDGE NO. 1 – SITE NO. 44-174

HIGHWAY 592 – REPLACEMENT OF SIX STRUCTURES

MINISTRY OF TRANSPORTATION, ONTARIO

GWP 5265-07-00; WP 5265-07-01

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield Limited (MH) on behalf of the Ministry of Transportation, Ontario (MTO) to provide detail foundation engineering services for the replacement of Little East River Bridge No. 1 (Site No. 44-174) over Highway 592 in Huntsville, Ontario. The proposed work is part of the replacement of six bridge structures along Highway 592. The Little East River Bridge No. 1 is located approximately 75 m south of Savage Settlement Road and approximately 1 km north of the Highway 11/Novar Road interchange in Novar, Ontario. The location of the existing bridge structure along Highway 592 is shown on the Key Map on Drawing 1.

The Terms of Reference (TOR) for the foundation investigation are outlined in MTO's Request for Proposal, dated September 2011. Golder's proposal (Scope of Work) for foundation engineering services associated with the Little East River Bridge No. 1 structure is contained in Section 6.8 of MH's Technical Proposal for this assignment. The work was carried out in accordance with Golder's Project Specific Supplementary Specialty Plan for foundation engineering services, dated March 21, 2012.

This report addresses the investigation carried out for the Little East River Bridge No. 1 structure and the associated approach embankments only.

The purpose of this investigation is to establish the subsurface conditions at the replacement bridge structure location, including the associated approach embankments, by borehole drilling and coring techniques, in situ testing and laboratory testing on selected soil samples. The borehole locations for this investigation were surveyed by Tulloch Geomatics Inc. (Tulloch), a professional surveying company retained by MH. The investigation area is shown in plan on Drawing 2.

2.0 SITE DESCRIPTION

The existing Highway 592 alignment is oriented generally in a south-north direction.

In general, the topography along Highway 592 consists of rolling terrain, including lakes, low-lying swamps containing areas of standing water, sparsely to densely populated tree covered areas. Land use in some areas consists of residential/recreational communities. The existing bridge is a single-span rigid frame structure with a span length of 6.1 m. The bridge structure and associated approach embankments are situated on a relatively flat, sparsely treed area surrounded by residential/recreational properties to the north and south and with Little East River flowing easterly at this location. The existing ground surface within the limits of the proposed structure and approach embankments is at about Elevation 322.5 m, referenced to Geodetic datum. The existing Highway 592 south and north approach embankments along the centreline are at Elevations 322.6 m and 322.5 m, respectively.

3.0 INVESTIGATION PROCEDURES

3.1 Foundation Investigation

The field work for the proposed bridge structure was carried out between May 14 and June 6, 2013 during which time a total of five boreholes were advanced at the location of the structure foundation footprints and approach embankments. In addition, Dynamic Cone Penetration Tests were carried out from the bottom of Borehole B1-02 and from the ground surface adjacent to Borehole B1-03 to determine the depth to refusal at

these locations. A summary of the respective boreholes advanced at each foundation element and approach embankment is presented below.

Foundation Unit	Borehole
South Approach Embankment	B1-01
South Abutment	B1-02
North Abutment	B1-03 and B1-05
North Approach Embankment	B1-04

The results of the borehole investigation and dynamic cone penetration tests are presented on the Record of Borehole sheets in Appendix A. The boreholes were advanced at the locations shown in plan on Drawing 2.

The field borehole investigation was carried out using a truck-mounted CME 55 drill rig supplied and operated by Landcore Drilling of Chelmsford, Ontario. The boreholes were advanced through the overburden using 120 mm and 203 mm outer diameter (O.D.) continuous flight hollow-stem augers and 'NW' casing. Soil samples were obtained at intervals of depth of about 0.75 m and 3.0 m, using a 50 mm outer diameter (O.D.) split-spoon sampler driven by an automatic hammer in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586 – Standard Test Method for Standard Penetration Test). Cobbles and boulders were cored using an 'NQ' size rock core barrel. The boreholes and DCPTs were advanced to depths of up to about 23.5 m and 25.4 m below existing ground surface, respectively. The DCPTs were terminated on refusal to further dynamic cone penetration.

The groundwater conditions in the open boreholes were observed during and upon completion of drilling operations, and a standpipe piezometer was installed in Borehole B1-04 to permit monitoring of the water level at that location. The piezometers consist of 38 mm diameter PVC pipe, with a slotted screen surrounded with sand sealed at a select depth within the borehole. The borehole and annulus surrounding the piezometer pipe above the screen and sand pack were backfilled to the surface with bentonite pellets/grout. Piezometer installation details and water level readings are described on the Record of Borehole sheets in Appendix A. All open boreholes were backfilled with cement grout by tremie technique upon completion and the piezometer in Borehole B1-04 was also abandoned with cement grout by tremie technique on May 15, 2013 in accordance with Ontario Regulation 903, Wells (as amended).

The field work was observed by a member of our engineering and technical staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling and sampling operations, logged the boreholes, and examined and cared for the soil samples. The soil samples were identified in the field, placed in appropriate containers, labelled and transported to our Mississauga geotechnical laboratory where samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Classification testing (water content, organic content, grain size distribution and Atterberg limits) was carried out on selected samples. The results of the laboratory testing are included in Appendix B.

The as-drilled borehole locations and ground surface elevations were surveyed by Tulloch. The locations given in the Record of Borehole sheets and shown on Drawing 2 are positioned relative to MTM NAD 83 northing and easting coordinates and the ground surface elevations are referenced to Geodetic datum. The borehole locations, ground surface elevations and drilled depths are summarized below.

Borehole	Location (MTM NAD 83)		Ground Surface Elevation	Borehole / DCPT Depth
	Northing	Easting		
B1-01	5035109.1	324438.5	322.6 m	8.2 m
B1-02	5035127.1	324448.4	322.5 m	19.8 m / 25.4 m
B1-03	5035139.4	324447.6	322.5 m	6.1 m / 18.9 m
B1-04	5035156.5	324456.9	322.5 m	9.8 m
B1-05	5035139.6	324452.1	322.5 m	23.5 m

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

As delineated in *The Physiography of Southern Ontario*[1], this section of Highway 592 lies within the physiographic region known as the "Number 11 Strip", with portions of Highway 592 in contact with the "Georgian Bay Fringe" region. The Number 11 Strip is a narrow belt that extends from Gravenhurst to North Bay and is characterized by deposits of sand, silt and clay, together with more recent swamp deposits between rock knobs and ridges. The bedrock in the area is typically highly deformed gneiss of the Moon River Domain of the Central Gneiss Belt, a subdivision of the Grenville Structural Province (Geology of Ontario, 1991)[2].

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced during this investigation, together with the results of the laboratory tests carried out on selected soil samples, are provided in Appendix A and B, respectively. The results of the in situ field tests (i.e. SPT 'N'-values) as presented on the Record of Borehole sheets and in Section 4.2 are uncorrected. The stratigraphic boundaries shown on the Record of Borehole sheets and on the profile and cross-section on Drawing 2 are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Test (SPTs). These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations. It should be noted that the interpreted stratigraphy shown on Drawing 2 is a simplification of the subsurface conditions.

In general, the subsurface conditions in the area of the proposed bridge structure consist of a surficial layer of asphalt over a deposit of fill associated with the Highway 592 embankments. The fill is underlain by a near surface layer of organic sand in places, and by deposits of silt and sand to sand and/or clayey silt. These deposits are in turn underlain by a deposit of sand and gravel to sandy gravel.

A detailed description of the subsurface conditions encountered in the boreholes at the abutments and approach embankments is provided in the following sections.

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

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

4.2.1 Asphalt

An approximately 25 mm to 90 mm thick layer of asphalt was encountered at the ground surface in all boreholes.

4.2.2 Fill

A fill deposit comprised of brown sand and gravel to gravelly sand to sand some gravel was encountered in all boreholes below the asphalt layer. The gravelly sand and sand some gravel portions of the fill contain trace to some silt, trace clay, organics. Pieces of wood were encountered within the fill deposit at the location of north abutment in Boreholes B1-03, B1-04 and B1-05, as shown on Figure B1 in Appendix B, and are inferred to be remnants of an existing corduroy roadbed. The top of the fill deposit is at between Elevations 322.5 m and 322.4 m and the thickness of the deposit ranges from 1.4 m to 3.7 m.

The SPT 'N'-values measured within the fill deposit range from 8 blows to 30 blows per 0.3 m of penetration, and 16 blows per 0.2 m of penetration, indicating a loose to compact relative density. In Boreholes B1-03 and B1-04, it is inferred that the split-spoon sampler was bouncing on wood pieces while obtaining the SPT 'N'-values for Samples 2 and 3, as such, the SPT 'N'-values are considered not representative of the fill material's relative density.

The natural water content measured on eight samples of the fill ranges from about 4 per cent to 27 per cent.

The organic content measured on two samples of fill is about 3 per cent and 7 per cent, with the greater organic content measured on a sample containing wood pieces.

The results of grain size distribution tests completed on four samples of the fill deposit are shown on Figure B2 in Appendix B.

4.2.3 Organic Sand

An approximately 0.8 m thick layer of dark brown organic sand, trace to some gravel, trace to some silt was encountered underlying the fill deposit in Borehole B1-05. The top of the deposit was encountered at Elevation 320.3 m

An SPT 'N'-value of 5 blows per 0.3 m of penetration was measured within this layer, indicating a loose relative density.

The natural water content measured on a sample of the organic sand layer is about 31 per cent.

The result of a grain size distribution test completed on a sample of the organic sand layer is shown on Figure B3 in Appendix B.

4.2.4 Silt and Sand to Sand

A deposit of non-cohesive soil comprised of brown to grey silt and sand to silty sand to sand trace to some silt was encountered underlying the fill deposit in Boreholes B1-01 and B1-02. The deposit contains trace to some clay and trace gravel as well as clayey silt seams within the upper 1.9 m portion of this deposit in Borehole B1-01. The top of the silt and sand to sand deposit is at Elevations 318.9 m and 319.5 m, and the

thickness of the deposit is 4.5 m and 2.6 m in Boreholes B1-01 and B1-02, respectively. Borehole B1-01 was terminated within this deposit at a depth of 8.2 m below ground surface (Elevation 314.4 m)

The SPT 'N'-values measured within this deposit range from 4 blows to 11 blows per 0.3 m of penetration, indicating a loose to compact relative density.

The natural water content measured on four samples of this deposit ranges from about 20 per cent and 24 per cent.

The results of grain size distribution tests completed on four samples of the deposit are shown on Figure B4 in Appendix B.

4.2.5 Clayey Silt

A deposit of grey clayey silt was encountered underlying the silt and sand deposit in Borehole B1-02, below the fill deposit in Borehole B1-03 and below the organic sand layer in Borehole B1-05. The deposit generally contains trace to some sand. The top of the clayey silt deposit was encountered between Elevations 319.5 m and 316.9 m and the thickness of deposit varies between 1.3 m and 2.6 m.

The SPT 'N'-values measured within this deposit range from about 3 blows to 7 blows per 0.3 m of penetration, suggesting a soft to firm consistency.

The natural water content measured on five samples of the deposit ranges from about 25 per cent to 36 per cent.

The results of grain size distribution tests completed on two samples of the clayey silt deposit are shown on Figure B5 in Appendix B.

Atterberg limits tests were carried out on three samples of the clayey silt deposit and measured liquid limits ranging from about 26 per cent to 31 per cent, plastic limits ranging from about 17 per cent to 21 per cent and plasticity indices ranging from about 9 per cent to 10 per cent. The results of Atterberg limits tests are shown on plasticity chart on Figure B6 in Appendix B and indicate that the material is classified as clayey silt of low plasticity.

4.2.6 Sand and Gravel to Sandy Gravel

A deposit of brown to grey sand and gravel to sandy gravel was encountered underlying the clayey silt deposit in Boreholes B1-02, B1-03 and B1-05 and below the organic sand layer in Borehole B1-04. The top of the deposit ranges from Elevations 319.5 m to 314.3 m and the thickness of the deposit ranges from 0.9 m to 19.2 m. Boreholes B1-02 to B1-05 were terminated within this deposit between Elevations 316.4 m and 299.0 m. The DCPTs advanced from the bottom of the sampled Borehole B1-02 (at a depth of 19.8 m below ground surface (Elevation 302.7 m)) and adjacent to Borehole B1-03 penetrated 5.6 m and 13.7 m into this deposit (based on the resistance to dynamic cone penetration) and is inferred to terminate within this deposit at a depth of 25.4 m and 18.9 m below ground surface (Elevations 297.1 m and 303.6 m), respectively.

The sand and gravel to sandy gravel deposit generally contains trace to some silt, trace clay and the upper 0.9 m portion of the deposit contains clayey silt seams in Borehole B1-05. Cobbles and/or boulders were encountered at varying depths throughout the deposit and were cored using an 'NQ' size rock core barrel as

summarized below. In general, the sizes range from about 107 mm to 671 mm. The photographs of the recovered cobbles and boulders are shown on Figure B7 in Appendix B.

Foundation Element/ Approach Embankment	Borehole	Top Elevation of Cored Cobbles and/or Boulders	Thickness
South Abutment	B1-02	313.0 m 311.8 m 309.4 m 307.7 m 304.1 m	0.9 m 1.5 m 0.3 m 0.4 m 1.4 m
North Abutment	B1-05	317.3 m 315.5 m 311.2 m 309.4 m 306.3 m 304.7 m	0.7 m 0.6 m 0.9 m 0.3 m 0.6 m 0.5 m
North Approach Embankment	B1-04	317.2 m 315.5 m	0.8 m 0.3 m

The SPT 'N'-values measured within the sand and gravel to sandy gravel deposit typically range from about 10 blows to 46 blows per 0.3 m of penetration, indicating a compact to dense relative density. SPT 'N'-values of about 34 blows to 50 blows per 0.15 m of penetration were recorded prior to split-spoon sampler refusal on cobbles and boulders within this deposit. The DCPT advanced from the bottom of Borehole B1-02 extends to effective refusal at 30 blows per 0.13 m of penetration and noticeable bouncing of the drive hammer, while the DCPT advanced adjacent to Borehole B1-03 encountered effective refusal at greater than 137 blows per 0.3 m of penetration. The Total Core Recovery of the cored cobbles/boulders samples generally ranges between about 20 per cent and 100 per cent, except in few instances where percentage of recovery was not recorded.

The natural water content measured on ten samples of the deposit ranges from about 6 per cent to 14 per cent.

The results of grain size distribution tests completed on six samples of the sand and gravel to sandy gravel deposit are shown on Figure B8 in Appendix B.

4.3 Groundwater Conditions

In general, the soil samples taken in the boreholes were moist to wet. During the drilling operations, artesian groundwater conditions were noted in Boreholes B1-02 and B1-05 when advancing the casing between depths of 5.2 m and 22.3 m below ground surface (between Elevations 317.3 m and 300.2 m) and in Borehole B1-03 upon completion of the dynamic cone penetration test at a depth of 18.9 m below ground surface (Elevation 303.6 m). The series of groundwater levels recorded in the drill casing during and upon completion of drilling/penetration were measured at depths ranging from 0.3 m to 0.8 m above ground surface (Elevations 322.8 m to 323.3 m). The groundwater levels measured in the open boreholes upon completion of drilling range from about 1.0 m to 1.6 m below ground surface (Elevations 321.5 m and 321.0 m) and 0.8 m above ground surface (Elevation 323.3 m).

A standpipe piezometer was installed in Borehole B1-04 to allow monitoring of the groundwater level at the site. The water level in the piezometer was monitored for five hours upon completion of the installation and then the piezometer was decommissioned. Details of the piezometer installation are shown on the Record of Borehole No. B1-04 in Appendix A, and the groundwater level measured in the piezometer is summarized below.

Borehole	Ground Surface Elevation	Depth to Water Level	Groundwater Elevation	Date of Measurement
B1-04	322.5 m	-0.1 m	322.6 m [1]	May 15, 2013

Notes:
1. Artesian Conditions

It should be noted that groundwater levels in the area are subject to seasonal fluctuations and precipitation events, and should be expected to be higher during wet periods of the year.

5.0 CLOSURE

Mr. Indulis Dumpis, a senior technician with Golder, directed the drilling program. This report was prepared by Mr. Al Varshoi, M.E.Sc., and reviewed by Ms. Veronica Ayetan, P.Eng., a geotechnical engineer with Golder. Mr. Jorge M. A. Costa, P.Eng., Golder's Designated MTO Contact for this project and Principal with Golder, conducted an independent quality control review of the report.

Report Signature Page

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Designated MTO Contact, Principal

AV/TVA/CN/JMAC/sm

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DRAWINGS

MINISTRY OF TRANSPORTATION, ONTARIO

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

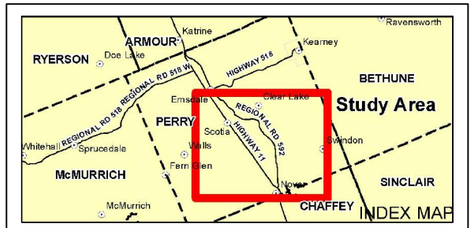
CONT No.
WP No. 5265-07-01

HIGHWAY 592
REPLACEMENT OF SIX STRUCTURES
KEY MAP

SHEET

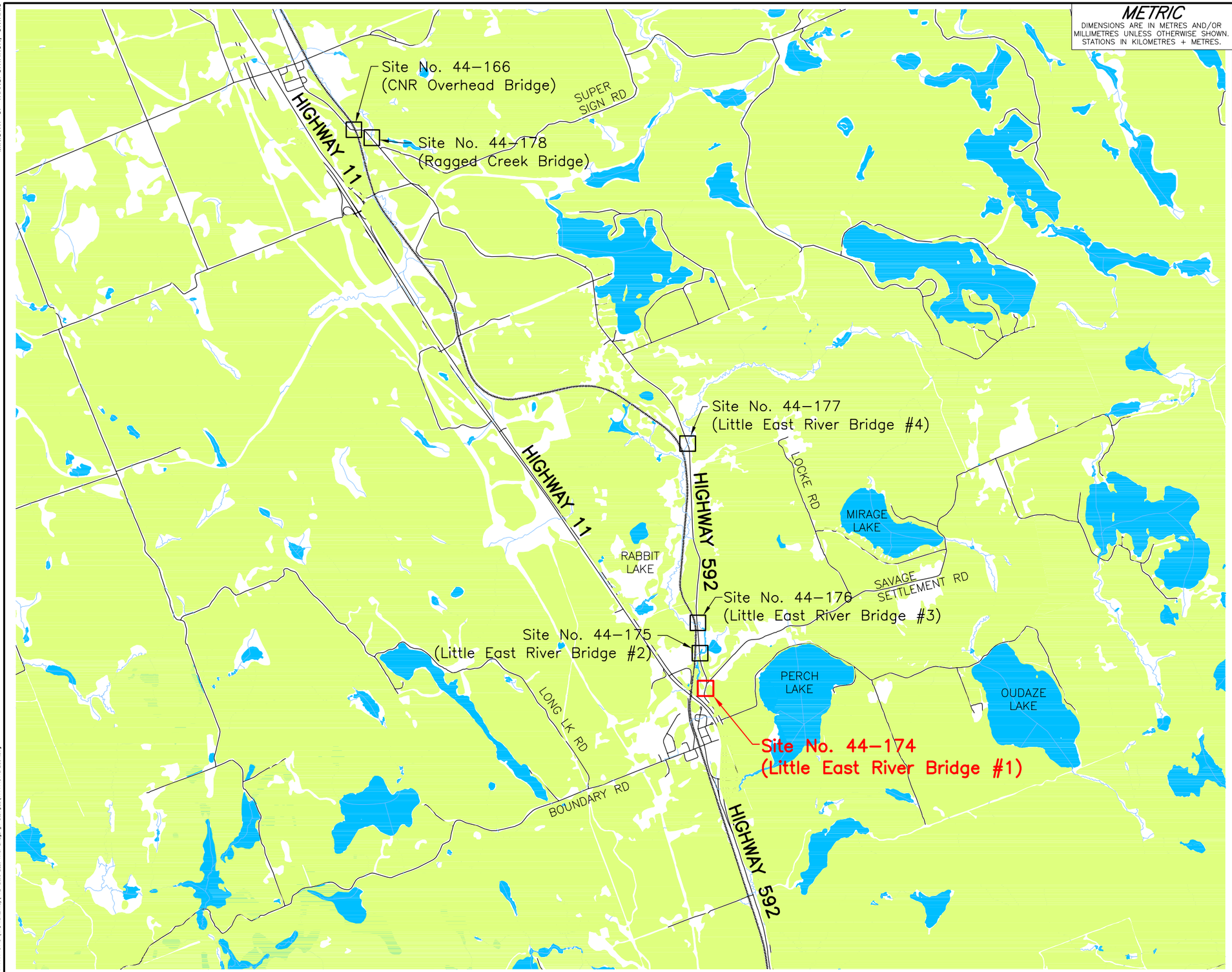
Golder Associates

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



INDEX MAP

N.T.S



PLAN
SCALE
500 0 500 1000m

REFERENCE

Base data – MNR NRVIS, obtained 2004, CANMAP v2006.4 Produced by Golder Associates Ltd. under licence from Ontario Ministry of Natural Resources

NO.	DATE	BY	REVISION

Geocres No. 31E-330

HWY. 592	PROJECT NO. 11-1111-0149		DIST.
SUBM'D. AV	CHKD. CN	DATE: Dec. 2013	SITE:
DRAWN: JFC	CHKD.	APPD.	DWG. 1

PLOT DATE: December 23, 2013
FILENAME: I:\Projects\2011\11-1111-0149 (Mnl, Huntsville)\-KB-Little East River Bridge #1 Stamped\11111101490001.dwg

MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

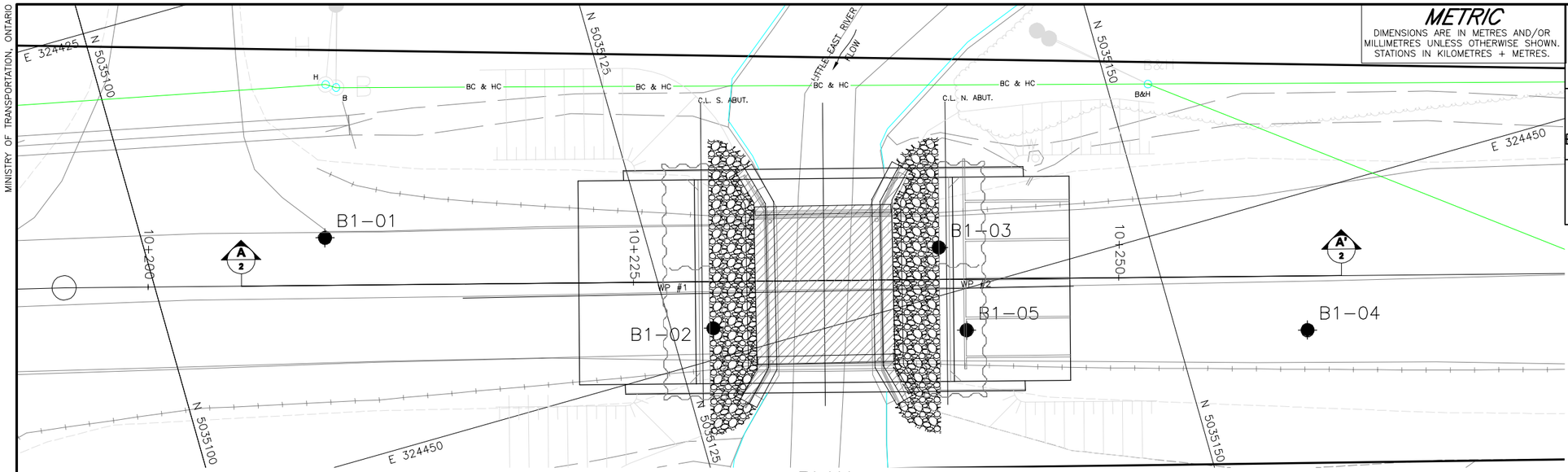
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WP No. 5265-07-01

HIGHWAY 592
LITTLE EAST RIVER BRIDGE #1
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



PLAN

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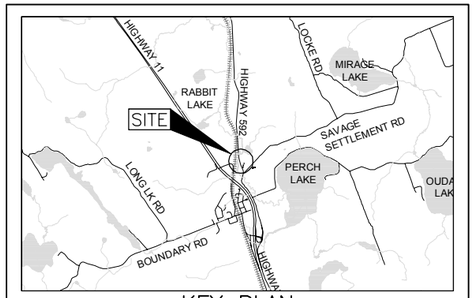

KEY PLAN

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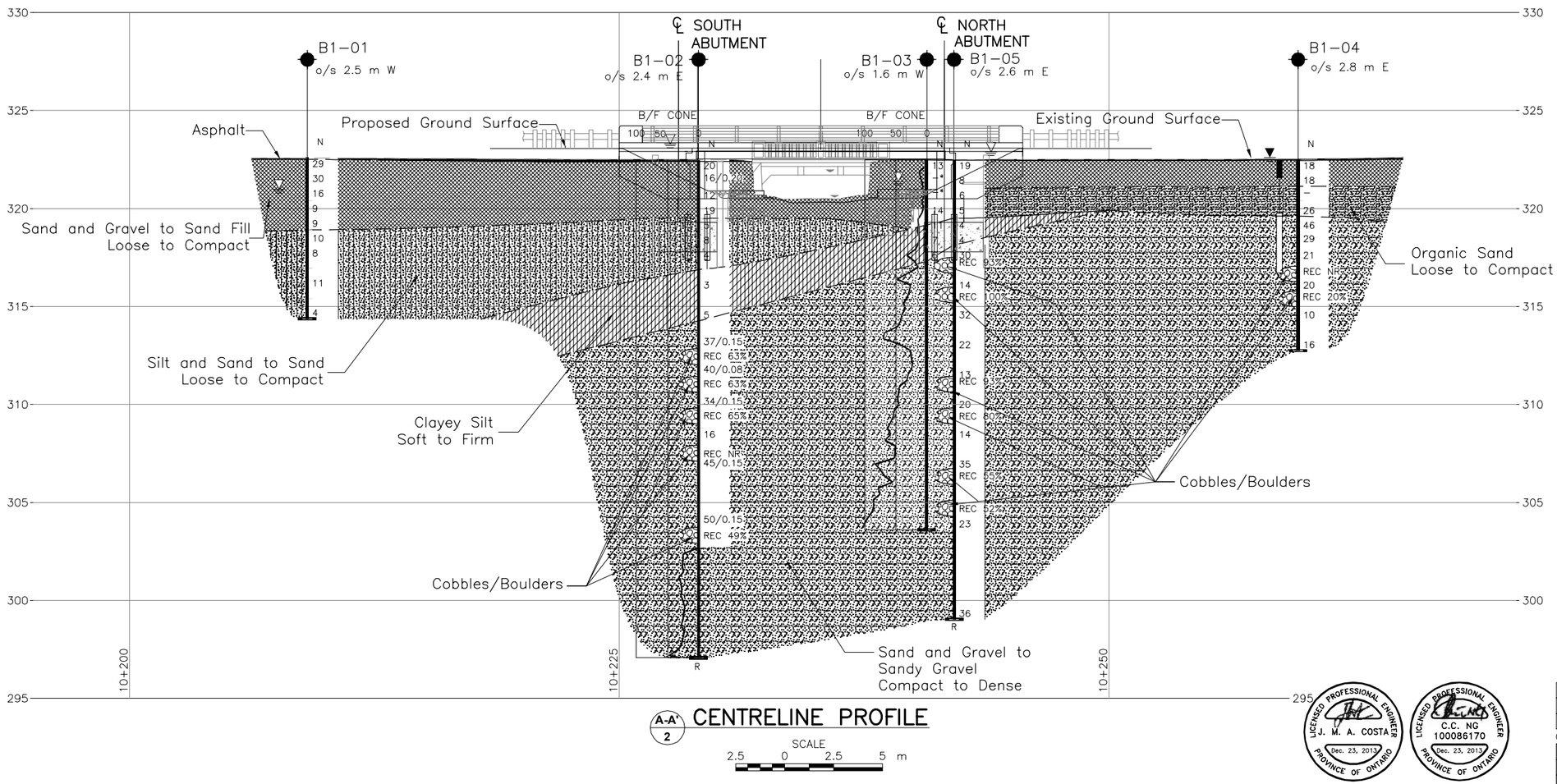

A-A' 2 CENTRELINE PROFILE

SCALE
2.5 0 2.5 5 m

LEGEND

- Borehole – Current Investigation
- Seal
- Piezometer
- N — Standard Penetration Test Value
- 16 — Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- REC — Total core recovery
- WL in piezometer, measured on May 14, 2013
- WL upon completion of drilling
- R — Refusal

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
B1-01	322.6	5035109.1	324438.5
B1-02	322.5	5035127.1	324448.4
B1-03	322.5	5035139.4	324447.6
B1-04	322.5	5035156.5	324456.9
B1-05	322.5	5035139.6	324452.1

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 MH, drawing file nos. X1114246_44-174_44-175_44-176align.dwg, x1114246_44177align.dwg, x1114246_44178_44166align.dwg and X1114246_44-174_44-175_44-176base.dwg, x1114246_44177base.dwg and x1114246_44178_44166base.dwg, received June 11, 2013 and General Arrangement Plan and Profile file no. 44174-01.dwg, received November 07, 2013.

LICENSED PROFESSIONAL ENGINEER
J. M. A. COSTA
Dec. 23, 2013
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
C.C. NG
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Dec. 23, 2013
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NO.	DATE	BY	REVISION

Geocres No. 31E-330

HWY. 592		PROJECT NO. 11-1111-0149	DIST.
SUBM'D. AV	CHKD. TVA	DATE: Dec. 2013	SITE: 44-174
DRAWN: JFC	CHKD.	APPD. CN/JMAC	DWG. 2

PLOT DATE: December 23, 2013
FILENAME: I:\Projects\2011\T-1111-0149 (Mnr, Huntsville)\-RB-Little East River Bridge #1 Stamped\1111101494B002.dwg

APPENDIX A

Record of Borehole Sheets

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
υ	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
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)

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

(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 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

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 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) Non-Cohesive (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.

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))	Sand and Gravel
	or With (cohesive)	Silty Clay with sand / Clayey Silt with sand

Golder Associates

RECORD OF BOREHOLE No B1-01

SHEET 1 OF 1 **METRIC**

PROJECT 11-1111-0149
W.P. 5265-07-01
LOCATION N 5035109.1 ;E 324438.5
ORIGINATED BY ID
DIST HWY 592
BOREHOLE TYPE 120 mm O.D. Hollow Stem Augers and NW Casing
COMPILED BY AV
DATUM Geodetic
DATE May 21, 2013
CHECKED BY TVA

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 (20 40 60 80 100): ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
322.6	GROUND SURFACE										
0.0	Asphalt (90 mm)										
0.1	Sand and gravel (FILL) Compact Brown Moist		1	SS	29		322				
			2	SS	30				○		
321.2											
1.4	Sand, some gravel, trace silt, trace organics (FILL) Loose to compact Brown Wet		3	SS	16	▽	321				
			4	SS	9		320		○		14 84 (2)
			5	SS	9						
318.9							319				
3.7	SILT and SAND, trace gravel, trace clay, containing clayey silt seams Loose Brown Wet		6	SS	10						
			7	SS	8		318		○		2 63 30 5
317.0							317				
5.6	SAND, trace gravel, trace to some silt Compact Brown Wet		8	SS	11				○		1 89 (10)
315.4							316				
7.2	Silty SAND, trace to some clay Loose Grey Wet		9	SS	4		315		○		0 64 29 7
314.4											
8.2	END OF BOREHOLE										

NOTE:

1. Water level at a depth of 1.6 m below ground surface (Elev. 321.0 m) upon completion of drilling.

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

Golder Associates

RECORD OF BOREHOLE No B1-02

SHEET 1 OF 2

METRIC

PROJECT 11-1111-0149
W.P. 5265-07-01
DIST HWY 592
DATUM Geodetic

LOCATION N 5035127.1 ;E 324448.4
BOREHOLE TYPE 203 mm O.D. Hollow Stem Augers and NW Casing
DATE May 15, 2013

ORIGINATED BY ID
COMPILED BY AV
CHECKED BY TVA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"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 (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
322.5	GROUND SURFACE										
0.0	Asphalt (90 mm)										
0.1	Sand and gravel (FILL) Compact Brown Moist to wet		1	SS	20		322				
			2	SS	16/0.20						
			3	SS	12		321		○		
			4	SS	19		320				
319.5											
3.0	SILT and SAND, trace to some clay Loose Brown becoming grey below a depth of 3.7 m Wet		5	SS	5		319				
			6	SS	8				○		0 41 51 8
			7	SS	4		318				
316.9							317				
5.6	CLAYEY SILT, trace sand Soft to firm Grey Wet		8	SS	3		316		○		
			9	SS	5		315		⊢○		0 5 65 30
314.3											
8.2	SAND and GRAVEL, trace to some silt Dense Grey Wet		10	SS	37/0.15		314				
	Artesian condition encountered when advanced casing to a depth of 9.1 m, water level recorded at 0.3 m above ground surface.		3	RC	REC 63%		313				
	Cobbles encountered between depths of 9.5 m and 10.4 m.						312				
	Cobbles and boulders encountered between depths of 10.7 m and 12.2 m.		11	SS	40/0.08						
			4	RC	REC 63%		311				
			12	SS	34/0.15		310		○		51 38 (11)
	Artesian condition encountered when advanced casing to a depth of 12.8 m, water level recorded at 0.5 m above ground surface. Cobbles encountered between depths of 13.1 m and 13.4 m.		5	RC	REC 65%						
308.8							309				
13.7	Sandy GRAVEL, trace silt Compact to dense Grey Wet		13	SS	16						
			6	RC	NR		308				

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No B1-02

SHEET 2 OF 2 **METRIC**

PROJECT 11-1111-0149
W.P. 5265-07-01
DIST HWY 592
DATUM Geodetic

LOCATION N 5035127.1 ;E 324448.4
BOREHOLE TYPE 203 mm O.D. Hollow Stem Augers and NW Casing
DATE May 15, 2013

ORIGINATED BY ID
COMPILED BY AV
CHECKED BY TVA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---							20 40 60 80 100	20 40 60		
	Artesian condition encountered when advanced casing to a depth of 14.3 m, water level recorded at 0.6 m above ground surface.		6	RC	NR						
			14	SS	45/0.15		307		○		69 26 (5)
	Cobbles encountered between depths of 14.8 m and 15.2 m.						306				
	Artesian condition encountered when advanced casing to a depth of 15.8 m, water level recorded at 0.8 m above ground surface.						305				
			15	SS	50/0.15		304				
	Cobbles encountered between depths of 18.4 m and 19.8 m.		7	RC	REC 49%		303				
302.7											
19.8	END OF BOREHOLE Dynamic Cone Penetration Test (DCPT)						302				
							301				
							300				
							299				
							298				
297.1											
25.4	END OF DCPT Refusal to Further Penetration (30 Blows / 0.13 m)										

NOTES:

1. Artesian conditions encountered during drilling:

Date	Depth (m) Water/Casing	W.L. Elev. (m)
05/15/13	-0.3/9.1	322.8
05/16/13	-0.5/12.8	323.0
05/16/13	-0.6/14.3	323.1
05/16/13	-0.8/15.8	323.3

NR - Not Recorded

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

Golder Associates

RECORD OF BOREHOLE No B1-03

SHEET 1 OF 2

METRIC

PROJECT 11-1111-0149
W.P. 5265-07-01
LOCATION N 5035139.4 ;E 324447.6
ORIGINATED BY ID
DIST HWY 592
BOREHOLE TYPE 120 mm O.D. Hollow Stem Augers and NW Casing
COMPILED BY GRL/AV
DATUM Geodetic
DATE June 3, 2013
CHECKED BY TVA

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 (20 40 60 80 100): ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
322.5	GROUND SURFACE						322				
0.0	Asphalt (25 mm)										
	Sand and gravel (FILL) Compact Brown		1	SS	13						
321.8											
0.7	Moist		2	SS	-*	▽	321		○		
	Sand, some gravel, trace silt (FILL) Compact Grey Wet		3	SS	-*						
	Pieces of wood between depths of 1.1 m and 2.1 m inferred to be remnant of Corduroy Road..		4	SS	14		320				
318.8			5	SS	11		319		○		18 79 1 2
3.7	CLAYEY SILT, trace to some sand Firm Grey Wet		6	SS	7				○		
317.3			7	SS	6		318		⊢○		0 8 65 27
5.2	SAND and GRAVEL						317				
316.4							316				
6.1	END OF BOREHOLE (Loss of water in casing)						315				
							314				
							313				
							312				
							311				
							310				
							309				
							308				

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No B1-03

SHEET 2 OF 2 **METRIC**

PROJECT 11-1111-0149
W.P. 5265-07-01
DIST HWY 592
DATUM Geodetic

LOCATION N 5035139.4 ;E 324447.6
BOREHOLE TYPE 120 mm O.D. Hollow Stem Augers and NW Casing
DATE June 3, 2013

ORIGINATED BY ID
COMPILED BY GRL/AV
CHECKED BY TVA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	END OF BOREHOLE (Loss of water in casing)						307 306 305 304				
303.6 18.9	END OF DCPT Refusal to Further Penetration (137 Blows / 0.3 m)							137			

NOTES:

1. Borehole terminated upon loss of water head in drill string.

2. Artesian condition encountered upon completion of DCPT and removal of the penetration cone, water flowing from ground surface.

3. Water level in open borehole measured at a depth of 1.1 m below ground surface (Elev. 321.4 m) upon completion of drilling.

4. A dynamic cone penetration test was advanced 1.5m north of Borehole B1-03 to confirm refusal.

* Split-spoon sampler bouncing on wood pieces; N-value not representative of soil relative density.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED; 20 40 60 80 100
WATER CONTENT (%): 20 40 60

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

Golder Associates

RECORD OF BOREHOLE No B1-04

SHEET 1 OF 1 **METRIC**

PROJECT 11-1111-0149
W.P. 5265-07-01
LOCATION N 5035156.5 ;E 324456.9
ORIGINATED BY ID
DIST HWY 592
BOREHOLE TYPE 203 mm O.D. Hollow Stem Augers and NW Casing
COMPILED BY AV
DATUM Geodetic
DATE May 14 and 15, 2013
CHECKED BY TVA

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 (○ 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 (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
322.5	GROUND SURFACE										
0.0	Asphalt (40 mm)										
0.1	Sand and gravel (FILL) Compact Brown Moist		1	SS	18		322				
321.1			2	SS	18						
1.4	Sand, some silt, some gravel, trace clay (FILL) Compact Dark brown Wet		3A 3B	SS	-*		321		○	OC = 6.7 %	12 68 16 4
	Pieces of wood at a depth of 1.7 m inferred to be remnant of Corduroy Road.		4	SS	26		320		○	OC = 2.8 %	
319.5											
3.0	SAND and GRAVEL, trace silt, trace clay Compact to dense Brown Wet		5	SS	46		319		○		
			6	SS	29						
			7	SS	21		318		○		43 51 (6)
	Cobbles encountered between depths of 5.3 m and 6.1 m.		1	RC	REC NR		317				
			8	SS	20						
	Cobbles encountered between depths of 7.0 m and 7.3 m.		2	RC	REC 20%		316				
			9	SS	10		315				
							314				
			10	SS	16		313		○		42 53 4 1
312.8											
9.8	END OF BOREHOLE										

NOTES:

1. Water level in open borehole at a depth of 1.0 m below ground surface (Elev. 321.5 m) upon completion of drilling.

2. Water level measurements in Piezometer:

Date	Depth (m)	Elev. (m)
05/15/13	-0.1**	322.6

3. Water level in piezometer monitored for 5 hours with pumping test carried out to confirm the water level; piezometer decommissioned on May 15, 2013 upon completion of monitoring.

NR - Not Recorded

* Split-spoon sampler bouncing on wood pieces; N-value is not representative of soil relative density.

$+^3, \times^3$: Numbers refer to Sensitivity

$\circ^{3\%}$ STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No B1-05

SHEET 1 OF 2

METRIC

PROJECT 11-1111-0149
W.P. 5265-07-01
LOCATION N 5035139.6 ;E 324452.1
ORIGINATED BY ID
DIST HWY 592
BOREHOLE TYPE 120 mm O.D. Hollow Stem Augers and NW Casing
COMPILED BY GRL/AV
DATUM Geodetic
DATE June 4 to 6, 2013
CHECKED BY TVA

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 (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
322.5	GROUND SURFACE										
0.0	Asphalt (25 mm)										
	Gravelly sand, trace to some silt, trace clay, trace organics (FILL) Loose to compact Brown to dark brown Moist to wet		1	SS	19		322				
			2	SS	8				○		27 61 10 2
	Pieces of wood between depths of 1.8 m and 2.1 m inferred to be remnat of Corduroy Road.		3	SS	6		321				
320.3											
2.2	ORGANIC SAND, trace to some gravel, trace to some silt Loose Dark brown Wet		4	SS	5		320		○		11 78 9 2
319.5											
3.0	CLAYEY SILT, trace to some sand Firm Grey Wet		5	SS	4		319		⊢○		
			6A 6B	SS	4						
318.2											
4.3	SAND and GRAVEL, trace to some silt, containing clayey silt seams to a depth of 5.2 m Compact to dense Brown Wet		7	SS	30		318				
	Artesian condition encountered when advanced casing to a depth of 5.2 m, water flowing from around the casing.		1	RC	REC 93%		317				
	Cobbles encountered between depths of 5.2 m and 5.9 m.		8	SS	14		316				
	Cobbles encountered between depths of 7.0 m and 7.6 m.		2	RC	REC 100%		315				
			9	SS	32				○		
	Artesian condition continues to a depth of 9.1 m, water level recorded at 0.4 m below ground surface.		10	SS	22		314				
			11	SS	13		313				
	Cobbles encountered between depths of 11.3 m and 12.2 m.		3	RC	REC 93%		312				
			12	SS	20		311		○		39 54 6 1
	Cobbles encountered between depths of 13.1 m and 13.4 m.		4	RC	REC 80%		310				
			13	SS	14		309				
							308				

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

Golder Associates

RECORD OF BOREHOLE No B1-05

SHEET 2 OF 2 **METRIC**

PROJECT 11-1111-0149
W.P. 5265-07-01
DIST ____ HWY 592
DATUM Geodetic

LOCATION N 5035139.6 ;E 324452.1
BOREHOLE TYPE 120 mm O.D. Hollow Stem Augers and NW Casing
DATE June 4 to 6, 2013

ORIGINATED BY ID
COMPILED BY GRL/AV
CHECKED BY TVA

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 (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	SAND and GRAVEL, trace to some silt, containing clayey silt seams to a depth of 5.2 m Compact to dense Brown Wet										
			14	SS	35		307	○	○		
	Artesian condition noted at a depth of 15.2 m, water flowing from around the casing.										
			5	RC	REC 55%		306				
	Cobbles encountered between depths of 16.2 m and 16.8 m.										
							305				
	Cobbles encountered between depths of 17.8 m and 18.3 m.		6	RC	REC 52%						
			15	SS	23		304		○		38 57 4 1
							303				
							302				
							301				
	Artesian condition encountered at a depth of 22.3 m, water level recorded at 0.4 m above ground surface.						300				
299.0			16	SS	36				○		
23.5	END OF BOREHOLE										

NOTES:

1. Water level in open borehole at a depth of 1.1 m below ground surface (Elev. 321.4 m) during drilling, measured on June 4, 2013.

2. Artesian conditions encountered during drilling:

Date	Depth (m) Water/Casing	W.L. Elev. (m)
06/05/13	-*/5.2	-*
06/05/13	-0.4/9.8	322.9
06/06/13	-*/15.2	-*
06/06/13	-0.4/22.3	322.9

* Water flowing around casing.

3. water level in open borehole at a depth of 0.3 m above ground surface (Elev. 322.8 m) upon completion of drilling.

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

APPENDIX B

Laboratory Test Results and Bedrock Core Photographs

Boreholes B1-03, B1-04 and B1-05

Borehole B1-03 Sample 3 | Borehole B1-05 Sample 3 | Borehole B1-04 Sample 3

REVISION DATE: April 13, 2011 BY: TVA Project: 09-1111-6014

PROJECT	**Little East River Bridge No.1 Highway 592 GWP 5265-07-00; WP 5265-07-01**
TITLE	**Wood Pieces Photograph – B1-02, B1-04 and B1-05 Highway 592**

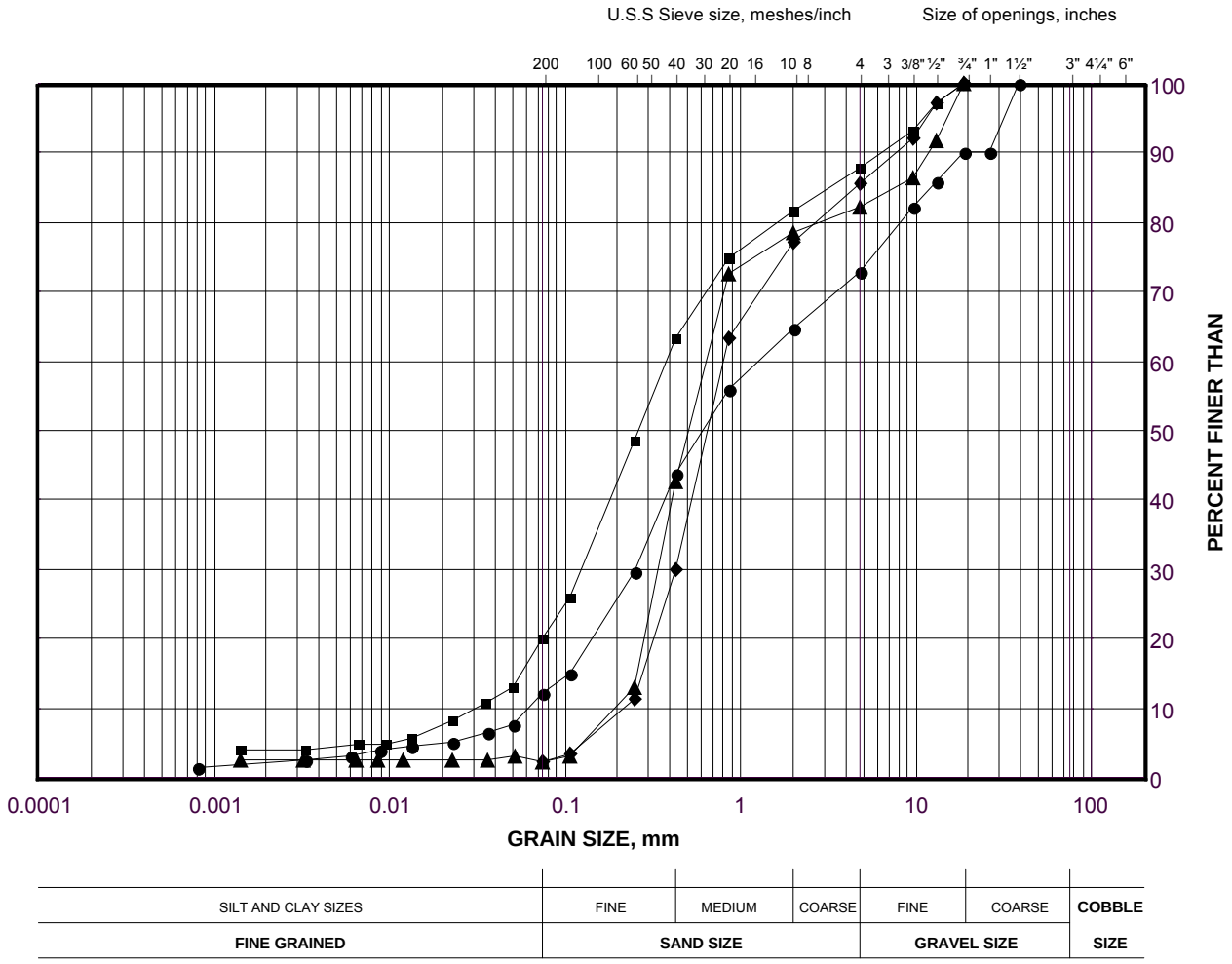
Golder Associates

PROJECT No. 11-1111-0149			FILE No. ----		
DESIGN	AV	AUG 13	SCALE	NTS	REV.
CADD	-- --		**FIGURE B1**		
CHECK	TZ	AUG 13			
REVIEW	JMAC	AUG 13			

GRAIN SIZE DISTRIBUTION

Sand to Gravelly Sand (Fill)

FIGURE B2



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	B1-05	2	321.4
■	B1-04	3A	320.8
◆	B1-01	4	320.0
▲	B1-03	5	319.1

Project Number: 11-1111-0149

Checked By: AV

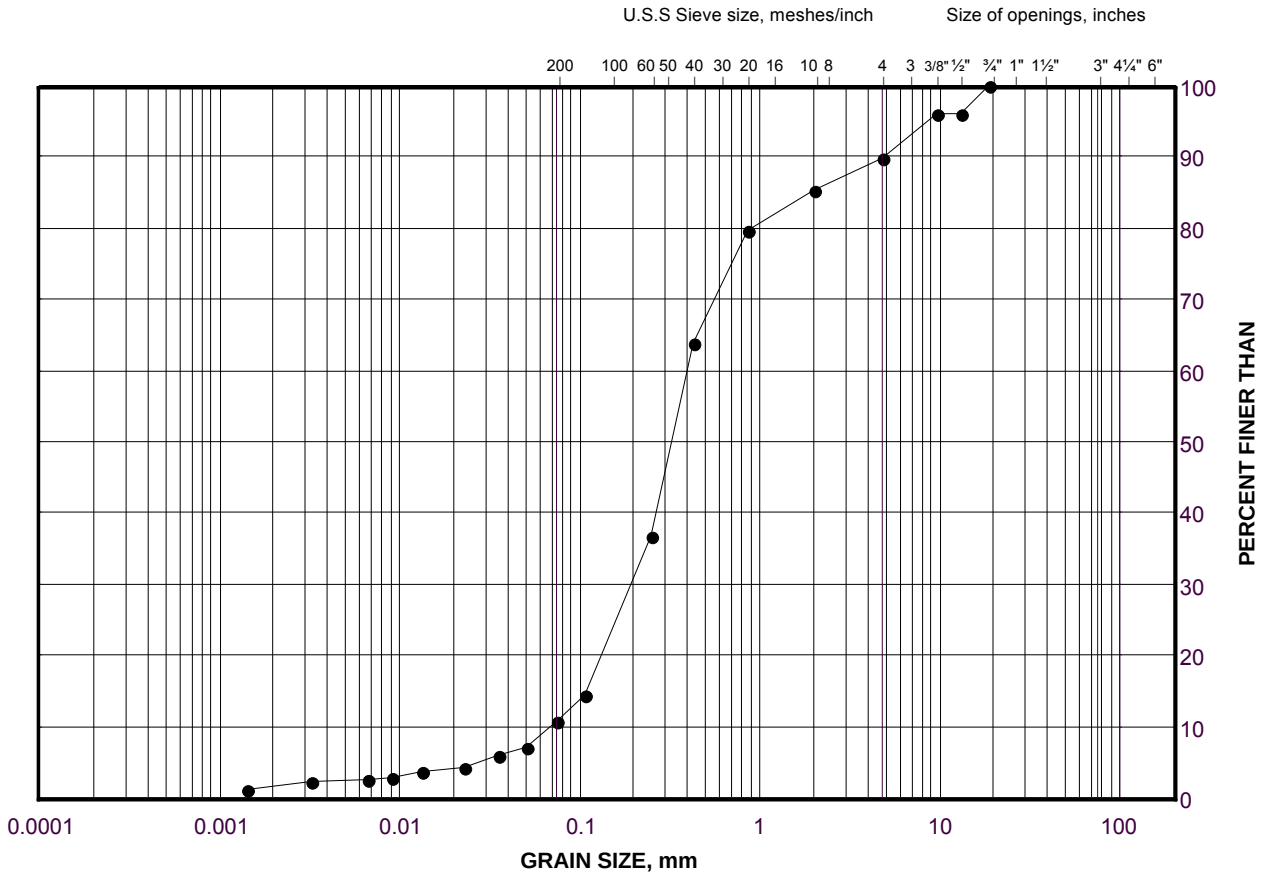
Golder Associates

Date: 21-Oct-13

GRAIN SIZE DISTRIBUTION

Organic Sand

FIGURE B3



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	B1-05	4	319.9

Project Number: 11-1111-0149

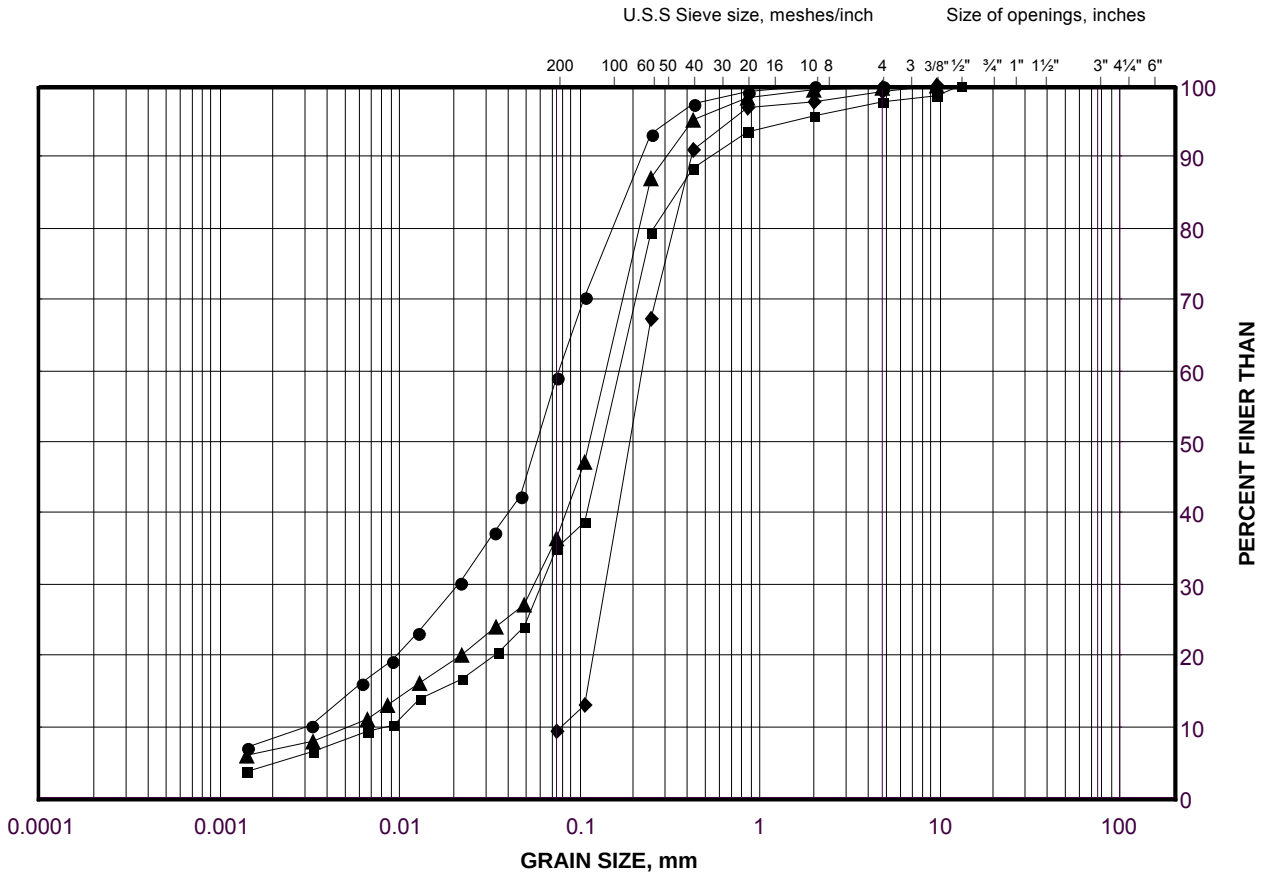
Checked By: AV

Golder Associates

Date: 21-Oct-13

GRAIN SIZE DISTRIBUTION
Silt and Sand to Sand

FIGURE B4



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	B1-02	6	318.4
■	B1-01	7	317.7
◆	B1-01	8	316.2
▲	B1-01	9	314.7

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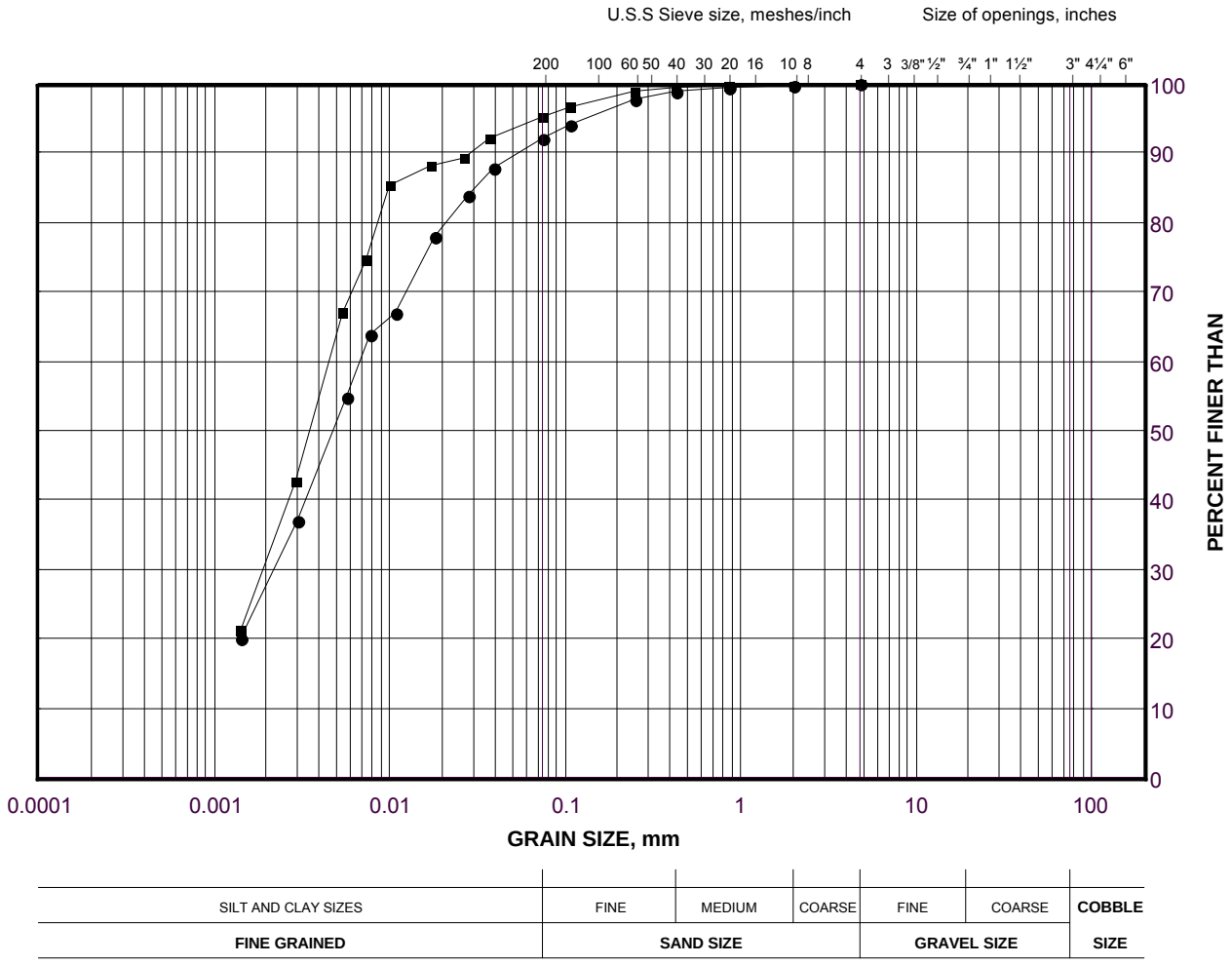
Date: 07-Aug-13

GRAIN SIZE DISTRIBUTION
Clayey Silt

FIGURE B5



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	B1-03	7	317.6
■	B1-02	9	314.6

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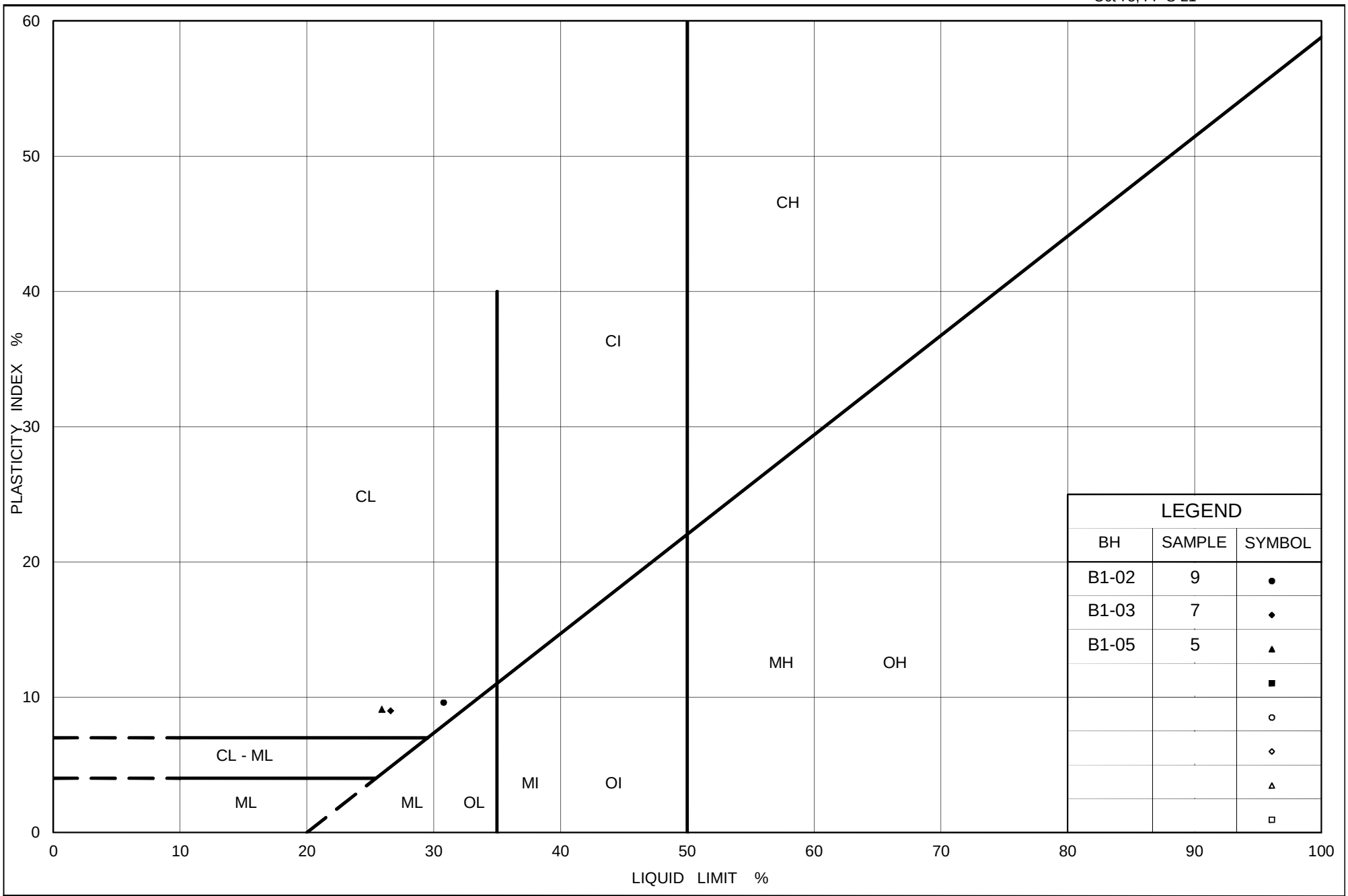

Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt

Figure No. B6

Project No. 11-1111-0149

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Boreholes B1-02 and B1-05

0 m	0.25 m	0.5 m	0.75 m	1.0 m	1.25 m	1.5 m
0 ft	1 ft	2 ft	3 ft	4 ft	5 ft	

Scale

PROJECT
Little East River Bridge No.1
Highway 592
GWP 5265-07-00; WP 5265-07-01

TITLE
Cobbles and Boulders Photograph – B1-02 and B1-05
Highway 592

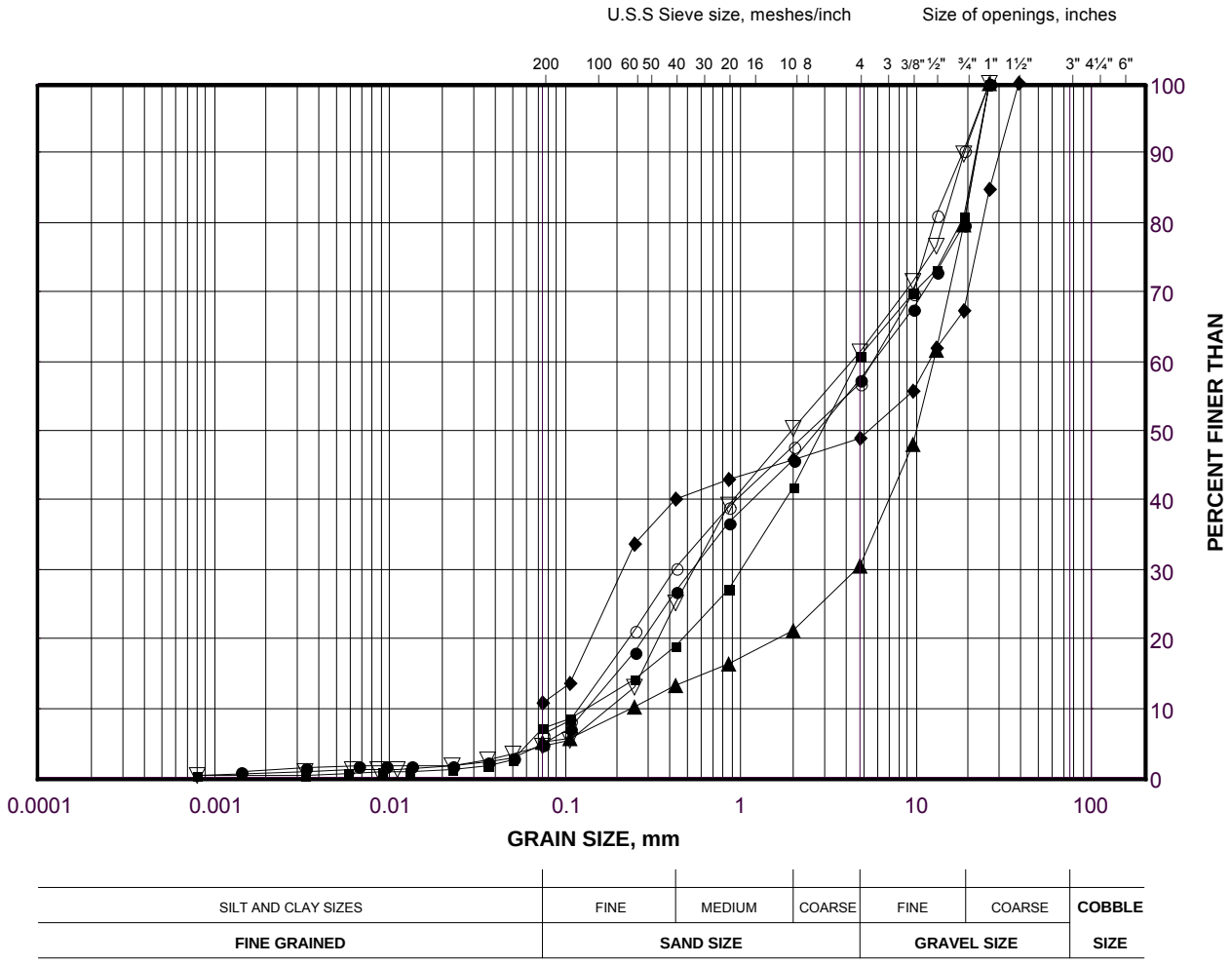
Golder Associates

PROJECT No. 11-1111-0149			FILE No. ----		
DESIGN	AV	AUG 13	SCALE	NTS	REV.
CADD	-- --				
CHECK	TVA	AUG 13	**FIGURE B7**		
REVIEW	JMAC	AUG 13			

REVISION DATE: April 13, 2011 BY: TVA Project: 09-1111-6014

GRAIN SIZE DISTRIBUTION
Sand and Gravel to Sandy Gravel

FIGURE B8



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	B1-04	10	313.1
■	B1-05	12	310.0
◆	B1-02	12	310.2
▲	B1-02	14	307.1
▽	B1-05	15	303.9
❍	B1-04	7	317.6

Project Number: 11-1111-0149

Checked By: AV

Golder Associates

Date: 07-Aug-13

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